THE ECOLOGY OF MARSH MOSQUITOES AND THEIR ATTRACTION TO MALLARD DUCKS, DOMESTIC CHICKENS AND YELLOW-HEADED BLACKBIRDS AT OAK HAMMOCK MARSH, MANITOBA

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ROBERT GENE ANTHONY FORTNEY

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DEDICATION

I dedicate this thesis to my late father Paul Bernard, who provided an inner strength, and to my mother Eileen Dorthea who was always there when I needed her.

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ABSTRACT

During the years of 1985 to 1987 a survey was carried out to determine the species of mosquitoes that were breeding and host seeking in Oak Hammock Marsh. The abundance of adult female mosquitoes in the marsh was monitored with Solid State Army Miniature (SSAM) light traps, which were used to trap host seeking adults. The abundance of raft laying species was also monitored in 1985 and 1986, using ovipools known to be attractive to Cx. tarsalis Coquillett, Cx. restuans Theobald and Cs. inornata (Williston). Larval breeding was monitored by regular sampling of 20 sampling sites within the marsh, to determine the species of mosquitoes breeding there during two summer seasons.

Species abundance, as determined by trap collections of adult females, varied each year. In 1985 the abundance of only the most common species, Cx. tarsalis, Cx. restuans, Ms. perturbans (Walker), An. earlei Vargas, Cs. inornata, was monitored. In 1986 and 1987, all mosquitoes were identified and Ae. vexans (Meigen) and Ae. flavescens (Muller) were the most numerous species in the collections. In 1987 the numbers of Ms. perturbans and An. walkeri Theobald were noticeably greater than in 1986.

Fourteen species were found to breed in the marsh during the 2 years of larval sampling; Cs. inornata, Ae. flavescens and Ae. vexans were the dominant species.

Cx. tarsalis egg rafts dominated, with a mean/weekly count of 16 egg rafts. Cs. inornata and Cx. restuans followed with mean/week counts of 4.4 and 3.7 repectively.

Ovarian parity was studied in females of several species collected in SSAM traps during 1984-1986, to determine the physiological age of the population. A maximum of 30 live adult female mosquitoes/week were removed from the collections. Cx. tarsalis probably completed 3 generations in 1984 and 1986 while in 1985 it appeared to complete only 2 generations. One-parous individuals were collected during the second week of June, 1985 and 1986, and in the second week in July in 1984. Tri-parous females were observed in August of 1984 and July of 1986. Ms. perturbans had single generations during both years, and nullipars were collected from June or July until August. One-parous individuals were collected in the third week of July in 1985, and the last week of June in 1986. One-parous individuals of An. walkeri were collected in June, 1987. There was an increase in nullipars in the third week in July, suggesting it may complete two generations in Manitoba.

A mosquito attraction study was conducted in 1986 and 1987. In 1986 two bait animals, the domestic chicken and the mallard duck, were used. A fan assisted box trap, the 'Fortney Fan Trap', was used to contain the bait and trap attracted mosquitoes. In 1987 the experiment was expanded to include an additional trap (Ehrenberg) and an additional bait species, viz, the yellow headed blackbird. Blackbirds were used in pairs while the other species were used as single animals/trap. Trapping was conducted 3 times weekly for 6 weeks in 1986 and for 10 weeks in 1987. In the 1986 study, fifteen species of mosquitoes were attracted to each bait species, totalling 943 mosquitoes. Three species, Cx. tarsalis, Ms. perturbans and Ae. vexans, accounted for 80% of the catch. The majority of Cx. tarsalis were attracted during the first week of August. The duck and chicken baits attracted 53% and 42% of the catch respectively. The duck bait was more attractive to Cx. tarsalis and Ms. perturbans, and several minor species, while chickens were more attractive to Ae. vexans. In 1987, 3319 mosquitoes were attracted comprising 14 species. An. walkeri was collected in large numbers in 1987. In 1986 four species accounted for 74% of the catch. The blackbirds attracted 48% of the catch, and were most attractive to Cx. tarsalis. The duck and chicken baits attracted 35% and 11% of the catch respectively.

Two flock cages, containing 7 - 10 birds of each bait species, were located in the vicinity of the single/paired attraction study. A mosquito flock trap was attached to each bird flock cage. The species of the mosquitoes attracted and whether they had bloodfed was recorded.

The flock traps attracted the same dominant species as the single/pair baited traps, however, the ranking of species attracted was reversed on the baits. Chickens were the most attractive bait, and *Ae*. *flavescens* was the most abundant species.

GENERAL INTRODUCTION

Mosquitoes are fairly ubiquitous in their distribution throughout the world and have long been linked with the distribution of pathogenic organisms causing disease to human populations. Mosquito biology and the relationships between mosquitoes and arboviruses, have been the subjects of research for more than a century. For example, the transmission of Yellow Fever virus in Cuba by mosquitoes was reported by Carlos Finlay in 1886 (Sosa 1989).

The association of the mosquito with other members of the animal community in which it is found has been considered as an important mechanism necessary in the maintenance of disease cycles involving humans. Population dynamics, host-seeking behaviour, arbovirus research and overwintering biology of Cx. tarsalis have been examined in great detail since Hammon and Reeves (1943) demonstrated the interrelationship between Cx. tarsalis and the Western Equine Encephalitis (WEE) virus. Since that time, many other species have been linked to this cycle.

WEE is an arbovirus affecting humans and horses, that is distributed across western Canada and the United States. The cycle that maintains this disease in nature involves a bird reservoir and a mosquito vector. Little is known about the overwintering biology of the disease, but Reisen and Monath (1987) suggested 3 possibilities: '(i) long term survival of infected overwintering life stages of primary or secondary vectors, (ii) chronically infected or hibernating vertebrates, and (iii) regional autumnal extinction followed by annual vernal re-introduction'. The principal vector in Manitoba is Culex tarsalis (Sekla et al. 1980) although many other species of mosquitoes may play a role in the transmission of this virus.

Oak Hammock Marsh is a remnant of a larger natural marsh known as St. Andrews Bog which in the 1800s was one of Manitoba's largest marshes, encompassing 47,000 ha. Presently the marsh is a Wildlife Management Area under provincial jurisdiction, that encompasses 3450 ha, of which 1,984 ha is marshland, 1296 ha is grassland and 243 ha are seeded in lure crops. The Oak Hammock Marsh Wildlife Management Area is located in the midst of an important farming area, 30 km north of the city of Winnipeg. The marsh was designed to act as a staging area, and provide nesting sites for migrating waterfowl. It also provides access to the marshland ecosystem for the tourist or the naturalist. This marsh provides a habitat for a wide variety of flora and fauna, including many types of aquatic and terrestrial insects.

Little research has been done to examine the potential of Oak Hammock Marsh with respect to mosquito production (Brust, pers. comm.). Sentinel chicken flocks have been used for several years to monitor levels of WEE virus. Antibodies to the virus have been isolated from chickens kept at Oak Hammock

Marsh from 1976 - 1985 (Brust, pers. comm.) and virus has been isolated from mosquitoes collected there (Sekla et al. 1980). The role of ducks, blackbirds or other marsh birds in the annual cycle of WEE has not been studied. It is not known if a marsh ecosystem is conducive to transmission of WEE virus, since vector species may not be attracted to aquatic waterfowl. If they are attracted, it would also be important to know if they feed on waterfowl or on other bird species that nest in the marsh.

The objectives of my research were: (i) to determine which mosquitoes breed in the marsh and their seasonal abundance, (ii) to examine the host preference of marsh mosquitoes, when several birds species native to the marsh are presented as potential hosts, and (iii) to examine the physiological age structure of the host-seeking adults, for several bird feeding species.

II. LITERATURE REVIEW

LITERATURE REVIEW

This literature review is the background on some of the major concerns regarding mosquitoes in Manitoba. The overwintering strategies for three important species [Cx. tarsalis Coquillett, Cs. inornata (Williston) and Ms. perturbans (Walker)] will be discussed and the bloodseeking behaviours and host preferences for these species will be briefly reviewed. The life histories and basic biology for Cx. tarsalis and Cs. inornata have been discussed by previous authors (Gallaway 1983, Buth 1983), and will not be discussed here. Marshes and wetlands in general have been described by Rubec and Pollett (1979), eliminating the need for any further discussion in this thesis.

In Manitoba, there are 45 species of mosquitoes (Wood et al. 1979). Many of these are not important as pest species, or as vectors of disease pathogens. Gadawaski (1990) lists 38 mosquito species collected as larvae or adults by the Insect Control Branch in the Winnipeg area. Ellis (1987) reported that Ae. vexans (Meigen) was regularly the most important pest species in Winnipeg. The major concern for the public is the annoyance of this species, when females feed, or attempt to feed, on humans.

There have been several outbreaks of Western Equine Encephalitis (WEE) in Manitoba in recent years, and a number of mosquito species may be infected with the virus. Some of our common species transmit the WEE virus to both humans and animals (Sekla 1976, 1982, Sekla et al. 1980, Artsob 1983). WEE is a viral infection affecting the central nervous system of humans and horses and has been responsible for infection rates of epidemic and epizootic proportions (Monath 1984). Culex tarsalis is the primary vector of WEE in Manitoba and elsewhere. Culeseta inornata may act as a secondary vector, involved in the amplification of the WEE virus in nature (McLintock and Rempel 1963). The first isolation of WEE from Ms. perturbans was made from a pool of live mosquitoes collected in 1977 in Manitoba (Sekla et al 1980). The role that this mosquito species may play in the dissemination among human and animal populations is unknown at this time (Brust pers. comm.).

The role of mosquitoes as human pests or as vectors of disease and subsequent methods of control will be better understood when the population dynamics and host-seeking behaviours of mosquitoes are understood. Knowledge of the age structure of the population as well as the natural factors affecting survival, fecundity and dispersal are essential to the understanding of the factors that affect mosquito abundance and pathogen transmission (WHO 1967).

Overwintering

The survivorship of any mosquito species depends on the ability of that species to survive during periods when adverse conditions prevail. These periods may be related to weather, climate or availability of a food resource. This period may be survived by entering a dormant state. Dormancy, that is initiated in response to low temperatures (northern climates), is termed hibernation. If it results from exposure to high temperatures (southern climates) it is termed aestivation. At the northern latitudes, there may be a complete suspension of reproductive activity, as well as both sugar and blood feeding. In the southern latitudes, reproductive activity may continue with or without the suspension of carbohydrate feeding (Reisen 1987).

Reisen (1987) suggested 4 strategies of overwintering: (i) univoltine species that overwinter as diapausing eggs, (ii) multivoltine species that overwinter as diapausing, drought resistant eggs, (iii) as hibernating larvae, (iv) as hibernating adult females. Reproductive or ovarian diapause normally occurs for mosquitoes that overwinter as inseminated adult females. In Canada, most species overwinter in the egg stage (Lewis 1987).

Culiseta inornata

Culeseta inornata exhibits the type (iv) strategy for overwintering, according to Reisen (1987). At northern latitudes, Cs. inornata females hibernate during winter, while at southern latitudes, females aestivate in summer and are active during winter. In Alberta, near Edmonton, few bloodfed, gravid and parous individuals were collected after the end of August, although, Cs. inornata may continue to fly until late October (Hudson 1977). Female Cs. inornata that had been transferred as new fourth instar, from 16 h daylength at 20°C, to 12 h daylength, 10°C, developed ovarian follicles characteristic of diapause (Hudson 1977), which is characterized by the absence of yolk granules in the oocyte (Barr 1974).

Mammal burrows may be used as shelters during the overwintering period (Hayles et al. 1979). According to Barr (1958), hibernation may begin in October in Minnesota. Shemanchuk (1965) stressed the importance of snow cover for survival of hibernating females. He also correlated emmergence with the spring soil temperature inversion, as well as 50°F air temperature. Adult females were first observed to emerge from mammal burrows during April, May and June of 1964 in southern Alberta.

Culex tarsalis

In Canada, Culex tarsalis overwinters as a fertilized hibernating female (Wood et al. 1979). Field collected Cx. tarsalis entered diapause when larvae or early pupae were transferred from summer (25°C, 16:8 [L:D] photoperiod) to winter (18°C, 10:14 [L:D] photoperiod) in Kern County, California. It was suggested that the older fourth instar larvae or young pupae are the immature stages that are sensitive to diapause induction cues (Reisen 1986). The 'diapause induced' larval stage does not hibernate, but adult females enter diapause. However, in California, larvae have been observed during the winter period. In Kern County, California, numerous larvae and pupae were found in 'duck club' ponds, during November and December of 1959 - 1960 (Washino and Bellamy 1963).

Overwintering Cx. tarsalis have been observed in a variety of different sites. Cellars and mines have been utilized (Bennington et al. 1958) as well as subterranean tunnels (Arntfield et al. 1982), and mammal burrows (Shemanchuk 1965). In Alberta, Cx. tarsalis began to enter mammal burrows in late August of (Shemanchuk 1965), while in Boulder, Colorado, overwintering females have been collected from mine tunnels in late September (Mitchell 1981). In Manitoba, the overwintering female that emerges in the spring is difficult to collect, possibly due to low survival rates (Brust pers. comm.). In 1987 Cx. tarsalis was collected in Winnipeg on May 13th (Ellis 1987), while in other years first collections of females are usually in June (Gadawaski 1990).

Mansonia perturbans

Mansonia perturbans overwinters as larvae, attached to the roots of aquatic plants, in the second, third or fourth larval stage. The larvae are not in a true diapause state and obtain their oxygen supply from the plant, while feeding on the detritus in the area of their attachment (Wood *et al*. 1979). In Minnesota, overwintering larvae have survived the winter period frozen solidly into the substrate of a permanent marsh (Rademacher 1979).

Bloodseeking and Host Preference

The host preference and bloodseeking behaviour of mosquitoes suspected as vectors of an arbovirus, is necessary information in epidemiological research. Adult females feed on plant sugars as a carbohydrate source, but require a blood meal for ovarian development (O'Meara and Evans 1973). The blood-feeding pattern of a mosquito species becomes important when a susceptible human population coexists with a mosquito population infected with a human disease-causing pathogen (Reisen and Monath 1987).

Culiseta inornata

Culiseta inornata, due to its feeding habits, is considered to play a minor role in the spread of WEE. *Culiseta inornata* has been considered primarily as a mammal feeder (Tempelis *et al*. 1967) and has been found to be infected with WEE (Sekla *et al*. 1980). At southern latitudes, *Cs. inornata* is actively hostseeking during the winter period and undergoes aestivation during the summer (Reisen 1987). The reverse occurs at northern latitudes, where this species hibernates during the winter (Hudson 1977). During a study on feeding behaviour in