ISBN 0-315-54855-X

SEASONAL ABUNDANCE, PHYSIOLOGICAL AGE, AND DAILY ACTIVITY OF HOST-SEEKING HORSE FLIES (DIPTERA: TABANIDAE) AT SEVEN SISTERS, MANITOBA, WITH AN EVALUATION OF PERMETHRIN SPRAY TREATMENTS AS A MEANS OF INCREASING THE PERFORMANCE OF GROWING BEEF HEIFERS SUBJECT TO HORSE FLY ATTACK.

by

Paul Edward Kaye McElligott, B.Sc.

A thesis
presented to the
University of Manitoba
in partial fulfillment of the
requirements for the degree of
Master of Science

Winnipeg, Manitoba
June, 1989

SEASONAL ABUNDANCE, PHYSIOLOGICAL AGE, AND DAILY ACTIVITY OF HOST-SEEKING HORSE FLIES (DIPTERA: TABANIDAE) AT SEVEN SISTERS, MANITOBA, WITH AN EVALUATION OF PERMETHRIN SPRAY TREATMENTS AS A MEANS OF INCREASING THE PERFORMANCE OF GROWING BEEF HEIFERS SUBJECT TO HORSE FLY ATTACK

BY

PAUL EDWARD KAYE McELLIGOTT

A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

ABSTRACT

Effects of biweekly permethrin treatments on the weight gain performance of growing beef heifers subject to attack by large numbers of blood-feeding tabanids was evaluated. In 1987 and 1988 respectively, groups of 55 and 72 heifers (of similar age and weight) were divided into two herds. Animals in one herd received biweekly whole-body sprays of permethrin (aqueous emulsion, 0.5% permethrin, applied at 1 L/animal), while the other herd was left untreated. Animals in both herds were weighed biweekly and those in one herd were treated concomitantly from early June through mid July. Permethrin spray treatments did not effectively reduce the impact of horse flies on the animals' weight gains. No consistent trend was apparent in differences between the average daily weight gains of animals in untreated and treated herds, and animals in both herds gained, on average, from 35.38 to 44.82 kg over the 6-week experimental period in both years.

Tabanids were trapped from dawn until dusk using four Manitoba Horse Fly Traps (MHFT's) at Seven Sisters, from mid May until mid July in 1987, and from mid May until mid August in 1988, to determine the seasonal activity patterns of the various species present. Thirty one tabanid species in four genera (<u>Hybomitra</u> (15 spp.), <u>Tabanus</u> (4 spp.),

Chrysops (11 spp.), Haematopota (1 sp.)), of which ten Hybomitra spp. were abundant, were present in MHFT catches. Hybomitra lurida (Fallen), and H. nitidifrons nuda (McDunnough) peaked in abundance in late May to early June; H. illota (Osten Sacken) and H. lasiophthalma (Macquart) in early June; H. affinis (Kirby), H. arpadi (Szilady), and H. zonalis (Kirby) in mid June; and H. epistates (O.S.) and H. pechumani Teskey & Thomas in late June to early August. Hybomitra trepida (McD.) peaked in abundance twice, in late June and early August. Tabanid density and diversity was greatest during June, and few flies were present at the site after mid July.

Subsamples (10-30 flies) of daily trap catches were dissected to determine seasonal changes in the per cent parity of ten abundant Hybomitra species. At the beginning of the flight season, 80 to 100% of flies dissected were nulliparous. As the flight season progressed, however, an increasing proportion of flies captured were parous. After approximately one month of flight activity, parity in all but three species reached levels approaching 100%, and remained high thereafter. Hybomitra lurida and H. nitidifrons nuda were 100% parous within two weeks of their first appearance in trap catches, and parity of H. trepida increased to 100% after four weeks, declined to 40% two weeks later, and rose again to 100% after a further 2 weeks.

Hourly trapping was carried out between 0530 hr and 2230 hr for four days weekly throughout the summers of 1987 and 1988, to determine the patterns of daily activity of nine tabanid species at Seven Sisters. One MHFT was used in 1987; four traps in 1988. Temperature and light intensity were recorded at hourly intervals in 1988 only. Hybomitra epistates and H. pechumani were most active during late morning or midday; H. arpadi and H. zonalis in early afternoon; H. affinis, H. illota, and H. lasiophthalma in late afternoon; and H. nitidifrons nuda and H. lurida in early evening. The morning onset of tabanid flight activity was usually temperature related, while the cessation of flight activity in the evening was either temperature or light related, depending on whether temperature or light intensity was first to fall below threshold levels. Tabanid flight activity was generally low at temperatures below 20° C, although H. lasiophthalma and H. affinis were caught at temperatures as low as 12° C. Little flight activity occurred at light intensity levels below 1000 lux. At Churchill, Manitoba, where hourly trapping was carried out in 1988, tabanid (H. affinis and H. frontalis (Walker)) activity was low below 14° C, although limited activity occurred down to 6° C.

TABLE OF CONTENTS

APPENDICES:

ACKNOWLEDGEMENTS

I take this opportunity to thank all who helped me throughout my M.Sc. program. In particular I thank my supervisor, Dr. Terry D. Galloway for his guidance, encouragement, humour, and accessability. I also thank the other members of my committee: Drs. Reinhart A. Brust, Garth K. Bracken, and Gary H. Crow, for their helpful advice and critical review of this manuscript. I am greatly indebted to Robert Currie and Shelley James who, as summer students, slaved on this project for many hours in the field and laboratory, and Ervin Bachmann who, as manager of the Seven Sisters Grassland Project, willingly shared with me his knowledge and expertise of livestock. Dr. Herb J. Teskey, Biosystematics Research Centre (Ottawa) provided invaluable taxonomic assistance.

This research was funded in part by an Manitoba Department of Agriculture Agri-Food grant through the Eastern Grassland Society. I thank the Society and its members, particularly Fraser Stewart, for their support and the use of their cattle. Further funding was provided by and the Faculty of Agriculture, University of Manitoba, and a U. of M. Graduate Fellowship. Financial support for the Churchill Expedition was furnished by the Association of Canadian Universities for Northern Studies. Special thanks are extended to the staff and students at the Churchill Northern Studies Centre for making my stay there so rewarding.

I thank Drs. Susan B. McIver and Gordon A. Surgeoner at the University of Guelph for fostering my interest in Entomology, and last but not least, I thank my parents for their love, encouragement and constant support in all of my endeavours.

LIST OF TABLES

Table

LIST OF FIGURES

Figure

FOREWARD

This thesis is written in manuscript format. As a result, some of the material presented in the Literature Review at the beginning of the thesis is repeated in the Introduction and Discussion sections of later chapters. The repeated description of the study area in each chapter may also seem redundant. If you, the reader, are interested in a broad overview of the literature related to this thesis, you will find it in the Literature Review. If your interest lies more in the specific research area discussed in one or more of the chapters, you are advised to skip over the Literature Review section and proceed directly to the chapter(s).

GENERAL INTRODUCTION

In the southeastern (s.e.) region of Manitoba, the boreal forest of northern Canada extends southward to the U.S. border and beyond. The part of this forest which lies adjacent to aspen parkland could, if cleared, provide excellent livestock pasture. In those areas which have been cleared for this purpose, however, large numbers of horse flies relentlessly harass pastured livestock throughout the summer months. These insects represent a serious deterrent to livestock production in s.e. Manitoba, since there are no methods currently recommended here for tabanid control (Manitoba Insect Control Guide, 1989).

Since 1979, Dr. Terry Galloway and his students in the Department of Entomology at the University of Manitoba have been studying the tabanid problem in s.e. Manitoba. Much of this work has been carried out at the Seven Sisters, Eastern Grassland Society Project, a Manitoba Agriculture pasture demonstration area which is plagued by very large numbers of horse flies annually from June until August. In particular, experiments have been conducted evaluating the application of contact insecticides to cattle as a means of tabanid control (Ralley 1986, Galloway, unpubl.) and examining the impact of horse flies on livestock behaviour (Ralley 1986). This present work represents the most recent step in procuring an overall picture of the biology, impact, and potential for control of horse flies at Seven Sisters.

My research on tabanids comprised three distinct areas of study:

1) an evaluation of spray applications of permethrin (a synthetic pyrethroid insecticide) as a means of improving the weight gains of cattle under intense tabanid attack,

2) an examination of patterns of seasonal abundance of those horse fly species common at the Grassland Project, and a description of seasonal changes in the physiological age structure of the populations of different species, and finally,

3) an examination of the daily activity patterns of the common tabanid species, and the effects of temperature and light intensity on the onset and cessation of each species' daily host-seeking activity. As a supplement to this last study, trapping was also conducted at Churchill, in northern Manitoba, to compare the activity of flies at Seven Sisters with conspecifics in the northern part of their range.

LITERATURE REVIEW

Forty eight species of horse and deer flies (Diptera: Tabanidae) are known to occur in Manitoba (Teskey, unpubl.). Females of all of these species feed upon the blood of warm-blooded animals at some point during their adult lives (Pechuman 1981, Pechuman et al. 1961, 1983), and the importance of horse and deer flies as pests stems from this blood-feeding habit. Biting tabanids can cause considerable nuisance to humans (Miller 1951, Hocking 1952, Hansens 1980a), and severely harass wild and domestic animals (Morgan 1987, Clark et al. 1976, Steelman 1976). In addition, tabanids vector a number of different pathogens among animals (Krinsky 1976, Foil 1989).

Impact of Tabanids on Livestock Production:

There are no published estimates of the impact of tabanids on livestock production in Manitoba, although enormous numbers of these flies can be observed circling and biting cattle here during early summer. Elsewhere in North America and in Europe, the impact of tabanid attack on livestock production has been estimated by several different techniques.

One method has been to estimate the amount of blood lost per animal per day to feeding tabanids (Clark et al.

1976, Hollander and Wright 1980, Miller 1951, Tashiro and Schwardt 1949, 1953). By this method, it has been estimated that individual cattle may lose up to 352 cc of blood per day to horse flies (Tashiro and Schwardt 1953), although estimates vary considerably among studies and tabanid species considered (Hansens 1980a). Blood-loss estimates consider only the direct effects of biting tabanids on cattle, however, and do not take into account the effects of annoyance caused by flies attempting to feed. Tabanids are telmophages, meaning that to obtain blood a fly pierces her host's skin with large, blade-like mouthparts. This lacerates the underlying tissues until a pool of blood forms, and from this pool the fly sponges her meal (Lall 1970, Miller 1951). Tabanid bites are extremely painful and consequentially, hosts are usually energetic in their attempts to dislodge feeding flies (Ralley 1986, Hughes et al. 1981). A dislodged fly may bite repeatedly in order to complete its meal, each bite causing the host considerable pain. The pain caused by tabanids repeatedly biting may have far greater adverse effects on host animals than simple blood-loss alone (Chvala et al. 1972, Anderson 1973, Anthony 1962, Krinsky 1976).

An alternative to blood-loss estimates has been to estimate the effect of tabanids on livestock performance. Performance in cattle is generally measured in terms of the weight gain of beef animals, or milk production by dairy cattle (Ensminger 1971, 1976). By comparing the performance of cattle during periods of tabanid attack with that of the same or similar animals in the absence of tabanids, an estimate of the total impact of tabanids upon livestock production (which takes into account both blood loss and annoyance effects) is obtained. Heavy tabanid attack is accompanied by reduced weight gains in beef cattle (Roberts and Pund 1974, Perich et al. 1986), reduced milk production (Bruce and Decker 1951, Christensen 1982, Minar et al. 1979, Grannett and Hansens 1956) and lowered milk quality (Bruce and Decker 1951) in dairy cattle.

Some hosts are less affected than others by attacking tabanids. Reactions of host animals to tabanids vary depending on factors such as the species(s) of flies involved, condition of host animal, and intensity of attack. Several authors have observed that cattle are irritated to different degrees by tabanids of different species, and it has been suggested that some species may bite more painfully than others (Blickle 1955, Hollander and Wright 1980, Issel and Foil 1984, Clark et al. 1976, Magnarelli and Anderson 1980). Different tabanid species preferentially feed on different regions of the host's body (Blickle 1955, Hollander and Wright 1980, Mullens and Gerhardt 1979) and this, too, may influence the irritation which they cause.

In general vigorous, healthy animals are better able to deal with attacking tabanids than unhealthy ones, as they are more energetic and more apt to dislodge feeding flies (Tashiro and Schwardt 1953, Morgan 1987). As well, sickly animals are more likely to find themselves separated from the herd, thereby losing the protection provided by adjacent herd members against tabanid attack. The immobilization of a tail or leg used in dislodging flies may also render an animal more susceptible to attack by biting tabanids (Morgan 1987, T.D. Galloway, pers. comm.).

As numbers of attacking tabanids increase, so does the amount of fleeing and dislodgement activity undertaken by the host animal, with a concurrent increase in the animal's energy expenditures (Hollander and Wright 1980, Clark et al. 1976). In cases of extreme attack, animals may become so stressed that they collapse from exhaustion (Ralley 1986). The number of horse flies attacking an animal is affected both by local tabanid population levels and the activity of the population at a given time. The animals is also affected by its degree of isolation from conspecifics and its physical position in a herd; attack rates are generally highest on isolated animals and those at the periphery of herds. Cattle (Ralley 1986) and horses (Duncan and Vigne 1979, Hughes et al. 1981) often aggregate into tight herds to minimize individual body exposure under conditions of intense tabanid attack.

The annoyance caused by biting tabanids forces cattle to occupy the daylight hours with avoidance and dislodgement activities at a time of the year (i.e. the summer months) when the most productive grazing should occur (Howell et al. 1949, Bruce and Decker 1951). Besides causing cattle to lose grazing time, tabanids also increase the susceptibility of animals to heat stress. Tabanid flight and host-seeking activity is most intense on hot, sunny days (Burnett and Hayes 1974, Alverson and Noblet 1977, Joyce and Hansens 1968, Hollander and Wright 1980), when cattle are already prone to heat stress (Finch et al. 1982, Schleger and Turner 1965).

The overall effect of tabanid attack is that cattle suffer through losses of blood, energy, and grazing time. As well, fly-stressed animals display reduced vitality and increased susceptibility to other stresses and disease. Because of these negative effects, and the fact that tabanids are present in pest numbers in many cattle-producing areas, tabanids have a profound impact on livestock production. Losses to the cattle industry in North America alone are estimated to exceed 30 million dollars annually (Perich et al. 1986).

Control Measures:

Methods employed in attempts to control horse and deer flies fall into three broad categories:

1. eradication or reduction of adult populations;
2. eradication or reduction of larval populations;
3. repelling or killing those adults attempting to blood feed, and those beginning to blood-feed.

1. Aerial applications of DDT, lindane, and dieldrin (Brown and Morrison 1955) and DDT, methoxychlor, and chlordane (Howell et al. 1949) have been employed to control adult tabanids in wooded areas. These control attempts, however, had little or no measurable effect on local horse and deer fly populations, either because the flies were inaccessible to the insecticides, or because flies were immigrating into the treated areas from elsewhere (Brown and Morrison 1955). Ground-based applications of resmethrin (Hansens 1980b) and/or permethrin (Hansens 1981) to control adult salt-marsh tabanids have also met with very limited success, presumably for the same reasons (Hansens 1981). In general, adulticiding programs aimed at tabanids are of little use. They are expensive, minimally effective, and potentially damaging to the environment by their indiscriminate destruction of non-target organisms.

2. Control of tabanid larvae has been attempted using chemical larvicides, or by physical manipulation of the larval habitat. Although the larval habitats of many tabanid species are poorly known or otherwise inaccessible to control measures (Teskey 1969, Roberts and Dicke 1964), a few tabanid species undergo larval development in discrete, well-defined areas, and larviciding can be a feasable method of controlling these species. This is the case for salt-marsh species, where local reductions of larval populations up to 100 per cent have been possible through a larvicide application (Hansens 1956, Jamnback and Wall 1957, Gerry 1949). Despite successful larval control, there are serious problems with larviciding techniques. As with adulticiding, reductions of local adult populations through destruction of larvae are often offset by immigration of adults into treated areas, making the technique only applicable to isolated marshes (Jamnback and Wall 1957). As well, levels of pesticides (such as DDT and dieldrin) which are sufficient to kill tabanid larvae have devastating effects on non-target organisms. (Hansens 1956).

Habitat alteration as a means of larval tabanid control is an alternative to chemical larviciding, but this technique is subject to a number of the same limitations as larviciding, such as limited applicability (e.g. suitable to