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A FURTHER CONTRIBUTION  
ON THE  
BIOLOGY OF *HYPODERMA*  
*LINEATUM*

By

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HONOURABLE MARTIN BURRELL,  
Minister of Agriculture,

Sir,

I have the honour to submit to you a report entitled "A Further Contribution on the Biology of *Hypoderma Lineatum*," by S. Hadwen, D.V.Sc., of the Veterinary Research Laboratory, Agassiz, B.C., and request that it be printed as Bulletin No. 21.

I have the honour to be,

Sir,

Your obedient servant,

F. TORRANCE,

*Veterinary Director-General.*

OTTAWA, 11th March, 1916.

# A Further Contribution on the Biology of *Hypoaerma Lineatum*.

(SEYMOUR HADWEN, D.V. Sc.)

AGASSIZ, B.C.

## SEASONAL PREVALENCE of *H. Lineatum* in 1915.

The following table gives the number of flies captured in April and May, the dates on which they were captured, and the meteorological record of these months:—

Date.	No. of Flies Taken.	Sunshine.		Temperature.		Rain.
		hrs.	min.	min.	max. ° F.	in.
April 15..	Two ♀ <i>H. lineatum</i> taken out of doors.....	10	30	39	74	
" 16..	.....	10	36	38	76	
" 17..	.....	9	42	35	75	
" 18..	.....	Dull.		37	74	
" 19..	.....	Dull.		36	66	
" 20..	.....	1	54	37	64	0.04
" 21..	.....	Dull.		35	71	
" 22..	Three ♀ <i>H. lineatum</i> taken.....	7	12	33	70	
" 23..	Two " ".....	6	42	31	69	
" 24..	One " ".....	3	54	36	70	
" 25..	.....	8	00	38	66	
" 26..	.....	5	48	42	60	
" 27..	Three ♀ <i>H. lineatum</i> taken.....	5	42	39	64	
" 28..	Three " ".....	Dull.		33	68	
" 29..	.....	9	48	31	56	0.03
" 30..	Flies seen at 11 a.m. cold wind.....	Dull.		36	58	
May 1..	.....		48	35	64	
" 2..	One ♀ <i>H. lineatum</i> caught.....	8	24	40	76	0.09
" 3..	Three " ".....	11	42	42	72	0.07
" 4..	.....	7	00	40	81	
" 5..	No flies captured, day warm.....	12	00	40	80	
" 6..	Day warm, evidently end of season.....	9	54	39	78	
	No more flies seen for the rest of the season.					

The season in 1915 was very early. In 1914 the first *H. lineatum* captured out of doors, was on May 18; however, it is possible that the insects appeared earlier, but were not observed. This year the first flies were taken on April 15.

The temperature records show that *H. lineatum* can withstand comparatively cold weather, and on two occasions they were seen ovipositing on cloudy days. It would be interesting to compare the weather records with those of other countries, for instance, England and Ireland, which have a similar climate to this. Seeing that *H. lineatum* can withstand low temperatures and appear so early in the season, it seems probable that many of the experiments made in Europe for the prevention of egg-laying by various dressings, have been started too late in the season. In some of the experiments in Ireland this is quite apparent, and in others it is not made clear whether the animals had been housed

up to the time of the experiment or not. The inconsistencies in some of the experiments with protective coverings may have been due to the fact that the early activity of *H. lineatum* was overlooked.

We have been unable to find correspondingly early records of flies captured in Europe. The probable reason for this is that the earlier fly, *H. lineatum*, causes so little annoyance to cattle compared to *H. bovis*, that it may have been overlooked. At Agassiz, yearly notes have been made on the first dates of appearance of the various blood sucking flies. This year, *Lyperosia irritans* was first noticed on April 12, *Stomoxys calcitrans* having also appeared. It was not until the 28th that the *Tabanidae* were seen, two specimens being caught on this date. These records may serve as a guide in other countries.

#### OVIPOSITION.

On April 15 a slight disturbance was noticed among the cattle. They were not stampeding, and only one of them, a young steer, ran, in a half-hearted manner. The cows lifted their tails, stamped and kicked a bit, but not one of them stampeded. I am sure, that very few farmers would have suspected the presence of the Warble-fly. At this point it might be well to mention that these are gentle animals, and that they are confined to a small paddock; it may be that range animals free to run where they please, would show greater alarm.

On four occasions, *H. lineatum* has been captured by hand on recumbent animals, two by myself and two by my cowman. Each time the fly was resting, or ovipositing, on the fore-foot, which was tucked in under the elbow. When ovipositing the fly backed up and pushed its ovipositor under the hairs. Numerous eggs were found on this part of the animal—*i.e.*, the side of the sternum beneath the elbow—so this seems a favourite spot for egg-laying.

On May 2, while watching for flies, I observed one sitting on the ground just behind and a few inches from the heel of a young heifer. While watching I saw it run backwards like a crab, reach upwards from the ground and oviposit on the hair which hangs down round the coronet. The attitude was reminiscent of the way in which a scorpion curls up its tail. This was repeated three times in succession. The same occurrence was noted subsequently several times on May 3. It seems that this site also is a favourite one for oviposition.

On May 3 another important observation was made on the egg-laying habits of this fly. A fly was observed on the ground near a recumbent cow; this insect ran backwards in the manner described above, and oviposited about 6 inches below the point of the ischium, where the cow's body touched the ground. From this point it laid eggs at intervals all along the side touching the ground, as far forward as the elbow, without touching the animal except with its ovipositor. This journey took some time, as the fly rested for a minute or two after ovipositing.

Numerous eggs have been found also between the point of the hock and the ischium, also on the inside of the legs. On one occasion seven eggs were found on the scrotum of a bull calf, and at other times they have been encountered on the tail.

From these observations it is evident that *H. lineatum* lays its eggs principally when an animal is lying down, and that it does so while standing on the ground, thus giving the animal a minimum amount of irritation. It has been noticed that cattle seem to lie more often on the left side, which may account for the fact that more lesions have been encountered on the left side, than on the right. In the observations which were made in 1914, nothing of this kind was noted, as the fly was not thought to attack resting animals. It was also an unfavourable season for *H. lineatum*.

The position of *H. lineatum*, when ovipositing on the animal, is always such that its head points in the same direction as the hairs. In plate 3, fig. 9, a fly can be seen ovipositing on a cow's tail.

Contrary to expectation, the flies seem to like shade. When the animals were standing up the fly frequently rested in the shade under a cow's heel and attempts to photograph it were frustrated by this habit.

With regard to any signs of irritation on the part of the cattle, when they were lying down, as far as one could see, they displayed no annoyance, probably because the fly was on the ground (plate 3, fig. 10). When standing up it was a different matter, since the fly was forced to grasp the hairs while ovipositing. The older animals would kick, switch their tails, and occasionally lick the part to allay the irritation, but in some situations they could not reach the part with their tongues. The cows did not run at all, and it was only the younger animals which did so.

#### THE EGG.

The number of eggs found on a single hair varied from one to fourteen (plate 1, figs. 1 and 2). Contrary to what has been observed in *H. bovis*, the eggs are often in full view, partly no doubt because eight or ten eggs in sequence take up a considerable space on the hair.

The time taken for eggs to hatch off the animals was about seven days, the shortest period being four to five days. Larvæ were seen emerging from the egg on several occasions. In one instance a young bull had been killed and the scrotum cut off. The skin was kept in the laboratory and not touched in any way. The larvae emerged by themselves on the seventh day. This disproves any idea that they require moisture to help them in emerging.

On another occasion some eggs were taken from an animal, together with a portion of the underlying skin. This was done at 11.45 a.m. A larva hatched at 12.15, a second at 2 p.m., and a third at 4.45 p.m. The interesting part of this hatching was that the egg next to the skin hatched first, and the other two in sequence. This is probably due to the fact that those nearest the skin derive most heat.

#### PENETRATION OF THE LARVÆ THROUGH THE SKIN.

April 24.—Twelve larvæ which had just hatched were placed on a calf's back. They worked actively, but none of them succeeded in going through the hide during the period of observation, 10.30 to 11.15.

Seeing that the larvæ worked so slowly, and there was so much difficulty in keeping the calf quiet, it was decided to abandon this method, and to try the effect of placing larvæ on a small piece of skin freshly removed from an animal, and watching them under a microscope.

April 24.—A small piece of skin was cut off, and five larvæ placed on it. Two of these made determined efforts to pierce the skin, from about 11.30 to 1 p.m., and succeeded in getting about half way in. The skin was then placed in an incubator at 88°F.; at about 2.30 the larvæ were apparently dead.

April 26.—A small piece of skin was removed from a cow, and twenty-three larvæ were placed on it at about 3 p.m. At 4 p.m. eight larvæ were removed, as they appeared to be lifeless; two more were taken off at 4.45. At 8 p.m. several of the larvae were working actively and were making progress. At 11 p.m. they had penetrated still further and were quite active.

April 27.—At 9.30 a.m. one of the larvæ had just about disappeared from sight, and at 2.00 p.m. one larva had completely penetrated the hide, and three others were three-quarters of the way in. After this time they apparently died; however, the skin was beginning to show signs of putrefaction.

April 28.—Experiment to try to discover the natural penetration of the skin by larvæ hatched on the cow. Removed a small piece of skin from the top of a cow's udder. Eight eggs were attached to a hair in the centre of this

piece of skin. There was a slight amount of subcutaneous inflammation. Six of the eggs were hatched and two unhatched. The hairs around the spot were clipped off, leaving only the hair to which the eggs were attached.

A larva was found close to this point, actively working and penetrating the skin. This was at 3.45 p.m. At 10.20 p.m. the larva was nearly three-quarters of the way in.

April 29.—The larva still showed signs of life, but at 8 p.m. though still alive it had not yet disappeared from sight. Photographs taken on April 28 show the larva partly through the skin (plate 1, figs. 3 and 4).

May 7.—Repetition of the previous experiment. Removed from a cow a piece of skin under-lying three hairs to which twelve eggs were attached. Nine of the eggs had hatched. At the foot of one of the hairs a small droplet of clear serum was exuding; this kept increasing in size. Evidently some force under the skin was expressing it.

The piece of skin was bent double and grasped with a strong forceps. This caused a larger flow of serum, and finally two larvæ were pressed out. One of these was extremely active and endeavoured to re-enter the hair follicle from which it had come out.

The eggs from which these larvæ emerged were laid on the 2nd or 3rd of May, and were first noticed on the latter date. They had been examined closely on the afternoon of May 6, and none were observed to be hatched, though it was difficult to make sure of this on a living animal.

Other experiments of a like nature were made, but were not so successful. Reasons for this will be found in the following paragraph.

#### METHOD OF PENETRATION.

Upon emerging from the egg the larva crawls actively along the hair to the skin. It is apparently aided in this by a sticky exudate with which it is covered, and which seems also to serve the purpose of preserving it from drying out. Upon reaching the root of the hair it begins to work with its mouth parts. In no instance was a larva observed to penetrate the skin otherwise than by way of the hair follicle. The adherence of the larva to the hair keeps it in proper position for penetration, and provides it with a *point d'appui*.

In some instances, freshly hatched larvæ quickly died, that is to say in half an hour or so, unless kept supplied with moisture. Once the mouth-parts were below the skin, however, the larva drew up moisture and was able to withstand the dry atmosphere.

In the experiments where pieces of skin were removed and larvæ put on, they were no doubt placed at a disadvantage. In the first place it is probable that the skin movements of the living animal may aid larvæ to penetrate; secondly, when working on skin which has been removed from the living animal, less serum exudes, the larvæ dry out more rapidly, and putrefactive changes come in. The pieces of skin were kept constantly moistened underneath.

These facts confirm the valuable observation made by Hewitt in 1914, who saw several larvæ of *H. bovis* penetrate the skin; and of Carpenter, Hewitt, and Reddin, who squeezed out a newly hatched maggot of *H. lineatum* from the skin of a cow. They mention the difficulty of watching the larvæ on a live animal, and say, "it took them about six hours to get into the skin; possibly the hair follicles may have facilitated entrance." The actual penetration of the skin by the larvæ of *H. lineatum* was not observed by them. It was for this reason that in the work here, small pieces of skin were removed, so that the work of the larvæ could be accurately observed under the microscope.

## SKIN LESIONS.

From an economic point of view the lesions produced by the penetration of *H. lineatum*, and possibly of *H. bovis*, are very important. I make this distinction because the eggs of *H. bovis* are laid singly upon a hair, and there would be less irritation at a given point than in the case of *H. lineatum*, where a number of larvæ enter the skin at the same point.

Carpenter, Hewitt, and Reddin mention the appearance of small pimples on the skin of the thighs, appearing a few days after the eggs of *H. lineatum* had been laid in this region. They also noticed that the skin was perforated with minute holes, from which a watery discharge flowed, and that this formed a scaly deposit on the skin. Evidently they did not encounter the serious lesions which I am about to describe.

For three years in succession severe rashes and skin lesions have occurred in the dairy herd of the experimental farm here. Their nature was not understood until the present year. During the course of experiments on egg laying, several batches of eggs were "ringed" and carefully watched to determine the time of hatching. Several times the eggs were found to have disappeared, and a scab had formed in their place. The animals had evidently felt some irritation and had rubbed the spot raw. To overcome this difficulty the cows were kept in stanchions, where they could not lick or rub themselves, and the following observations are the result:—

Following the penetration of the larvæ down the hair follicles, serum is exuded which dries on the surface of the skin, completely covering its pores. The subsequent skin lesions are, I believe, entirely due to the introduction of bacteria, to the variety to which these belong, and to the power of resistance of the particular animal. The perforations mentioned in the work already cited have not been encountered here. The larvæ gained entrance by way of the follicle, and as soon as they had penetrated the skin, the opening they made was filled up with a serous exudate. On pieces of skin through which larvæ had passed and which were examined under the microscope, no visible openings were left. In some instances no further symptoms have been noticed, except perhaps a slight thickening of the skin and a gluing together of the hairs (plate 2, fig. 8). In other cases there has been intense irritation and a dermatitis has been set up. The accompanying illustrations (plate 2, figs. 5-7) demonstrate this condition. The formation of a scab occurs and a circular patch of skin dies; when this is lifted off, two or three small conical pits filled with pus are visible. Sometimes the inflammation is more extensive, and large oedematous areas have been noticed, extending into the deep tissues.

In the outbreaks of previous years a number of bad sloughs have occurred, some of them on the upper part of the udder, and on the thighs. Other parts where serious lesions have been encountered are in the line from the point of the ischium and the patella, and some few patches on the flanks, becoming more numerous until they reach the sides of the sternum, under the elbow. Some quite large lesions have been noticed on the tail, but very few at any rate noticeable ones below the knee and the hock; however, in this district cattle often develop lameness at this time of year, which might quite well be caused by the larvæ. The point has not yet been proved. Seeing that the penetration of the larvæ produces a definite disease, I would propose the name "hypodermal rash."

Thus the principal damage done by the larvæ is to the hide, and is caused by the bacteria which they introduce beneath it. Fortunately the better parts of the leather are not touched, as when an animal is skinned most of the affected parts will be found on the edges. Also the leather in those parts of the skin preferred by the larvæ is coarse and porous. Then again the damage is done at a time when the hides are most valueless, owing to the emergence of

the grubs from the back. Des Gayets, *et al*, quote Arloing, Cornevin and Thomas, who incline to the belief that the germs of symptomatic anthrax gain entrance through the openings in warbles. This does not seem at all probable, seeing that the cavity is well lined, and that the warbles are on the back. But the penetration of the newly-hatched larvæ would be a very likely method of carrying the infection of either symptomatic or true anthrax. The fact that the larva works in those portions of the animal which come in contact with the soil, renders this hypothesis more tenable.

*Treatment.*—The conclusions drawn from this year's work point to the possibility of previous attempts at treatment having been made too late in the season, and encourage the belief that some preparation may yet be found which is efficacious.

In conclusion, I desire to express my thanks to Dr. F. Torrance, Veterinary Director General, who has afforded me every facility for conducting the investigation.

### SUMMARY.

*Hypoderma lineatum* may be captured out of doors as early as April 15, in exceptional years; but seeing that it has been proved to withstand low temperatures it has probably been overlooked in other seasons, both at home and abroad. On two occasions it was captured in the absence of sunshine.

Oviposition takes place principally when the animals are lying down.

The longest time for the eggs to hatch on the cattle was seven days.

Larvæ were made to penetrate pieces of skin, which had been removed from cattle. They crawled down the hairs and entered by way of the follicles.

A single larva was found penetrating the skin of a cow under natural conditions.

Two larvæ which had penetrated the skin were squeezed out.

Serious skin lesions were caused by the penetration of the larvæ, for which the name "hypodermal rash" is proposed.

The principal skin lesions were found: from the point of the ischium to the hock—on the top part of the udder—from the point of the ischium to the patella—slightly on the flanks, and abundantly on the sternum behind the elbow.

The damage done to the hide by the larvæ entering is confined to the poorer parts of the leather; but the injury caused by the entrance of pus organisms and others may produce fatal diseases, such as anthrax and blackleg.

### APPENDIX I.

#### DIFFERENCES BETWEEN *Hypoderma bovis* DE GEER AND *Hypoderma lineatum* VILLERS.

The illustrations of Warble flies which are to be found in the different text books, are many of them very misleading and inaccurate. It is for this reason that the coloured illustrations in this article were made. They were painted by Mr. C. W. Young, who has taken exceptional pains to make them accurate in every detail, especially in the colouring.

The drawings may be termed composite ones, they are based on the examination of thirty specimens of *H. bovis* and fifteen of *H. lineatum*. Mr. Young has skilfully combined the parts and has made an average specimen of each species. Fresh specimens were used for *H. bovis*, and dried ones for *H. lineatum*.

In reading the various descriptions of the flies, it is quite apparent that the colouring is hard to describe; one author calls the tail end lemon yellow, another red orange, etc. These differences are no doubt due to the fact that the body



colour of the flies is black, and that the colouring in the hair changes according to the light and position the insect is viewed in.

While making measurements and comparisons between the two flies, several marked differences have been noted. Some of these do not appear in the published descriptions, and are therefore given in detail. The average distance between the eyes of *H. bovis* taken across the frontal region just in front of the ocelli, is of 1.9 mm. In *H. lineatum* the distance is just the same.

The average length of *H. bovis* (dried specimens) is of 14 mm. and only 12.7 mm. in *H. lineatum*. It is apparent that in proportion to the size of the insect, the distance between the eyes is greater in *H. lineatum*. The eye in *H. bovis* measures 1.9 mm. at its greatest diameter, in *H. lineatum* 1.6 mm.

The most noticeable difference between the two flies is to be found in *H. bovis*, the yellow hair on the anterior part of the thorax partly obliterates the lines on the back. In *H. lineatum* the lines are bare. This distinction is the most important of all in separating the two species, and is mentioned in all the descriptions.

The wing veins in *H. bovis* are of a dark brown colour, in *H. lineatum* they are nearly black.

The alulæ in *H. bovis* have a reddish brown border, in *H. lineatum* they are uniformly white.

On the under surface of the thorax and the anterior part of the abdomen *H. bovis* is much blacker than *H. lineatum*.

In some illustrations of *H. bovis* the abdomen looks swollen and long, this is probably due to the fact that the newly emerged flies are often seen in this condition, which persists for an hour or so. But soon after emergence the flies void a quantity of milky excrement and the condition then disappears.

An important character which holds true in all the specimens examined, is to be found on the legs. *H. bovis* has clean legs with comparatively few hairs. The legs of *H. lineatum* are rougher and more hairy, especially the tarsi.

There are other differences such as the colouring on the tail end of *H. bovis* which is of an orange yellow, and of *H. lineatum* which is reddish orange. However, nothing further need be said as the drawings will speak for themselves.

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## EXPLANATION OF PLATES 1 TO 5.

Fig. 1. Eggs of *Hypoderma lineatum* attached to hairs. Fourteen eggs on a single hair.

Fig. 2. Four eggs on a hair, greatly enlarged. Two eggs are split open, showing method of emergence.

Fig. 3. Larva of *H. lineatum* penetrating a hair follicle. A circle surrounds the larva.

Fig. 4. Enlargement of the larva shown in Fig. 3.

Fig. 5. Lesions of the skin caused by entrance of warble larvæ. Note lesions on the tail.

Fig. 6. The same animal two days later.

Fig. 7. Lesions on cow's udder and on the line between the point of the ischium and the hock.

Fig. 8. Two circular spots, photographed soon after the larvæ had entered. The oozing of serum has matted the hairs.

Fig. 9. *Hypoderma lineatum*, ovipositing on cow's tail.

Fig. 10. Cows resting while flies were ovipositing upon them. The cow seen in the foreground is the one shown in figs. 5 and 6.

Fig. 11. *Hypoderma bovis*, enlarged three times.

Fig. 12. *Hypoderma bovis*, natural size.

Fig. 13. Hind leg of *Hypoderma bovis*.

Fig. 14. *Hypoderma lineatum*, enlarged three times.

Fig. 15. *Hypoderma lineatum*, natural size.

Fig. 16. Hind leg of *Hypoderma lineatum*, compare with Fig. 13.

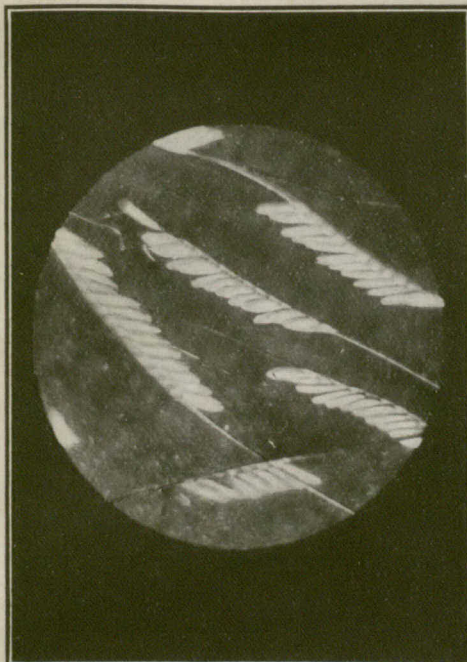


Fig. 1

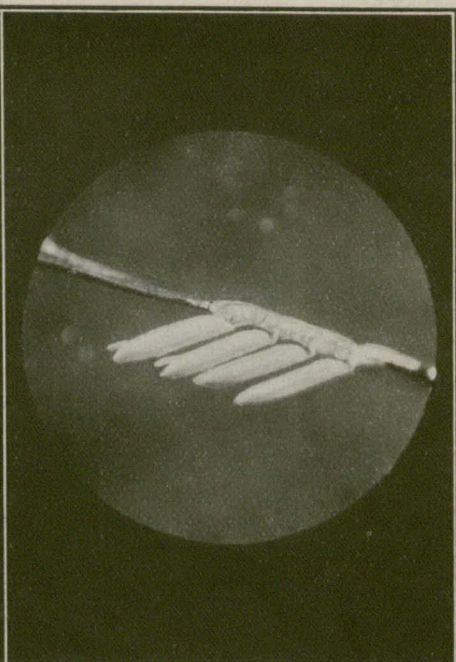


Fig. 2



Fig. 3



Fig. 4

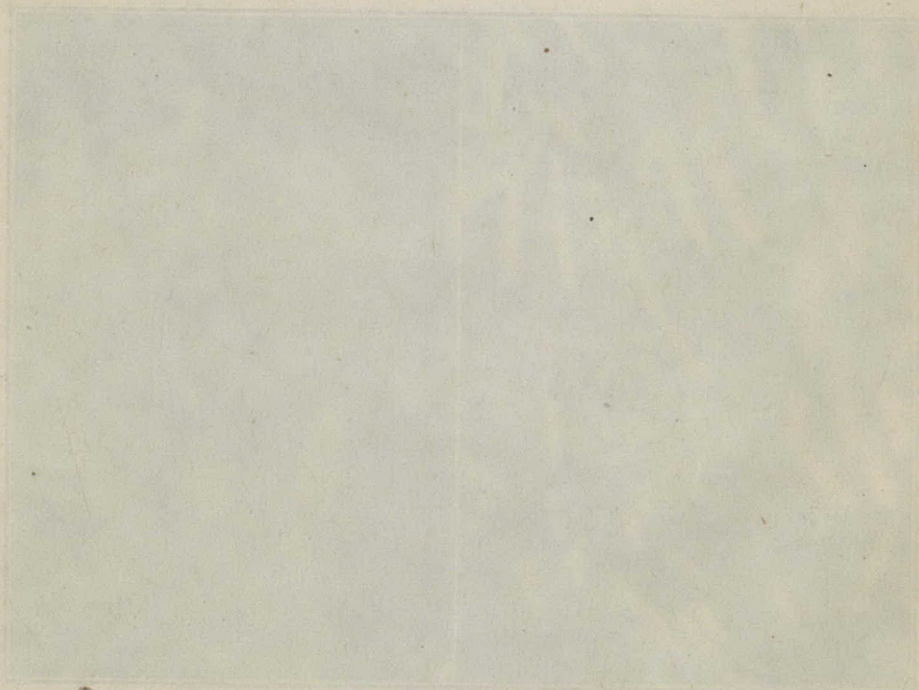
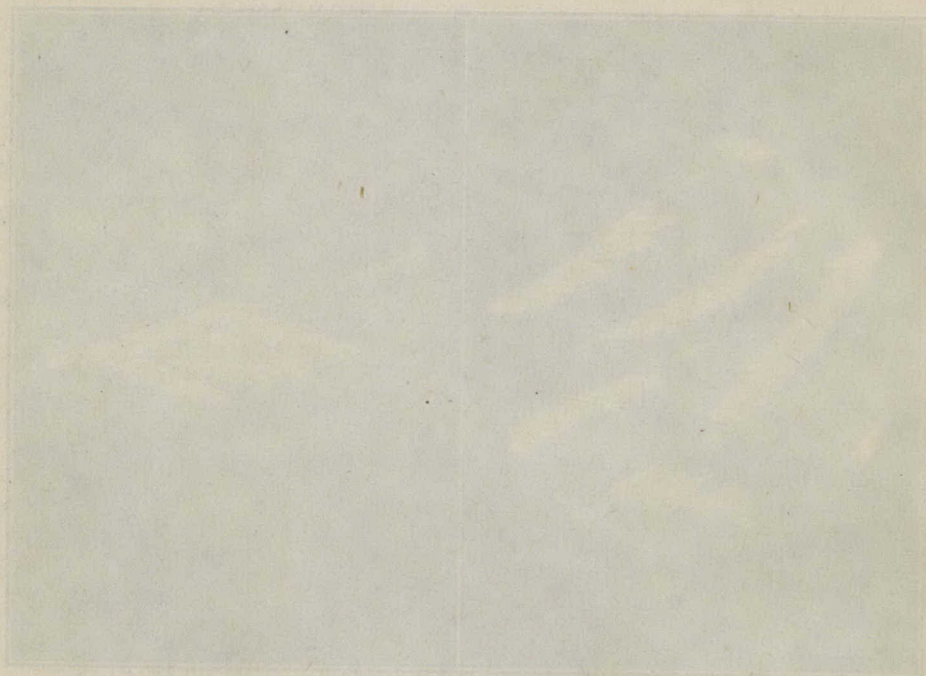




Fig. 5

Fig. 6

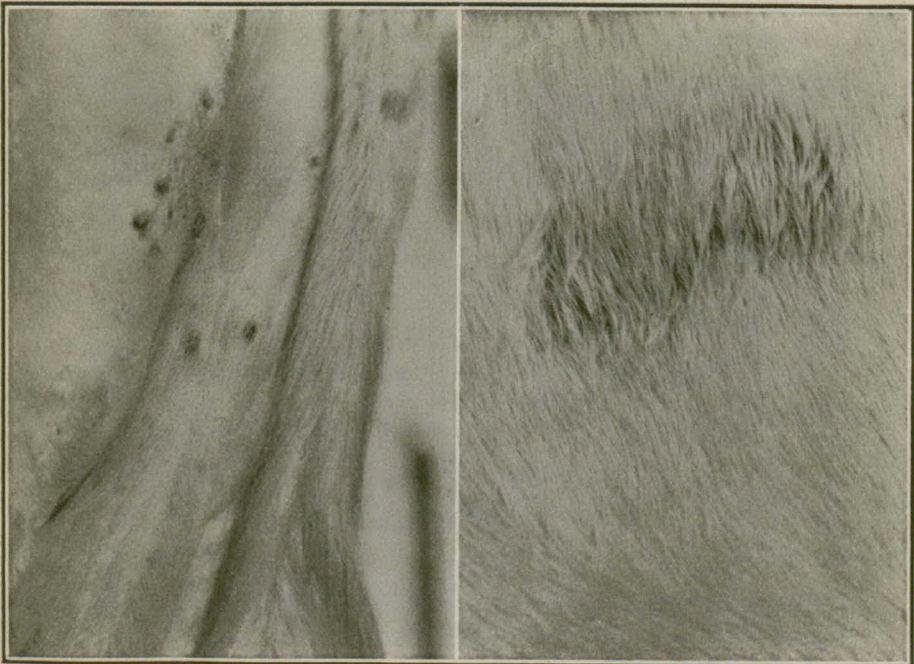


Fig. 7

Fig. 8

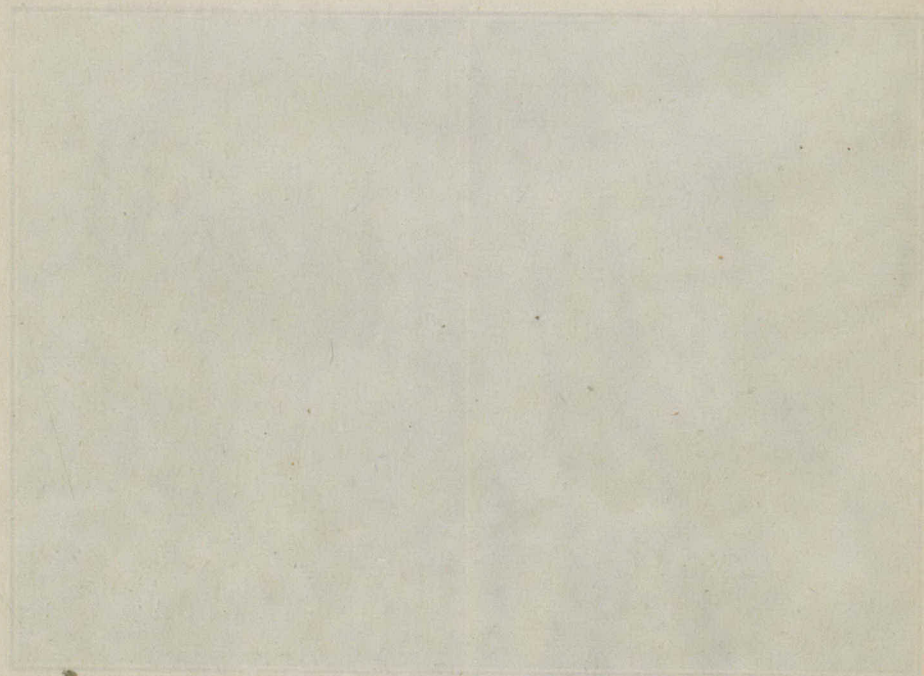
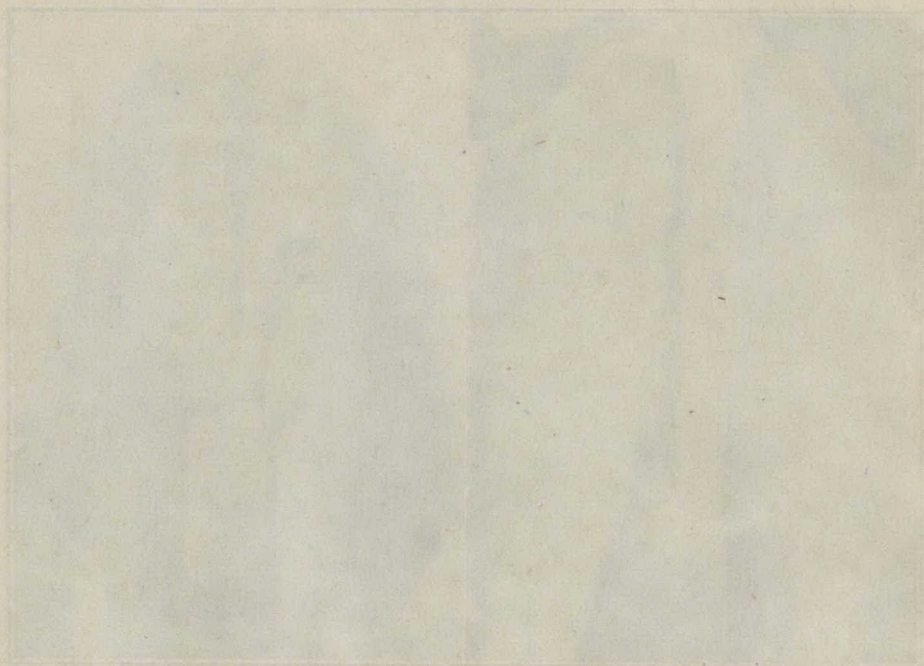




Fig. 9



Fig. 10







Fig. 11



Fig. 12

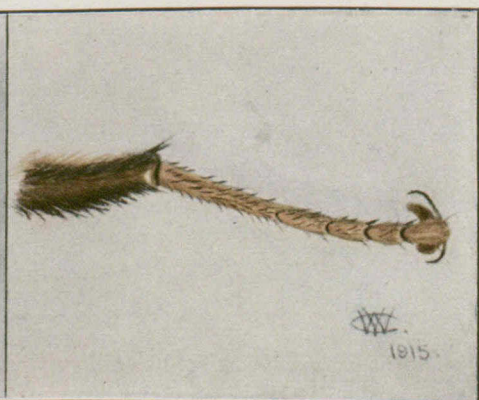


Fig. 13





Fig. 14



Fig. 15

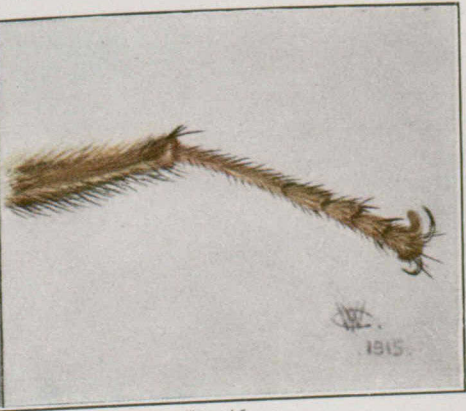


Fig. 16

