

The Seasonal Dynamics and Host-Parasite Relationship of
Opisocrostitis bruneri (Baker), a Flea on Franklin's Ground
Squirrel, Spermophilus franklinii (Sabine) Near Birds
Hill Park, Manitoba.

by

Todd Raymond Reichardt

A thesis
presented to the University of Manitoba
in partial fulfilment of the
requirements for the degree of
Masters of Science
in
Department of Entomology

Winnipeg, Manitoba

(c) Todd Raymond Reichardt, 1989

National Library
of Canada

Canadian Theses Service

Bibliothèque nationale du
Canada

Service des thèses
canadiennes

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-48099-8

The Seasonal Dynamics and Host-Parasite
Relationship of Opisocrostis bruneri (Baker),
a Flea on Franklin's Ground Squirrel,
Spermophilus franklinii (Sabine)
Near Birds Hill Park, Manitoba.
by
Todd Raymond Reichardt

MASTER OF SCIENCE

© 1989

Permission has been granted to the LIBRARY OF THE UNIVERSITY OF MANITOBA to lend or sell copies of this thesis, to the NATIONAL LIBRARY OF CANADA to microfilm this thesis and to lend or sell copies of the film, and UNIVERSITY MICROFILMS to publish an abstract of this thesis.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

I hereby declare that I am the sole author of this thesis.

I authorize the University of Manitoba to lend this thesis to other institutions or individuals for the purpose of scholarly research.

Todd Raymond Reichardt

I further authorize the University of Manitoba to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

Todd Raymond Reichardt

The University of Manitoba requires the signature of all persons using or photocopying this thesis. Please sign below, and give address and date.

ACKNOWLEDGEMENTS

I would like to thank first and foremost my supervisor and friend Dr. Terry D. Galloway. His endless patience, support and guidance were invaluable to my program. I would also like to thank Terry for the risk he took by employing the student that tried to fit an asilid into a bumblebee couplet.

I would like to thank Dr. J. O. Whitaker for identifying mite specimens. I would like to thank my committee members, Drs. R.A. Brust and T.A. Dick for their comments and advice on the manuscript. I would like to thank the Royal Municipality of Oak Bank for permission to use the field sites.

The program was funded from an operating grant provided from NSERC to Dr. T.D. Galloway. I would also like to thank Ms. Cheryl Oakden for typing the manuscript. I would also like to thank my fiancée, Edie Arney, for her endless source of love and support. Thank you.

DEDICATION

I would like to dedicate this thesis to my late grandmother, Marie Carriere, who inspires me to persevere through difficult times and pursue my goals. Thanks Grandma.

ABSTRACT

The host-parasite relationship between the flea, Opisocrostitis bruneri and its primary host, Franklin's ground squirrel, Spermophilus franklinii was evaluated during a 2 year study.

Adult male ground squirrels were first captured each year on 5 May. The adult males were reproductively fit during the first two weeks of May. Adult female squirrels were first captured 5-8 days after the first male capture. Mating and subsequent parturition probably occurred in early May and mid-late June, respectively. The first observed signs of above ground juvenile squirrel activity were in mid-July. Adult squirrels immerged to hibernate in early August, followed by the juvenile females and males in early to mid-September.

Thirty-six individual squirrels were involved in 95 total captures in 1982. In 1983, 40 individual squirrels were involved in 161 total captures. The recapture rate of S. franklinii was 2.6 and 4.0 in 1982 and 1983, respectively. Adult squirrels constituted approximately 75% of the total captures and this stage was most frequently recaptured in 1982 and 1983.

Eight hundred and forty-nine and 1503 O. bruneri were removed from S. franklinii in 1982 and 1983, respectively.

Adult male squirrels were most frequently infested and contributed 43% and 64% of fleas collected in 1982 and 1983, respectively.

The observed sex ratio (m/f) of fleas removed from S. franklinii was 0.70 and 0.73 in 1982 and 1983, respectively. The biweekly sex ratio (m/f) favoured female fleas in each trapping period throughout the season except during a two week period starting at the beginning of May and the end of June.

The observed prevalence of O. bruneri from all captured S. franklinii was greater than or equal to 0.75. The observed biweekly prevalence on adult male and female squirrel was always greater than or equal to 0.73 and 0.67, respectively. Juvenile male and female squirrels were always infested. Two discrete peaks of mean intensity of adult fleas were observed in early May and late August.

Female fleas containing immature ovarioles (stage 0 and 1) with or without sperm in the spermatheca were predominant during the first three trapping periods. Parous females predominated during the remaining trapping periods.

Oogenesis of O. bruneri was not stimulated by the oestrous cycle of female S. franklinii. Parous female fleas containing sperm within the spermatheca were found throughout the entire season.

O. bruneri completes at least two generations per year in Manitoba. Peaks of nulliparous female fleas were observed

in early May and early July. The shift in biweekly observed sex ratio (m/f) favouring males occurred during these periods.

Opisocrostis bruneri was generally infested with two different mites, Psyllanoetus spp. and Trichouropoda spp. The haemocoel of the flea was occasionally occupied by allantonematid nematodes. The cysticercoïd stage, presumably of Hymenolepis citelli, was removed from the mid-gut of one flea and gregarine cysts were frequently found within the mid-gut of O. bruneri.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS iv

DEDICATION v

ABSTRACT vi

<u>Chapter</u>	<u>PAGE</u>
I. INTRODUCTION	1
II. REVIEW OF PERTINENT LITERATURE	9
2.1 FRANKLIN'S GROUND SQUIRREL	9
2.1.1 Historical Background	10
2.1.2 Description	12
2.1.3 Distribution	12
2.1.4 Life History	13
2.1.5 Behavior	15
2.1.6 Related Research	16
2.2 <u>Opisocrostis bruneri</u>	17
2.2.1 Historical Background	17
2.2.2 Description	17
2.2.3 Distribution	19
2.2.4 Related Research	20
III. MATERIALS AND METHODS	22
3.1 DESCRIPTION OF STUDY SITES	22
3.2 TRAPPING REGIME	25
3.3 REMOVAL OF ECTOPARASITES	28
3.4 DESCRIPTION OF FEMALE REPRODUCTIVE ORGANS .	30
IV. RESULTS	35
4.1 MAMMAL CAPTURES	35
4.1.1 General	35
4.1.2 1982	36
4.1.3 1983	36
4.2 FLEAS REMOVED FROM <u>S. franklinii</u>	36
4.2.1 1982	36
4.2.2 1983	38
4.3 INFESTATION PARAMETERS OF <u>O. bruneri</u>	39
4.3.1 1982	39
4.3.2 1983	48
4.3.3 1983 - Plot 5	48

4.4	REPRODUCTIVE CONDITIONS OF <u>O. bruneri</u>	50
4.4.1	1982	50
4.4.2	1983	52
V.	DISCUSSION	56
5.1	HOST-PARASITE RELATIONSHIP	56
5.2	SEASONAL DYNAMICS OF <u>O. bruneri</u>	60
5.3	LIFE HISTORY OF <u>O. bruneri</u>	63
VI.	CONCLUSION	71
	LITERATURE CITED	73

Appendices

A.	APPENDIX A	79
A.1	DISSECTION OF <u>O. bruneri</u>	79
A.1.1	Preparation	79
A.1.2	Procedure for the dissection of male fleas	79
A.1.3	Procedure for the dissection of female fleas	79
B.	APPENDIX B	82
B.1	PARASITES AND ASSOCIATES OF <u>O. bruneri</u>	82
B.1.1	External Associates	82
B.1.2	Internal Parasites	82

LIST OF TABLES

<u>Table</u>	<u>page</u>
1. Description of the ovarian developmental stages based on the measurement of the largest proximal oocyte found within female <u>Opisocrostitis bruneri</u> removed from <u>Spermophilus franklinii</u> near Birds Hill Park, Manitoba, 1982-1983	32
2. Summary of <u>Spermophilus franklinii</u> captured in 1982-1938 near Birds Hill Park, Manitoba, and the number of captures (C), per cent of total captures (%), individuals (I), per cent of total individuals (%) and recapture rates (RR)	37
3. Summary of the observed sex ratios (M/f), including totals (T) of male (M) and female (F) <u>Opisocrostitis bruneri</u> removed from <u>Spermophilus franklinii</u> near Birds Hill Park, Manitoba, 1982-1983	40
4. Observed sex ratios (M/F) of <u>Opisocrostitis bruneri</u> removed from <u>Spermophilus franklinii</u> captured (C) near Birds Hill Park, Manitoba, 1982-1983	41
5. Infestation parameters including prevalence (P) and mean intensity (MI) for <u>Opisocrostitis bruneri</u> removed from <u>Spermophilus franklinii</u> captured (C) near Birds Hill Park, Manitoba, 1982-1983	42
6. Infestation parameters including prevalence (P) and mean intensity (MI) for <u>Opisocrostitis bruneri</u> removed from adult male <u>Spermophilus franklinii</u> captured (C) near Birds Hill Park, Manitoba, 1982-1983	43
7. Infestation parameters including prevalence (P) and mean intensity (MI) for <u>Opisocrostitis bruneri</u> removed from adult female <u>Spermophilus franklinii</u> captured (C) near Birds Hill Park, Manitoba, 1982-1983	44
8. Infestation parameters including prevalence (P) and mean intensity (MI) for <u>Opisocrostitis bruneri</u> removed from juvenile male <u>Spermophilus franklinii</u> captured (C) near Birds Hill Park, Manitoba, 1982-1983	45

9. Infestation parameters including prevalence (P) and mean intensity (MI) for Opisocrostis bruneri removed from juvenile female Spermophilus franklinii captured (C) near Birds Hill Park, Manitoba, 1982-1983 46
10. Comparison of biweekly mean intensity (MI) for Opisocrostis bruneri removed from Spermophilus franklinii captured (C) in main study site and plot 5 near Birds Hill Park, Manitoba, 1983 49
11. Percentage (%) of ovarian stage ratings (0-2) assigned to female Opisocrostis bruneri (with sperm present within the spermatheca) and total female fleas (T) removed from Spermophilus franklinii captured near Birds Hill Park, Manitoba, 1982 52
12. Biweekly summary of ovarian stage ratings (0-2), including total fleas removed (T) and percentage of fleas with the same reproductive status (%), assigned to parous (corpus luteum present) female Opisocrostis bruneri with (Present) and without (Absent) sperm in the spermatheca, removed from Spermophilus franklinii captured near Birds Hill Park, Manitoba, 1983 55

List of Figures

<u>Figure</u>	<u>page</u>
1. Distribution of <u>Opisocrostitis bruneri</u> and <u>Spermophilus franklinii</u>	2
2. Distribution of <u>O. bruneri</u> , <u>Spermophilus tridecemlineatus</u> and <u>S. richardsonii</u> (dotted line represents range extension)	3
3. Schematic representation of above ground activity of <u>Spermophilus franklinii</u> in Manitoba (lined areas indicate immergence of squirrels)	6
4. Adult male <u>Spermophilus franklinii</u> near Birds Hill Park, Manitoba	11
5. Adult male (upper) and female (lower) <u>Opisocrostitis bruneri</u> removed from Franklin's ground squirrels	18
6. Location of Birds Hill research study site in Manitoba, Canada (numbers indicate provincial highways)	23
7. Representation of typical oak-aspen parkland habitat of <u>Spermophilus franklinii</u> at Birds Hill, Manitoba, June 1982	24
8. Trapping grid on study plots three and four at Birds Hill, Manitoba (shaded area = forest, open area = ecotone) (open circles = trapping on site for first three weeks in 1982, closed circles = trapping for entire 1982 and 1983 season)	26
9. Tomahawk live trap model numbers 202 (centre) and number 101 (right) used to capture <u>S. franklinii</u> with Masonite ^o shelters protected animals from severe weather conditions	27
10. Photographic representation of the ovarian ratings assigned to ovarioles developing within <u>Opisocrostitis bruneri</u>	33
11. Graphic illustration of the ovarian ratings assigned to ovarioles developing within female <u>Opisocrostitis bruneri</u>	33

12. The corpus luteum, a follicular relic within the lateral oviduct of a female <u>Opisocrostis bruneri</u>	34
13. (a) Totals of female <u>Opisocrostis bruneri</u> with sperm present or absent in the spermatheca (SP.), and (b) totals of ovarian ratings from female <u>Opisocrostis bruneri</u> collected from <u>Spermophilus franklinii</u> near Birds Hill Park, Manitoba in 1982	51
14. (a) Totals of female <u>Opisocrostis bruneri</u> with (Y) and without (N) sperm within the spermatheca (corpus luteum present (P) or absent (A)), and (b) totals of ovarian ratings from <u>Opisocrostis bruneri</u> collected from <u>Spermophilus franklinii</u> near Birds Hill Park, Manitoba in 1983	54
15. Profile of <u>Opisocrostis bruneri</u> ovarian development as predicted by the relationship observed between <u>Spilopsyllus cuniculi</u> and <u>Oryctolagus cuniculus</u>	65
16. Schematic diagram of the posterior abdominal region, including the female genitalia within <u>Opisocrostis bruneri</u>	80
17. An anoetid mite under an <u>Opisocrostis bruneri</u> abdominal sternite	83
18. Adult female allantonematid nematode removed from the haemocoel of a female <u>Opisocrostis bruneri</u> .	84
19. The cysticercoïd stage, presumably, of <u>Hymenolepis citelli</u> removed from the haemocoel of <u>Opisocrostis bruneri</u>	84

Chapter I

INTRODUCTION

Opisocrostitis bruneri (Baker) is primarily associated with Franklin's ground squirrel, Spermophilus franklinii (Sabine), but also regularly infests two secondary hosts, the thirteen-lined ground squirrel, S. tridecemlineatus (Mitchell) and Richardson's ground squirrel, S. richardsonii (Sabine) (Holland 1949, 1985). Opisocrostitis bruneri has been recorded from a wide variety of accidental hosts, including Mustela, Peromyscus, Marmota, Taxidea, Vulpes, Thomomys, Sylvilagus, Canis and Felis (Smit 1983). The geographic distribution of O. bruneri overlays its primary and secondary hosts, S. franklinii, S. richardsonii and S. tridecemlineatus respectively (Holland 1952) (Figs. 1,2). In Canada, O. bruneri has been reported from Alberta, Saskatchewan, Manitoba, and within the Lake of the Woods region of Ontario (Perdue 1980, Smit 1983, Holland 1985).

Prince (1943) was the first to emphasize the potential of O. bruneri as a plague vector. Fifty per cent of fleas from S. richardsonii in Potter County, South Dakota transmitted plague bacillus to healthy animals in the laboratory. Prince remarked on the surprisingly high rate of transmission, "Thus a continuous chain of fleas capable of transmission of plague, and of hosts which have been infected extends from the Rocky Mountains and western North Dakota

Figure 1: Distribution of Opisocrostitis bruneri and Spermophilus franklinii (adapted from Perdue 1980, Banfield 1981, Hall 1981, and Holland 1985).

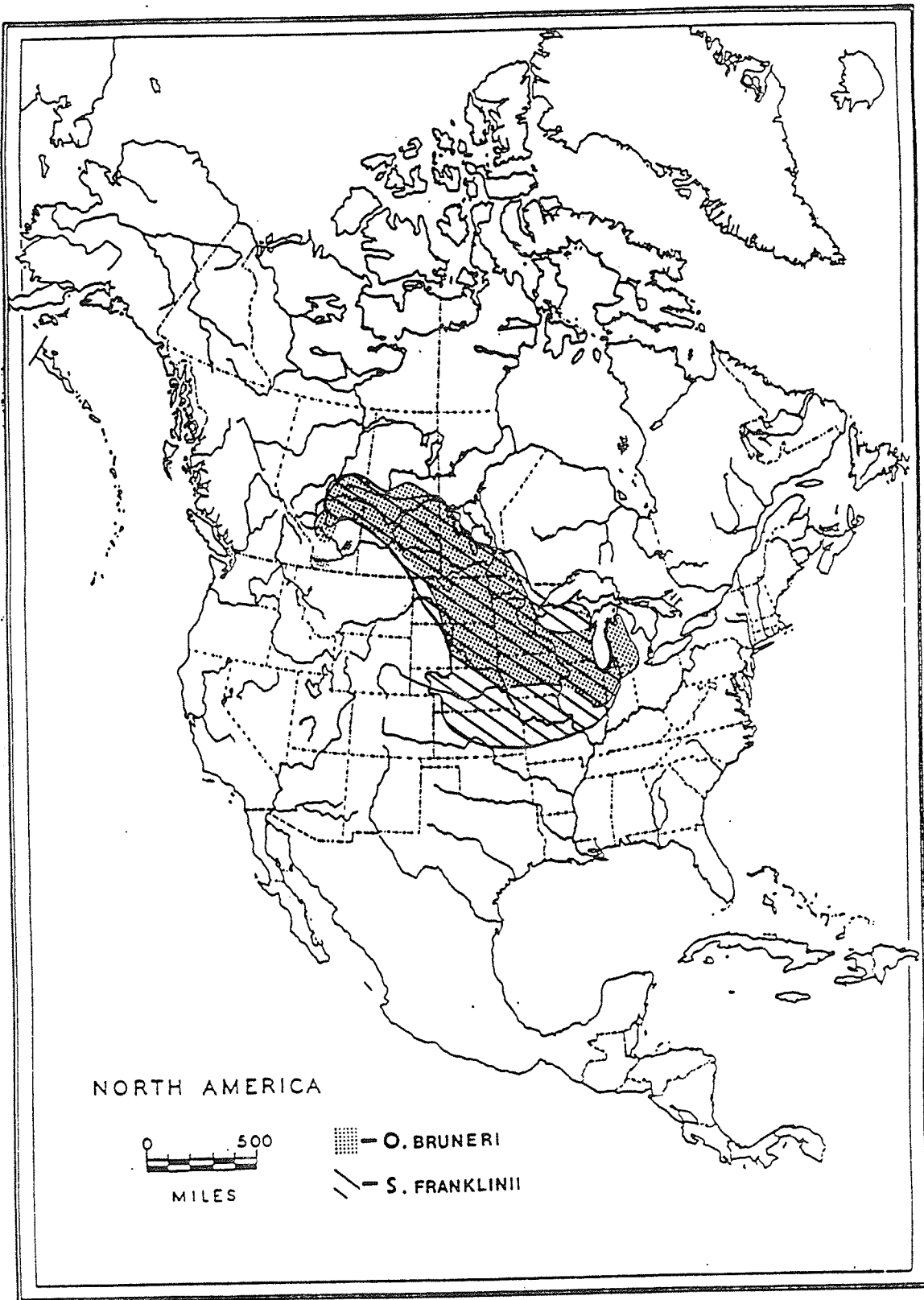
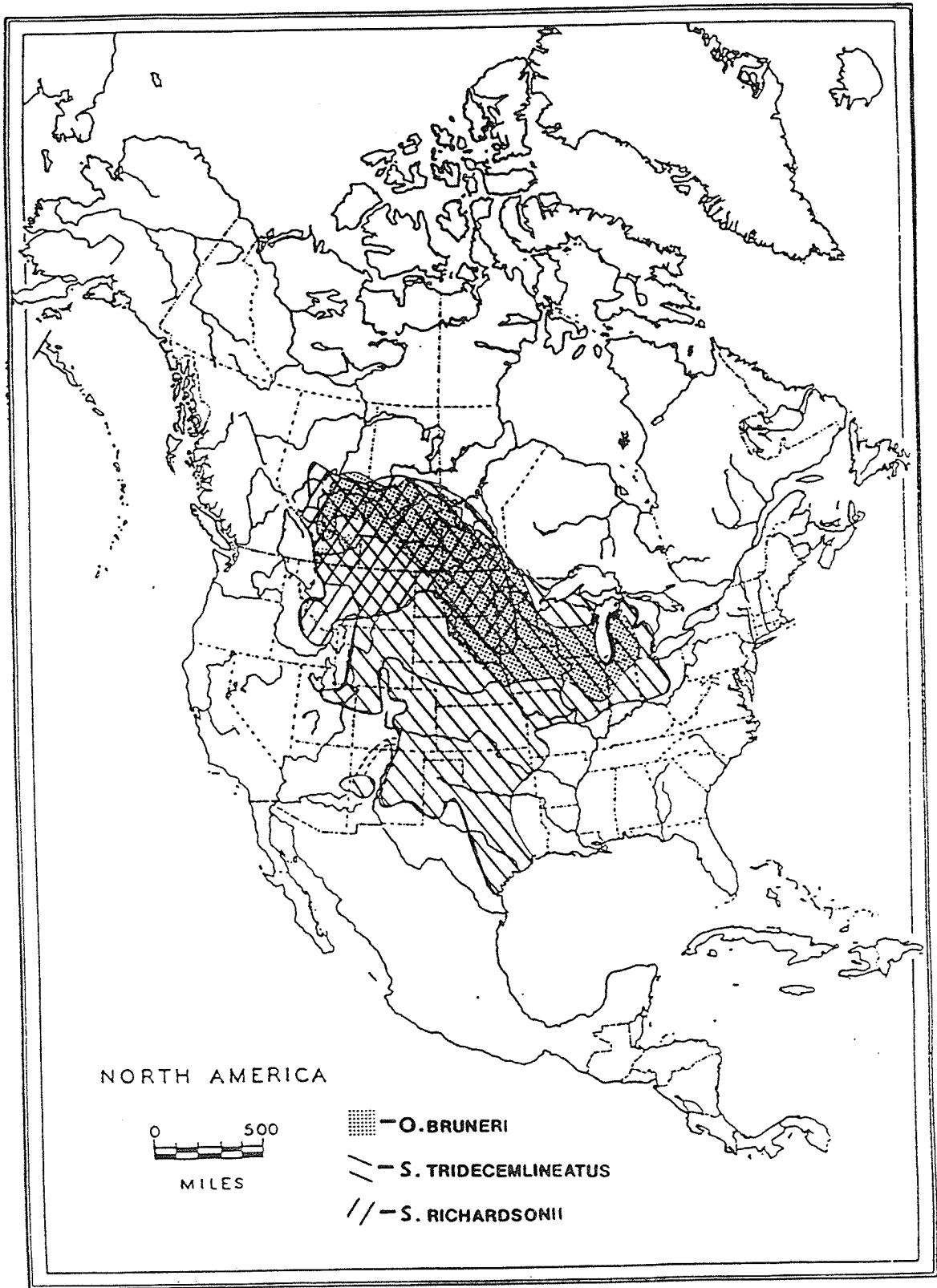


Figure 2: Distribution of Opisocrostitis bruneri,
Spermophilus tridecemlineatus, S. richardsonii.
(Dotted line represents range extension)
(adapted from Perdue 1980, Banfield 1981, and
Holland 1985).



in which plague prevails, to the west of the Mississippi River". Hubbard (1947) and Holland (1949) also stressed the importance of O. bruneri as a potential vector of sylvatic plague, though it is not yet established as a natural vector (Traub 1983) to man or ground squirrel.

The transfer of sylvatic plague from O. bruneri into an urban cycle depends on the opportunity of S. franklinii to maintain close contact near populated areas. Spermophilus franklinii inhabits transitional or disturbed areas; primarily oak-aspen parkland in and along the woodland-field ecotone and also along farms, suburbs, campgrounds and beach front (Banfield 1981). Transfer of fleas could occur in a transitional zone such as a sanitation dump site, between infected Spermophilus spp. and non-infected Rattus spp. The urban cycle commences when infected fleas, not necessarily O. bruneri, are transferred to uninfected Rattus spp.

Franklin's ground squirrel exhibits the lowest level of social behaviour among the six Spermophilus species in Canada (Kivett et al. 1976). Adult squirrel interaction is highest during the spring mating season. Adult and yearling males emerge from hibernation in breeding condition in late April to early May and establish breeding territories (Michener 1984). Mating commences in 1 to 2 weeks, when the monoestrus females emerge and continues 2 to 3 weeks hence (Fig. 3). Parturition occurs within approximately 28

days (Murie 1973). The young of the year begin above ground activity by the first week of July in Alberta. Adult males immerse to hibernate in late July followed by non-reproductive females and reproductive females. Juveniles hibernate in late August to early September (Banfield 1981) (Fig. 3).

The seasonal dynamics of O. bruneri on a secondary host have been investigated in two studies. Hendricks (1967) reported the infestation parameters for O. bruneri removed from S. tridecemlineatus. Two peaks of infestation (mean intensity) occurred during June and October, respectively. Kinzel and Larson (1973) investigated the relative abundance and geographic distribution of O. bruneri and Thrassis bacchi bacchi (Roth.) found on S. tridecemlineatus in North Dakota. Relative abundance was inversely related to geographic region, where T. b. bacchi was abundant in the west and O. bruneri predominant in the east. The authors suggested that the change in relative abundance across the state was due to different abiotic conditions, such as elevation and rainfall, within each region. Hendricks (1967) and Kinzel and Larson (1973), also associated abiotic conditions with changes in infestation during the year. The data from both studies were collected from several sites rather than one fixed location or host population for an entire season. Hence the conclusions from those studies may have been influenced by variation among sampling localities.

Figure 3: Schematic representation of the above ground activity of Spermophilus franklinii in Manitoba

(lined areas indicate immergence of squirrels and are separated by .5 week intervals).

Legend

M=mating

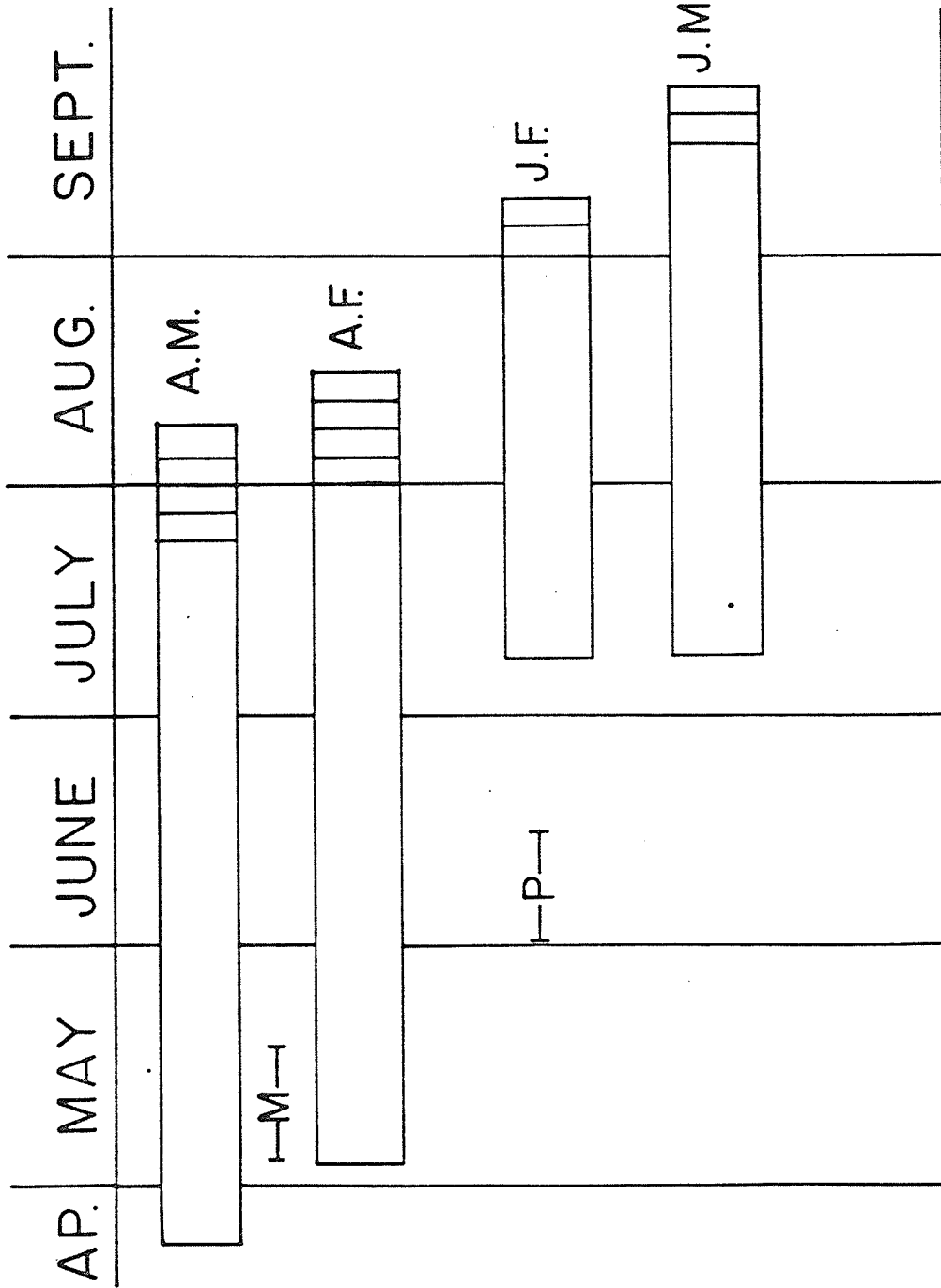
P=parturition

A.M.=adult male squirrel

A.F.=adult female squirrel

J.F.=juvenile female squirrel

J.M.=juvenile male squirrel



Seasonality of O. bruneri on S. franklinii was first assessed in 1979 near Birds Hill, Manitoba (Burachynsky and Galloway 1980). Adult flea populations were highest in mid-May and early September, respectively; the first peak occurred during the reproductive period of its monoestrous host, S. franklinii. The prevalence of infestation of O. bruneri on S. franklinii was $\geq 98\%$ during all season. Holland (1949) reported that O. bruneri was closely associated and almost exclusively found on S. franklinii. The high degree of association may have also resulted in the dependence of reproductive cues from S. franklinii to initiate reproduction in O. bruneri. Such a relationship had been previously observed between Spilopsyllus cuniculi Dale and Oryctolagus cuniculus (L.) (Rothschild and Ford 1973).

The life history and reproductive activity of the European rabbit flea, Spilopsyllus cuniculi was the most intensive flea study undertaken. Rothschild and Ford (1973) discovered that ovarian development in S. cuniculi was initiated by circulating estrogen and prolactin in the pregnant female rabbit host, Oryctolagus cuniculus. The ovarioles of S. cuniculi were quiescent throughout the year unless a blood meal was drawn from a reproductively active doe. The reproductive condition was closely monitored by removal and inspection of ovarian tissue. Subsequently the reproductive condition of S. cuniculi and O. cuniculus were synchronized throughout the year. This intrinsic relationship

was interpreted as a highly developed host-parasite system that ensures future generations of fleas a food source, since all eggs are laid within a nest containing new born rabbit kittens.

The present study is the first attempt to identify whether O. bruneri requires reproductive stimuli from its host to initiate ovarian development, as in the observed reproductive synchrony of S. cuniculi. If ovarian development of O. bruneri is stimulated by reproductive hormones, then parous females should be present only during the host's reproductive period. The objective, therefore, was to determine seasonal dynamics, reproductive activity of female fleas, and the host-parasite relationship between a population of Opisocrostis bruneri and Spermophilus franklinii near Birds Hill Park, Manitoba.

Chapter II

REVIEW OF PERTINENT LITERATURE

2.1 FRANKLIN'S GROUND SQUIRREL

2.1.1 Historical Background

Franklin's ground squirrel was first described as Arctomys (Spermophilus) franklinii, in honour of Sir John Franklin, the commander of the Overland Expedition of 1819-1822. In 1821, Sir John Richardson first discovered S. franklinii populations near Carlton House (Prince Albert), Saskatchewan. Sir Joseph Sabine later described S. franklinii based on specimens sent from Saskatchewan. A comparative description of several spermophiles, including S. franklinii, and other quadrupeds was reported by Richardson (1829).

Franklin's ground squirrel is known by several other common names; the bushy-tailed ground squirrel, grey ground squirrel, scrub-gopher, the grey-cheeked spermophile and the whistling gopher (Seton 1909). The clear, musical call of S. franklinii was described by Seton (1909) who remarked, ". . . This is the musician of the family. Its ordinary note heard in the brushwood is in a high degree musical, resembling the voice of some of our fine bird singers".

2.1.2 Description

Franklin's ground squirrel more closely resembles a tree squirrel than other ground squirrel because of its long, bushy tail which comprises two-thirds of its total length (Jackson 1961, Woods 1980, Banfield 1981, Hazard 1982, Wooding 1982, Jones et al. 1983)(Fig. 4). The skull is relatively long, particularly the rostrum, with a narrow zygomatic process and a narrow flat cranium (Banfield 1981). The narrow skull is uncharacteristic of the sciurids.

The pelage is short and particularly wiry during the summer months. The anterior dorsal region is light grey and the remaining regions are olive brown. Each hair is speckled with one or two black bars. The cream-coloured undercoat remains thin throughout the season except during hibernation. There is a white circle around each eye. The black-tipped tail is covered with long, silver black-banded hairs. The feet are furred with grey hair and the toes have long claws. The pinnae of the ears are small and often flush with the head.

One annual molt begins in early May and lasts until mid-June (Jackson 1961, Banfield 1981, Wooding 1982). Jones et al. (1983) suggested that S. franklinii undergoes two annual molts, the first in spring after mating and the second in late summer, although no specimens of the sub-genus Poliocitellus (such as S. franklinii) were examined. Hansen

Figure 4: Adult male Spermophilus franklinii near Birds Hill
Park, Manitoba.