A STUDY OF MYIASIS IN MAN AND OTHER ANIMALS IN MANITOBA

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Victor Ian Enrique Murray

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ABSTRACT

The study has been undertaken for the first time in the Province of Manitoba to determine the different types of myiasis, and the myiasis-producing Diptera which occur in the province. Two types of myiasis were observed - obligatory and facultative. The types of obligatory myiasis recorded were furuncular or subcutaneous myiasis produced by members of the genera Cuterebra, Hypoderma and Wohlfahrtia; and myiasis of the mouth, nose, and sinuses by members of the genera Cephenemyia and Oestrus. Facultative myiasis involving "fly strike" in sheep was caused by Phormia regina and wound myiasis was produced by Phaenicia sericata. There were no actual cases of accidental myiasis, but flies capable of producing this type of myiasis were collected. Two earlier cases recorded from man in Manitoba were of creeping eruption by the first stage larvae of Gasterophilus intestinalis. They were reported by Austmann in 1926, and Bedford in 1933. Furuncular myiasis caused by larvae of Wohlfahrtia vigil was reported by Duncan in 1961, and traumatic myiasis by larvae of Phaenicia sericata was reported by Poetker in 1962. There was also an example of blood-sucking maggots of birds by larvae of Apaulina avium, and another of spurious myiasis in a chicken by larvae of Musca domestica.

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Within the Order Diptera, there are sucking and non-sucking flies which transmit pathogenic organisms to men and other animals mechanically - by their body hairs, pulvilli, mouth parts, vomitus, or feces - to an abrasion or opening on the host's body. The sucking or hematophagous diptera also transmit pathogens cyclically through their salivary secretions while feeding. In contrast, some non-sucking diptera invade animal tissues and organs in their larval stages and produce the pathological condition of myiasis.

It was the purpose of this investigation:

1. To study the etiologic agents of myiasis, and;
2. To determine the different types of myiasis which occur in the Province of Manitoba.

By means of a study of myiasis, the identity of the causative agents, their habits, habitats, and hosts, as well as the incidence of infestation can be determined and control measures utilized. Myiasis-producing flies heavily parasitize animals such as cattle, sheep, horses and deer. Human beings,mainly infants, also the wounded or the insane are affected by these flies, and as a result they constitute a health hazard to man.

According to the habits of myiasis-producing flies, three types of myiasis are known to exist, obligatory, facultative and accidental. Obligatory myiases occur in specific regions of the living animals, e.g., in the nasal cavity of

sheep and deer, and in this case the dipterous larvae exist only as true parasites. Facultative myiases occur in fresh wounds and diseased tissue of living animals, and the dipterous larvae can live a parasitic or saprozoic life. Accidental myiases occur in living animals and the larvae inhabit regions inaccessible to observation, e.g., the vagina and intestines of human beings. Thus from an economic, veterinary, or medical viewpoint, the study of myiasis is important.

The present study deals with two classes of obligatory myiasis, subcutaneous and nasal; observed and reported cases of facultative myiasis, and human case histories. Spurious myiasis, hematophagy by maggots, and flies capable of causing accidental myiasis are also mentioned.

REVIEW OF THE LITERATURE

One hundred and forty-seven years ago, Kirby and Spence (38) used the word "scholechiasis" in reference to the invasion of animal tissue by insect larvae in general. Hope (36), however, proposed to limit that term to use in connection with lepidopterous larvae and suggested the new term "myiasis" which is now in general use to indicate the conditions resulting from the invasion of tissues and organs of man and animals by dipterous larvae.

Hope (loc.cit.) classified myiasis on the basis of the habits of dipterous flies while Bishopp (5) classified myiasis according to the parts of the body affected. Patton (47) in 1921 indicated that Bishopp's classification was unsatisfactory and proposed instead three categories; specific, semi-specific and accidental. These categories, based on the habits of the flies, give a better indication of their relation to their hosts, and, on such a basis, are of greater interest to the zoologist and entomologist. But Patton (loc.cit.) unlike Hope (loc.cit.) extended the use of the term myiasis to include all stages of Diptera on the ground that the eggs, pupae, and even adults may occasionally be found in the human body. This situation is of limited occurrence, and as James (37) indicated in 1947, "Patton's usage of the term was unnecessary since the larvae are the active stage in relation to myiasis".

Up to the present, James (loc.cit.) has presented the most concise work on "The Flies that cause Myiasis in Man"

which is almost indispensable to the medical entomologist. In his work he has summarized relevant biological and pathological information concerning myiasis-producing flies of the world which affect the human host, and has presented guides for their identification. A further guide to the identification of myiasis-producing Calliphorids can be located in "The Blowflies of North America" by Hall (32).

Walker (61) first recorded furuncular myiasis in North America produced by Wohlfahrtia vigil (Walker, 1920). He (62,63) also published a brief account of eight cases in man and later described characteristics which facilitated the identification of the three larval stages. Further observations on the behaviour of W. vigil and descriptions which presented definite characters by which each larval instar may be recognized were made by Ford (23,24).

Bennett (2) provided important data on the life cycle, incidence of parasitism and host-parasite relationship of Cuterebra emasculator (Fitch, 1856). All stages were described and the missing characteristics, necessary for identification, were provided. He further compared the genus Cuterebra to Cephenemyia and transposed the latter from the Cuterebridae to the Oestridae. Bennett (loc.cit.) later discussed the biology of Cephenemyia phobifera, the pharyngeal bot of the white-tailed deer. In his work, he has described the incidence of parasitism during the year on the

different age classes of the host, the degree of parasitism in relation to second growth forests and mature deciduous forests, the phases of development of the larvaeduring the year, and the effects of the parasite on the host. This work is a valuable contribution to the biology of C. phobifera in relation to myiasis.

Several of the recent works on myiasis have been of an experimental nature. Some of the experiments involved external and systemic control of larvae found in cattle (17,18,19,20,50,52,56,), horses (42,58,59), and sheep (12, 13,21,43,48,49), as well as control by sterilization of the male flies (39,55). Other experimental procedures dealt with the transplantation of larvae (53), the ecology of cuterebrid larvae (54), the respiration of eggs and larvae of myiasis-producing flies (34), external, subcutaneous and gastro-intestinal experimental myiasis (33); artificial infestation with cattle grubs (64), toxicity (25), flocculation tests (45), and histopathological studies (65). Many investigators have also entertained the idea of tracing the evolution of myiasis-producing flies on the basis of their posterior spiracular plates. Since facultative parastic larvae have simplier posterior spiracular plates than obligatory parasitic larvae, this idea seems feasible.

MATERIALS AND METHODS COMMON TO ALL PHASES OF THE STUDY

1. SOURCES OF DATA

The main sources of data can be classified under two headings:-

a. Interviews

Circulars asking for materials toward the study of myiasis were issued to hospitals and veterinarians in the Province, but the response was surprisingly poor. The procedure was then replaced by interviews.

Many medical doctors,nurses and laboratory technicians in several hospitals; many veterinary doctors, farmers and agricultural officers in Manitoba were interviewed in order to collect pertinent information necessary for the study.

b. Field Work

Field work involved trips to various rural areas and abattoirs in the Province in order to:-

1. trap and net different myiasis-producing flies, and:
2. collect larvae from infected animals.

Whenever facultative parasitic dipterous larvae were collected alive, some were preserved and others reared to the adult stages. The preserved and live specimens of larvae were identified and later confirmed by the identification of

the adult specimens. Further confirmation was obtained by comparing the adults with the adults stored in the Entomological Museum, University of Manitoba.

2. METHODS

The technique adopted in the preparation of larval specimens for identification was as follows:

a. Fixation

There are several methods for the preservation of larval specimens, but a combination of formalin, ethyl alcohol and acetic acid (F.A.A.) was preferred to the others.

F.A.A. neither causes the burning sensation to the eyes of the user as does formalin, nor produces the discolouration of the larval integument as does 70 to 80 per cent alcohol. Such discolouration was observed mostly with the muscoid type of larvae. By boiling the larvae in water before fixing, however, this disadvantage of the alcohol could be offset.

b. Hot Caustic Evisceration

The larval specimens if preserved should be soaked in water to remove as much fixative as possible prior to boiling in the hot caustic solution. Boiling in 2 molar sodium hydroxide is employed to expose the sclerotized areas which are used in identification. The process of boiling is facilitated by making pin holes ventrally in the smaller larvae, and by the removal of the internal organs through a ventral incision

in the larger larvae. The extent to which the larvae should be boiled varied with the size as well as with the freshness of the specimens. The point of clearance is recognizable when the sclerotized structures become clearly visible through the hyaline integument of the larva. Cleared larvae were then placed in boiling water for about ten to fifteen minutes to remove any excess of sodium hydroxide and to facilitate dehydration. If the larvae are dehydrated without boiling, they tend to become brittle and discoloured.

Two different sets of materials were dehydrated and cleared (see Table I),

1. larvae or parts of larvae cleared in 2 molar sodium hydroxide
2. whole larvae not cleared in 2 molar sodium hydroxide

c. Mounting

Mounts were made in Canada balsam and in Permount. Some mounts were made flat but the cover glasses were supported at the edges by bits of glass. Other mounts were made in cells of glass tubing varying in diameter from 12 to 20 mm. cut to heights varying between 5 to 10 mm.

The cut tubes were cemented with Carter's Clean Grip Rubber Cement to the glass slides and partially filled with Canada balsam or Permount. The larva was then immersed in it, and more mounting fluid added until the container was filled.

TABLE I

DEHYDRATION AND CLEARING PERIODS OF SPECIMENS

Solutions	Whole specimens previously boiled Approx. time	Whole specimens previously not boiled Approx. time
70% Ethyl alcohol	20-30 minutes	20-30 minutes
80% " "	20-30 "	20-30 "
95% " "	20-30 "	8-12 hours
95% " "	20-30 "	40-60 minutes
Absolute Ethyl alcohol	30-60 "	1-2 hours
*Abs.Ethyl OH. and Xylol	10-20 "	20-30 minutes
Abs. " " "	10-20 "	20-30 "
Xylol	10-20 "	10-20 "
Xylol	3-5 "	5-10 "
Cedar wood oil	40-60 "	5-10 hours

* Absolute Ethyl OH -+ Xylol 1:1

It was observed that if the container and contents were left to stand overnight covered with a Petri dish, and refilled the following day, bubbles rarely appeared beneath the cover slip. The gentle lowering of the cover slip from one end to the other also prevented the presence of bubbles. Larvae which were cleared and stained with Acid Fuchsin or Gower's carmine and mounted in the above manner exhibited greater contrast of the distinguishing characteristics.

3. METHOD OF GROUPING

The classification used in this work is a combination of Patton's (47) categories, modified as:-

A. 1. Obligatory myiasis,

2. Facultative myiasis,

3. Accidental myiasis and

Bishopp's (5) categories modified as:-

B. 1. Traumatic (wound) myiasis,

2. Furuncular or subcutaneous myiasis,

3. Myiasis of the mouth, nose and sinuses.

This dual method of grouping has the advantage of combining biological and pathological data which may be of interest to the entomologist and pathologist.

Hematophagy by maggots is considered as a related phenomenon to true myiasis. Spurious myiasis is also mentioned.

OBLIGATORY MYIASIS

"This group includes all those Diptera whose larvae are found only in living tissue, the flies selecting a number of tissues or organs, or one particular organ, depending on the species, in which or near which to lay their eggs or deposit their larvae", Patton (47). These larvae are the most serious myiasis-producing forms from an economic standpoint.

The types of obligatory myiasis observed were:-

1. Furuncular or subcutaneous myiasis caused by the Hypodermatidae, Cuterebridae and Sarcophagidae,
2. Myiasis of the nose, mouth and sinuses caused by the Oestridae (see Table II).

1. FURUNCULAR OR SUBCUTANEOUS MYIASIS

Furuncular or subcutaneous myiasis is the parasitic invasion of the subcutaneous tissue of the host by dipterous larvae. The larva first penetrates the unbroken skin or opening of a hair follicle. It may remain at the point of entry or migrate varying distances through the host's body. When it comes to rest, a boil or furuncle forms which has a small opening to the exterior to permit breathing. The larva gradually enlarges the opening and then emerges. In the opening of the furuncle secondary infection by bacteria or by maggots of other myiasis-producing flies may occur. The absence of such infection, however, results in the rapid

TABLE II

OBLIGATORY MYIASIS-PRODUCING DIPTERA FROM MANITOBA

Family and Species	Furuncular or Sub-cutaneous	Nose, Mouth and Sinuses	Gastro-intest-inal	Host	Locality	Collector	Date
GASTEROPHILIDAE							
Gasterophilus nasalis			x	horse	Winnipeg	V. Murray	June 1, 1962
G. intestinalis			x	horse	Winnipeg	V. Murray	June 1, 1962
"	x			man	Winnipeg	G. V. Bedford	June 30, 1932
"	x			man	Lundar	K. J. Austmann	Aug. 1925
G. haemorrhoidalis			x	horse	Winnipeg	V. Murray	Mar. 1962
HYPODERMATIDAE							
Hypoderma bovis	x			cattle	Winnipeg	J. A. McLeod	Apr. 30, 1943
"	x			"	Rivers	V. Murray	May 3, 1965
"	x			"	Oak River	V. Murray	May 9, 1963
"	x			"	Moline	V. Murray	May 28, 1963
H. lineatum	x			cattle	Roland	L. McCallum	Mar. 14, 1962
"	x			"	Winnipeg	V. Murray	June 8, 1962
"					Oak River	V. Murray	Apr. 10, 1965
"	x			"	Rivers	V. Murray	Apr. 25, 1965
Oedemagena tarandi	x			caribou	Beverly Lake	O. Peterson	June 10, 1949
CUTEREBRIDAE							
Cuterebra grisea	x			field mouse	Rennie	C. H. Buchner	Apr. 15, 1958
C. angustifrons	x			house mouse, mink	Winnipeg	J. A. McLeod	Oct. 30, 1942
C. tenebrosa	x			house mouse	Winnipeg	J. A. Allen	_____, 1940

continued

TABLE II CONTINUED

Family and Species	Furuncular or Sub-cutaneous	Nose, Mouth and Sinuses	Gastro-intest-inal	Host	Locality	Collector	Date
Cuterebra sp.	x			dog	Winnipeg	W. G. Jones	Aug. 8, 1961
SARCOPHAGIDAE							
Wohlfahrtia vigil	x			man	Winnipeg	D. Duncan	July 3, 1961
"	x			mink	Old Kildonan	J. Allen	_____, 1940
"	x			"	S. Manitoba	J. Allen	_____, 1940
OESTRIDAE							
Cephenemyia trompe		x		white-tailed deer	Hadasville	V. Murray	Apr. 19, 1962
"		x		"	Whiteshell	V. Murray	Mar. 17, 1962
C. phohifera		x		"	Hadasville	V. Murray	Apr. 19, 1962
"		x		"	Duck Mt.	V. Murray	Mar. 26, 1962
"		x		"	Turtle Mt.	V. Murray	Mar. 18, 1962
"		x		"	Whiteshell	V. Murray	Apr. 4, 1962
"		x		"	Marchand	V. Murray	Apr. 11, 1962
"		x		"	Peonan Pt.	V. Murray	Mar. 6,-26 1963
Oestrus ovis		x		sheep	Winnipeg	V. Murray	Oct. 1962

healing of the furuncle after the larva emerges.

The genera found responsible for this type of myiasis during the present survey were (a) Hypoderma, (b) Cuterebra and (c) Wohlfahrtia. These first two genera are discussed below and the third is discussed under human case histories, page 68.

(a) Family: Hypodermatidae, Genus: Hypoderma

I. Introduction

Larvae of Hypoderma were found in the spinal cavity as early as 1888 by Hinricksen*. Curtice reported finding "larvae in the wall of the oesophagus, in the pleura near the eleventh rib, in the subcutaneous tissue of the back and in the subcutaneous tumors which open through the external skin." Hadwen (26,27,28) reported the injuriousness of warbles to cattle, discussed the life cycle and seasonal development of both species and demonstrated the ability of the larvae to penetrate bovine skin. He (29) also described the biologies of both species, the effects of parasitism and suggested methods for their prevention and treatment.

Bishopp et al (6) presented an adequate discussion on cattle grubs, their biologies, and suggestions for control. Carpenter et al* applied tobacco powder as dressings to the backs of cattle which proved to be effective. From 1947 to the present, control measures have ranged from external treatment with Derris powder and Rotenone to systemic treatment

* Data taken from Bishopp et al (11).

with Trolene, Ruelene, Coral, and Ronnel. Teskey (57) has stated that in ten years since 1948, cattle grub populations have been reduced from twelve to one grub per animal in Ontario.

In the present study the writer has recorded cases of subcutaneous myiasis in the cattle of Manitoba produced by H. bovis and H. lineatum. The effects of systemic treatment on warbles and the incidence of warble infestation in cattle in the Rivers, Oak River and Moline districts, as well as the environmental factors which may influence the development of the grubs are discussed.

2. Materials and Methods.

From September 15, 1964 to June 4, 1965, 659 cattle (293 calves 1-2 years and 366 adults, 3+ years old), located on eighteen farms in the Oak River, Moline, and Rivers districts, were used to determine the incidence of warble infestation in these areas. Four hundred and forty-three of these were used to determine the effects of Ruelene pour-on treatment, a systemic larvicide, on warbles. The recommended dose was 1 ounce per 100 lbs. by body weight up to 8 ounces. This treatment was applied during the period from September 15 to November 25, 1964. The remaining 216 animals were not treated and therefore were used as controls. Warble specimens were obtained and identified during the study. Other specimens were obtained from Roland and Manitoba animals slaughtered at

St. Boniface. All specimens of warbles obtained by the writer were identified according to the keys of Bishopp (6) and James (37).

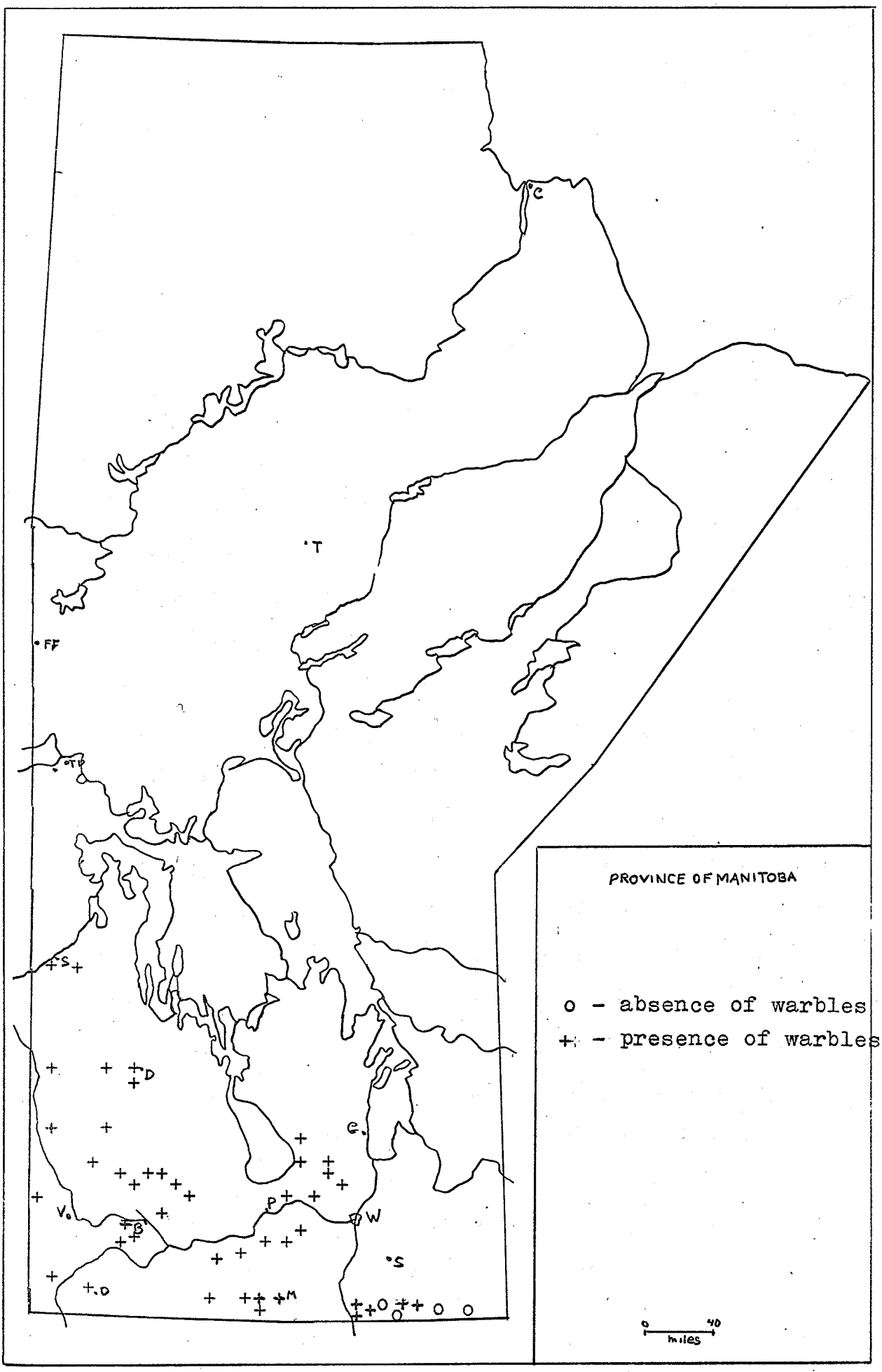
Through questionnaires, information on the incidence of warble infestation in the South Eastern portion of Manitoba (see Fig.1) was obtained from I. Goossen, the veterinarian of that area, and the data pertaining to the type of soil, drainage and moisture content and the type of vegetation were obtained from J. A. Negrych, the Agricultural Representative. The data on altitude and natural vegetation were obtained from the Detailed Relief and Drainage and Vegetation maps issued by the Department of Industry and Commerce, Province of Manitoba. The distribution of warbles in other areas in Manitoba was confirmed by other veterinarians and farmers through questionnaires and interviews.

3. Results

Warble specimens collected from Roland, Moline, Oak River and Rivers districts and Manitoba animals slaughtered at Customs Abattoir demonstrate that H. lineatum and H. bovis are present in Manitoba.

On March 6, 1965, five farms in the Rivers district reported the appearance of warbles in their calves, especially in their steers. The distribution of the warbles was irregular. They were observed along the ribs half way down

FIGURE 1. Map of Manitoba Showing Some Known Areas of Warble Infestation.


C
T
FF
S
D
E
V
P
W
S
M
O
PROVINCE OF MANITOBA
o - absence of warbles
+ - presence of warbles
0
40
miles

the side of the animal's body, behind the hip bones and on either side of the spinous process. As the number of warbles gradually increased to a peak which lasted from the first to the third week in April, they were highly concentrated along the region of the backbone in the area of the last three pairs of ribs. The first warbles emerged on April 10 and by May 28 only eighteen of the 120 infested animals had warbles. Warble specimens collected in April were H. lineatum while other specimens collected in May were H.bovis (see Table II). Specimens extracted on June 4 by squeezing were H. bovis. The difference in warble development illustrates that a seasonal distribution exists for both species. Larval specimens of H. lineatum collected on June 8, 1962, may have been the result of limiting factors on their rate of development (see Table II).

The data with regard to warble infestation in the Oak River, Moline and Rivers districts are discussed in Table III. While there is a negligible difference in the per cent infestation between the steers (31 per cent) and the heifers (29 per cent), there are approximately the same number of warbles in the steers (9) and heifers (6). A low incidence (8 per cent) occurs among the adults with each infested adult having, on the average, two warbles. The incidence of warble infestation in cattle demonstrates that the calves have more warbles and a higher per cent infestation per

TABLE III

INCIDENCE OF WARBLE INFESTATION IN CATTLE IN THE OAK RIVER, MOLINE AND RIVERS DISTRICTS
1964 - 1965

Farm Number	Number of Cattle Examined		Number of Cattle with Warbles		Average Number of Warbles per Animal		Number of Adults Examined	Number of Adults with Warbles	Average No. of Warbles per adult
	Steers	Heifers	Steers	Heifers	Steers	Heifers			
1	15	9	2	1	2	1	35		
2							20	10	3
3	22	6	8	2	14	6	46	2	2
4	2						20		
5	12	12					20		
6	13	3					11	1	1
7	8	7	1		1		15		
8	13	17	6	3	4	1	20	6	1
9		6					7		
10	6	5					17		
11	3	6	3	6	8	6	14	3	1
12	16	4	12	3	15	10			
13	9	7	7	3	10	6	8	3	4
14	8	7					8		
15	5	9	5	9	13	8	17		
16	4	5	4	5	12	6			
17	25	15					80		
18	9	5	5	4	15	6	28	6	4
Total	170	123	53	36	94	50	366	31	16
Aver.No. of Warbles per Animal					9.40	5.50			2.28
Per cent of Animals Infested			31.18	29.26				8.46	

animal than the adults.

Comparison with Table IV and Table V indicates that almost twice as many steers and three times as many heifers are infested in the Rivers district as in the Oak River and Moline districts. In the Rivers district, also the calves have twice as many warbles as the calves in the Oak River and Moline districts. On the other hand, the difference in the per cent infestation and the number of warbles per addult are insignificant for the separate localities. The variation in the infestation for the separate areas can be explained by the fact that while many farmers in the Oak River and Moline districts used control measures against the warbles, many farmers in the Rivers district had failed to do so.

The data for the untreated cattle are presented in Table VI. There is a marked difference between the per cent infestation of the heifers (85 per cent) and the steers (67 per cent) but there are more warbles to be found on the steers (12) than on the heifers (7). This situation seems to indicate a sexual difference to parasitism by warbles. The adults, however, are less heavily infested (12 per cent) and have approximately three warbles per animal. This difference in the infestation between the calves and the adults may be explained by an age resistance or resistance due to previous infestations. Some idea of systemic treat-

TABLE IV

INCIDENCE OF WARBLE INFESTATION IN CATTLE IN THE RIVERS DISTRICT, 1964 - 1965

Farm Number	Number of Cattle Examined		Number of Cattle with Warbles		Average Number of Warbles per Animal		Number of Adults Examined	Number of Adults with Warbles	Average No. of Warbles per Adult
	Steers	Heifers	Steers	Heifers	Steers	Heifers			
12	16	4	12	3	15	10			
13	9	7	7	3	10	6	8	3	4
14	8	7					8		
15	5	9	5	9	13	8	17		
16	4	5	4	5	12	6			
17	25	15					80		
18	9	5	5	4	15	6	28	6	4
Total	76	52	33	24	65	36	141	9	8
Aver. No. of Warbles per Animal					13	7.20			4
Per cent of Animals Infested			43.42	46.15				6.38	

TABLE V

INCIDENCE OF WARBLE INFESTATION IN CATTLE IN THE MOLINE AND OAK RIVER DISTRICTS
1964 - 1965

Farm Number	Number of Cattle Examined		Number of Cattle with Warbles		Average Number of Warbles per Animal		Number of Adults Examined	Number of Adults with Warbles	Average No. of Warbles per adult
	Steers	Heifers	Steers	Heifers	Steers	Heifers			
1	15	9	2	1	2	1	35		
2							20	10	3
3	22	6	8	2	14	6	46	2	2
4	2						20		
5	12	12					20		
6	13	3					11	1	1
7	8	7	1		1		15		
8	13	17	6	3	4	1	20	6	1
9		6					7		
10	6	5					17		
11	3	6	3	6	8	6	14	3	1
Total	94	71	20	12	29	14	225	22	8
Aver.No. of Warbles per Animal					5.80	3.50			1.60
Per cent of Animals Infested			21.27	16.90				9.69	

TABLE VI

INCIDENCE OF WARBLE INFESTATION IN UNTREATED CATTLE IN THE RIVERS, MOLINE, AND OAK RIVER DISTRICTS
1964 - 65

Farm Number	Number of Cattle Examined		Number of Cattle with Warbles		Average Number of Warbles per Animal		Number of Adults Examined	Number of Adults with Warbles	Average No. of Warbles per Adult
	Steers	Heifers	Steers	Heifers	Steers	Heifers			
3	22	3	8	2	14	6	46	2	2
11	3	6	3	6	8	6	14	3	1
12	16	4	12	3	15	10			
13	9	7	7	3	10	6	8	3	4
15	5	9	5	9	13	8	17		
16	4	5	4	5	12	6			
18	5	5	5	4	14	6	28	6	4
Total	64	39	44	33	86	48	113	14	11
Aver.No.of Warbles per Animal					12.28	6.85			2.75
Per cent of Animals Infested			68.75	84.61				12.38	

ment with Ruelene on warbles is presented in Table VII. There are minor differences in the infestation between the steers (8 per cent) and the heifers (5 per cent), as well as the number of warbles per steer (2) and heifer (1). The adults, too, have a low incidence of warble infestation (7 per cent) and about two warbles per adult.

Comparison with Table VI and Table VII shows that the untreated steers are about eight times more heavily infested than the treated steers and the untreated heifers seventeen times more heavily infested than the treated heifers. There are almost six times as many warbles in the untreated calves as are to be found in the treated calves. The adults show little difference in the per cent infestation and in the number of warbles between the treated and untreated animals. This shows that the number of warbles in the adults are not influenced by treatment. Ruelene, therefore, is an effective larvicide against warbles in calves but of minor effect against warbles in the adults. This means that age rather than treatment is the determining factor in the reduction of warbles in the adults.

The data in Table VIII indicate that the nature of the soil, its drainage and moisture content may influence warble population more than altitude and vegetation types. The absence of warbles in those areas (Fig.2, Table VIII) may be due to a predominantly sandy loam type of soil with patches of clay and

TABLE VII

EFFECT OF RUELENE POUR-ON TREATMENT ON WARBLES IN CATTLE IN THE RIVERS, OAK RIVER AND MOLINE DISTRICTS
1964 - 1965

Farm Number	Number of Cattle Examined		Number of Cattle with Warbles		Average Number of Warbles per Animal		Number of Adults Examined	Number of Adults with Warbles	Average No. of Warbles per Adult
	Steers	Heifers	Steers	Heifers	Steers	Heifers			
1	15	9	2	1	2	1	35		
2							20	10	3
3		3							
4	2						20		
5	12	12					20		
6	13	3					11	1	1
7	8	7	1		1		15		
8	13	17	6	3	4	1	20	6	1
9		6					7		
10	6	5					17		
14	8	7					8		
17	25	15					80		
18	4								
Total	106	84	9	4	7	2	253	17	5
Aver.No.of Warbles per Animal					2.33	1			1.66
Per cent of Animals Infested			8.49	4.76				6.72	

TABLE VIII

EFFECTS OF ENVIRONMENT OF WARBLE POPULATION IN SOME AREAS IN MANITOBA

Areas	Altitude	Nature of Soil	Drainage	Moisture Content	Degree of Infestation	Natural Vegetation
	ft.					
Stuartburn	900-950	Sandy loam to silty clay	Fair	xx	-	Aspen and willow predominate with elm, ash, burr oak and [maple]. Frequent box elder meadow openings.
Gardenton	950-1000	" "	Fair	xx	-	
Piney	1100-1200	Sandy loam with peat	Poor	xx to xxx	-	Mixed stands of broad-leaf and coniferous species, chiefly spruce and aspen
Sprague	1100	" "	Poor	xxx	-	
Woodmore	950-1000	Light sandy soil with rock out-crops. Some wet or swampy areas	Fair	x	xxx	Mainly aspen, small quantities of spruce, white elm, green ash cotton wood, burr oak, balsam poplar, [Manitoba maple]. box elder
Vita	950-1000		Fair	x	xxx	
Sundown	1000-1100		Fair	x	xxx	
Dominion City	800-850	Heavy clay	Fair	xx	x	Predominantly grassland with scattered groves of willow and aspen. Transition of lightly treed areas to forest
Ridgeville	" "	" "	Fair	xx	x	
Emerson	" "	" "	Fair	xx	x	
Arnaud	" "	" "	Fair	xx	x	
Greenridge Area	" "	" "				

continued/

TABLE VIII CONTINUED

Areas	Altitude	Nature of Soil	Drain-age	Moisture Content	Degree of Infestation	Natural Vegetation
Moline	ft. 1660-1800		Good	xx	x	Predominantly grass-land with scattered groves of willow and aspen. Transition of lightly treed areas to forest
Cardale	" "	Heavy black loam	Good	xx	x	
Oak River			Good	xx	x	

- ; absence

x ; low

xx ; moderate

xxx ; high

(More than 15 grubs per head of cattle is regarded as a heavy infestation)

peat, fair to poor drainage and high moisture content. In areas where the soil is of clay, with fair to good drainage and high moisture content, warble infestation tends to be low. Warbles appear to develop abundantly where the soil is a light sandy type with fair drainage and low moisture content.

4. Summary

While H. lineatum and H. bovis are widely distributed in Manitoba, there is a seasonal difference in their development. Thirty-one per cent of the heifers, 29 per cent of the steers and 8 per cent of the adults in the Oak River, Moline and Rivers districts are infested with warbles, but the cattle in the Rivers district are more heavily parasitized than those in the Oak River and Moline districts. Calves have a higher per cent infestation and more warbles per animal than the adults. Untreated calves are more heavily parasitized with warbles than calves treated with Ruelene, but there is little difference between the treated and untreated adults. A sexual difference to parasitism by warbles appear to exist between the steers and heifers.

The only areas in the province which are known to the writer to be warble free are Stuartburn, Gardenton, Piney, and Sprague. The development of warbles may be influenced more by the nature of the soil, its drainage and moisture

content than by altitude and vegetation types.

(b) Family: Cuterebridae; Genus; Cuterebra

1. Introduction

Parasitism by cuterebrid larvae has been recorded and described for over a century, but the actual mode of entry is still unknown. Parker and Wells (46) mechanically transferred larvae of C. tenebrosa to prairie dogs and recovered some of the larvae from the subcutaneous tissue which indicated that they are able to penetrate the unbroken skin. Taxonomic characters of the larvae of C. buccata and C. cuniculi are discussed by Knipling and Broody (40), C. emasculator by Bennett (2), and C. angustifrons by Dalmat (16). Geis (25) discussed the effects of rodent warbles on South Michigan cotton-tail rabbits while Robets (51) and Bennett (loc.cit.) reported cuterebrid infestation complicated by myiasis producers. In Manitoba Buchner (9) obtained larvae of C. grisea from Peromyscus maniculatus, Allen (11) reported C. tenebrosa infecting a house mouse and McLeod (see Table II) reported larvae of C. angustifrons naturally infecting a house mouse and a mink. The house mouse infected by C. angustifrons and two other specimens stored in the Zoology Department, University of Manitoba were examined by the writer.

2. Results

On the house mouse one furuncle was located in the sub-

anal region and another in front of the left thigh. The presence of the larvae near the hind region would undoubtedly impede its progress and thus make it susceptible to predation. Two other unidentified cuterebrid species were removed from the backs of dogs in Manitoba. These specimens have been sent to Ottawa to be identified (see Table II).

2. MYIASIS OF THE MOUTH, NOSE AND SINUSES

Nasal myiasis is a diseased condition in the mouth, nose and sinuses of the host produced by certain obligatory parasitic dipterous larvae. The larvae either penetrate through the external nares to the nasal cavities, mouth and accessory sinuses, or more rarely, through an injury in the head region.

Emphasis will be placed on the first mentioned route of infection because it was the only one encountered in this study. The condition found to occur in Odocoileus virginianus (Zimmerman) the white-tailed deer, and in the sheep of Manitoba was produced by members of the genera Cephenemyia and Oestrus respectively.

(a) Family: Oestridae; Genus - Cephenemyia

1. Introduction

In North America, Hunter (1915) considered Cephenemyia as a genus of the Oestridae. Townsend (60) and later James

(37) placed the genus into the Subfamily Cuterebridae. Bennett (2) disputed the family status of Cephenemyia on a comparative basis with the cuterebrids and finally placed Cephenemyia in the Superfamily Oestridae which is in agreement with the concept of this family by Curran (15). Several reports indicate that the larvae of Cephenemyia migrate randomly through the body of the host. Larvae of C. trompe located in the throat and gullet of caribou were reported by Buckell (10), newly hatched larvae of C. phobifera in the stomach and intestines of deer by Herman (35) and larvae and puparia of C. phobifera in the feces of deer by Blickel (8). Bennett (4) found larvae of C. phobifera and Cowan (13) larvae of C. jellisoni in such abnormal sites as the lungs, trachea, mouth and oesophagus of deer. The effects of parasitism is discussed by Hadwen (30), Cowan (13), Bennett (4) and Fitch (29). Bennett (4) in his description "On the Biology of C. phobifera," proposed the term "pharyngeal bots" instead of "nose bots" because of their location in the retropharyngeal region. It is true that second and third larval instars are usually found in the retropharyngeal region during their development, but later they are found in various areas in the nasal cavities, especially shortly prior to pupation. Also, first instar larvae would be excluded if the term "pharnyngeal bots" is used because they are commonly located in the nasal cavities. On such a basis, the writer prefers the term "nose bots"

because all the stages would be included. For the purpose of identification of the Cephenemyia species of North America in the larval stages and as adults, the taxonomic key by Bennett and Sabrosky (3) provides the most valuable source of information.

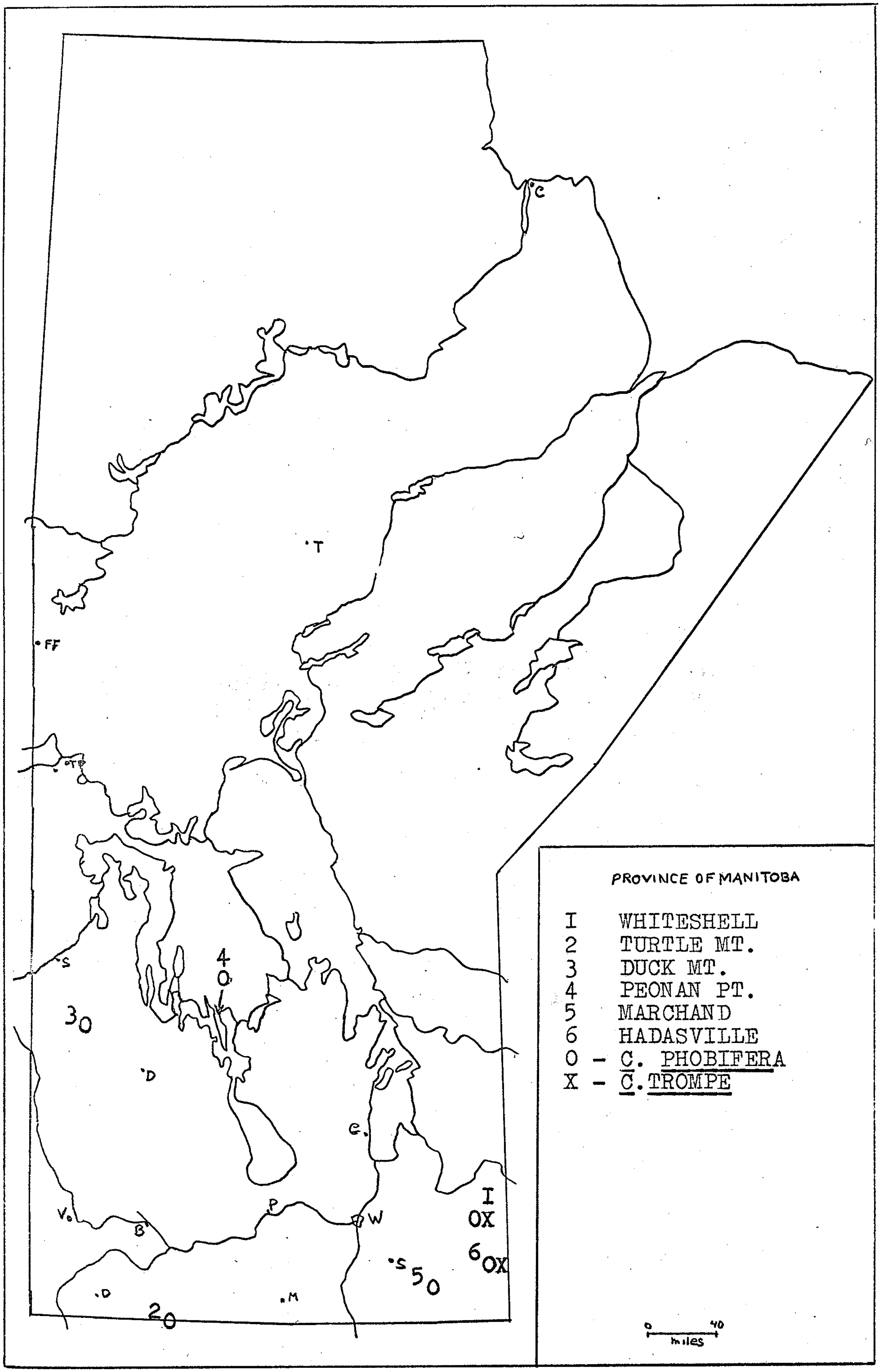
Work on Cephenemyia species has already been conducted in all the provinces of Canada with the exception of Manitoba and Quebec. The present work incorporates the result of the first survey in Manitoba. Members of this genus have been identified in six areas in Manitoba namely, Whiteshell, Turtle Mt., Duck Mt., Hadasville, Marchand and Peonan Point (Figure 2). The species identified were C. trompe and C. phobifera according to the key of Bennett and Sabrosky (3).

The materials and methods, and results are herein discussed. A brief note on nose bots in sheep will also be included.

2. Materials and Methods

From December 30, 1961 to April 18, 1962 and December 29, 1962 to April 19, 1963 the Wildlife Branch, Province of Manitoba, undertook a project to determine "The Biology of Reproduction of Odocoileus virginianus (Zim.), the white-tailed Deer". Collections made in this investigation also provided material for the present study. One hundred and thirty-three heads were obtained, of which there were 89 adults and 44 fawns. The heads were delivered as shot and

FIGURE 2. Map of Manitoba Showing Known Distribution of Some Species of *Cephenemyia*.


PROVINCE OF MANITOBA
I WHITESHELL
2 TURTLE MT.
3 DUCK MT.
4 PEONAN PT.
5 MARCHAND
6 HADASVILLE
0 - C. PHOBIFERA
X - C. TROMPE
0 40
miles

had to be frozen for storage.

The frozen heads were partially thawed overnight as this procedure facilitated sawing. The first fifteen heads were cut transversely at the level of the maxillary sinuses but without success. Later specimens were split down the midline through the brain and on one side of the nasal septum until the nasal passages and nasopharyngeal regions were exposed. This latter procedure proved successful. The first method may have caused some infected cases to go unobserved since most larvae were located in the nasopharyngeal region. In the second method, first instar larvae were obscured by extensive blood clots and undigested foods in the nasal cavities and may have gone unnoticed. Larvae specimens collected were preserved in 80 per cent alcohol. First, second and third stage larvae were then separated, counted and identified to determine the species and phase of development. Data for the incidence of infestation in the white-tailed deer in the province of Manitoba included a study on the distribution of Cephenemyia species and their cervid host as well as a comparison of infestation with regard to the area, age class, sex and average larvae per head from December to April in 1962 and 1963.

3. Results

Twenty one (15.8 per cent) of the 133 heads collected from eight areas in Manitoba were naturally infected with

larvae of Cephenemyia species (Table IX). Of the two species identified (Table IX, Figure 3), C. phobifera was obtained from six of the areas studied, and C. trompe from two, namely Hadasville and the Whiteshell. The data in Table IX, Figure 4, illustrate that C. phobifera (93.2 per cent) is more widespread in its distribution than C. trompe (6.8 per cent). The distribution of infested deer in Table IX, Figure 5 indicates that Peonan Point (22.2 per cent) is the most heavily infested area studied. Other areas included the Whiteshell (19.6 per cent), Turtle Mt., (14.6 per cent), and Duck Mt. (7.2 per cent). Infested samples also were collected from Hadasville and Marchand, but the samples were too small to be of statistical value. A negligible difference in the incidence of infestation between the fawns and adults is also indicated in Table IX. Reference to Table X shows a small difference in the incidence of infestation between the males (19.2 per cent) and the females (14.9 per cent). The incidence of infestation and the number of larvae per head were compared among deer of different age classes (Table XI). The data (Table XI and Figure 6) show that deer 3 to 4 years old are uninfected, while the percentage infestation of those 1 to 2 years old is almost twice as heavy as those of the age groups 5 months to 1 year and 5 years and over. Conversely, infested deer 5 months to 1 year and 5 years and over harbored

TABLE IX

CEPHENEMYIA SPECIES AFFECTING THE WHITE-TAILED DEER IN MANITOBA DURING DECEMBER 30, 1961 TO APRIL 19, 1962 AND DECEMBER 28, 1962 TO APRIL 18, 1963 (PERCENTAGE INDICATED IN BRACKETS)

Area	No. of deer Examined		No. of deer Infested		Total No. of Deer		No. of larvae	
	Adults	Fawns	Adults	Fawns	Examined	Infested	C.phobifera	C.trompe
Whiteshell	19	7	3	2	26	5(19.6)	68(27.3)	9(3.6)
Hadasville	2	-	2	-	2	2	30	8
Turtle Mt.	26	15	3	3	41	6(14.6)	77(30.9)	-
Duck Mt.	28	14	2	1	42	3(7.2)	19(7.6)	-
Peonan Pt.	11	7	3	1	18	4(22.2)	34(13.7)	-
Marchand	2	1	1	-	2	1	4(1.6)	-
Elkhorn	1	-	-	-	1	-	-	-
Ft. White	-	1	-	-	1	-	-	-
Total	89	44	(14(15.8)	7(15.9)	133	21(15.8)	232(93.2)	17(6.8)

FIGURE 3. Percentage Distribution of *Cephenemyia* Species Recorded from Some Areas in Manitoba.

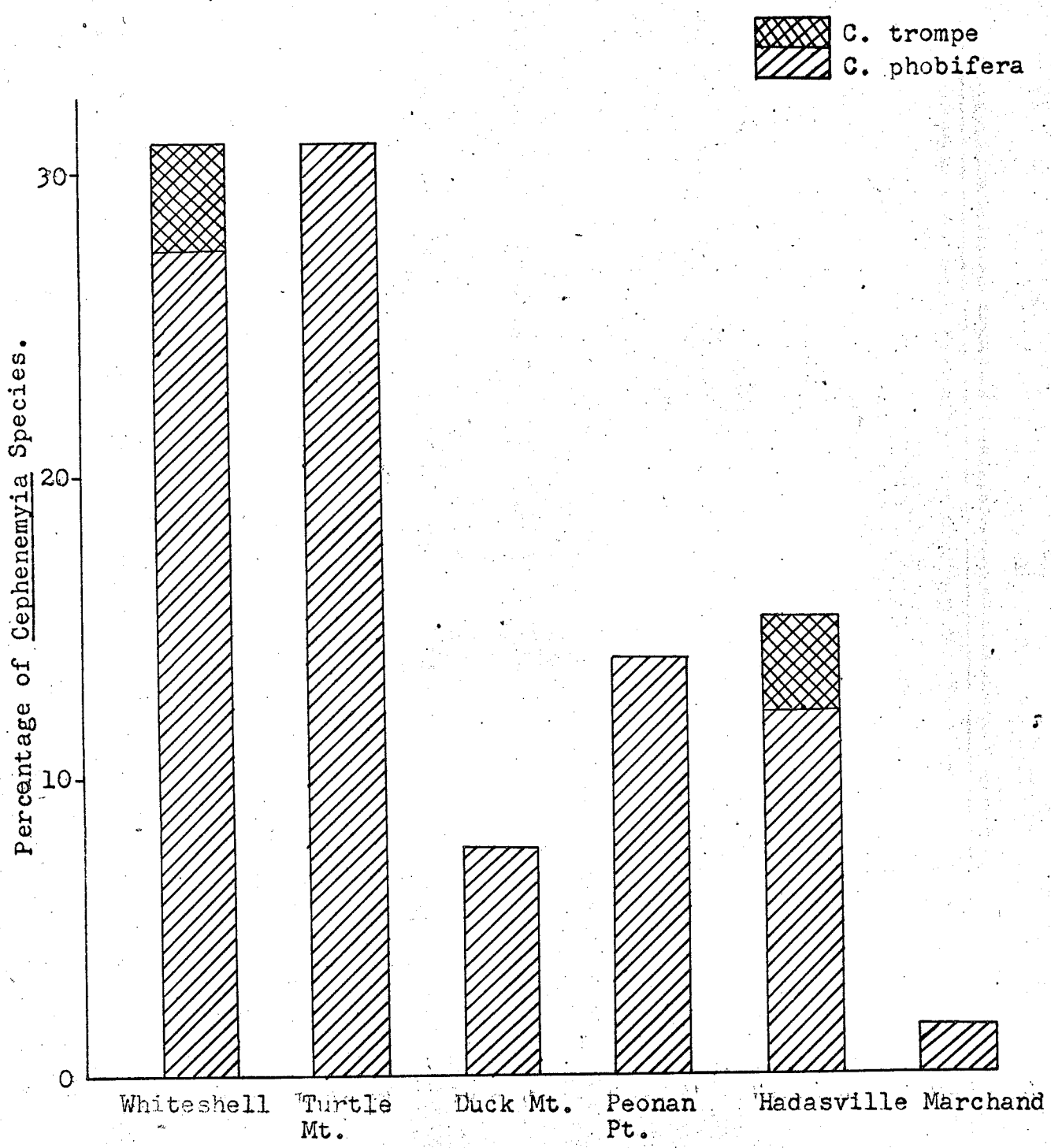

C. trompe
C. phobifera
Percentage of Cephenemyia Species.
30
20
10
0
Whiteshell
Turtle Mt.
Duck Mt.
Peonan Pt.
Hadasville
Marchand

FIGURE 4. Relative Abundances of *Cephenemyia* Species in Infested Deer Recorded from Some Areas in Manitoba.

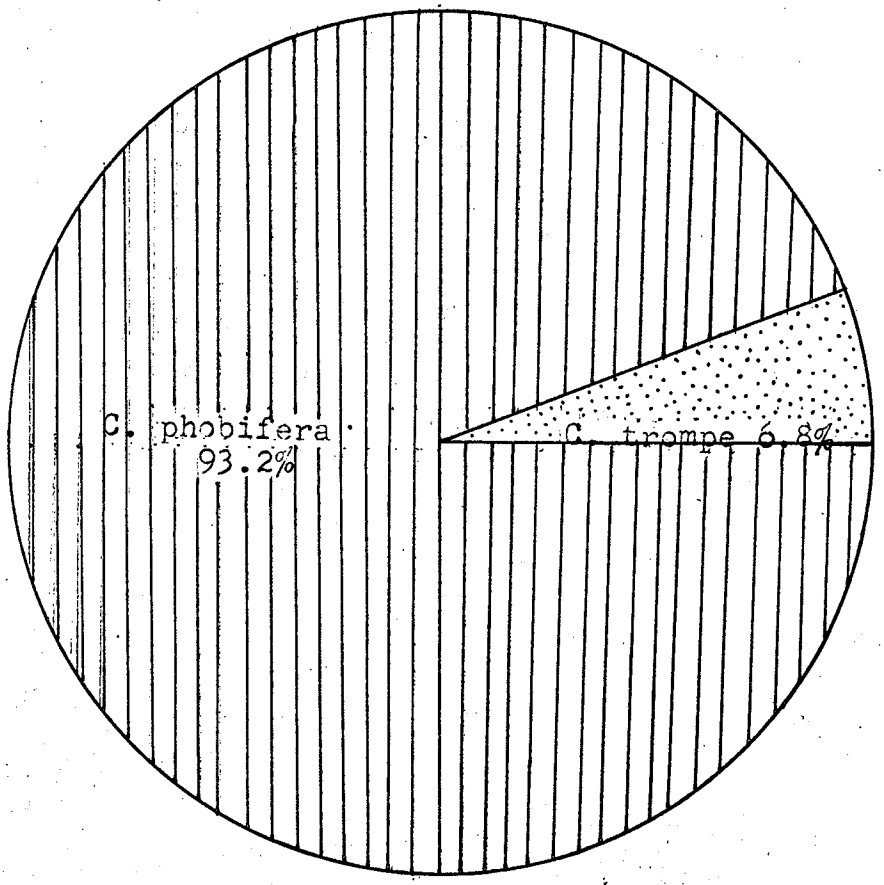

C. phobifera
93.2%
C. trompe 6.8%

FIGURE 5. Percentage of Infested Deer Recorded from Some Areas in Manitoba.

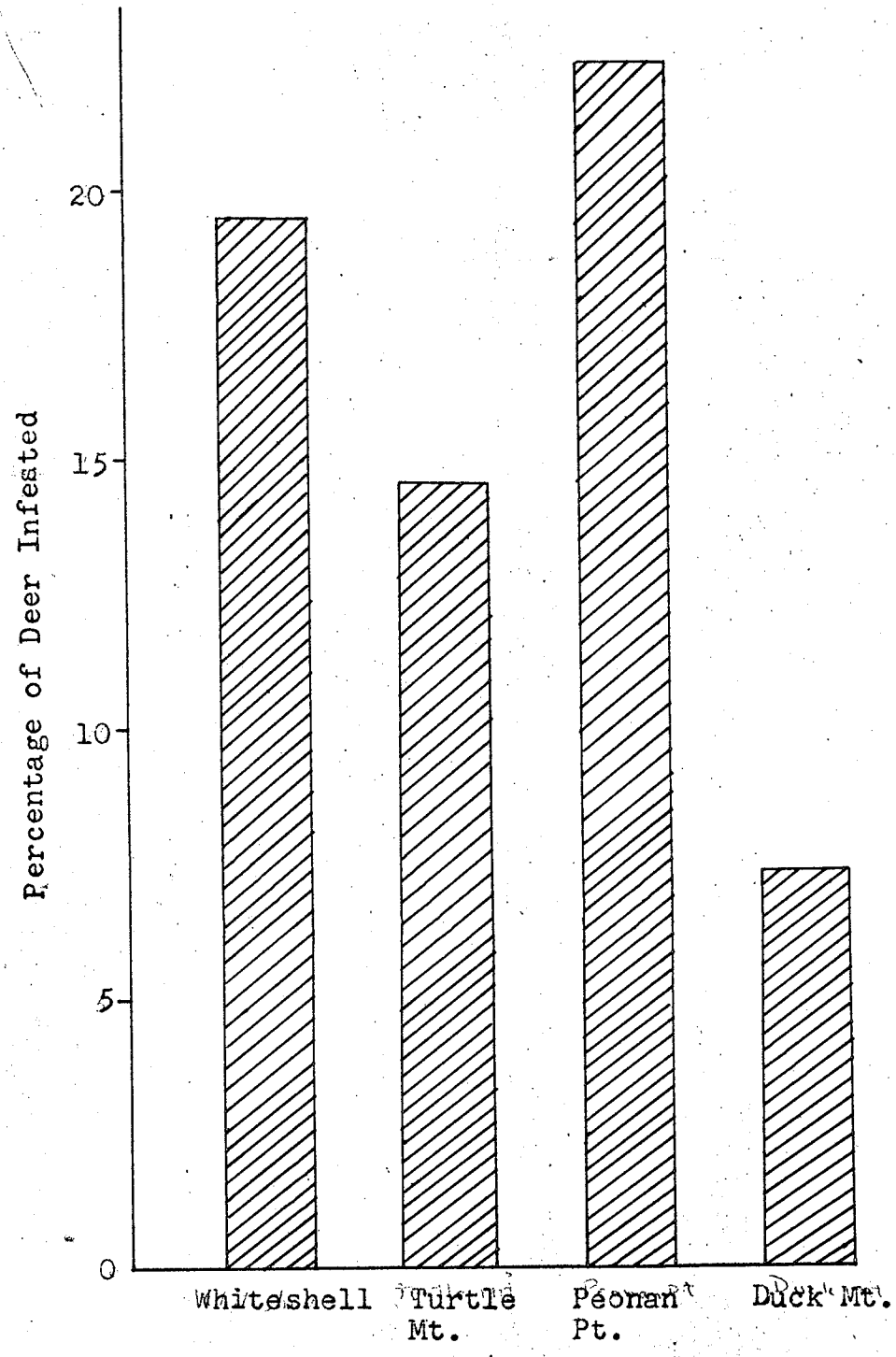

Percentage of Deer Infested
20
15
10
5
0
Whiteshell
Turtle Mt.
Peonan Pt.
Duck Mt.

TABLE X

SEXUAL DIFFERENCE IN THE INCIDENCE OF INFESTED DEER IN MANITOBA DURING DECEMBER 30, 1961 TO APRIL 19, 1962 AND DECEMBER 29, 1962 TO APRIL 18, 1963 (PERCENTAGE IN BRACKETS)

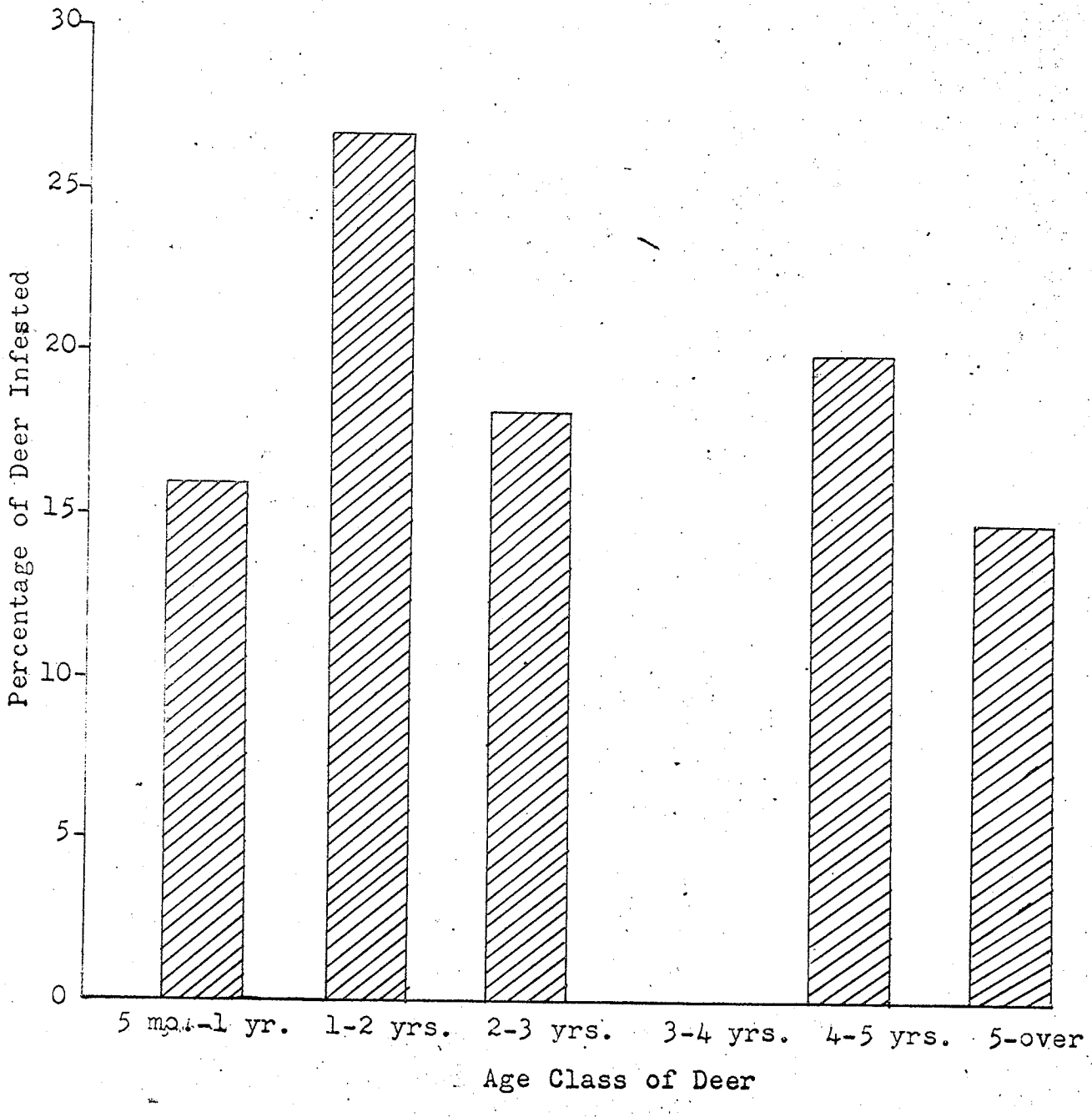
Area	Total Number of Deer Examined		Infested	
	♂	♀	♂	♀
Whiteshell	2	24	1	4
Turtle Mt.	10	31	3	3
Duck Mt.	9	33	-	3
Peonan Pt.	4	14	-	4
Hadasville	-	2	-	2
Marchand	1	1	1	-
Elkhorn	-	1	-	-
Ft. Whyte	-	1	-	-
Total	26	107	5(19.2)	16(14.9)

TABLE XI

INCIDENCE OF INFESTATION AND NUMBER OF BOTS PER HEAD IN DEER OF DIFFERENT AGE CLASSES (DEC.30, 1961-APRIL 19, 1962 AND DEC. 29, 1962-APRIL 18, 1963)

Age class	Total animals	Number infected	Percent positive	Total larvae	Average/ head
5 mo. - 1 yr.	44	7	15.9	104	14.9
1 yr. - 2 yr.	15	4	26.7	28	7
2 yr. - 3 yr.	11	2	18.2	14	7
3 yr. - 4 yr.	10	-	-	-	-
4 yr. - 5 yr.	5	1	20	3	3
5 yr. - over	48	7	14.6	100	14.4

FIGURE 6. Percentage of Infested Deer in the Different Age Classes.


30
25
20
15
10
5
0
Percentage of Deer Infested
5 mo.-1 yr.
1-2 yrs.
2-3 yrs.
3-4 yrs.
4-5 yrs.
5-over
Age Class of Deer

twice as many larvae per head as those 1 to 2 years old (Fig.7). The presence of first instar larvae and the wide diversity of the sizes in the second and third instar larvae during March and April demonstrate a difference in the rate of development and alternatively there may be a diapause. Larvae were observed to be distributed all the way from the external nares to the nasopharyngeal region. The anterior ends of the third instar larvae in the nasal cavity were directed towards the opening of the external nares (Fig.8), while those found in the nasopharyngeal region were directed towards the oral cavity (Fig.9). Such different migratory patterns seem to indicate that the larvae could be eliminated through the mouth or nose prior to pupation.

4. Summary

One hundred and thirty-three heads of Odocoileus virginainus, the white-tailed deer, in Manitoba were examined for nose bots. One hundred and seven were females and 26 males, of which 89 were adults and 44 fawns. Two species of Cephenemyia - C. trompe and C. phobifera, which parasitized these animals, were identified. Parasitism by nose bots was determined in six areas of the province and appears to be widespread in distribution. The incidence of infestation is similar in the fawns and adults, but fawns and old adults (5 years and over) show a higher infestation of larvae per head than any other age class. The females are as heavily

FIGURE 7. Average Larvae per Head of Infested Deer According to the Different Age Classes.

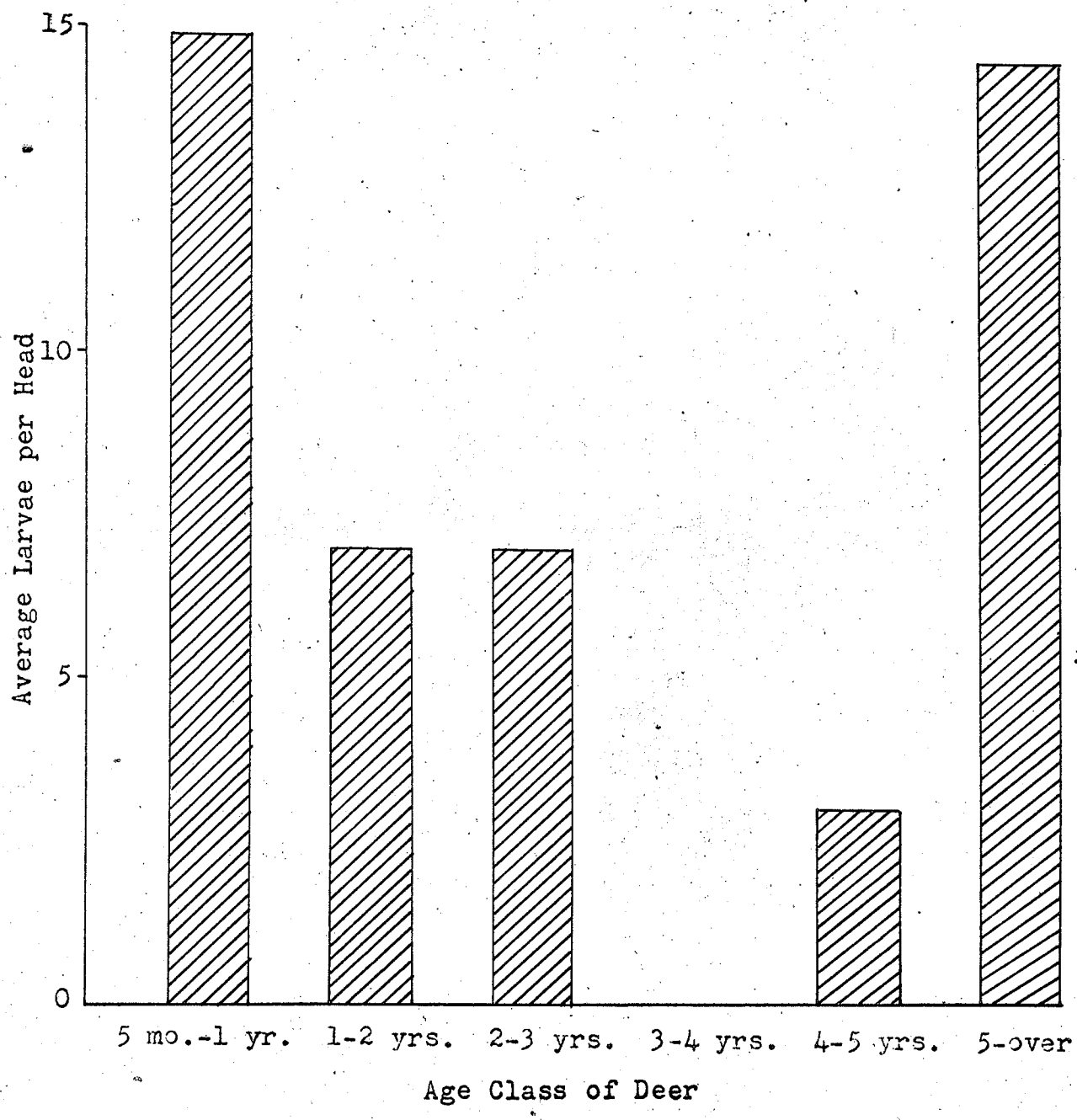

15
10
5
0
Average Larvae per Head
5 mo.-1 yr.
1-2 yrs.
2-3 yrs.
3-4 yrs.
4-5 yrs.
5-over
Age Class of Deer

FIGURE 8. *Cephenemyia phobifera* in the Nasal Cavity of the White-tailed Deer.

FIGURE 9. Cephenemyia phobifera in the Naso-pharyngeal Region of the White-Tailed Deer.

infested as the males. The larvae were found distributed in the host from the external nares to the nasopharyngeal region. Some larvae were found in the mouth and oesophagus, on the soft palate, in the trachea, and embedded in the muscle tissue. The presence of first instar larvae and the wide diversity in the development of the second and third instar larvae during March and April indicate a difference in the rate of development and possibly a diapause.

Note on Nose Bots in Sheep

Twenty five sheep heads from Manitoba were collected in October 1962, from Swift's Abattoir. Fifteen heads were examined and all were found to be naturally infected with the first instar larvae of Oestrus ovis. They were located mainly in the maxillary and nasal sinuses, but were also distributed in various parts of the nasal passages.

DIPTERA PRODUCING FACULTATIVE MYIASIS

"This group includes all those flies which though normally breeding in the bodies of dead animals, and even in vegetable matter occasionally lay their eggs or deposit their larvae in or near fresh wounds and diseased tissue of man and other animals", (Patton, 47).

Many members of this group are of little importance from the standpoint of human and animal myiasis except during great infestations, e.g., "fly strike" in sheep or the attack of blow flies on the wounded, senile or insane man or animal.

The families represented in this study are the Calliphoridae and Sarcophagidae (see Table XII). Many of the genera and species were not obtained from actual cases of myiasis, but were trapped. They were, however, determined by Hall (32) and James (37) to cause traumatic myiasis in several areas of North America.

Phormia regina, the causative agent of "fly strike" in sheep, Phaenicia sericata producing traumatic myiasis in man, sheep, rats, mice and fox; as well as reports of traumatic myiasis will be discussed below.

(a) Family - Calliphoridae; Genus - (a) Phormia

1. Introduction

Phormia regina (Meigen), the black blow fly, is a facultative saprophagous parasite causing wound myiasis. This fly

TABLE XII

FACULTATIVE MYIASIS-PRODUCING DIPTERA RECORDED FROM MANITOBA

	Traumatic	Collector	Locality	Year
SARCOPHAGIDAE				
Sarcophaga haemorrhoidalis	X	V. Murray	Winnipeg	July 19/61
S. barbata	X	V. Murray	Winnipeg	July 8/62
S. striata	X	V. Murray	Poplar Point	July 9/62
CALLIPHORIDAE				
Phormia regina	X	V. Murray	Steinbach	June 27/62
Phormia regina	X	V. Murray	Roland	July 7/63
Protophormia terraenovae	X	V. Murray	Steinbach	June 27/62
Phaenicia sericata	X	H. Young	Fort Garry	Sept. 2/61
Lucilia illustris	X	V. Murray	Oak Point	June 17/62
Phaenicia sericata	X	W. Poetker	Winkler	June 16/62
Lucilia caesar	X	V. Murray	Oak Point	June 17/62
Calliphora vicinia	X	J. Hawley	Roland	May 16/62
Calliphora vomitoria	X	V. Murray	Winnipeg	June 8/62
Callitorga macellaria	X	V. Murray	Steinbach	June 27/62
Cynomyopsis cadaverina	X	V. Murray	Winnipeg	June 7/62

has been recorded by Bishopp and Laake (6), Chandler (11), and James (37) to be the principal agent of "fly strike" in sheep in Texas. Hall (32) has discussed the seasonal distribution of the flies and the causes for "fly strike" infestation in sheep, while Monnig (44), and Knipling et al., (41) have reported the effects of parasitism on the sheep during such infestations. In Manitoba, P. regina was determined by the writer to be the principal agent of "fly strike" in sheep. Some secondary invaders have also been identified. The materials and methods as well as the results are discussed below.

2. Materials and Methods

The materials for the study of "fly strike" in sheep were obtained through interviews, specimens collected from cases of "fly strike" and experiments. Veterinarians were interviewed to collect information on the incidence of "fly strike" in their separate localities. Individual cases from six flocks were examined and larvae were obtained for identification and rearing experiments. Other experiments using traps with wool were conducted from June to August 1962 to determine the causative agent of "fly strike" in the sheep of Manitoba and the possible factors necessary for the infestation. All specimens obtained by the writer were identified according to the keys of Hall (32) and James (37).

Experiment 1.

On July 7, 1963, fifty larvae were collected from a

freshly infected lamb at Roland. Ten of the larvae were preserved in 80 per cent alcohol and the remaining forty reared to the adult stage.

Experiment II

At Steinbach a lamb's tail which fell off after docking was suspended in a six-sided gauze trap, 18"x18"x18", supported on a metal frame with one side opened, and placed in a shaded area where the sheep usually rested. The tail had a pungent smell, raw exposed areas and mucous secretions.

Experiment III

Experiment II was repeated at the University campus under similar conditions, except the tail was moistened with water.

Experiment IV

Samples of fresh wool taken from a lamb were used under five different conditions:

1. Wool soiled with faeces,
2. Wool soiled with urine,
3. Wool soiled with blood,
4. Wool dampened with water,
5. Dried wool.

These samples were suspended in traps and placed in the open pasture where the sheep were grazing on a hot day. The traps used were six-sided (18"x8"x8") and made of 0.2 cm copper-wire

meshwork supported on a wooden frame. One side of each trap was opened.

Experiment V

Experiment IV was repeated using the stale wool from that experiment as well as fresh wool. The copper-wire mesh traps were placed in the shaded areas of the pasture anc checked at 9:00 a.m., 12:00 p.m. and 5:30 p.m.

Experiment VI

Samples of fresh wool moistened with blood and urine were placed in gauze traps at Balmoral and Stonewall.

3. Results

Several cases of "fly strike" in sheep which occurred during the late spring and summer of 1961 were reported from Carman, Portage la Prairie, Stonewall, Hamiota and Steinbach by resident veterinarians. In 1962 five infested flocks were reported. A flock at Hamiota and another at the University campus, Manitoba were infected following small wounds produced by shearing. At Steinbach ten cases from three flocks occurred due to docking, castration and minute wounds resulting from shearing. In Roland four cases in a flock which resulted from small wounds produced from shearing were observed in 1963, and in 1964 two cases in a flock at Bradwardine were due to docking.

Observations during this present study reveal that when

a sheep is infected with "fly strike", it becomes separated from the flock and tends to hide in shaded areas under trees, among tall grass or among shrubs. It stands with its head down and does not feed. The infected sheep also tends to rub against obstacles or bite at those areas where the larvae are located. If the infestation is in the hind region, stamping of the hind legs and wagging of the tail are symptoms characteristic of traumatic myiasis. Other symptoms were marked debility, loss of appetite, emaciation, loss of milk with subsequent death of the lambs, destruction of tissue and death by toxemia or septicemia. Larval specimens collected from five of the infested flocks and reared to the adult stage were identified mainly as Phormia regina with few examples of Phaenicia sericata.

Most of the larval specimens collected from another infested flock at Steinbach were identified as Callitroga macellaria. These flies were most abundant only because the wounds were fetid and suppurative. Other specimens of larvae and adults were Phormia regina, Protophormia terrae-novae, and Phaenicia sericata.

The results of the individual experiments are as follows:

Experiment I - The forty adults were Phormia regina. Of the ten preserved specimens, eight were P. regina and two were Phaenicia sericata.

Experiment II - After one hour, members of Phormia regina, Protophormia terrae-novae, Lucilia caesar and Phaenicia sericata were trapped.

Experiment III - The flies collected were [illegible] Phormia regina and Protophormia terrae-novae.

Experiment IV - Stomoxys calcitrans was in the trap containing the wool dampened with blood. No other flies were trapped. The presence of S. calcitrans could be explained as a feeding response, since specimens of these flies collected at Steinbach had distended abdomens filled with blood.

Experiment V - P. regina was collected from the trap which contained blood and urine. The numbers were greatest in the trap with fresh wool dampened with fresh blood.

Experiment VI - P. regina was again attracted to wool dampened with blood more readily than wool dampened with urine.

4. Summary

Phormia regina is widespread in its distribution in Manitoba. Experimental evidence and examination of larval specimens obtained from cases of "fly strike" indicate that P. regina is the principal agent of "fly strike" in the sheep of Manitoba. Other flies which occur in the province and which are involved in "fly strike" are Callitroga macellaria, P. terrae-novae, P. sericata and L. caesar. The flies were attracted to wounds and wool soiled with blood or urine. The effects of parasitism may range from a period of debility of the host to its death.

(b) Family - Calliphoridae: Genus - (b) Phaenicia

1. Introduction

Phaenicia sericata is a saprophagous facultative parasite which is attracted to pungent odours emanating from wounds or decomposing animal matter. Its life cycle, habits and identification characteristics of the larvae and adults are discussed by Hall (32) and James (37). The materials and methods and the results are discussed later.

2. Materials and Methods

Adults and larvae specimens of P. sericata were collected from infected animals. Most of the larval specimens were identified and reared to the adult stage, while the remainder were preserved in 80 per cent alcohol. Members of P. sericata were reared several times on putrid meat to determine the life cycle and behaviour of these flies. Other experiments on the behaviour of these flies were performed by using a freshly killed crow in a gauze trap 18"x18"x18", and young mice tainted with putrid meat and untained young mice in separate copper wire traps 18"x8"x8".

3. Results

Incidences of infestation were observed in infected and healthy tissue of sheep, in young rats and in a fox. The only infestation in man by P. sericata is discussed in the case histories on page 69 .

Since members of P. sericata were attracted to the trap about half an hour after the death of the crow and

increased greatly in numbers by one to two hours, these flies are attracted to pungent odours emanating from decomposing animal tissue. Members of P. sericata were attracted to and deposited their eggs on the tainted mice while the untainted mice were unaffected. This behaviour signifies that pungent odours also initiate oviposition. The eggs were located at the immediate points of entry into the host's beak, mouth and anus - which indicates an adaptation towards survival.

The life cycle of P. sericata lasts from two to three weeks. On July 20, 1961 a female specimen, resting at an angle of approximately 60 degrees to the base of the container, deposited eggs at an average rate of one egg every forty-five seconds through its everted ovipositor beneath putrid meat. The creamy white eggs were placed in a shingle-like manner by the manipulation of its everted ovipositor and right hind tarsus until all the hollows in the egg mass were filled. The number of eggs were approximately 300, many of which hatched in about ten to twelve hours. The three larval stages were completed in five to seven days. They were negatively phototactic. Many larvae migrated several yards prior to pupation and within twenty-four hours brown puparia were formed. After ten to twelve days the adults began emerging during the morning hours between 6 and 9 a.m.

4. Summary

A man and wounded animals were infected with larvae of P. sericata. The adult females were attracted to pungent odours emanating from decomposing animal tissue. Pungent odours also seem to initiate oviposition. The creamy white eggs, arranged in a shingle-like manner were located first at the immediate points of entry into the host. The larvae were negatively phototactic, facultative parasites. The life cycle of these flies lasts from two to three weeks.

(c) Reports on Cases of Traumatic Myiasis

A few veterinarians reported cases of traumatic myiasis, but no larvae were sent in for identification and the fly species involved were not determined.

Dr. D. M. Meagher, from Carman, reported that in 1961 there were nine cases of traumatic myiasis recorded from the Carman area. Seven of the cases involved fly strike in two different flocks of sheep. In the first flock, there were five cases due to late shearing, and matting of wool in the buttock regions of diarrhoeic animals. Two cases, due to docking and castration, were observed in the second flock.

The eighth case was a sow "blown" with maggots due to laceration of the vulva lips following farrowing. Matted hair, in a senile Scotch collie, due to diarrhea produced

the ninth case.

Dr. T. J. Lawson, from Carman reported two cases in 1961 and one in 1962. In 1961, fly strike was evident on a sheep in a wound caused by dogs. This case was complicated by Clostridium chauvoei septicum and malignant edema.

In the same year, several (no statistical data recorded) cattle were blown by Calliphorids following dehorning. The effects observed were - slow gait, head held downwards as a sign of sinus trouble and a rise in temperature of 2-3 degrees.

Dr. Y. G. Kjernisted, from Stonewall reported two cases in cattle during 1961. One was due to wet belly in calves and the other due to dehorning.

Reports of wound myiasis, during 1961, were obtained from other veterinarians, which can be summed up as follows:

Fly strike in sheep and infestations of cattle due to dehorning were recorded from Steinbach, Portage la Prairie and Stonewall.

Infestation of wounded dogs were recorded from Portage la Prairie, Stonewall, Winnipeg, St. Vital, Carman, Neepawa and Steinbach.

It can therefore be safely stated that traumatic (wound) myiasis caused by blow flies is of widespread occurrence during the summer months in the Province of Manitoba.

CASE HISTORIES

In August, 1925, Austman (5) recorded the first case of "creeping eruption" by Gasterophilus intestinalis in Manitoba. This case occurred in a young university graduate while assisting his father in the hay fields with horses. The second case, recorded by Bedford (6), occurred on June 30, 1932, (see Appendix for the Report).

On June 24, 1961, a case of cutaneous myiasis was reported from the Children's Hospital in Winnipeg, Manitoba by Duncan. The child, N. D., was three weeks of age, and lived in the Winnipeg area. Prior to admittance, the parent observed pustules on the child's chest, neck and arm. The following day, larvae were seen crawling about it's body. Clinical diagnosis showed multiple ulcerated lesions in the arm, neck and chest. White blood cell counts showed a shift to the left and a marked eosinophilia due to the infectious process produced by the presence of the larvae. The child soon recovered after the removal of the larvae and was discharged on July 3, 1961. One larva was reared to the adult stage and proved to be Wohlfahrtia vigil (Walker) on examination.

On August 10, 1961, a 60 year old woman from Kirkness, Manitoba was admitted to the St. Boniface General Hospital for traumatic myiasis. When admitted, she reported, that flies were observed entering her dress sleeves and a few

days later she observed larvae crawling on her arm. None of the larvae were recovered for examination. The case revealed that her left breast was almost destroyed. There were also large ulcerations and pockets under the skin of the breast, but the wounds were clean. Clinical examination proved the case to be that of carcinoma of the left breast.

On June 16, 1962, L.D., 11 years of age, from the Winkler area, Manitoba, was admitted to the Winnipeg Children's Hospital for second and third degree burns by Poetker. This case was complicated by traumatic myiasis near the anal region. One larva was obtained for identification and proved to be Phaenicia sericata (Meig.).

FLIES PRODUCING ACCIDENTAL MYIASIS

This group consists of an assemblage of more or less unrelated Diptera, the larvae of which occasionally find their way into the gastro-intestinal tract, urinary passages, etc., of other animals and exist there as parasites. Members of this group usually breed on dead animal and vegetable matter. The larvae may enter the gastro-intestinal tract of animals when ingested with contaminated food or water. The method of entrance of the larvae into the urinary passages and bladder is not known. Purulent material at the external region of the urinary organs may, however, provide a suitable habitat for egg deposition. The young larvae on hatching may then migrate to the upper regions. Such a mode of entry into the female organs is quite possible, but is questionable for the males. The genera and species mentioned in this group were not obtained from actual cases of myiasis, but were collected in Manitoba during the study. They were, however, determined by James (47) to produce accidental myiasis in man (see Table XIII).

TABLE XIII

ACCIDENTAL MYIASIS-PRODUCING DIPTERA RECORDED FROM OTHER PARTS OF THE WORLD (JAMES (47))

Family and species	Types of myiasis		
	Traumatic	Gastro-intestinal	Bladder and urinary passages
MUSCIDAE			
Stomoxys calcitrans	x	x	
Muscina stabulans	?	x	x
Musca domestica	x	x	
PSYCHODIDAE			
Psychoda albipennis			x
DROSOPHILIDAE			
Drosophila melanogaster		?	

BLOOD SUCKING MAGGOTS AND SPURIOUS MYIASIS

1. BLOOD SUCKING LARVAE

In the single case of blood sucking larvae which came to the writer's attention, the organisms belonged to the Calliphoridae, sub-family-Chrysomyinae; genus and species - Apaulina avium (Shannon and Dobroscky). These larvae which were found in the nests of certain birds, are stored in the Zoology Department, University of Manitoba.

2. SPURIOUS MYIASIS

One case of spurious myiasis, produced by the larvae of Musca domestica in the gizzard of a chicken from Winnipeg, was reported in October, 1962 by Isa. Some of the larvae were alive and some were crushed by the grinding action of the gizzard. There was slight mechanical damage to the epithelium of the oesophagus and gizzard.

SUMMARY AND CONCLUSIONS

Myiasis is classified according to two general plans:

1. according to the habits of the flies, Patton (59) and
2. according to the tissues and organs attacked, Bishopp, (9).

It is difficult to separate the habits of the flies from their habitat, and thus a dual classification was adopted. This dual classification, it is hoped, will satisfy the interests of both the entomologists and the parasitologists.

In the present study, myiasis is classified as obligatory, facultative or accidental when the habits of myiasis-producing flies were considered. When the tissues and organs are affected obligatory myiasis is further sub-divided into: (1) myiasis of the mouth, nose and sinuses, produced by members of the genera, Cephenemyia and Oestrus; (2) furuncular or subcutaneous myiasis by Hypoderma, Oedemagena, Cuterebra and Wohlfahrtia.

Facultative myiasis is classified as traumatic and is caused by members of the genera, Phormia and Phaenicia. Possible causes of accidental myiasis and flies capable of producing this type of myiasis are included. Case histories in man which are recorded in Manitoba are discussed. One case of blood-sucking maggots and another of spurious myiasis are briefly mentioned.

Obligatory and facultative myiasis are widespread in distribution in the Province of Manitoba. The hosts of such myiasis-producing flies include man as well as wild and domesticated animals, but ungulates tend to be the most heavily parasitized of all the animals studied. Parasitism by these flies may result in the degeneration in the quality of the animals and subsequent economic loss. It may also be a factor in the balance of nature since parasitized animals are more susceptible to predation. On the other hand, obligatory myiasis-producing flies are more advanced in the scale of evolution than facultative myiasis-producers since the latter forms are gradually adapting to a parasitic life.

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APPENDIX

Clinical history, -- J. P., a farmer, aged 29 years, was admitted to the Winnipeg General Hospital on June 30, 1932, suffering from an injury to the left eye. While in hospital he complained of an itching eruption on the flexor surface of the left forearm. The patient's description is as follows: "I first noticed it about four or five days after I was in the hospital. It looked like a mosquito bite, and was very itchy. Then in a few days it started to spread around my wrist. I noticed it always moved at night. Some nights it did not travel as far as on a warm night. As it moved along, the skin healed up behind it". In his opinion the eruption was due to an insect. During the last few days he thought the insect had "backed-up".

When a clinical examination was made on July 22, 1932 the eruption presented itself as a tortuous raised and palpable dark brown linear lesion. For about one inch the lesion was acutely inflamed, and presented the appearance of an herpetic eruption, five or six vesicles being grouped together. There was a narrow inflammatory zone fading into the normal epidermis at the adjacent loops of the tract.

From Bedford (6).