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

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MASTER OF SCIENCE

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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, Opisocrostis 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 cysticercoid 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

LIST OF TABLES

List of Figures

Chapter I

INTRODUCTION

Opisocrostis 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). Opisocrostis 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 Opisocrostis bruneri and Spermophilus franklinii (adapted from Perdue 1980, Banfield 1981, Hall 1981, and Holland 1985).

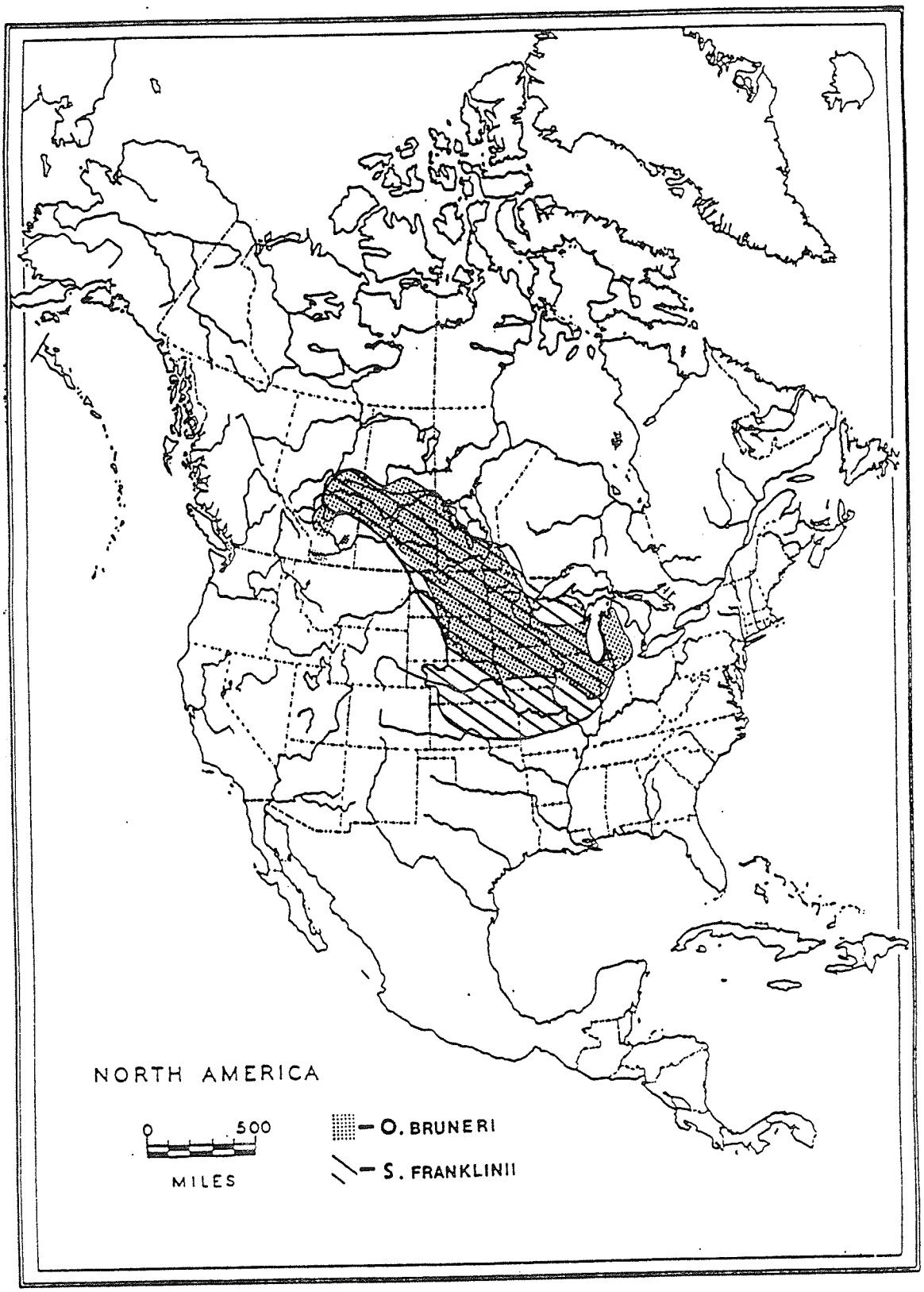
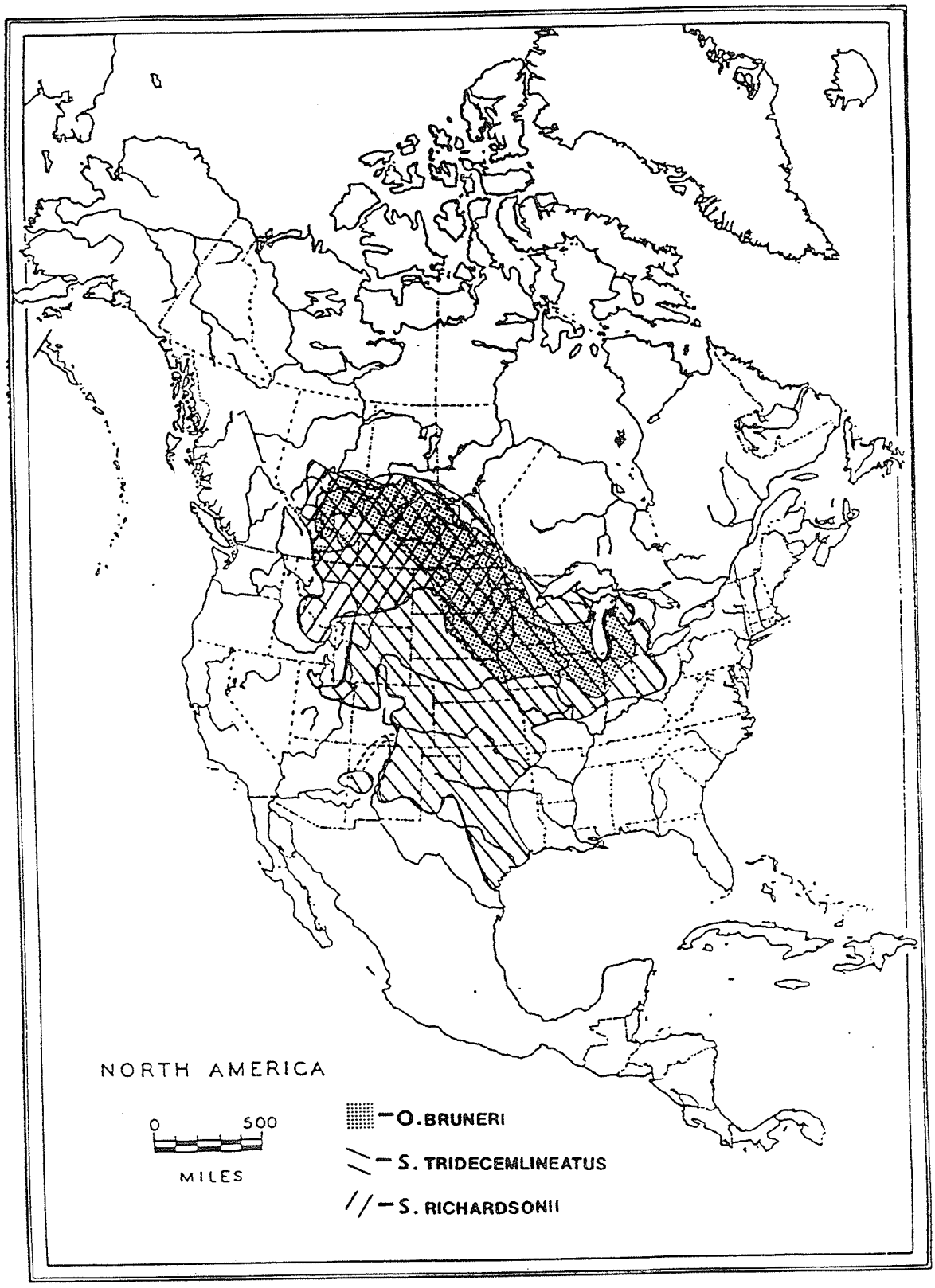

NORTH AMERICA
0
500
MILES
— O. BRUNERI
— S. FRANKLINII

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


NORTH AMERICA
0
500
MILES
O. BRUNERI
S. TRIDECEMLINEATUS
S. RICHARDSONII

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 immerge 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

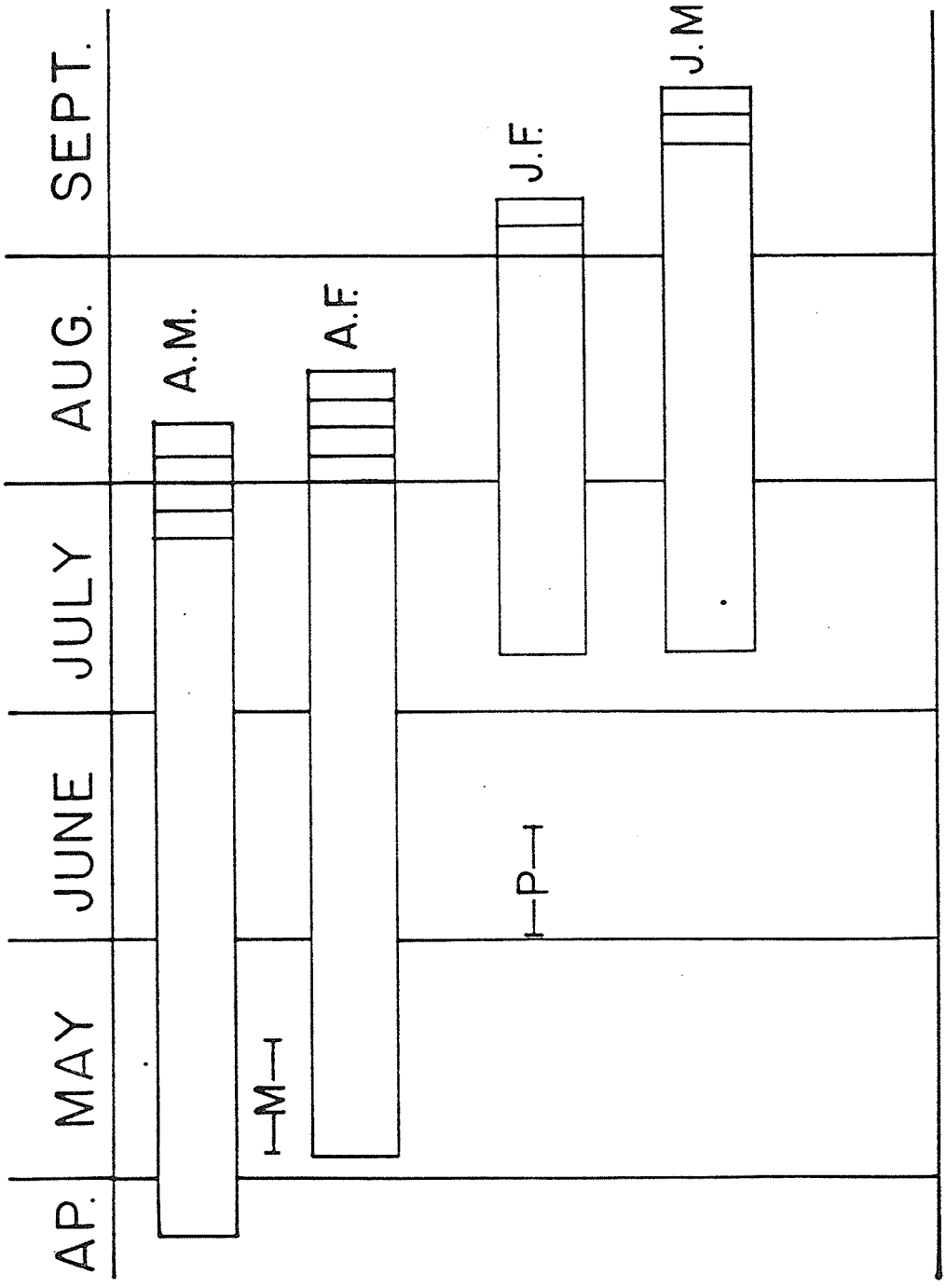
P=parturition

A.M.=adult male squirrel

A.F.=adult female squirrel

J.F.=juvenile female squirrel

J.M=juvenile male squirrel


AP.
MAY
JUNE
JULY
AUG.
SEPT.
A.M.
A.F.
J.F.
J.M
M
P

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 monoestrus 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.