

The University of Manitoba Field Station Delta Marsh
1982 Annual Report Number 17



THE UNIVERSITY OF MANITOBA FIELD STATION
(DELTA MARSH)

SEVENTEENTH ANNUAL REPORT

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Editorial Committee: R.M.R. Barclay
S. G. Sealy
J.M. Shay
M.T. Sheridan

Faculty of Science
The University of Manitoba
Winnipeg, Manitoba R3T 2N2

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DIRECTORS REPORT 1982

The University Field Station continues to be an active focus for research and teaching. It serves the needs of field courses, workshops, seminars and short courses and increasing use by researchers. These varied contributions make the Field Station a vital unit in the University's academic program. 1982 was certainly a successful season.

1982 PERSONNEL

Staff

Dr. Jennifer M. Shay	Director
Dr. Robert M.R. Barclay	Resident Biologist

Support Staff

Mr. Ken May	Caretaker
Mrs. Diane May	Cook/Housekeeper
Mr. George Cosens	Summer Assistant
Ms. Adele Vust	Summer Assistant
Ms. Lucia Flynn	Administrative Clerk (January to August)
Ms. Joyce Kendrick	Administrative Clerk (from August)

Faculty

Dr. Tom Booth	Department of Botany
Dr. J. Bruce Falls	Department of Zoology, University of Toronto
Dr. Jack Gee	Department of Zoology
Dr. Gordon G.C. Robinson	Department of Botany
Dr. Spencer G. Sealy	Department of Zoology

Graduate Students

Gloria Biermann	Department of Zoology
Gordon Goldsborough	Department of Botany
Dan Guinan	Department of Zoology
Heidi den Haan	Department of Zoology
Andrew Horn	Department of Zoology, University of Toronto
Tawfik Muhsin	Department of Botany
Iain Suthers	Department of Zoology
June Tugwood	Department of Zoology
P.L. Wong	Department of Biology, Lakehead University

Project Assistants

Barbara Beaver	Department of Zoology
Friederike Schneider	Department of Botany, NSERC Summer Scholar
Melissa Todd	Department of Zoology
Christina Zarowsky	Department of Zoology, University of Toronto

Research

Don Thompson completed his MSc. thesis and has begun a Ph.D. program in the Department of Plant Science. Fifteen research projects were undertaken, five by faculty members, four by Ph.D. candidates, five by MSc. candidates and one by an NSERC Summer Scholar. Project titles and investigators are given below:

Barclay, R.M.R. Ph.D.	Foraging behaviour of the insectivorous bats at Delta Marsh
Pohajdak, G.C.	Dynamics of foraging and food resource use in a community of nesting birds (Ph.D. candidate)
den Haan, H.	Patterns of fall migration and molt in wood warblers (MSc candidate).
Falls, J.B. Ph.D.	Song matching in western meadowlarks.
Goldsborough, G.	An investigation of the influence of herbicides upon algal communities. (MSc candidate)
Guinan, D.	Foraging strategy of house wrens. (MSc candidate)
Horn, A.	Graded signals in the song repertoires of western meadowlarks. (Ph.D. candidate)
Muhsin, T.	Mycological studies of selected salt marsh succulents. (Ph.D. candidate)
Schneider, F.	An investigation of colonization of submerged surfaces by diatoms. (NSERC Summer Scholar)
Sealy, S.G. Ph.D.	Population structure in birds in the dune ridge community. Dynamics of breeding in a passerine bird community.
Shay, J.M. Ph.D.	A <u>Phragmites australis</u> dominated community three years after spring, summer and fall burning.
Suthers, I.M.	Distribution and reactions to hypoxia of some marsh-dwelling fish. (MSc candidate)
Tugwood, J.	Habitat variables affecting host-nest selection by the brown-headed cowbird. (MSc candidate)
Wong, P.L.	Studies of the acuarioid nematodes of waders and rails. (MSc candidate)

The Annual Seminar was held on January 23rd 1982 with progress reports given by faculty and graduate students. Dr. Bruce Batt, from the Delta Waterfowl Research Station, gave a paper on their Marsh Ecology Research Program.

Teaching

Introductory Ecology (1.228/22.229) instructed by Dr. Robert Barclay, and the Flora of Manitoba (1.231) jointly taught by Dr. David Punter and Mr. Al Rogosin both had enthusiastic participants. To help students plan their summer courses we intend to provide one year's advance notice of the courses that will be offered.

The traditional fall courses Field Ecology (1.342/22.345) instructed by Drs. J. Gee and T. Booth and Landscape Field Ecology (31.705) by Dr. J.M. Shay occupied the end of August and beginning of September. Dr. Sealy brought his Ornithology (22.468) course to the Station for a weekend in September and a class of cultural geographers from the University of Regina under the guidance of Dr. Paul Housley visited us for a 5-day period in October.

Dr. Michael Bruser Bursary

Congratulations to Iain Suthers who was the 1982 recipient of this award.

Continuing Education

Two of the scheduled four courses had sufficient enrollment to allow them to take place. Winter Survival (Dr. R. Riewe) and Nature Photography (Robert Taylor) were as successful as usual.

Judy Hay, who had been the mainstay of the campus end of the Marsh Series of weekend courses for nearly a decade, retired in September. Her enthusiasm, adaptability and good humour overcame many problems. We extend to Judy our sincere thanks for her co-operation over the years and our warmest good wishes for a long and enjoyable future.

Acknowledging the importance of providing an opportunity for naturalists and others to participate in informative short courses we have designed a pilot series of weekend programs similar to the Marsh Series. These will be less costly than the latter because we plan, initially, to utilize free publicity (eg. CBC public affairs announcements) and volunteer instructors. The first of these weekend programs entitled "Marshes and Man" was successfully organised by Drs. Robert Barclay and Jennifer Shay in October. Survival and bird migration courses are scheduled for the spring of 1983.

School Programs

Unfortunately, due to lack of staff the 1981 school ecology program had to be reduced in scope. This year, the Resident Biologist Robert Barclay, offered a broad program that attracted a large number of schools. In addition, St. Johns High School and St. James Collegiate organised their own residential 3-day outdoor experience programs.

Other Uses

There is an increasing demand for use of the Field Station as a haven for University workshops and other seminars. We were able to accommodate seven such groups and a weekend conference for the Prairie Division of the Canadian Association of Geographers.

General

We launched no major construction projects although a number of improvements were made. In the interests of energy conservation, styrofoam insulation was installed under Agassiz, Criddle and Tyrell. A concrete floor was poured in the Bell House, a new septic field was built for both cottages, our largest boat, the Notropis, was refurbished and made seaworthy and we acquired a small tractor for grass cutting, snow blowing and other jobs. Because the Blind Channel is being used more by researchers, the access ditch was deepened and a dock built near the Station. This means we will no longer have to transport canoes through the adjoining Portage Country Club property. Trainees from the Portage Regional Work Activity Training Program assisted in scraping the old paint off Tyrell and Criddle in preparation for repainting, and the usual run of maintenance jobs were cheerfully undertaken, thanks to the efforts of both staff and graduate students.

On July 10th we invited the general public to an Open House. Judged by the attendance, it was a great success with about 200 visitors touring the displays and laboratories. I appreciate the enthusiasm with which the research students and staff organised the exhibits, tours and refreshments.

Robert and Robin Barclay completed their first year at the Station. We hope they have enjoyed their stay as much as we have their presence with us. Lucia Flynn left the campus office and Joyce Kendrick came on staff to assume that position.

A number of our researchers utilize the Portage Country Club property for their studies. We warmly acknowledge their kindness and co-operation.

The resident and part time staff play an important role in the effectiveness of the program. Those who stay for a short or long time at the Station owe a great deal to Diane and Ken May, Adele Vust and George Cosens. They maintain the day-to-day operation and greatly contribute to the effectiveness of the 2,900 user days. To all involved in the operation, my sincere thanks.

Jennifer M. Shay

Resident Biologist's Report

Robert Barclay

In a number of ways 1982 saw changes at the field station, with increased use, the rejuvenation of the high school program and the initiation of a long range monitoring project.

The High School Ecology Program was reinstated after a one year's absence and was expanded to include students from grade 7 on up. This was done because of the shift in emphasis on ecology to the grade 9 curriculum and, judging from the response of schools from across the province, we have succeeded in filling a definite need. A total of 24 school groups participated in the program in 1982 with 713 students. This was the second highest number since the inception of the program and bookings for this coming spring indicate numbers will increase to our capacity. With the younger age of participating students, changes to some of the exercises and their related materials were necessary and are being completed this winter.

An encouraging trend was the increased research use of the station by students and staff from universities other than the University of Manitoba. This greatly enhances the diversity of research and academic stimulation present during the summer. In part due to this trend, a weekly series of "informal" seminars was continued this year in which all researchers at the station were encouraged to outline their investigations so that the entire station "community" was aware of the research that was being conducted. I believe this is vital in the cooperative atmosphere which makes a field station so unique and hopefully the series will be expanded in the years to come. Several more structured seminars were presented by a variety of visiting researchers and were well received by field station and waterfowl station personnel. Again, these hopefully can be expanded and the interactions between the neighbouring stations thereby increased.

In conjunction with the alterations to the hay lease practices at Inkster farm, a rethinking of our use of the fields was undertaken in the spring. The northernmost portion of the fields have now been designated as areas for research and will be left to return to more natural conditions. As part of this, four permanent transects were established and data were collected along them during the Introductory Ecology field course. Data on floral composition, density, biomass etc., as well as insect and small mammal populations will be collected each year in order to monitor the secondary succession.

Additions to our small mammal and bird collections were made during the year and these are proving very useful for high school, university and continuing education teaching purposes. An insect collection was

started this summer with the cooperation of many of the residents. This will be increased in scope in coming years and will hopefully include a reasonable representation of the species present in the area.

As usual, several special occurrences of biological note took place during the year. Spring bird migration sightings included a Golden-Winged Warbler, Red-headed Woodpecker, Northern Mockingbird, Winter Wren, Scarlet Tanager and several Whip-poor-wills. Iain Suthers collected specimens of Brown Bullheads, Tadpole Madtoms and Mudminnows, species not known previously, from the marsh or Lake Manitoba. For the second winter in a row, snow during 1981/82 was scarce (except in the dune ridge) and in association with record low temperatures, likely resulted in the extremely low numbers of small mammals found in the marsh, in particular meadow voles and weasels. Muskrats were also scarce in the vicinity of the station whereas skunks and red squirrels were abundant. The Forster's tern colony was not active in Forster's Bay this summer, possibly due to the low water levels.

As always, countless people helped with numerous tasks all year. Ken May and George Cosens took over the weather station duties when my nighttime research activities started in the spring and all the summer residents assisted in the general operation of the station. To everyone I pass on my appreciation.

Prehistory of Delta Marsh

A Brief Sketch by Tom Shay

Department of Anthropology
University of Manitoba

Manitoba was first settled by Native cultures near the end of the Ice Age, about 12,000 years ago. As ice sheets melted and spruce forests expanded on the southwestern uplands of the province, groups of hunters entered the area in search of mammoth and other game. Isolated finds of fluted spear points belonging to the early portion of what archaeologists call the Paleo-Indian stage bear mute testimony to the former presence of these hardy colonists. At this time, the rest of Manitoba was uninhabitable and either buried deep under ice or covered by the waters of Glacial Lake Agassiz. The area which is now Delta Marsh was under about 100 meters of water.

In the ensuing few thousand years, this Ice Age climate and landscape changed dramatically. By 9,000 years ago, ice had disappeared from all but the far north, Lake Agassiz had drained and the spruce forests had been replaced by prairie and parkland in the western uplands and Manitoba lowlands, and by mixed forests on the Canadian Shield in the east. This shift to grassland attracted bison in large numbers which in turn drew more people into the region. Numerous finds of points and several excavated camp sites belong to this later Paleo-Indian incursion that lasted until about 7,000 years ago.

The retreat of Agassiz left a number of lakes in the lowlands including Winnipeg, Manitoba and Winnipegosis. Levels in these lakes were not static but fluctuated a number of times between 8,000 and 4,500 years ago. Such oscillations were probably due to wet and dry climatic cycles. At any rate, there is little evidence of human occupation in the province during most of this time. These events coincide with the part of the Archaic stage of Manitoba prehistory that lasted from 7,000 to 2,200 years ago.

Wet meadows and marshes surrounded these predecessors of the modern lowland lakes although Delta Marsh as we know it did not come into existence until about 2,000 years ago. Between 4,500 and 2,000 the Assiniboine River drained into Lake Manitoba. Spring floods of the river brought thousands of tons of sand and silt into the southern part of the lake a few miles west of the present University Field Station. When the Assiniboine became diverted to its present course, this massive sand accumulation was worked, through wave action, into the dune ridge that presently separates the marsh from the lake. By 2,000, climates and environments throughout Manitoba had become much like those of today. For this and perhaps other reasons human populations appear to have expanded markedly about the same time.

Although we know of late Archaic occupation through scattered finds and excavated sites, most prehistoric material in the vicinity of Delta Marsh as well as elsewhere belongs to the following Woodland stage that began about 200 BC and lasted until European contact in the 1700's. It was during the Woodland stage that a number of major cultural innovations appeared including the use of the bow and arrow, pottery and burial in earthen mounds. Quantities of arrow points as well as several types of pottery are known for the marsh area and there is a burial mound near Westbourne. No doubt, hunting and gathering groups were attracted to habitats such as Delta Marsh by the variety and abundance of fish, waterfowl and upland game and the opportunities for gathering quantities of roots, berries and nuts.

The most common artifacts found along the lake shore, sand ridges in the marsh and on the Portage plain are points and other stone tools. Woodland styles include Pelican Lake (300 BC to AD 600), Sonota (0 to 800 AD), Avonlea (200 to 800 AD) and Plains and Prairie side-notched (800 to 1750 AD). Some of the tools are made of a dark brown translucent stone, Knife River flint. Unlike other materials that are locally obtainable, this stone derives from deposits in central North Dakota some 400 km distant and most likely was traded into Manitoba.

Although we have some inkling of the cultural sequence in the marsh area during the past several thousand years, we need to know much more about earlier periods as well as about local ecological, technological and social developments among these prehistoric inhabitants. As more surface finds accumulate and sites are discovered and excavated, this fascinating history of past cultures can be better understood and appreciated.

Foraging Strategies of Insectivorous Bats at Delta Marsh, Manitoba

Robert M.R. Barclay

University Field Station (Delta Marsh)
University of Manitoba

INTRODUCTION

Although the foraging strategies of bats, particularly tropical species, have been studied on a populational level, individual patterns of behaviour and sex and age differences have not been investigated to any extent. In addition, the general ecology and behaviour of three of the species of bats found in Manitoba, Lasiurus cinereus (the hoary bat), L. borealis (the red bat), and Lasionycteris noctivagans (the silver-haired bat), are poorly understood due to the bats' solitary, tree-roosting habits.

The purpose of this research is thus twofold: 1) to investigate the ecology and behaviour of the three poorly understood species, and 2) to determine how foraging strategies vary with respect to the age, sex and reproductive condition of the individuals and how the strategies relate to the social organization of the different species.

The three tree-roosting species are the most common bats in the Delta Marsh area and occur in reasonably large numbers. The bats are migratory and are present in the area from May through September. All three species have been described as preying heavily on moths in at least some locations where they have been studied (Ross, 1967; Whitaker, 1972; Black, 1974; Belwood, 1982).

METHODS

The first year of the research was conducted from 1 May to 21 September 1982. Species abundance and habitat use patterns were investigated along three transects established within the Field Station property and that of the Portage Country Club. The transects covered the four main habitat types in the area: the beach/lake, dune ridge, marsh meadows (meadow) and marsh channels and bays (marsh), and were each traversed one to three times per week, at three different times during the night: early (immediately after sunset), middle, and late (just before sunrise). Each transect took approximately two hours to traverse and covered approximately 6 km. Although attempts were made to cover all 3 transects in all 3 time periods each week, this was not always possible.

Bat activity was monitored along the transects using a QMC mini bat detector tuned to 35 kHz and a Lincoln microphone (Simmons et al., 1979) in conjunction with a period meter and an NLS MS-15 oscilloscope. This allowed me to identify the bats to species on the

basis of their echolocation calls since both the sound and oscilloscopic display of the calls of the different species were easily distinguishable (Fig. 1). Bat passes and feeding buzzes (the rapid production of echolocation calls as a bat attempts to capture an insect) for each species were counted for each section of the transect. Moonlight, wind and temperature data were also noted. As well, I made visual observations of bats at dusk, dawn and periods of sufficient moonlight.

Bats were captured using Tuttle harp traps (Tuttle, 1974) placed along the ridge road where the trees formed narrow flyways. Captured bats were identified, sexed, aged, weighed to the nearest 0.1 g and banded on the forearm with coloured split-rings. They were held until the following day so that feces could be collected for analysis.

Roosting L. cinereus were located during the day by walking through the ridge from the Assiniboine Diversion to Cram Creek (3 km). Some were subsequently observed at dusk as they left to forage and feces were collected from underneath the roosts.

Insects were sampled at approximately weekly intervals from the beginning of May until mid-September using sticky and malaise traps. Eleven sticky traps composed of an 11 cm diameter, 38 cm long black plastic tube covered in Tanglefoot, were placed in different habitats and at different heights (Table 1) in order to sample the abundance and distribution of nocturnal insects. Five black malaise traps were also set in different areas (Table 1). All traps were set at dusk and retrieved at dawn. Insects were then counted, identified to order or lower taxa, dried for 24 hours at 90° C and weighed. Insects under 2 mm body length were not included since they are unlikely to be taken as prey by insectivorous bats (e.g. Anthony and Kunz, 1977).

RESULTS

Although as in 1981, L. borealis was the most common species captured (Table 2), the transect data indicated L. noctivagans was actually the most common species in the area followed by L. cinereus, L. borealis and Myotis lucifugus, in that order (Table 3). Furthermore, L. borealis was not present throughout the entire summer and L. noctivagans and L. cinereus are the only species resident in the ridge (Fig. 2). This seasonal data also indicated that a short spring migration of all species occurred with a more prolonged fall movement through the area. M. lucifugus was the first species to arrive and leave the study area while the migratory species were still present in small numbers until mid-September.

The trapping data reveals that male and female L. borealis appear to migrate south at different times, a trend supported by limited trapping data from 1981 (Fig. 3).

Activity of all species was highest along either side of the ridge (Table 4) depending to some extent on the wind as bats tended to be more common on the lee side (Table 5). Visual observations indicated that the bats generally flew up near the tree tops (7-15 m). Activity was low over the meadows and marsh although it increased over the marsh in August and September when bats were observed feeding low over the water in the lee of the Phragmites and Typha.

Feeding activity of each species (measured by the number of feeding buzzes) was also highest along the ridge with lower levels over the marsh and meadows (Table 4). Feeding rate (the ratio of buzzes/passes) declined sharply late in the year (May to July average 0.29 buzzes/pass; August to September average 0.05 buzzes/pass).

The foraging behaviours of the four species differed somewhat although there was no discernable habitat or temporal separation of the species. Often all four species could be found in close proximity to one another. Feeding rates, however, differed markedly with L. noctivagans feeding much faster than the other species (Table 3). One individual produced 71 feeding buzzes in 4.5 min as it fed over the ridge road.

Although no habitat or temporal segregation of the species was noted, individual L. cinereus often flew back and forth along 40-50 m routes usually in the lee of the trees in windy conditions, or in the vicinity of outdoor lights. These individuals stayed for up to 45 min or more in the same location and aggressively chased out other bats from the area, emitting audible vocalizations while diving from behind and above the other individual. In one instance, a red bat released near a hoary was attacked in this manner seven times within one minute and although it avoided the hoary on most occasions, it was "hit" on at least two and disappeared from the area about one minute after release. No other species were observed behaving in this way and L. cinereus were the only bats heard emitting social calls in flight.

Fourteen individuals and family groups (adult female and two young) of L. cinereus were found roosting in trees in the ridge from late June until mid August. Several of the family groups were likely the same individuals which had simply moved from one roost to another, but up to four groups were present at one time. Since observations at dusk revealed that lactating females left their young in the roost when they went to feed, groups found day after day in the same roost site were more than likely the same individuals. One such group remained in the same roost for at least 41 days. Seven of the eight trees used as roosts were green ash (Fraxinus pennsylvanica), all located on the south side of the ridge and providing openings suitable for flight paths. The bats roosted 7 to 12 m up in the trees usually out near the end of a branch. The two groups which remained in the same place the longest roosted in the midst of a clump of ash seeds.

Observations of two groups for over three weeks each indicated that females left non-volant young at dusk and disappeared from the immediate area to feed. In one case, both young took their first observed flights 25 days after the group was first located. In both groups, the young left their roost each night well after the female (20-30 min) but this interval decreased over the following two weeks. Both groups remained together for at least two weeks after the young were volant although individuals within a group left the roost and foraged independently each night.

Nineteen insect sampling periods through the summer revealed a seasonally fluctuating nocturnal insect fauna with generally higher levels in June and July than May, August and September (Fig. 4). Sharp peaks in numbers and biomass were due primarily to chironomid hatches. In general, biomass and number of insects were closely related although individual taxa could dominate one but not the other index of abundance. For example, while chironomids far outnumbered all other insects, because of the small size of some species, their dominance in terms of biomass was not always as great (Table 6). Other insects accounted for minor percentages of the overall sample although peaks in some taxa, notably Trichoptera and Ephemeroptera, were noted. Lepidoptera were generally not abundant although in August and September, as smaller insects declined, moths occasionally dominated the samples, particularly in terms of biomass.

Insects were most abundant (numbers and biomass) over the marsh and ridge as indicated by the 0 and 2 m malaise and sticky traps (Table 7) but there was also a distinct increase in abundance with height in the ridge, especially in May through July. Unfortunately high traps were not set in the other habitats but if the high sticky traps are included in the analysis, the highest insect abundance was nearly always found in the ridge. High traps will be set next year in the other habitats to confirm this. Insect abundance was also influenced by wind direction as 10 of 11 samples taken during a south wind had higher biomass on the beach (north side of the ridge) than the road side (south) while only 1 of 4 taken during a north wind was distributed in that way.

DISCUSSION

Much of the data from this project are still preliminary, but some aspects have been clarified. The transect and trap data indicate that four of the six species of bats found in Manitoba occur at Delta, contrary to Tamsitt's (1962) study in which only Myotis lucifugus and L. noctivagans were mentioned. Only L. noctivagans and L. cinereus, however, are permanent summer residents in the ridge although a small colony of M. lucifugus was still present in the same farmhouse south of Delta mentioned by Tamsitt (1962). The lack of Eptesicus fuscus and M. septentrionalis, the other two species found in the province, and the low numbers of M. lucifugus, probably results from the scarcity of suitable hibernacula in southern Manitoba.

A relatively synchronous spring migration of bats appears to occur in the area at the end of May and beginning of June with a more prolonged, less obvious movement in July through September. It is likely that the bats use the lake shoreline as a landmark and follow along it. The timing of migration agrees with observations in other areas (e.g. Barbour and Davis, 1969), and M. lucifugus arrives and leaves first likely because of the proximity of hibernation sites. The temporal segregation of the sexes apparent in the migration of L. borealis has been noted in other areas (see Shump and Shump, 1982) but has not been adequately explained. Their absence in the ridge during mid summer is also curious since the species is found in summer to the south and north of the study area and the high insect densities around the marsh should provide an abundant source of prey.

The activity of all species at Delta appears to correlate spatially with the areas of greatest insect abundance. During most of the summer the highest insect densities are along the ridge, up fairly high on the lee side and bat foraging activity is concentrated there. Although insects are also common over the lake and marsh since many emerge from the water as adults, winds concentrate the insects in the ridge and likely also hamper the bats' flight thus resulting in the lower bat activity in those areas. Later in the summer, when the overall insect densities decline, due in particular to the drop in chironomids, foraging activity declines and is more spread out. Again, however, bats foraging in the marsh remain in the lee of the vegetation and are still not common over the larger more open bays.

In terms of habitat use, the species of bats at Delta do not seem to differ, but other aspects of their foraging strategies do vary somewhat. At least some L. cinereus are territorial, as Belwood (1982) recently found in Hawaii as well, but I can not yet say how consistent an individual's territory or behaviour is. The areas the bats defend would appear likely to contain greater prey densities (due to winds or lights) and should thus be valuable resources. In addition, L. cinereus is the largest species in the area and is thus presumably physically capable of aggressively evicting other bats from their territory whereas the reverse might not be possible. Associated with this territorialism, L. cinereus feeds at a rather slow rate indicating that they may be selecting only certain types of prey from what is available. In other areas this species is selective, concentrating on moths (Ross, 1967; Black, 1974; Belwood, 1982). My fecal analysis is not yet complete but preliminary results indicate that although L. cinereus is selective in that they do not prey on the most abundant nocturnal insects (chironomids), they are not moth specialists either. Beetles and odonates appear to be common components of their diet, at least at certain times of the night. Further research on this aspect and the costs and benefits of territoriality will be completed in the coming years.

Lasionycteris noctivagans also feeds primarily in the ridge but is not territorial and feeds much more rapidly than L. cinereus, as if it is much less selective in its prey preferences. Little is known regarding this species and it will be interesting to determine what its diet consists of in an area so dominated by chironomids.

The roost sites of L. cinereus were similar to those found by Sealy (1978); high in trees on the south side of the ridge. The apparent selection of ash is interesting but will need to be confirmed with more data. The stability of the family groups after the young are volant is also interesting since females of other temperate species appear to leave their young shortly after the young are flying. Very little information exists concerning migratory species, however, and it may be that whereas females of hibernating species have been selected to curtail parental care due to the need to build up fat reserves and move to the hibernation sites for mating, females of migratory species can afford to prolong parental care.

Obviously many questions have been brought up by these preliminary data. This coming year the temporal nature of bat activity and insect abundance will be determined and a more in-depth study of the social and foraging behaviours of L. cinereus will be started using radiotelemetry.

ACKNOWLEDGEMENTS

The field work could not have been accomplished without the tireless assistance of Melissa Todd and Robin Barclay and the sharp eyes of Gloria Biermann-Pohajdak, Dan Guinan and Spencer Sealy who spotted most of the roosting bats. Other residents of the field station kindly paddled late transects against cold and wind. Ken May fixed my bat traps when they collapsed and M.B. Fenton kindly loaned me vital equipment. I wish to thank the Portage Country Club for permission to work on their property. Financial assistance was provided by Operating and Equipment grants from the Natural Sciences and Engineering Research Council of Canada and a grant from the University of Manitoba.

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Table 1. Insect trap sites.

Location	Sticky Height (m)	Malaise Height (m)
Lake (20 m out from shore)	0	
Beach	2, 7	2
Ridge- Clearing south side	2, 5, 10	2, 10
- PCC Lawn	2	
- Inside woods	2	
Marsh Meadow	2	2
Marsh (Blind Channel)	0	0

Table 2. Bats caught in trap during 1982.

	<u>Lasiurus borealis</u>		<u>Lasionycteris noctivagans</u>		<u>Lasiurus cinereus</u>		<u>Myotis lucifugus</u>		*
	♂	♀	♂	♀	♂	♀	♂	♀	
Adult			5	7	0	7	2	15	
Subadult			2	2	6	2	3	6	
Unknown	37	29							
Total/Sex	37	29	7	9	6	9	5	21	
Total/ Species	66		16		15		26		

Table 3. Total activity and feeding rate (Buzzes/Passes) for all species over the entire summer.

	Passes	Buzzes	Passes/Buzzes
<u>Lasionycteris noctivagans</u>	1291	417	0.32
<u>Lasiurus cinereus</u>	560	65	0.12
<u>L. borealis</u>	483	20	0.04
<u>Myotis lucifugus</u>	146	19	0.13

Table 4. Bat activity and feeding levels in different habitats for all species combined over the whole summer.

Location	Activity			Feeding		
	N	Passes/Hour	%	N	Buzzes /Hour	%
Ridge -Road	1626	24.3	40.4	390	5.8	57.4
-Beach	552	20.2	33.6	64	2.3	22.8
Marsh	256	12.9	21.4	14	0.7	7.0
Meadow	119	2.8	4.7	55	1.3	12.9

Table 5. Influence of wind on number of bat passes (all species) per hour on either side of the ridge.

	North Wind	South Wind
North (Beach)	1.1	25.4
South (Road)	33.8	26.0

Table 6. Percent of all traps through the summer dominated by different types of insects with respect to numbers and biomass. Numbers in parentheses are total number of traps.

Insect	Sticky (167)		Malaise (74)	
	#	Dry Weight (g)	#	Dry Weight (g)
Chironomidae	92.8	71.3	78.4	60.8
Lepidoptera	1.2	6.0	2.7	12.2
Culicidae	2.1	5.4	6.8	8.1
Trichoptera	0.9	4.8	6.8	8.1
Other	3.0	12.5	5.3	10.8

Table 7. Number of sampling nights with the greatest biomass in the different habitats, using 0 and 2 m traps or including the 10 m ridge trap.

Trap	Marsh	Ridge(road)	Beach	Meadow	Lake	
Sticky	6	2	0	3	5	
Malaise	<u>4</u>	<u>5</u>	<u>4</u>	<u>0</u>	<u>-</u>	*
Total	10	7	4	3	5	*
Including 10 m Sticky	3	8	2	0	2	

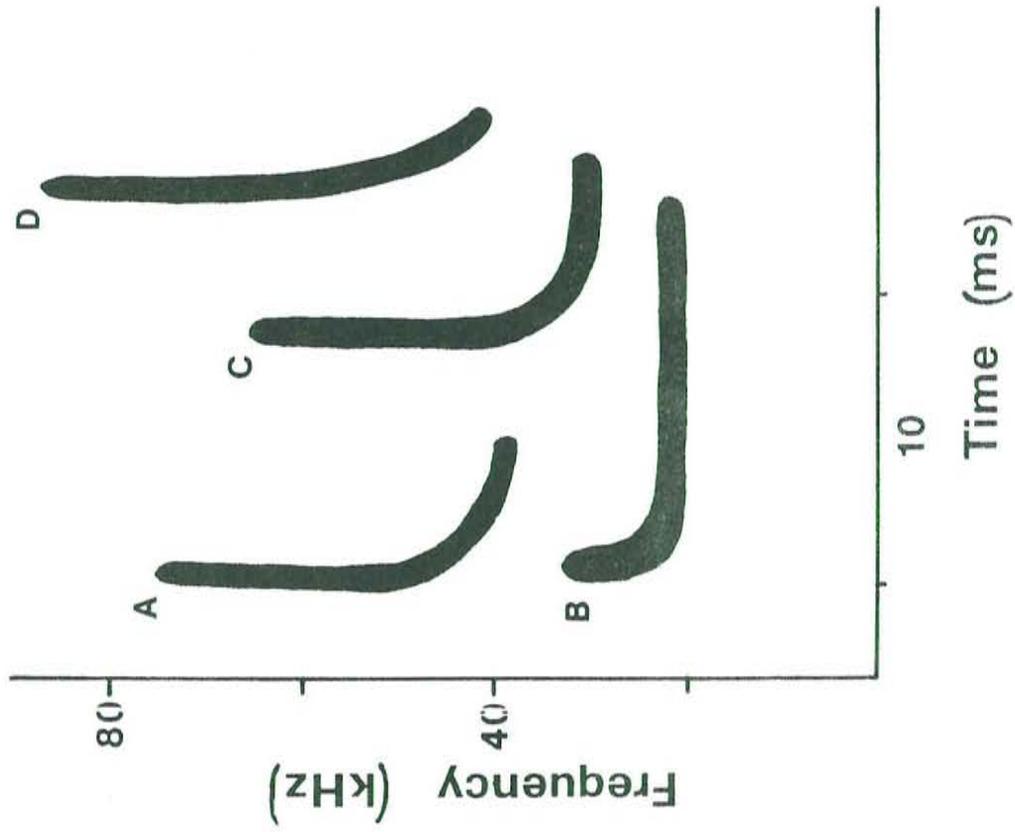


Figure 1. Diagram depicting the oscillographic display of the echolocation calls of the bat species present at Delta Marsh, A) Lasiurus borealis B) L. cinereus, C) Lasionycteris noctivagans and D) Myotis lucifugus.

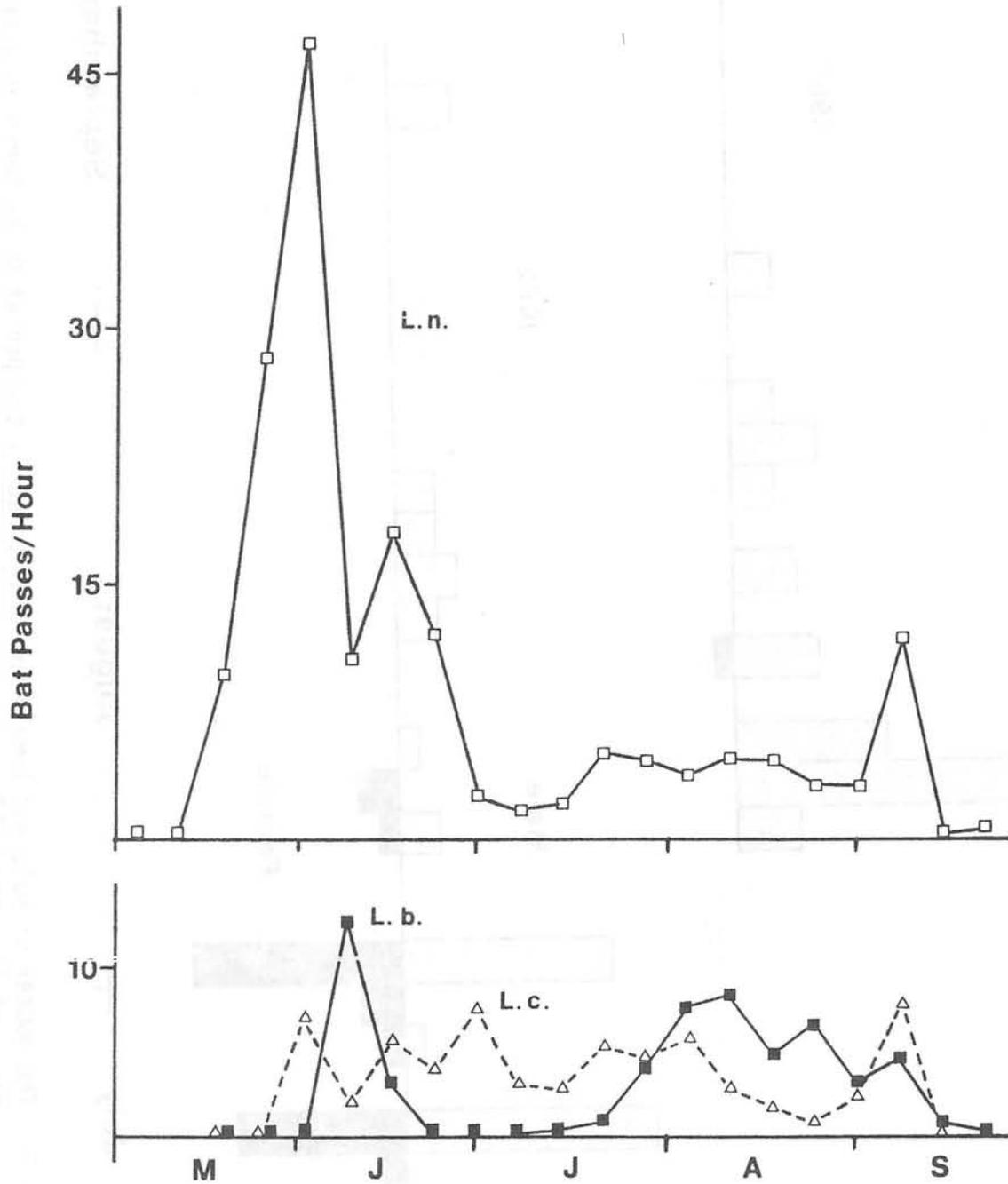


Figure 2. Seasonal activity of the three migratory species at Delta Marsh.

L.n. = Lasiionycteris noctivagans

L.b. = Lasiurus borealis

L.c. = L. cinereus

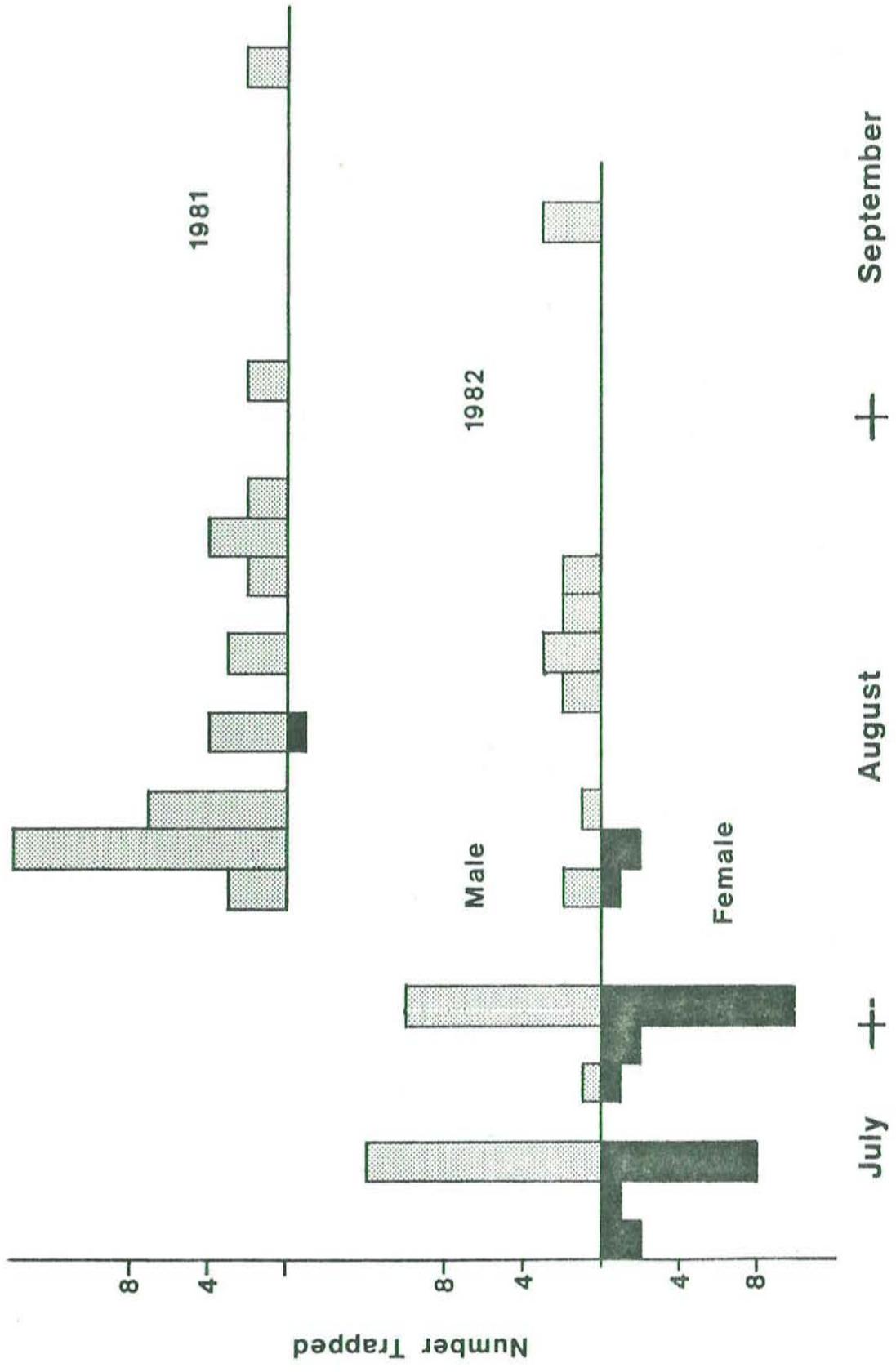


Figure 3. The number of male and female Lasiurus borealis trapped at Delta Marsh at different times of 1981 and 1982.

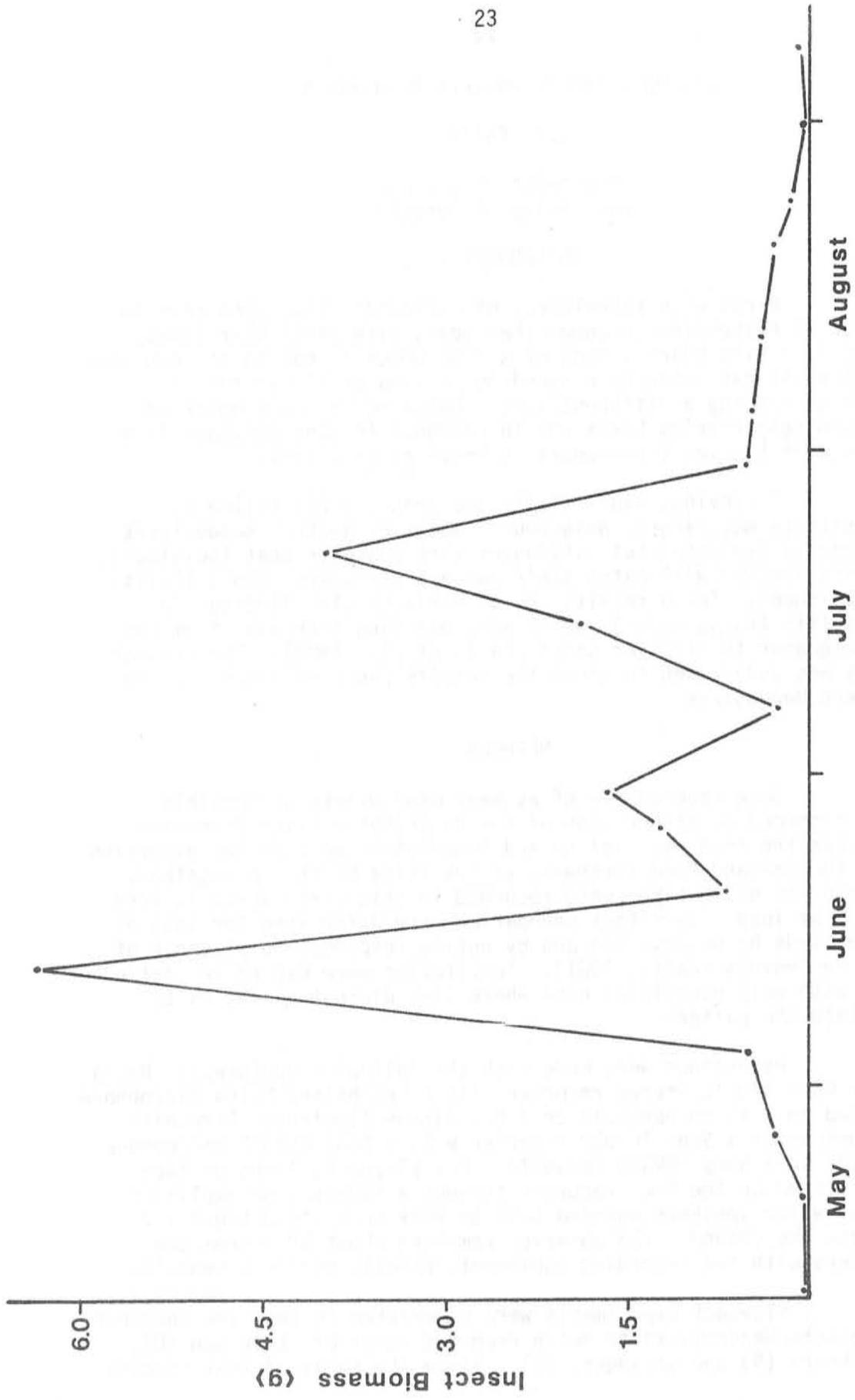


Figure 4. Seasonal abundance (dry biomass) of all insects trapped during 1982 in sticky traps.

Song Matching in Western Meadowlarks

J.B. Falls

Department of Zoology
University of Toronto

INTRODUCTION

Birds with repertoires of different song types have the option of responding to songs they hear, with particular types. Thus, if a bird hears a song of a type which it has in its own repertoire, it can match by responding in kind or it can fail to match by singing a different song. Matching has been observed between neighbouring birds and in response to song playback in a variety of species (references in Krebs *et al.*, 1981).

A previous study (Falls and Krebs, 1975) failed to demonstrate matching of neighbours' songs by Western Meadowlarks (*Sturnella neglecta*) but subsequent work suggests that individuals of this species will match their own and strangers' songs (Falls, unpublished). These results are at variance with findings in Great Tits (*Parus major*), where song matching decreases from own to neighbour to stranger songs (Falls *et al.*, 1982). The present study was undertaken to check the results reported above for the Western Meadowlark.

METHODS

Song repertoires of as many meadowlarks as possible, were recorded on either side of the Assiniboine River Diversion and near the road parallel to and immediately east of the diversion from the Oakland Road northward to the Delta Marsh. Altogether, repertoires of 40 birds were recorded in this strip which is more than 5 km long. Territory boundaries were determined for most of these birds by observation and by noting responses to playback of song recordings (Falls, 1981). Territories were mapped in continuous rows with only occasional gaps where time did not permit us to complete the pattern.

Recordings were made with the following equipment: Nagra IV or Uher 42001C stereo recorder with a Sennheiser MK104 microphone mounted in a 45 cm parabola or a Dan Gibson Electronic Parabolic Microphone or a Sony TC-D5M recorder with a Sony ECM33F microphone mounted in a Sony PBR330 parabola. For playback, loops of tape were played on the Uher recorder through a Kudelski DH amplifier to two wafer speakers mounted back to back on a stand about 1.2 m above the ground. The observer remained about 50 m from the speakers with the recording equipment, usually beside a vehicle.

Playback experiments were undertaken to test the tendency of Western Meadowlarks to match recorded songs of their own (O), neighbours (N) and strangers (S). Since the songs of this species

are distinctive and stereotyped, it was not difficult in most cases to classify songs into types by ear. For pairs of neighbouring birds a song type was selected which they had in common; this provided for playback of O and N songs. A song of the same type recorded at least 1.5 km away provided a similar S song. Most experiments were carried out at roughly the centre of each test bird's territory. O, N and S songs were presented on separate occasions at least two days apart. For some birds a second set of experiments was carried out at the common boundary between the two neighbours. In this case, each experiment counted for both birds: an O for one and an N for the other or an S for both. A few birds were used with two different neighbours; in such a case a different song type was used for each pair of neighbours.

To avoid possible effects of singing before the experiment, the playback was not begun until the test bird (or both birds in the case of edge experiments) had been silent for at least 5 min. Then, 12 identical songs were played at 10-s intervals, followed by a further 3 min period of observation. During the entire 5 min, songs, perch changes and locations of the test bird were noted and usually recorded on tape. Thus, it was possible by transcription of the tape to determine:

- a) whether or not the first or second song given after the playback began, was a match. Credit was given for a full match if the first song was of the same type as the playback. A half match was awarded if the first song was different but the second song was a (delayed) match. If a bird matched on the first song and then switched immediately this was also considered a half match.
- b) number of songs given in the 5-min. period.
- c) number of switches between different song types.
- d) number of perch changes.
- e) closest approach to the speaker in m.
- f) time spent within 20 m of the speaker in s.
- g) latency in s (from the beginning of playback) to either the first song or approach within 20 m.

Experiments were carried out mainly before 1200 and after 1900 h CDT. Periods of strong wind or heavy rain were avoided.

The experiments were presented in different sequences for different birds. Experiments on the same bird were at least 2 days apart, and paired neighbours were not tested on the same day. Within a day, we tried to arrange the sequence of experiments so that playback was not conducted at locations less than 1 km apart in the same 2-h period. We also tried to avoid testing birds in the same order on different days.

Only experiments in which a bird sang were used in the analysis. If no song was heard, a particular experiment might be repeated twice. If there was no response at all, an experiment could be repeated after 2 h. If the bird was not in evidence or the result was confused (identity of the responder was uncertain) repeats were delayed until after the planned sequence on that bird was completed.

Experiments began on June 18 and ended on July 20, 1982 by which time some individuals had ceased to respond.

The frequency of matching (M) and non-matching (NM) was assessed by means of G tests. For other comparisons χ^2 and "t"-tests were used.

RESULTS

Altogether, 127 experiments were completed satisfactorily. Table 1 shows that the frequency of matching was significantly heterogeneous among the six different types of presentations. However, there was no difference between combined centre and edge experiments; there was 44% matching at the centre compared with 45% at the edge. When results were grouped according to stimulus song, matching decreased from O to S to N songs. Further analysis showed that the proportion of matches was significantly different between these three categories. Since recorded repertoires averaged about 7 songs and previous research has shown that Western Meadowlarks sing their different song types with approximately equal frequency (Falls and Krebs, 1975), we may expect a match by chance in about 14% of trials. Thus, the response to N songs was no more than would be expected by chance. Matching to O and S songs was significantly above chance level by this criterion (χ^2 tests, $p < 0.001$).

DISCUSSION

Our results confirm that Western Meadowlarks match their own and strangers' songs but not those of neighbours. Furthermore, they match their own songs more than those of strangers; so matching decreases in the order O, S, N. This is different from the order found in Great Tits by Falls *et al.* (1982), namely, O,N,S. In the Great Tit it was found that neighbours' songs (of the same type) are more similar than those of strangers; in other words they are convergent. Neighbouring Great Tits also share more song types than strangers. We have not yet compared detailed similarity between songs of neighbouring Western Meadowlarks. However, among the 40 birds recorded this year near Delta, there were no significant differences in number of shared song types between neighbours as compared with birds separated by 0.5 to 1.0 km. or birds separated by more than 3.0 km ("t" tests). Since these differences in song sharing between species probably reflect different timing in the process of song learning, it seems unlikely that neighbouring Western Meadowlarks will show convergence in details of their songs

as do Great Tits. If we compare matching of Great Tits to N and S songs that are equally similar to O songs, we find a tendency to match S songs more than N songs. Thus, if song similarity (within the same type) is removed, both species show the same pattern.

How can we account for the order of matching tendencies observed in these two studies? Both Western Meadowlarks and Great Tits customarily repeat their songs in bouts of the same type: AAABBBBCC etc. It has been suggested that this type of singing is controlled by a combination of facilitation and inhibition resulting from the delivery of each song (Hinde, 1958). Thus, having commenced to sing a song type, a bird tends to continue with that type for several renditions. It seems possible that hearing a song from a nearby external source may activate the same mechanism as hearing a bird's own song. If this explanation is correct, we should expect a bird that has not been singing to match a recording of its own song; in effect, the playback would have started it on a new bout. This is what we have observed. We might further expect that songs similar but not identical to its own would elicit somewhat less matching and this also was observed in the case of stranger's songs. But why were neighbours' songs not matched (this has been found repeatedly for Western Meadowlarks)? Since there is no reason to suppose that they are different from strangers' songs, we must look for a different explanation. Neighbours' songs are familiar to birds, as has been shown for many species including Western Meadowlarks (Falls and d'Agincourt, 1981). Thus, on hearing a neighbour's song, a bird may not associate it with its own song but recognize it for what it is. On the other hand, in the case of a stranger's song, no such recognition occurs; there is uncertainty concerning the identity of the song and it may elicit a match. This is a causal explanation of matching and does not suggest what, if any, the function of matching may be in territorial encounters. At the present time, this is still unclear. However, matching does associate the response with a particular signal; that is, it directs the response to the individual singer. Beyond that, matching may indicate the nature of the response in a qualitative or quantitative fashion. We have not yet fully analysed the other measures of response taken in the course of our experiments. However, there do not appear to be any striking differences in the measurements between matching and non-matching responses.

ACKNOWLEDGEMENTS

I especially thank Christina Zarowsky, who ably assisted with the field experiments and Andy Horn who helped from time to time and in several ways. The research was supported by NSERC Grant A0898. I appreciate the facilities provided by the University of Manitoba Field Station (Delta Marsh).

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Table 1. Matching and non-matching in response to song playback

Responses	Treatments (songs and locations)						Totals
	Own		Stranger		Neighbour		
A*	Centre	Edge	Centre	Edge	Centre	Edge	
Matches	20	9	16.5	5	6	0	56.5
Non-matches	11	3	22.5	5	20	9	70.5
Totals	31	12	39	10	26	9	127
B**	Own		Stranger		Neighbour		
Matches	29		21.5		6		56.5
Non-matches	14		27.5		29		70.5
Totals (% matches)	43 (67)		49 (44)		35 (17)		127 (44)

* $\underline{G} = 24.9$, d.f. = 5, $p < 0.01$; ** $\underline{G} = 20.18$, d.f. = 2, $p < 0.01$.

Effect of Two Herbicides on Periphytic Algal Productivity

Gordon Goldsborough

Department of Botany
University of Manitoba

INTRODUCTION

While the efficacy and toxicology of herbicides in the aquatic environment have undergone much investigation, study has centered only on macrophytic vegetation (Walker 1964, Wile 1967, Bowmer *et al.*, 1979) or phytoplankton (Tucker and Boyd 1978). Effects on the periphyton, which may account for the largest proportion of primary production in littoral systems, have been documented rarely (Girman 1976).

The present study attempted to examine some effects of the triazine herbicides simazine and terbutryn on periphytic algal productivity and to compare their relative toxicities.

MATERIALS AND METHODS

Seven PVC cylinders were positioned in the Blind Channel in water approximately 60 cm deep. Reagent grade herbicide powder (98% a.i.) in gauze sacs was added to each of six cylinders to give concentrations of 0.1, 1.0, and 5.0 mg/L simazine and 0.01, 0.1, and 1.0 mg/L terbutryn in the 300L cylinder volume. The seventh cylinder served as an untreated control. Weekly measurements of actual herbicide concentration in each cylinder were made using ultraviolet spectrophotometry (Mattson *et al.* 1970).

Extruded acrylic rods (1.0 m long by 0.62 cm diameter), placed upright in the cylinders, acted as substrata for algal colonization. At weekly intervals following initial placement (on the same day as herbicide addition), three colonized rods were randomly selected from each cylinder, broken into 10 cm pieces, and transported to the lab in GF/C filtered marshwater. A 2 cm segment was selected from three further rods from a position on each corresponding to 30-32 cm above the marsh sediments. These were placed in individual tubes of GF/C filtered water and taken to the lab for determination of photosynthetic rate.

Periphyton on whole rods was removed with a No. 2 hard-bristled paintbrush into filtered water, then filtered under vacuum onto fiberglass filters and frozen until analysis. Pigments in these samples were extracted into 90% acetone using a tissue grinder and the concentration of chlorophyll *a* measured *trichromatically* (Strickland and Parsons 1968). The concentration was expressed as amount of chlorophyll *a* per unit substratum surface area.

Tubes containing 2 cm rod segments were inoculated with 1 mL standardized $\text{NaH}^{14}\text{CO}_3$ (ca 0.5Ci/mL) and incubated in a growth chamber at approximately 50 $\mu\text{E}/\text{m}^2/\text{s}$ and 20°C for three to four hours. Samples were filtered to collect dislodged periphyton. Rod segments and filters were fumed over concentrated HCl to remove residual labelled inorganic carbon, then placed in a vial containing 10mL Bray's scintillation fluid (New England Nuclear). After allowing a period of 24 hours for the rod and filter to dissolve, sample radioactivity was determined with a Picker Liquimat 220 scintillation counter with correction for color quenching by the channels ratio method. Carbon assimilation rate of periphyton per unit rod surface area was calculated from the formula:

$$\text{ugC fixed}/\text{cm}^2/\text{hr} = \frac{\text{DPM (S)} \times \text{C} \times 1.05}{\text{DPM (T)} \times \text{A} \times \text{T}}$$

where DPM (S) and DPM (T) are activities remaining after incubation and total added (dpm) respectively, C is dissolved inorganic carbon present in cylinder water (mgC/20mL) 1.05 is a ^{14}C discrimination factor, A is rod surface area (cm^2) and T is incubation time (hours).

RESULTS

Concentrations of each herbicide remained near the theoretical levels for the first two weeks of the experiment (Figure 1) with the exception of the 5.0 mg/L simazine treatment, which, due to an applied quantity above maximum herbicide solubility in water, was considerably less than the predicted level. A strong north wind just prior to the third week caused marsh water levels to rise approximately 30 cm, causing cylinders to be flooded for a 30-hour period. Subsequent monitoring showed that the herbicides were flushed from all cylinders although low residual levels were detectable in the highest simazine and terbutryn treatment cylinders until the end of the experiment. The flooding was fortuitous in allowing examination of periphytic community recovery following herbicide-induced inhibition.

Chlorophyll *a* levels at 0.1 mg/L simazine varied widely (Figure 2), but were at least equal to those of the control. Following flooding (week 3), the level decreased to slightly less than the control. For both higher levels of simazine, chlorophyll *a* levels were significantly less than the control, but in neither case did chlorophyll increase to the level of the control within the six week period of the experiment.

All levels of terbutryn resulted in significantly less chlorophyll *a* accumulation than on control substrata (Figure 2). Following herbicide loss, only the lower herbicide treatment levels increased in chlorophyll, while the highest concentration chlorophyll levels remained about the same.

Similar trends were observed for periphytic photosynthetic rate (Figure 3). The 0.1 mg/L simazine level was not significantly different from the control, but the chlorophyll levels for all other simazine treated cylinders and all terbutryn treated cylinders were less than the control in proportion to herbicide concentration. Increase in photosynthetic rate relative to the control was observed in all cylinders following flooding with the exception of the 1.0 mg/L terbutryn treatment, which did not change significantly.

DISCUSSION

Close correspondence was observed between substratum chlorophyll level and photosynthetic rate at all herbicide treatment levels, indicating that both are individually appropriate for assessment of herbicidal effects on periphyton. However, there is some evidence (Goldsborough and Robinson unpublished data) that the ratio of photosynthetic rate to unit chlorophyll varies with herbicide treatment, so this ratio was not used to contrast the toxicities of the two herbicides.

By comparison of chlorophyll level and photosynthetic rate for simazine treatments (Figures 2 and 3), the EC₅₀ value (effective concentration of herbicide giving 50% inhibition of chlorophyll synthesis or photosynthesis) for the periphytic community (using only preflood data) lies in the range of 0.1 to 1.0 mg/L. This compares favorably with a range of 0.025 to 0.25 mg/L simazine reported by Girman (1976) for periphyton on artificial substrata. Terbutryn treatment, on the other hand, resulted in an EC₅₀ in the range of 0 to 0.01 mg/L, indicating that terbutryn is at least twice as toxic to the periphytic community as simazine.

An alternate means of comparing the toxicities of the two herbicides is to take the ratio of mean preflood chlorophyll in the 1.0 mg/L simazine treatment to the mean in the 1.0 mg/L terbutryn treatment. Assuming that chlorophyll level is a function of herbicidal effect, the ratio indicates the degree to which terbutryn inhibits chlorophyll synthesis as compared to simazine at the same concentration. Similar calculations can be performed using the mutual 0.1 mg/L concentration and photosynthetic rate means for both herbicides.

Both chlorophyll and photosynthesis gave similar results at each herbicide concentration (Table 1). At 0.1 mg/L, terbutryn was approximately 55 times more toxic to periphyton than simazine, whereas the difference dipped to 10 times at 1.0 mg/L. This effect of concentration can be rationalized by observing that a large increase in toxicity is seen between 0.1 and 1.0 mg/L simazine, meaning that these concentrations fall on the sigmoidal portion of a dose-response curve. The comparatively small difference in effect between 0.1 and 1.0 mg/L terbutryn locates these concentrations on the plateau of the curve. Thus, while terbutryn is a more powerful herbicide than simazine at lower concentrations, the difference between them decreases as higher levels are used.

All treated cylinders except the one assigned the highest level of terbutryn exhibited recovery both in terms of chlorophyll a and photosynthetic rate. The rate of increase in each parameter was equal to or greater than the control, suggesting that long-term effects on community productivity would not be observed. This does not, however, preclude community structural changes. The lack of recovery at 1.0 mg/L terbutryn probably relates to the residual concentration following flooding (Figure 1) which exceeded the concentration in the 0.01 mg/L cylinder. The latter treatment produced a marked phytotoxic effect in the preflood period, so effects at the residual levels detected were to be expected.

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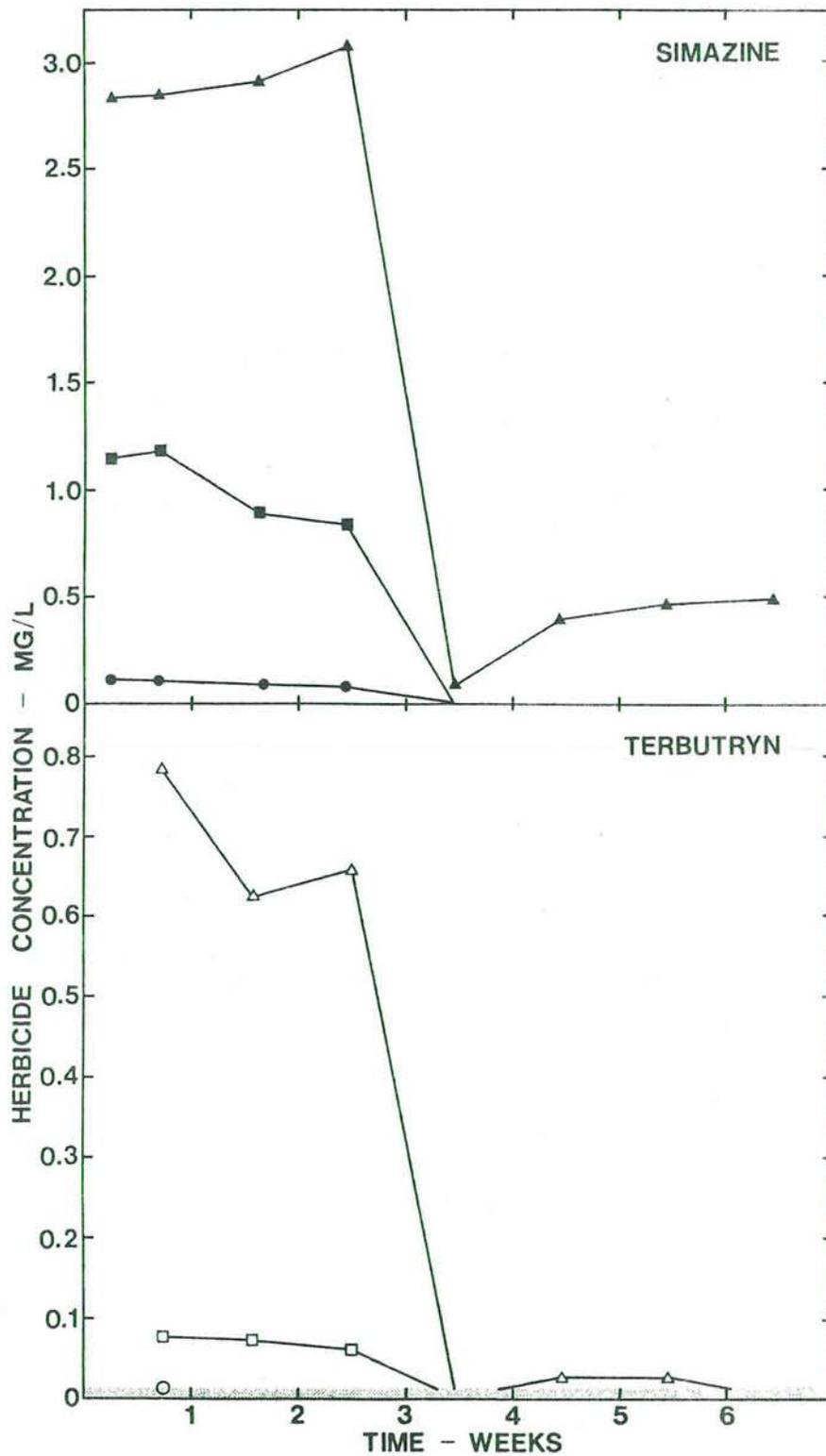


Figure 1: Actual concentrations of simazine at 0.1 (●), 1.0 (■), and 5.0 (▲) mg/L levels, and terbutryn at 0.01 (○), 0.1 (□), and 1.0 (△) mg/L levels in herbicide-treated cylinders over the 6-week period of the experiment. Cylinder flooding occurred before week 3.

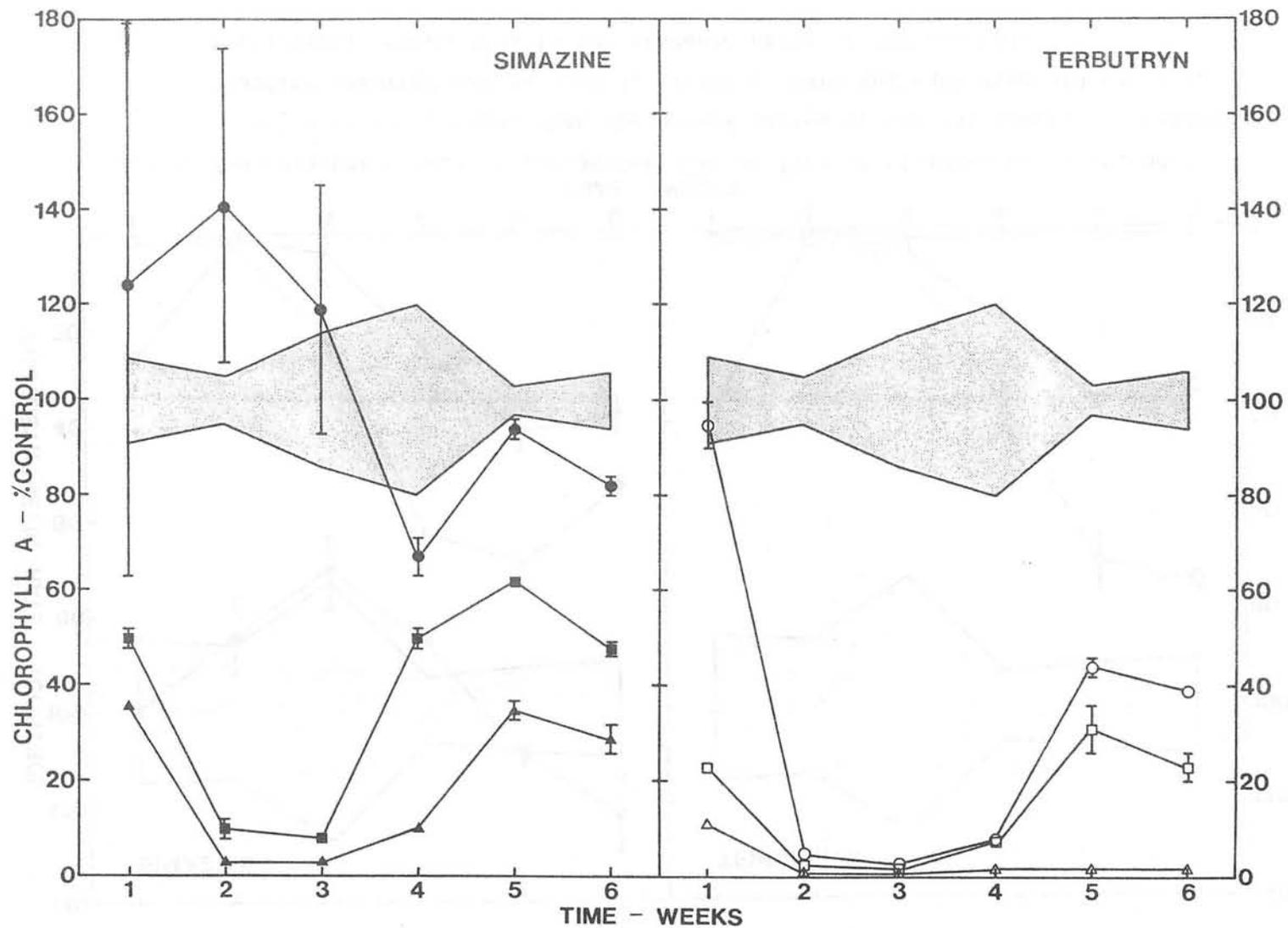


Figure 2: Chlorophyll a levels (uncorrected for phaeopigments) of periphyton sampled from herbicide-treated cylinders relative to the control over the 6-week period of the experiment. Cylinder flooding occurred before week 3. Vertical bars indicate standard error of replicates; shaded area is S.E. of the control.

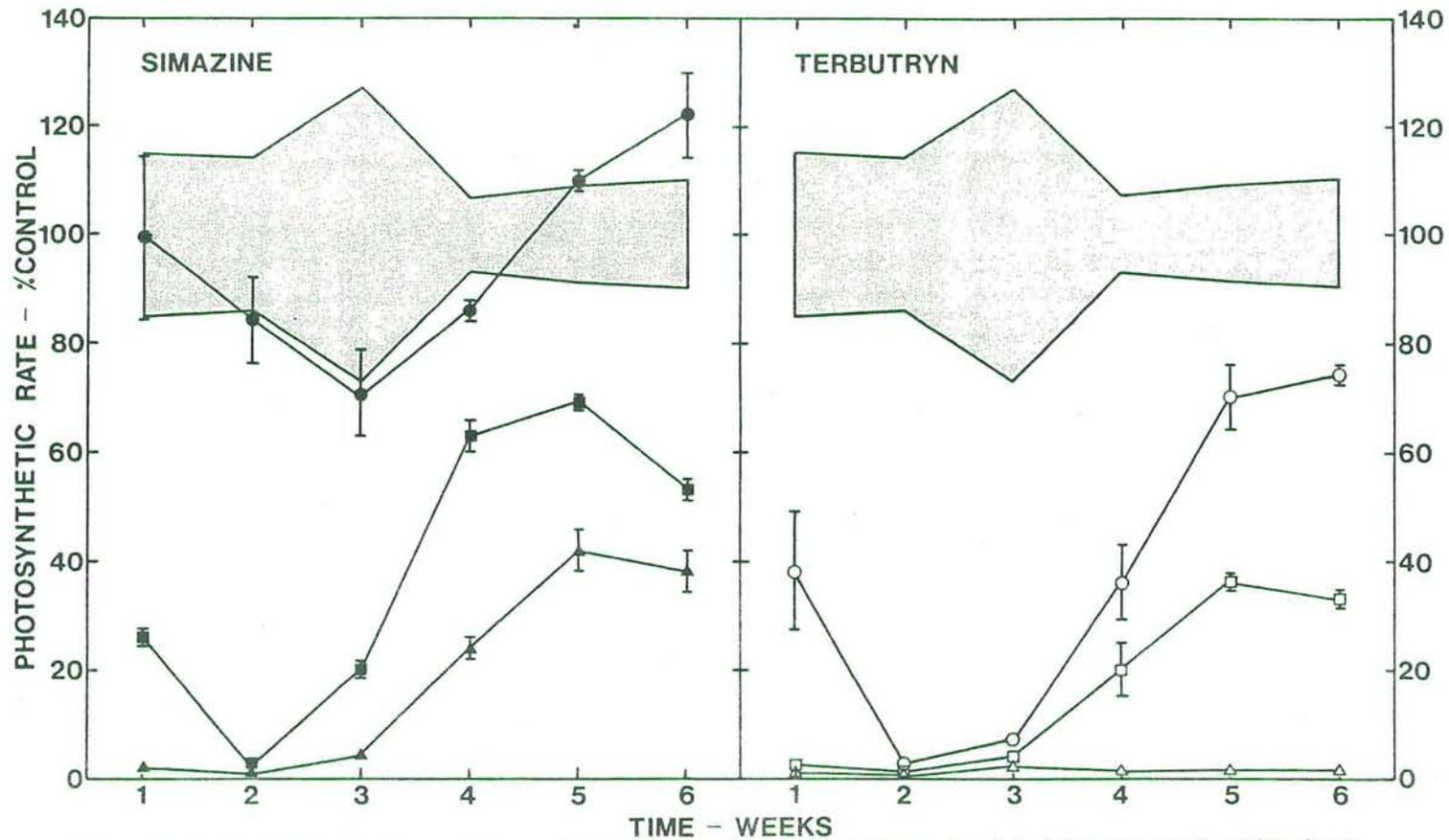


Figure 3: Photosynthetic rate of periphyton sampled from herbicide-treated cylinders relative to the control over the 6-week period of the experiment. Cylinder flooding occurred before week 3. Vertical bars indicate standard error of replicates; shaded area is the standard error of the control.

Table 1: Ratio of mean chlorophyll a (or photosynthetic rate) of periphyton over the 3-week pre-flood period at similar levels of simazine and terbutryn.

Herbicide Conc. (mg/L)	Chlorophyll	Photosynthesis
0.1	54.08	56.48
1.0	10.42	9.83

Dissolved Silicon Dynamics in a Marsh Channel

Gordon Goldsborough

Department of Botany
University of Manitoba

INTRODUCTION

In the course of investigations on marsh water chemistry, water in the recently dredged channel entering the Blind Channel was assayed for dissolved silicon. Curiously, the level found was up to four times greater than in the adjacent marsh and was higher than the concentration in water of Lake Manitoba, which on the southernmost end overlies silica sand. Further monitoring was undertaken over a subsequent four month period to detect changes in concentration and to theorize on the causal factors.

MATERIALS AND METHODS

Five sampling sites were established in a transect running from the canoe dock at the farthest extent of the channel to a point approximately 150 m into the Blind Channel (Figure 1). Near the dock, samples were collected from just below the water surface (site 2) and at the channel bottom in water of about 0.75 m depth (site 1). Other sites were positioned midway along the channel (site 3), at the outlet of the channel into the marsh (site 4), and alongside a series of PVC cylinders positioned in the Blind Channel for other experiments (site 5). Samples collected at sites 3, 4, and 5 were from the top 10 cm of the water column.

Sampling was conducted at the five sites at three times during the summer of 1982 (5 June, 9 July, 21 August). Regular collections at sites 2 and 5 were made at weekly intervals. In the latter part of the summer, water was also collected from the inside of a cylinder at site 5. These collections coincided with daily measurements of surface oxygen (standardized at a constant time of day to reduce diurnal fluctuation effects) at site 5 and in the cylinder using a YSI Model 51B oxygen meter.

Fifty ml. aliquots of water were analyzed for dissolved orthosilicate (usually within two hours of collection) using the molybdenum blue colorimetric method (Stainton *et al.* 1977). Half or 0.25 dilutions were often necessary to reduce color intensity sufficiently to allow absorbance measurement with a Pye-Unicam SP-600 ultraviolet spectrophotometer.

RESULTS AND DISCUSSION

Silicon concentration was consistently higher at site 1 than at site 2 (Figure 1), although the gradient with water depth was most pronounced on August 21. A net decreasing trend with increasing distance from the dock was observed on all three dates.

During early sampling, silicon levels at site 2 appeared to increase as water level in the channel increased. Subsequently, a plot of silicon concentration at site 2 versus water depth measured at the canoe dock (calculated as a three-day mean to buffer short-term fluctuations in level) (Figure 2) shows high correlation. Notably, the brief period of high water level from August 7 to 9 corresponds closely with a sharp peak in silicon concentration. A much poorer correlation is seen between channel water level and silicon at site 5 (Figure 2).

An important feature of Figure 2 is that with the exception of a period at the end of July, silicon level was always higher at site 2 than at site 5. One may hypothesize that increasing amounts of marsh water would be mixed with channel water as water level increased. Since the former is lower in dissolved silicon than the latter, flooding should lead to decreased channel silicon levels in the channel. Yet, it is clear that the opposite occurred. Explanation of this phenomenon may lie in the depth-gradient of silicon between sites 1 and 2 (Figure 1). If silicon levels in bottom water were significantly higher than overlying water, marshwater inflow, especially if rapid, would mix the water column, resulting both in higher surface concentrations and a less pronounced depth gradient. Evidence for this is seen in the June 5 and July 9 samples (Figure 1). Each sampling was preceded by a sharp increase in water level (Figure 2). Comparatively, the transect at August 21 did not closely follow a water level peak, and its depth gradient of silicon was most pronounced.

These data explain neither the reason for increased silicon concentration in the channel nor the reason for elevated bottom silicon levels. Circumstantial evidence suggests that water oxygenation may be involved. In the water contained by the PVC cylinder at site 5, periods of low oxygen (compared to surrounding marsh water) appeared to correspond with elevated silicon level (Figure 3). As cylinder-water oxygen content increased relative to the adjacent water, silicon concentration decreased. Similar correlations between dissolved oxygen and silicon have been reported both in whole lakes and artificial tanks (Mortimer 1941, 1942). By extrapolation, low oxygen levels in the channel may be predicted. Similarly, silicon concentration of lake and river sediments have been found to be up to eight times higher than overlying water (Harriss 1967). If the source of silicon is the sediments (as suggested by Figures 1 and 3, the latter a case in which elevation of dissolved silicon in the cylinder could be explained only as the result of input from the sediments), degradation of organic material on the bottom (leading to high biochemical oxygen demand-BOD-and thus low water oxygenation), especially of silicon-rich wetland grasses (Parry and Smithson 1964) common to emergent marsh vegetation, could explain these observations.

Hecky *et al.* (1973) suggested that liberation of silicon from diatom frustules would occur more rapidly under aerobic conditions, due to decomposition of the organic layer surrounding the frustule which normally hinders dissolution. In the present context, oxygenated water may serve to remove the organic layers surrounding the siliceous bulliform cells of grasses deposited in the sediments, thereby stimulating silicon release.

Thus, it may be that dredging of previously buried organic deposits exposed them to oxygenated water producing high channel levels of dissolved silicon. The oxygen was drawn from the water to supply sediment BOD, with silicon being liberated. Turbulence caused by rapid marshwater influx distributed the silicon throughout the water column. Since channel concentrations exceeded those of the marsh, transfer of silicon would occur into the marsh so that highest concentrations were encountered at the dock, which was the farthest limit of influent water effect.

ACKNOWLEDGEMENTS

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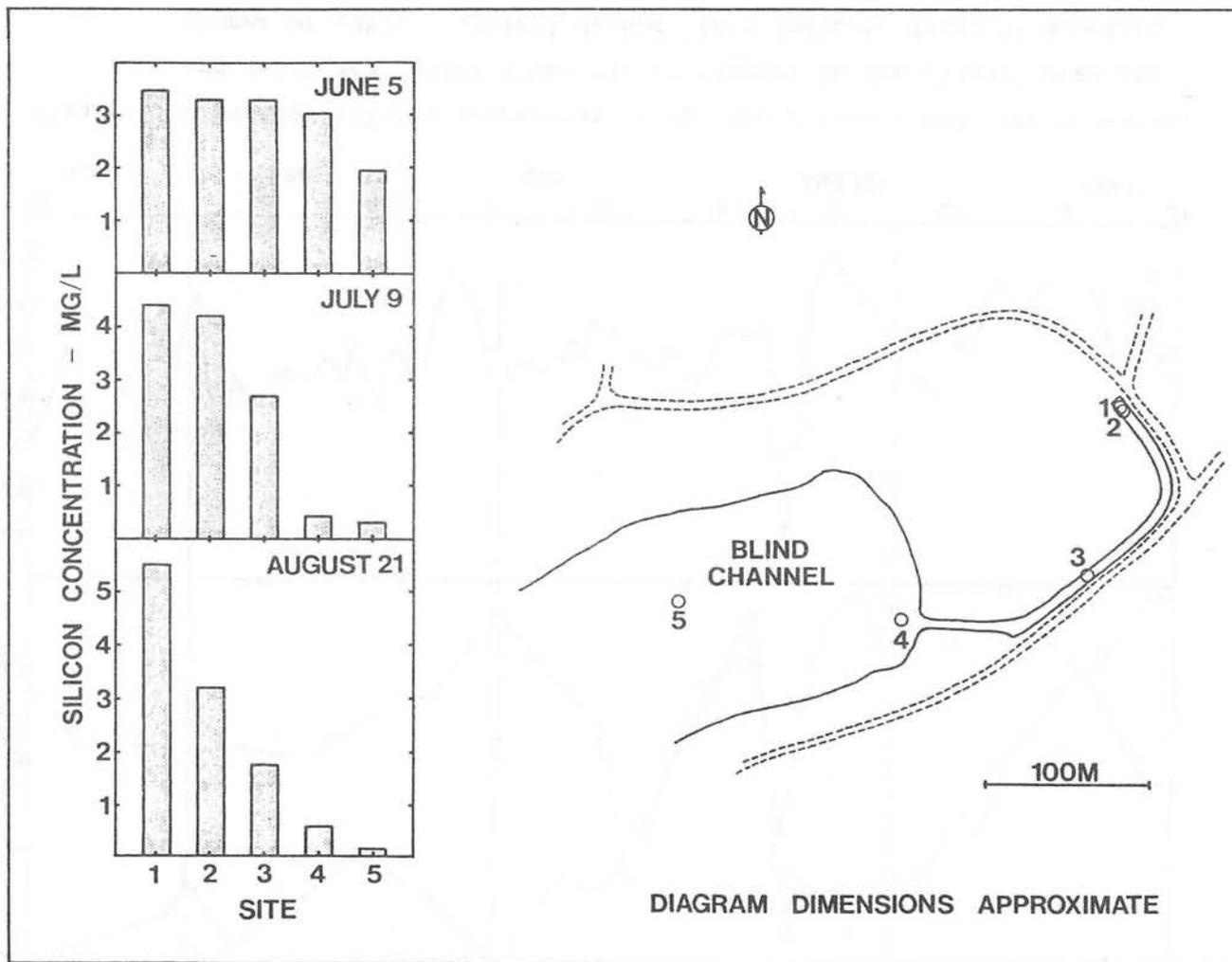


Figure 1: Diagram indicating approximate locations of sampling sites 1 to 5 in the dredged channel and in the Blind Channel. Inset: Dissolved silicon concentration at each of the sampling sites at three dates during the summer of 1982.

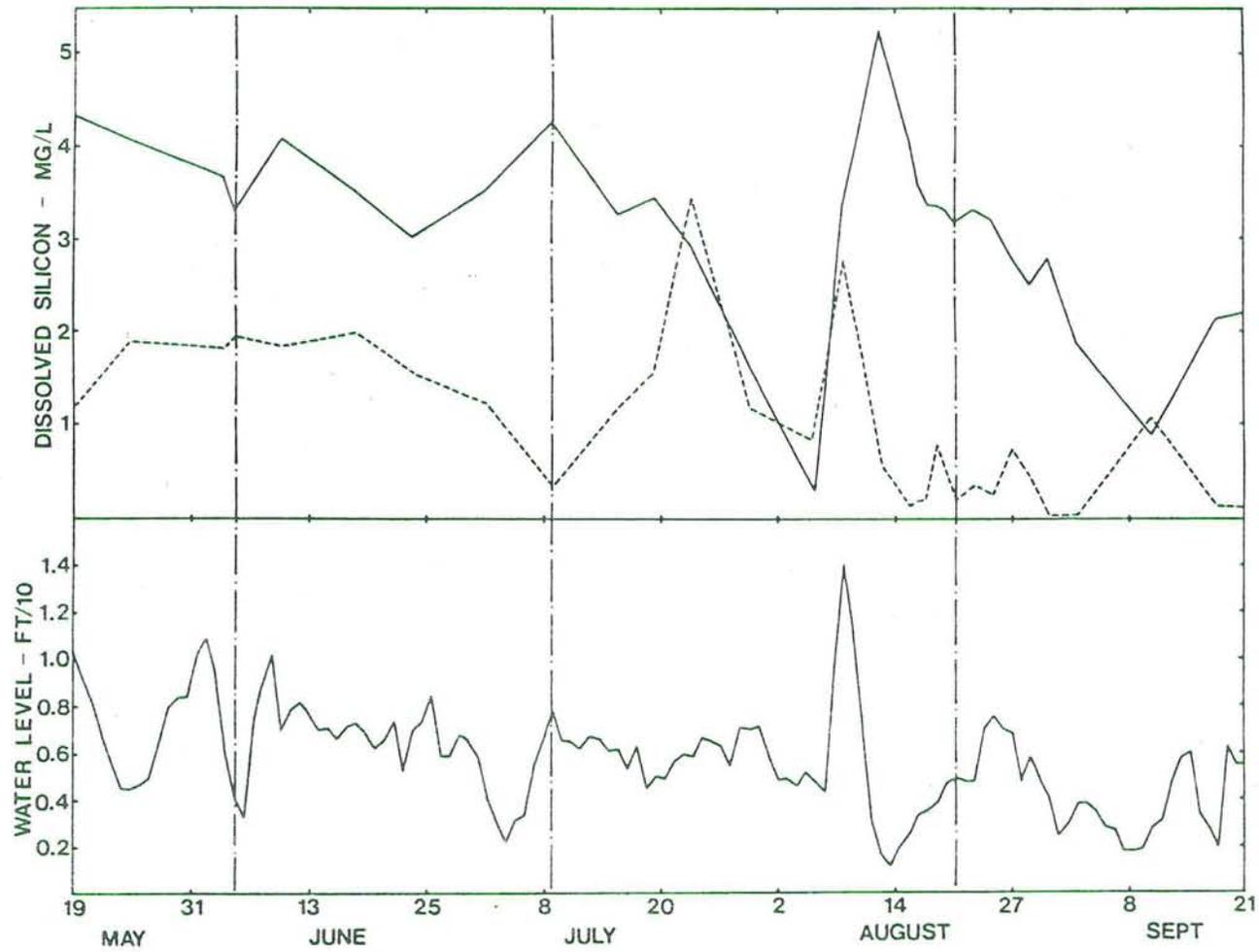


Figure 2: Dissolved silicon concentration at site 2 (—) and site 5 (---), and 3-day mean water level (lower figure) in the channel over the summer of 1982. Vertical dashed lines indicate dates of sampling at sites 1 to 5.

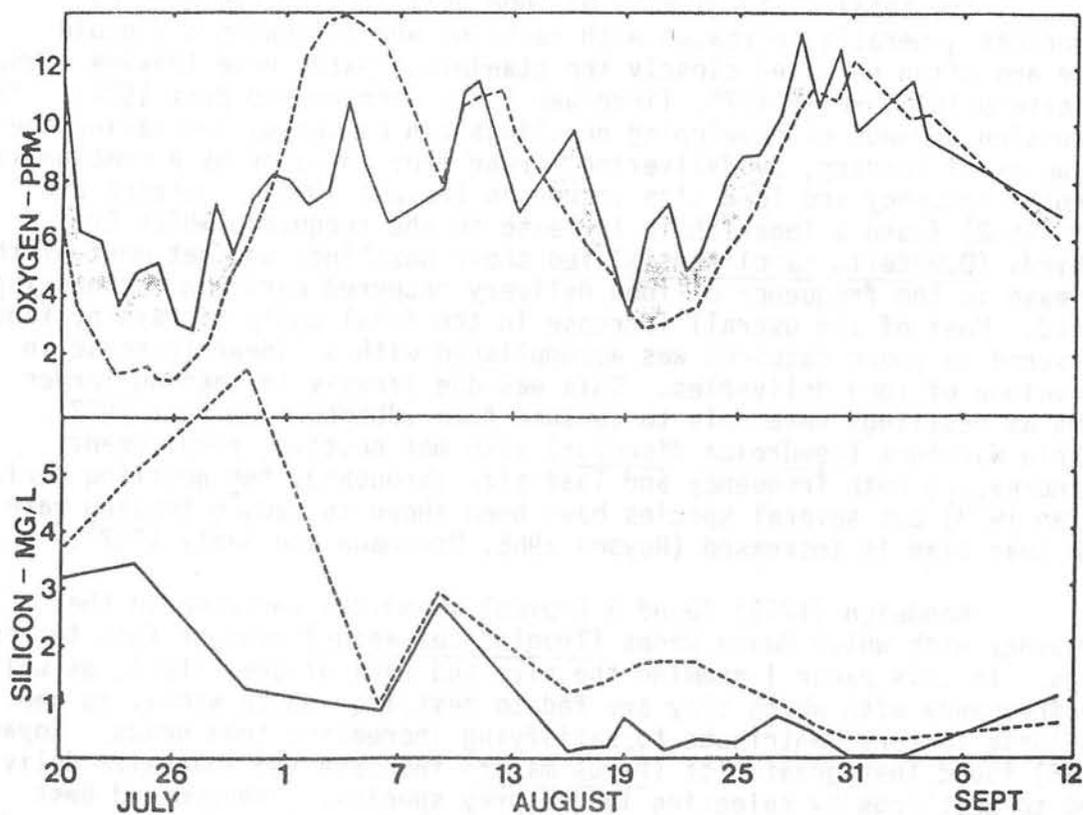


Figure 3: Dissolved oxygen (upper) and silicon (lower) at site 5 (—) and inside an adjacent PVC cylinder (---) over a 6-week period in 1982. Shaded areas indicate periods of oxygen deficit in the cylinder relative to surrounding water.

The Importance of Feeding Frequency, Load Size and Prey Characteristics
to House Wrens Feeding Nestlings

Dan Guinan

Department of Zoology

University of Manitoba

INTRODUCTION

The total daily biomass of food delivered to the nest by passerines generally increases with nestling age following a sigmoid curve and often parallel closely the standard growth curve (Royama 1966, Westerterp 1973, Walsh 1978, Tinbergen 1981, Johnson and Best 1982). The increasing demands of developing nestlings can be met by increasing the frequency of feeding, by delivering larger prey loads or by a combination of both frequency and load size increases (Royama 1966). Johnson and Best (1982) found a logarithmic increase in the frequency which Gray Catbirds (Dumetella carolinensis) fed their nestlings so that most of the increase in the frequency of food delivery occurred early in the nesting period. Most of the overall increase in the total daily biomass of food delivered to young catbirds was accomplished with a linear increase in the volume of food deliveries. This was due largely to feeding larger items as nestlings were able to consume them (Johnson and Best 1982). Prairie Warblers (Dendroica discolor) also met nestling requirements by increasing both frequency and load size throughout the nestling period (Nolan 1978) but several species have been shown to reduce feeding rate when load size is increased (Royama 1966, Biermann and Sealy 1982).

Kendeigh (1952) found a typical sigmoidal increase in the frequency with which House Wrens (Troglodytes aedon) brought food to nestlings. In this paper I examine the size and taxa of prey items, as well as the frequency with which they are fed to nestling house wrens, to see how these factors contribute to satisfying increasing food needs. Royama (1966) found that great tits (Parus major) increase the load size delivered to nestlings by selecting larger prey species. Johnson and Best (1982) determined that the variability in volume of food load increased with nestling age but the number of items per load was unrelated to age. Yellow warblers (D. petechia) generally brought more prey items per load when feeding older nestlings (Biermann and Sealy 1982). European Starlings (Sturnus vulgaris) used multiple prey loading, as well as switching to a more easily obtainable but less preferred prey species (Tinbergen 1981) to meet the demands of artificially increased broods and food deprived nestlings.

METHODS

The study was conducted on a 3-km portion of dune ridge forest between the outlets of the Assiniboine River Diversion and Cram Creek at Lake Manitoba. The composition and structure of the overstory vegetation has been analyzed by MacKenzie (1982). House wrens nested in natural cavities, nest boxes and a variety of artificial sites of which 4, 2 and 1, respectively, are represented in this analysis. These nests were selected because adults returning with nestling food were not obscured by vegetation and could be observed from within 20 m (9X binoculars, 25X telescope) with a minimum of disturbance. Activity at the nests was observed in a series of 1/2-hour periods throughout the time when wrens on the study area were feeding nestlings (18 June-27 July 1982).

During each observation period the number of loads brought to the nest by each parent was recorded. Sex could be determined in individually color-banded birds and with behavioural characteristics, particularly singing by males. The number of items and their taxonomic category were recorded. Most prey items were identified to order where possible, although adult Diptera could usually be distinguished at the family level. Most holometabolous insect larvae could not be distinguished and have been grouped together for analysis. Araneida, Ephemeroptera, and Chironomidae were also important enough to merit individual examination but all other taxonomic categories were lumped for analysis. The lengths of prey items were estimated as a proportion of culmen length. Nest chronology was followed or estimated by adult activity as an index of nestling age.

Prey items in adult bills could only be identified under certain lighting conditions at some nests which excluded a completely randomized test of time of day effects. Most observations were conducted throughout the morning and in the evening. Brood size could not be determined accurately in most natural nest sites and no brood size factors were analyzed. For some comparisons the nestling period was divided into three stages: I. the first five days including the day of hatching (day 1); II. the last five days of nestling life including the estimated or observed day of fledging; III. the intermediate five, six or seven day period. This method produced greater confidence in assigning stages because the day of hatching and fledging could be accurately estimated from adult behavior where nest contents could not be observed. Most of the variation in age at fledging probably relates to asynchrony in hatching date or delayed fledging due to weather conditions, rather than factors related to feeding efficiency (but see Zach 1982).

RESULTS AND DISCUSSION

The number of feedings in each 30 minute observation increased with nestling age, reaching a maximum on the twelfth day then declining until fledging (Fig. 1). The feeding frequency approximates a sigmoid curve as found in Great Tits (Royama 1966) Eastern Bluebirds (*Sialia sialis*) (Pinkowski 1978) and an earlier study of House Wrens (Kendeigh 1952). Royama (1966) found that the average daily biomass of food intake closely paralleled the nestling growth curve of Great Tits. The frequency of feeding however did not follow the growth curve and displayed greater variation with brood size and season in Great Tits as well as Purple Martins (*Progne subis*) (Walsh 1978). In these species most of the daily increase in food brought to the nest was accomplished with increasing load size.

Zach (1982) found a logistic model best predicted the growth curves of nestling House Wrens for weights up to the asymptote at 11.81 days. House Wren feeding frequency also best fit a logistic scale of nestling age for the entire nestling period ($r=0.72$, $p<0.025$) and when values from the post-asymptotic recession are disregarded ($r=0.72$, $p<0.005$) (Ricklefs 1968, Zach 1982). The recession in nestling weight, although highly variable, was more like the marked pre-fledging decrease in swifts, swallows and some oceanic birds than of a typical passerine in Zach's (1982) study of house wrens. The post-asymptotic recession in feeding frequency in this study (Fig. 1) is also pronounced although the sample size is statistically invalid. A similar recession occurred in the frequency with which Eastern Bluebirds fed nestlings (Pinkowski 1978) and this was due primarily to a drop in male feedings. In this study the percentage of male feedings dropped during the last stage of the nestling period but was highly variable between observations (Table 1A). This may be a factor in the variability which Zach (1982) found in the weight of nestlings just prior to fledging.

The apparent correlation between the feeding frequency of this study and the standard growth curve (Zach 1982) indicates that frequency of feeding may be important as a factor which house wrens can manipulate to meet the caloric demands of developing nestlings. Table 1 shows that while frequency changed with nestling age and season, several factors related to the type and size of prey load also changed in a manner suggesting that they may also contribute to increasing the daily food intake of nestlings. The relative effects of frequency and prey load characteristics can be compared by examining how these change with nestling stage in contrast to date. The asynchrony of wren nests on the study area allows this comparison but a significant and unmeasurable interaction remains. Most nests in the first of four arbitrary date categories, for example, contained stage 1 nestlings (Fig. 2).

The average number of prey items per load increased with nestling age (Table 1A) but the size of prey items shows no clear relationship. The load size and size of prey may be inversely related so that by selecting a smaller prey type which can be multiple loaded, a bird can increase or maintain the biomass of food in each load.

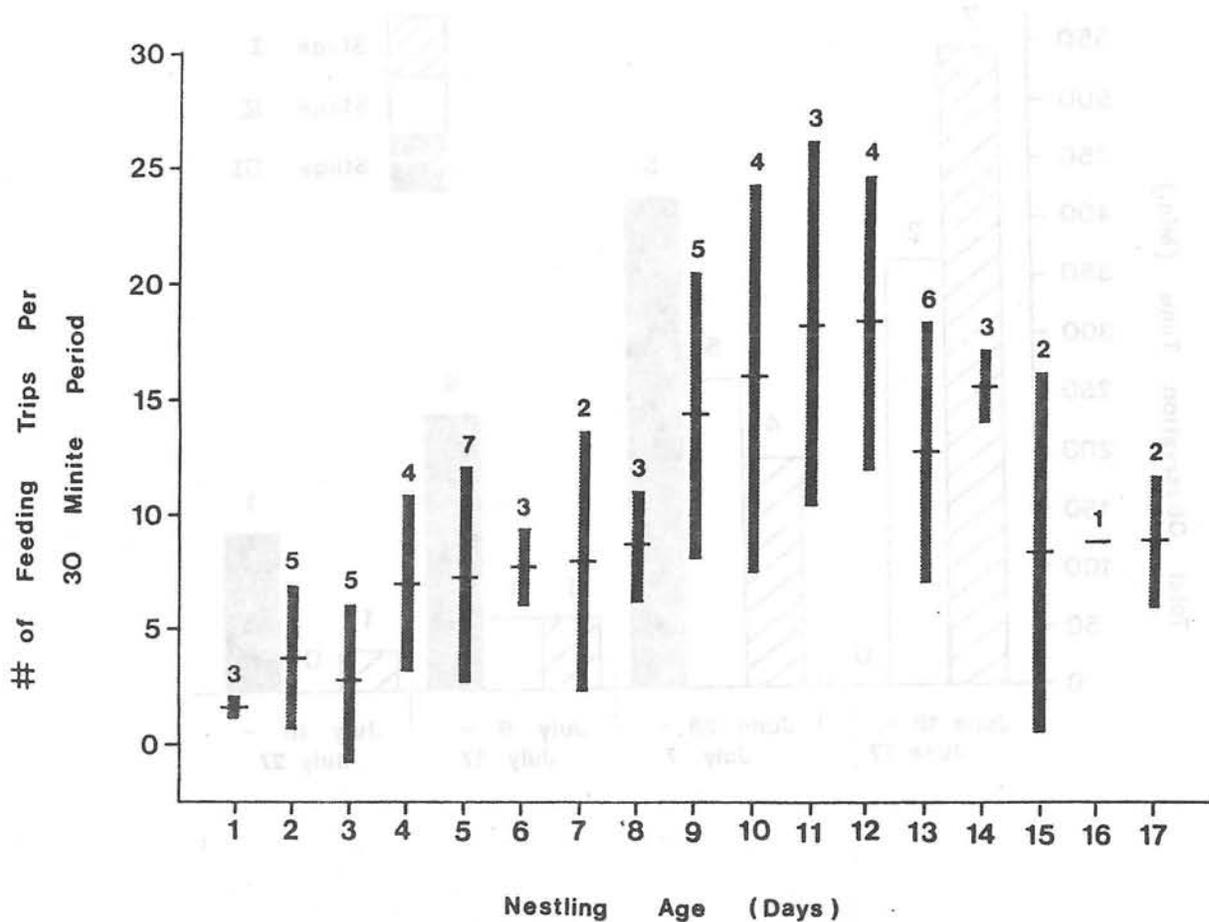


Fig. 1. Frequency of feeding trips to the nest by House Wrens with nestlings of increasing age. The day of hatching of the first egg is represented as day I. The horizontal line is the mean and the vertical bar is one standard deviation on either side of the mean for each point in the distribution. The number of 30 minute observations involved in the calculations at each nestling age is indicated above each bar.

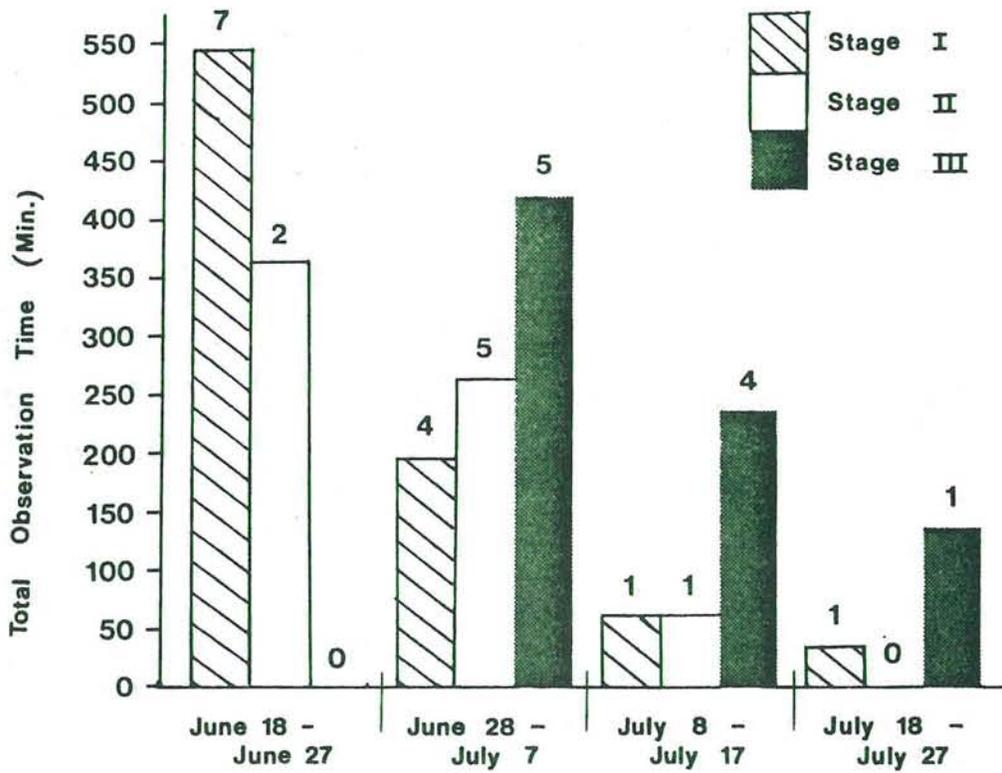


Fig. 2. Overlap between nestling stage and date of observation expressed as the total length of observations (min.). Numbers above the bars indicate the number of nests included in the calculation for that category. All observations equal to or greater than 10 minutes in duration are included (\bar{X} =28.9, range: 10-95 min.).

Table 1. Nestling feeding characteristics of House Wrens at different stages of nesting development (A) and times in the breeding season (B). Means, standard deviations and sample sizes are presented.

		No. Feedings Per 30 Min.	No. Items Per Load	Prey Length (Prop. of Culmen)	% of Male Feedings	
		$\bar{X} \pm SD$ (N)	$\bar{X} \pm SD$ (N)	$\bar{X} \pm SD$ (N)	$\bar{X} \pm SD$ (N)	
A	NESTLING AGE	Stage I	5.38±3.42 (24)	1.01±0.02 (29)	0.68±0.35 (27)	83.42±21.42 (19)
		Stage II	12.95±6.93 (19)	1.23±0.28 (22)	1.03±0.61 (24)	55.80±21.09 (19)
		Stage III	14.81±5.05 (16)	1.60±0.72 (22)	0.84±0.48 (22)	55.24±27.34 (22)
B	DATE	Jn18-Jn27	7.26±6.14 (27)	1.02±0.05 (28)	0.92±0.60 (3)	74.60±26.04 (24)
		Jn28-Jl 7	10.81±7.60 (26)	1.23±0.27 (31)	0.92±0.48 (34)	49.06±26.04 (26)
		Jl 8 -Jl17	11.36±6.04 (11)	1.30±0.28 (11)	0.56±0.09 (11)	55.02±22.27 (10)
		Jl18-Jl27	14.44±7.28 (9)	2.06±1.11 (8)	0.62±0.22 (9)	66.01±26.33 (11)

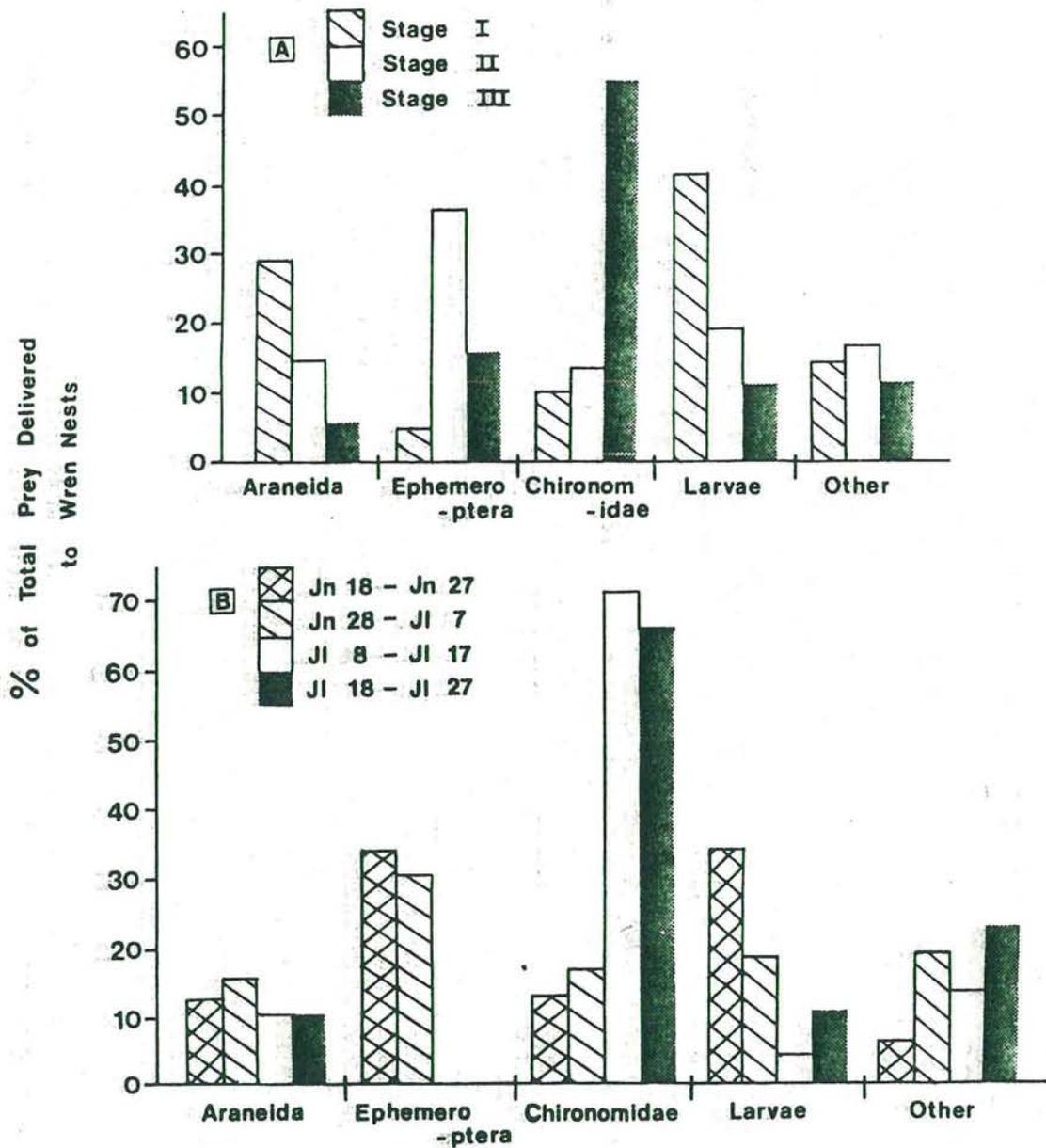


Fig. 3. Percentage of prey items in five categories fed to nestling House Wrens at different stages of development (A) and times in the breeding season (B).

Concurrent with the drop in prey size of third stage nestlings is a significant dominance of chironomids in the diet (Fig. 3A). This group is the most consistent component of multiple prey loads and appears to be suitable for multiple loading because individuals can be grasped by their legs, wings or narrow abdomens. A similar relationship holds during the second half of the dates on which wrens feeding nestlings were observed (Table 1B). Size of prey decreases while load size increases and chironomids form the majority of prey items identified (Fig. 3B).

There is therefore some indication that the size of prey and load size are not important in the overall increase in total food biomass delivered to wren nests. They may depend more on what prey items are available or most easily obtained than on a decision by the birds to select smaller prey which can be taken in multiple loads. The inverse relationship between load size and prey length might have been more rigid during the first nestling stage if a volume or biomass of prey could have been estimated because of the large proportion of larvae (Fig. 3A) which probably have a greater biomass per unit length than the other prey types. Spiders are also taken more frequently to young nestlings (Fig. 3A) but approximately equally during all date classes (Fig. 3B). This has been found in several other insectivorous passerines and may involve nutritional selectivity or a decreased exoskeletal digestibility in young passerines (Royama 1966, Pinkowski 1978). In this study its presence may increase confidence in drawing conclusions from the data despite small sample sizes.

CONCLUSIONS

Prey items selected as food for young house wrens changed with nestling age and time of nesting and probably produced the observed variations in prey size and load size. This indicates that frequency of feeding was important in meeting the assumed increase in the daily intake of nestlings. The frequency of feeding closely followed the increase in weight of nestlings determined by Zach (1982) approximately 300 km east of the present study site. Royama (1966) and Walsh (1978) found that size of prey increased with the standard growth curve but frequency was variable and largely unrelated. House wrens in this study may have been able to meet increasing nestling requirements primarily by making more frequent visits to the nest because of the abundance of ephemeral adult insects which emerge from the surrounding aquatic habitats to mate (see Busby and Sealy 1979, Biermann and Sealy 1982). This could be tested by experimental increases in brood size or nestling hunger level. If the house wrens at Delta are not limited by the availability of prey but can meet increasing demands by feeding more frequently they should use this strategy to meet experimental increases in food requirements.

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Patterns of Fall Migration and Molt in Warblers
(Aves: Parulinae) in Southern Manitoba

Heidi E. den Haan

Department of Zoology
University of Manitoba

INTRODUCTION

Long-term banding of passerine birds during their fall migrations has provided information on the patterns of migration and molt in several species. Johnson (1963), Hussell (1980, 1981, 1982 a,b), and Sealy and Biermann (1981) have shown that adult and immature Empidonax flycatchers differ from each other in their fall migration patterns. The adults migrate first, and undertake the prebasic molt of their flight feathers after they have reached their southern wintering grounds, while immatures migrate at a later date. Varying strategies of migration and timing of molt are also emerging in wood warblers as a result of banding studies conducted at several localities in North America (Murray 1965, 1966, 1976, 1979; Stewart et al. 1974; Ralph 1976, 1978, 1981; Dunn and Nol 1980).

Passerines have been mist-netted and banded during the nesting season on the forested dune ridge, Delta Marsh, for the past nine years, but not until 1982 was the fall movement of warblers through the study area documented. The study area is part of the forested dune ridge that extends 25 km along the southern shore of Lake Manitoba and separates it from the Delta Marsh. During 1982, I banded 1210 warblers of 20 species (Table 1). The Yellow Warbler (Dendroica petechia) was handled in very large numbers, while most of the other species were sparsely represented. A total of 6 species was handled in large enough numbers to warrant analysis this season.

Field work was initiated in 1982 to document the timing of migration of each migratory species with respect to age, and where possible, sex, and to study the molt of the species that migrate through the Delta Marsh area. The molt and fall departure from the study area by summer resident Yellow Warblers received special attention. Due to its preliminary nature, this report is limited to a discussion of the migration patterns of six warbler species.

METHODS

Mist-netting in the past has been conducted in various locations along a 3-km portion of the dune-ridge forest. The present study focused on a 0.3-km segment within this area located just west of the University of Manitoba Field Station (Delta Marsh), on the property of the Portage Country Club. The dune ridge averages 80 m in width and the forest canopy averages 10 m in height on the study area.

I chose eight netting sites along the east-west axis of the dune ridge and placed the nets in various positions that covered "typical" dune-ridge habitat on a north-south gradient. Birds were netted almost daily between 10 June and 8 September and 3-5 days/week until 24 October. I caught warblers that ranged from 6.5 to 22.0 g and used a combination of nets of 30 and 36 mm mesh sizes (four of each) in the manner suggested by Karr (1979). All eight nets were 4-tiered, black and 12.5 m long. An access lane of 1 m was cleared at each net site. Each netted individual was identified and given a numbered aluminum band. Yellow Warblers (because of on-going research with this species on the study area) were also given a unique combination of celluloid color bands.

Warblers were aged by "skulling", a technique described by Miller (1946) and outlined in Volume 2 of North American Bird Banding Techniques (1977). This method is used by other researchers and it permits hatching year (HY) birds, juveniles hatched in the current calendar year, to be separated reliably from after-hatching-year (AHY) birds, or birds that are older. At the end of September, any birds that were not definitely determined as HY were classified as birds of unknown age (U) because "early season" HY's may have acquired fully ossified skulls by this time.

Each bird's flattened wing was measured to the nearest 1.0 mm and exposed culmen was measured to the nearest 0.1 mm. All birds were weighed to the nearest 0.1 g on a triple beam balance. Individuals were also examined for wing, tail and body molt. Body molt was recorded as either present or absent within the capital, spinal, ventral, alar, and caudal feather tracts. Right-side measurements of the rectrices and remiges were made from the birds as time allowed. An index will be used to compare the degree of molt both inter- and intraspecifically. Primary molt in each individual will be scored following a system similar to Newton's (1966): 0, an old feather; 1, a missing feather; 2, a small pin to one-quarter grown; 3, one-quarter to half grown; 4, half to three-quarters grown; 5, three-quarters to full length. A sum of 45 therefore means that molt is complete (5 for each of the 9 primaries), whereas a score of 0 indicates that none of the primaries had molted.

RESULTS AND DISCUSSION

The data presented below concern the fall migration of the Tennessee Warbler (Vermivora peregrina), Orange-crowned Warbler (V. celata), Yellow-rumped Warbler (Dendroica coronata), Ovenbird (Sieurus aurocapillus), and Northern Waterthrush (S. noveboracensis). The Yellow Warbler will be considered separately because it breeds on the dune-ridge study area. The data for these six species are plotted in Figures 1-4. Table 2 summarizes the conclusions drawn from these graphs for five of the species and Table 3 summarizes the Yellow Warbler data.

Ratio of age classes - The percentages of AHY birds given in Table 2 do not show any trends in the migration patterns. In fact, the only warblers that provide data "typical" of an inland banding station are the Orange-crowned Warbler and perhaps the Yellow-rumped Warbler (Fig. 4). Ralph (1981) reported that the proportion of young at inland sites is usually 65-75% whereas proportions along coasts are generally 85-90%. This high incidence of young on the coasts has been termed the "coastal effect" (Ralph 1981). Murray (1966) argued that the coastal effect is caused by differential behaviour of adults and young when they return to land after finding themselves over the ocean at the end of a nocturnal migratory flight. He believed that young birds stop at the first available landfall, whereas adults are more likely to continue farther inland (Murray 1966). A coastal effect caused by differential behavior of adults and young birds is even thought to occur on the Great Lakes (Dunn and Nol 1980). Ralph (1981) argued against this hypothesis since it requires that any bird offshore at dawn (1) have enough energy reserves, (2) have offshore winds slower than its airspeed, and (3) be able to relocate land. An alternative hypothesis states that high percentages of young denote the periphery of a species' migration route (Ralph 1981). Ralph believes the coastal effect reflects concentrations of inexperienced birds, almost entirely young birds on their first trip, beyond the edges of the species' regular overland migration routes.

The Northern Waterthrush data (Fig. 3A) are comparable to that of the coastal stations - 86% of the migrants were HY birds. On the New Jersey coast, Murray (1966) and Ralph (1981) reported 87% HY's and 84% HY's, respectively, for the same area. This raises three questions about the dune ridge: (1) Why is the proportion of AHY birds so low? (2) Is there a coastal effect to consider on the dune-ridge (according to Dunn and Nol (1980), a site within 5 km of a shoreline is a coastal site)? (3) If so, why does this effect not occur in any of the other species examined? The netting period in my study was such that adults could not have been missed if they had been in the area. These questions are worth considering and it will be interesting to see if this trend is confirmed after the field work in 1983.

The Tennessee Warbler (Fig. 2) and Ovenbird (Fig. 3B) data contrast sharply with those of the waterthrush. Hatching-year birds consisted of only 34% and 30% of the population, respectively. Perhaps the Delta Marsh area is in the center of the migration route of these species; according to Ralph (1981), high percentages of young denote the periphery of a route.

Migration patterns - Figures 1-4 reveal four patterns. In the AHY age class, the Tennessee Warbler showed a bimodal distribution (Fig. 2); the Orange-crowned Warbler (Fig. 4B) and Northern Waterthrush (Fig. 3A) have no pronounced peaks; the Yellow-rumped Warbler, is normal (Fig. 4A); and the Ovenbird is skewed (Fig. 3B). In the HY age class, the Tennessee Warbler (Fig. 2) and Orange-crowned Warbler (Fig. 4B) have no pronounced peaks, the Northern Waterthrush is bimodal (Fig. 3A), the Yellow-rumped has a skewed distribution (Fig. 4A), and the Ovenbird is normal (Fig. 3B).

The skewed curves correspond to a migration in which there is no gradual build up to a peak, but rather a sudden appearance of many birds. Hall (1981) described this as a "wave migration" and is best demonstrated in HY Yellow-rumped Warblers (Fig. 4A).

Synchrony of movement of age classes - In the Yellow-rumped and Orange-crowned Warblers, the two age classes appear to migrate at essentially the same time (Fig. 4A and 4B). In the Tennessee Warbler (Fig. 2) and Ovenbird (Fig. 3B), the AHY birds precede the HYS but in the Northern Waterthrush (Fig. 3A), the HY birds precede the AHY although there are too few adults in the sample to draw any firm conclusions in this case.

Murray (1966) found that age classes of these species migrated synchronously on the New Jersey coast, as did Hall (1981) for the Tennessee Warbler in the mountains of northern West Virginia. The small number of AHY birds may be responsible for the similarity between age classes on the coast (Murray 1966). Although it is not clear why various stations show differences in the timing of migration of the different age classes, Hall (1981) stated that this may be due to the differences in the populations sampled. The coastal stations handle mostly HY birds and the Pennsylvania station handles birds which are feeding through the valley, and are not actively migrating when caught, while the Allegheny Front station in West Virginia handles birds that are actively migrating.

Yellow Warbler - The Yellow Warbler nests in high numbers on the forested dune ridge (Biermann and Sealy 1982; Goossen and Sealy 1982). The numbers of AHY and HY birds captured and recaptured in 1982 are plotted in Figures 1A and 1B. Table 3 summarizes the conclusions drawn from these graphs. Of the total number captured, 29% were AHY birds and 71% were HY's. The recapture rate (60%) for adult yellows is high (Table 3). This is shown clearly in Figure 1B and is a good indication that I was handling resident adults throughout the season. Between the end of July and early August the warblers were secretive and quiet while they were molting and were therefore not netted in large numbers. Their rate of capture increased again toward mid-August but soon dropped off completely, after they started to move south. This represents a skewed distribution (Fig. 1B) - the capture rate is high in June but there does not appear to be any significant influx of new adults at anytime, as the capture rate decreases.

Only 13% of HY warblers were recaptured. These included birds that were banded as nestlings on the study area and also those that were caught in the nets as fledglings. Although the HY's display a normal distribution, the recaptures occur only during the first half of the season (Fig. 1A). During the periods August 3-5 and 9-11 there were 50 and 25 birds caught with only 3 and 1 recaptures, respectively (Table 3). After this period there were essentially none and there was only a slight increase in numbers (Fig. 1A). The data for HY's in August contrast sharply to those in July (Table 3). These birds may have arrived from off the study area.

It appears from these data that the Yellow Warbler migrates asynchronously with the HY individuals that were reared on the study area apparently leaving it 2-3 weeks before the adults.

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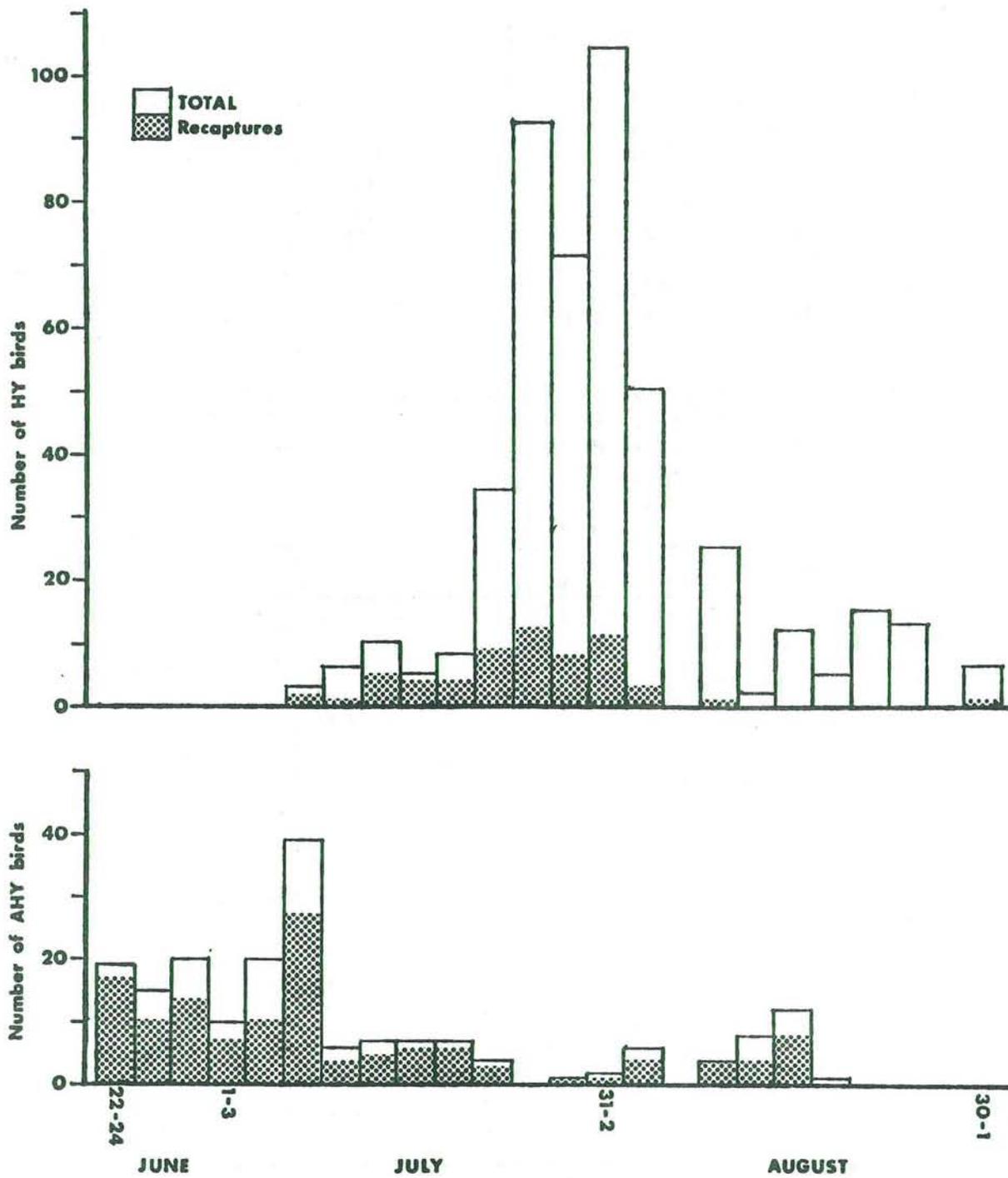


Fig.1. Numbers of adult (AHY) and immature (HY) Yellow Warblers captured and recaptured on the forested dune ridge, Delta Marsh, 1982.

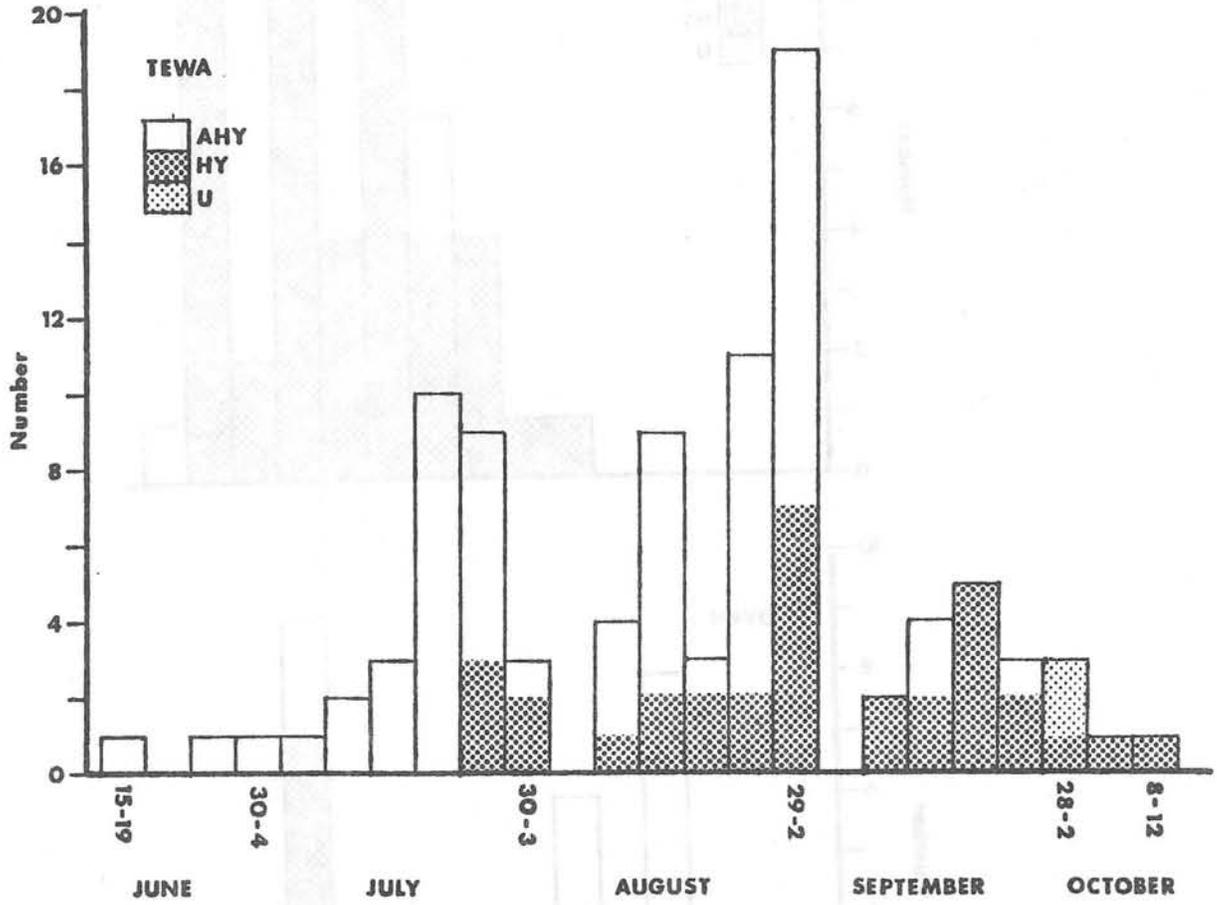


Fig. 2. Fall migration of Tennessee Warblers on the forested dune ridge, Delta Marsh, 1982.

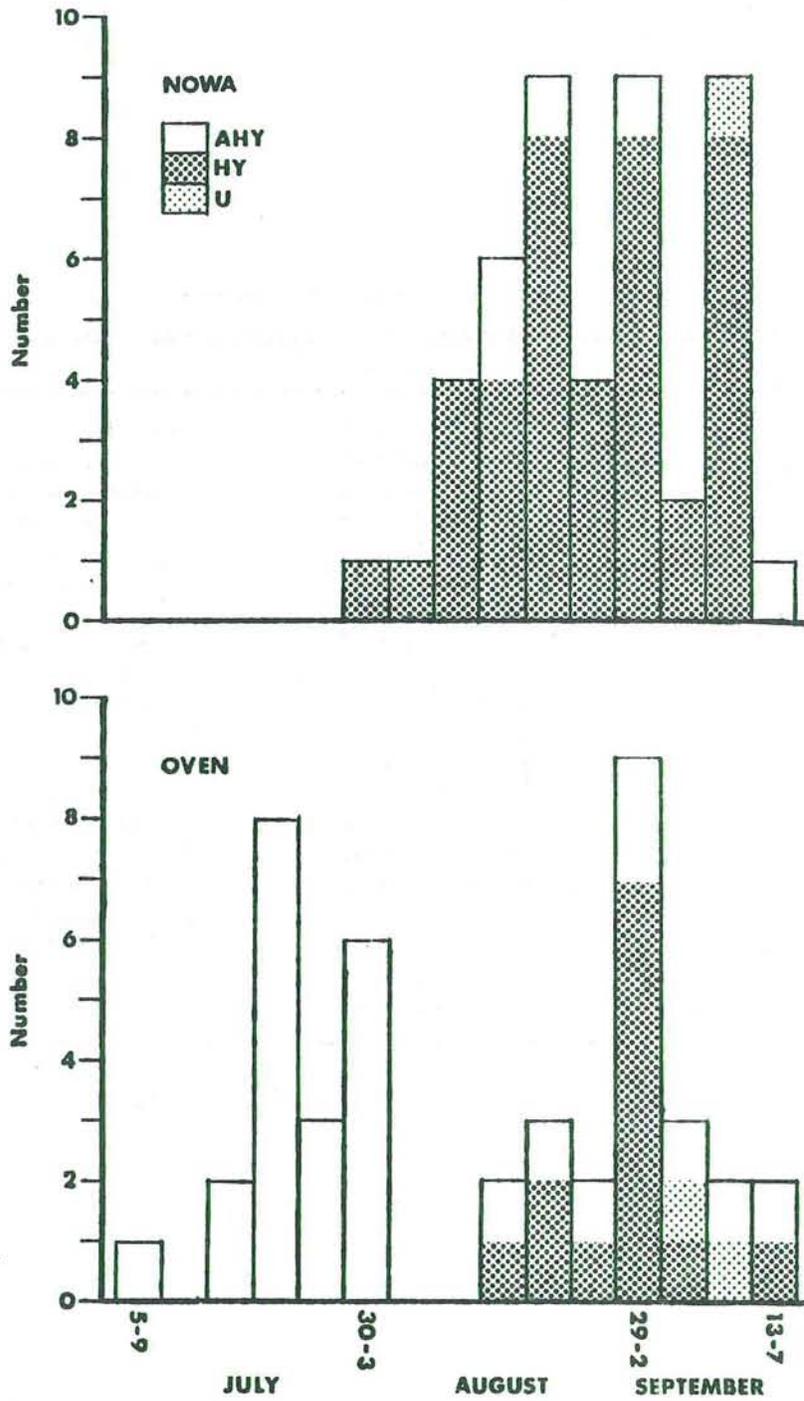


Fig. 3. Fall migration of the Northern Waterthrush (NOWA) and Ovenbird (OVEN) on the forested dune ridge, Delta Marsh, 1982.

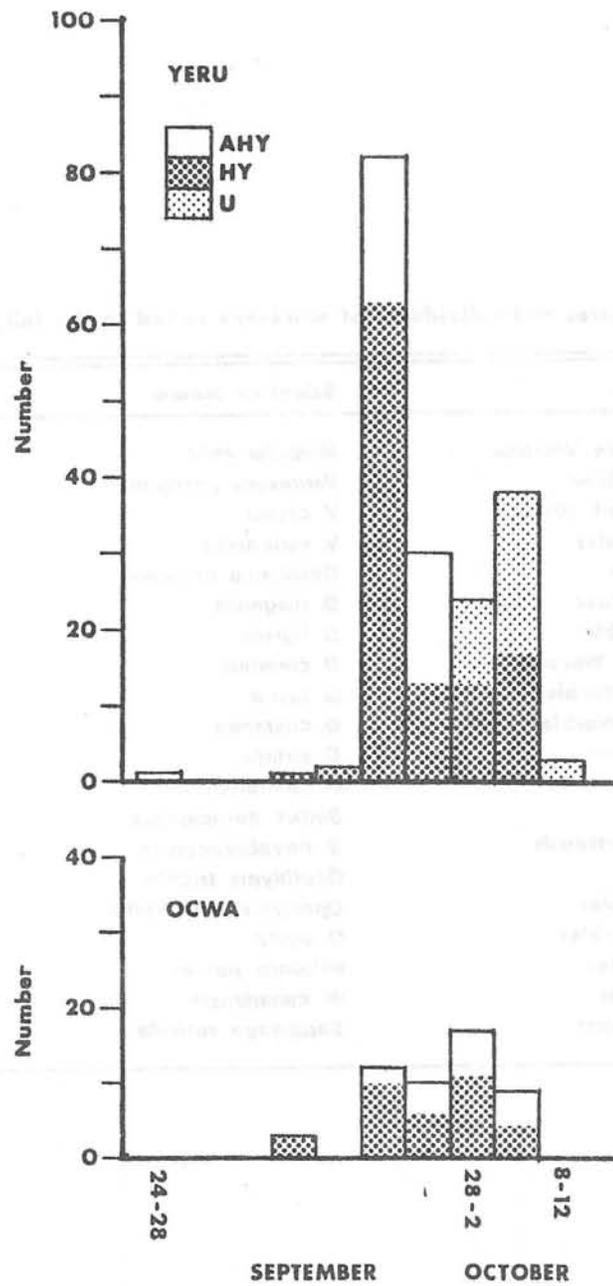


Fig. 4. Fall migration of the Yellow-rumped Warbler (YERU) and Orange-crowned Warbler (OCWA) on the forested dune ridge, Delta Marsh, 1982.

Table 1. Species and individuals of warblers netted in the fall, 1982.

Common Name	Scientific Name	Number Netted
Black-and-white Warbler	<i>Mniotilta varia</i>	19
Tennessee Warbler	<i>Vermivora peregrina</i>	96
Orange-crowned Warbler	<i>V. celata</i>	51
Nashville Warbler	<i>V. ruficapilla</i>	6
Yellow Warbler	<i>Dendroica petechia</i>	659
Magnolia Warbler	<i>D. magnolia</i>	7
Cape May Warbler	<i>D. tigrina</i>	1
Yellow-rumped Warbler	<i>D. coronata</i>	178
Blackburnian Warbler	<i>D. fusca</i>	1
Bay-breasted Warbler	<i>D. castanea</i>	6
Blackpoll Warbler	<i>D. striata</i>	9
Palm Warbler	<i>D. palmarum</i>	11
Ovenbird	<i>Seiurus aurocapillus</i>	43
Northern Waterthrush	<i>S. noveboracensis</i>	45
Yellowthroat	<i>Geothlypis trichas</i>	24
Mourning Warbler	<i>Oporornis philadelphia</i>	4
Connecticut Warbler	<i>O. agilis</i>	8
Wilson's Warbler	<i>Wilsonia pusilla</i>	4
Canada Warbler	<i>W. canadensis</i>	6
American Redstart	<i>Setophaga ruticilla</i>	32

Table 2. Summary of migration patterns of warblers in 1982.

Species	N	% AHY	% HY	% U	Range ¹		Pattern ²		Timing ³
					AHY	HY	AHY	HY	
Tennessee	96	66	34	--	June 18-Sept. 23	July 25-Oct. 9	b.m.	n.p.	AHY
Orange-crowned	51	33	67	--	Sept. 20-Sept. 26	Sept. 8-Oct. 4	n.p.	n.p.	Syn.
Yellow-rumped	178	20	60	20 ⁴	Aug. 26-Sept. 26	Aug. 30-Oct. 4	n.	skwd.	Syn.
Ovenbird	43	65	30	5	July 9-Sept. 17	Aug. 17-Sept. 17	skwd.	n.	AHY
Northern Waterthrush	45	11	86	3	Aug. 10-Sept. 17	July 30-Sept. 12	n.p.	b.p.	HY

1. Mist netting was continuous from June until 24 October.
2. Migration patterns: n = normal distribution, n.p. = no pronounced peak, skwd. = skewed distribution, b.p. = broad peak distribution, b.m. = bimodal distribution.
3. Synchrony of migration: syn. = age classes move together, HY = first year birds come earlier than old birds, AHY = old birds come earlier than first year birds.
4. Percentage of AHY and/or HY cannot be accurately measured due to the large proportion of birds arriving too late in the season to rely on aging techniques and therefore labelled as unknown (U) age.

Table 3 Numbers of adult (AHY) and immature (HY) Yellow Warblers captured and recaptured on the Delta Beach ridge in 1982.

3-day periods	Total banded	% Total recaptured	AHY	%AHY recap.	HY	%HY recap.
June 22-24	19 (17) ¹	89%	19 (17) ¹	89%		
25-27	15 (10)	67	15 (10)	67		
28-30	20 (13)	65	20 (13)	65		
July 1- 3	10 (7)	70	10 (7)	70		
4- 6	20 (10)	50	20 (10)	50		
7- 9	42 (29)	69	39 (27)	69	3 (2) ²	67%
10-12	12 (5)	42	6 (4)	67	6 (1)	17
13-15	17 (10)	59	7 (5)	71	10 (4)(1) ³	50
16-18	12 (10)	83	7 (6)	86	5 (2)(2)	80
19-21	15 (10)	67	7 (6)	86	8 (4)	50
22-24	38 (12)	32	4 (3)	75	34 (8)(1)	26
25-27	92 (12)	13	0		92 (8)(4)	13
28-30	72 (9)	13	1 (1)	100	71 (5)(3)	11
31- 2	106 (12)	11	2 (1)	50	104 (2)(9)	11
Aug. 3- 5	56 (7)	13	6 (4)	67	50 (2)(1)	6
6- 8	—	—	—	—	—	—
9-11	29 (5)	17	4 (4)	100	25 (1)	4
12-14	10 (4)	40	8 (4)	50	2	0
15-17	24 (8)	33	12 (8)	67	12	0
18-20	6	0	1	0	5	0
21-23	15	0	0	0	15	0
24-26	13	0	0	0	13	0
27-29	—	—	—	—	—	—
30- 1 ⁴	6 (1)	17	0	0	6 (1)	17

¹Numbers in parentheses are recaptures of individuals banded 1974 to 1981 which returned to the study area in 1982, and of those banded in 1982.

²Numbers in parentheses are recaptures of individuals banded as nestlings in 1982.

³Numbers in parentheses are recaptures of individuals banded as HY fledglings in 1982.

⁴Last 3 day period in which Yellow Warblers were captured, despite continuous netting until Oct. 24.

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Short-term Responses of Western Meadowlarks to Repertoires of
Graded Sizes - - a Preliminary Study

Andrew Horn

Department of Zoology
University of Toronto

INTRODUCTION

In most species of singing birds, each individual sings more than one song or phrase type (Hartshorne, 1973; Dobson and Lemon 1975). While the adaptive value of such repertoires has been studied through interspecific comparisons and by measuring differential reproductive success within a species, few studies directly test how repertoires of senders affect the behaviour of recipients on a short time scale, that is, what repertoires communicate (Krebs and Kroodsma 1980).

The Western Meadowlark (*Sturnella neglecta*), an icterid, is an ideal subject for repertoire studies, with its small repertoire of short, highly contrasting song types. The birds repeat each song type several times before switching to another song type. Two other icterids, Red-winged Blackbirds (Smith and Reid 1979) and Eastern Meadowlarks (d'Agincourt 1981), switch song types more frequently in territorial encounters and courtship than at other times. Also, when a territorial intrusion is simulated by playback, Western Meadowlarks usually switch immediately after playback begins (Falls and Krebs 1975; Falls and d'Agincourt 1982). Switching, then, may be a graded signal of the sender's readiness to interact, either aggressively, in a territorial encounter, or sexually, in courtship (Falls and d'Agincourt 1982). Two potential sources of information are increased as switching rates increase: the number of song types presented in a given period, and the number of switches per se. Whether receivers use this information has not been tested.

This study tests whether the number of song types presented in a given period affects Western Meadowlarks in a graded way, especially in terms of their aggressive behavior. Single-song bouts like those used here for playback have only been observed in intense territorial encounters and never for longer than several seconds (A. Horn, unpublished data). Such unnatural bouts were used in the hope that large differences in the stimuli would yield clear differences in the responses, and facilitate the interpretation of the results. Thus these results are only preliminary.

METHODS AND MATERIALS

Four songs of four song types were copied from a recording of a Western Meadowlark's repertoire onto experimental tapes. Each tape had 12 songs, with one song every 10 seconds. Four experimental tapes contained only one song type (AAAA...), four had two song types

alternating (ABAB...), and one had four song types in succession (ABCDABC...). In all cases the order in which the recorded bird originally sang the song types was preserved.

The experimental birds inhabited roadside fields and aspen pastures near Portage la Prairie, Manitoba. Birds were tested from May 1982, to July 1982, at all times of the day.

In each experiment, all three experimental tapes were played, with two minutes of playback and three minutes of post-playback observation for each tape, followed by two minutes during which the next tape was prepared. An Atlas mid-range horn on a one-meter tripod, connected by a 70 m wire to a Kudelski DH amplifier and a Nagra IV recorder was used for playback. All possible combinations and sequences of the experimental tapes were tested, each on a different bird, along with three extra trials, yielding a sample size of 51.

Latency to first song, song type switches, changes of perch, and closest approach to the speaker made by the experimental bird were noted in the playback and post-playback periods by an observer 70 m from the speaker. Data from playback and post-playback periods were pooled and the Wilcoxon signed ranks test was used to test for differences between treatments.

RESULTS

Means and standard errors of behavioral variables for each treatment are listed in the Table 1. The large standard errors of these variables may reflect the fact that test birds were not in the same breeding conditions and the speaker was not placed in equivalent places for each experiment.

Experimental birds moved more in playbacks of the ABCD tape than in playbacks of either ABAB or AAAA tapes ($p < 0.005$). They also approached ABCD playbacks more closely than ABAB playbacks ($p < 0.05$). However, they approached AAAA playbacks more closely than ABAB playbacks ($p < 0.05$), and there was no significant difference in approach between AAAA and ABCD treatments.

In contrast, ABAB playbacks elicited more song than ABCD playbacks ($p < 0.05$), and more song switches than either ABCD or AAAA playbacks ($p < 0.05$). Since birds that sing less must also switch less, the number of switches per song were also compared for each treatment. No significant differences were found, suggesting that switching did not vary independently of number of songs.

No other significant differences between treatments were found.

Table 1. Means and standard errors of behavioural variables for each playback treatment. N=51 in all cases.

Variable	Experimental tape		
	AAAA	ABAB	ABCD
Latency to 1st song (seconds)	45 \pm 7.6	41 \pm 6.7	47 \pm 8.1
Songs	20 \pm 1.7	23 \pm 1.7	20 \pm 1.7
Switches	2.3 \pm .31	2.9 \pm .36	2.5 \pm .32
Perch changes	3.3 \pm .42	3.5 \pm .43	4.4 \pm .32
Closest approach (meters)	14 \pm 3.9	16 \pm 4.1	13 \pm 1.8

DISCUSSION

Since three measures of aggression, perch changes, number of songs, and closest approach - gave conflicting results, the experiment is hard to interpret. In natural encounters, meadowlarks sing less during the displays that immediately precede attack (Lanyon 1957; pers. obs.); this may explain the fewer songs and closer approach in ABCD than in ABAB playbacks. Singing from a distance may therefore be an intermediate response. In that case one would expect closer approaches to ABCD than AAAA playbacks. Although the results were in this direction, the difference was not significant.

The number of song types between recurrences of each song type is lower in the ABAB tapes (ABA; recurrence interval=1) than in the ABCD tapes (ABCD; recurrence interval=3), so perhaps small recurrence intervals stimulate more songs and switches, while a higher number of song types may stimulate more changes of perch. Also, as mentioned before, the playback sequences used were unusual in that they were long sequences of evenly spaced, single-song bouts. Natural single-song bouts may not last as long as the playbacks did and inter-song intervals are irregular (A. Horn, unpublished data), so these factors may have complicated the results.

In any case perch changes and songs, used in most playback experiments to measure strength of response, are not equivalent in this species, or they would have given similar results. These behaviours, and previously ignored behaviours such as posturing and plumage displays, should be studied in natural encounters, to clarify our understanding of playback responses. Such field observations without playback will continue at Delta in 1983. Partly because of the results of this experiment, the observations will focus on song type sequences and inter-song intervals, not just switches.

ACKNOWLEDGEMENTS

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Mycological Studies on Salt Marsh Plants *

Tawfik M. Muhsin

Department of Botany
University of Manitoba

INTRODUCTION

Few studies on salt marsh plants have been published (Pugh, 1960, 1962, 1974; Pugh and Williams, 1968). Most of these works are on rhizosphere fungi. However, very little attention, if any, has been given to the fungi associated with live roots and shoots of salt marsh inhabiting plants. Therefore, this project has been designed to study the taxonomy and ecology of fungi associated with six salt marsh plants: Salicornia europaea L., Suaeda depressa (Pursh) Wats., Glaux maritima L., Puccinellia nuttalliana (Schult.) Hitchc., Hordeum jubatum L., and Atriplex patula L.

MATERIAL AND METHODS

Two collecting sites were established at Delta Marsh, Manitoba. Seven collections were made at each site during a 3-month period (6 June to 6 September, 1982). For the isolation of fungi from roots and shoots of each plant, the following technique was used. Roots and shoots of the collected plants were cut into small pieces, washed thoroughly with sterilized water, plated on 2 different media and incubated for seven days at 20°C., and subsequently the growing fungi were identified.

RESULTS AND DISCUSSION

Twenty genera of fungi were isolated from these selected plants. The genus Alternaria was the most common on all six plants. Twelve species belonging to this genus were described. Taxonomic studies of the other genera and species are still underway.

From the available data, populations of Alternaria are the highest in comparison with other genera. The total number of isolations of this genus is 1141 (out of 4380 root/shoot pieces plated), the percentage frequency being 26.1%. The data also show a fluctuation in number of isolations according to the collection date, plant type, plant part (roots and shoots), plant phenology, location, and some environmental factors (i.e. temperature, salinity, and soil moisture). In addition, some fungal species are dominant while others are rare, and certain species are found existing on all six plants while others are restricted to one plant.

Such differences in mycoflora could be related to plant biochemistry, surface phenomena or to some other factors. Further studies relating to these factors are currently being conducted.

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Dynamics of Foraging and Food Resource Use in a
Community of Dense Nesting Insectivorous Birds

Gloria C. Pohajdak

Department of Zoology
University of Manitoba

INTRODUCTION

The ecological relationships among species that comprise bird communities have long intrigued ecologists. In community studies, emphasis has generally been placed on the ways in which species use or partition resources (Schoener 1974). In recent studies of foraging relationships among species in avian communities, only the foraging behaviour and foraging habitats of each species have been determined, except for occasional weak attempts to sample the food supply. The results have generally been lumped for the entire period of the study, (usually without comment) as if all observations had been obtained at the same time, (but see Eckardt 1979). This approach to the study of communities gives insight into species relationships, but is of limited value since several factors probably influence the observations that are made and therefore the results of the studies (Grubb 1979).

First, the availability or accessibility of prey to the foraging birds should be assessed, to ensure that changes in abundance or composition of prey are not affecting the birds' foraging behaviours or habitat preferences during the study. Second, breeding activity and the chronology of habitat changes as plants grow, leaves enlarge and flowers are produced, may affect where and how the birds forage. Evidence suggests that adult birds' foraging behaviour changes as they forage for food for their young (Root 1967, Orians 1980, Knapton 1980). Thirdly, since the availability of prey probably changes as weather conditions change, and since weather may also affect the feeding behaviour of the birds, changes in temperature, cloud cover, wind speed and direction should be examined to determine if they affect the foraging behaviour and habitat use of foraging birds.

Most recent studies have concentrated on arranging the species along axes that separate them into foraging guilds. However, spatial segregation in foraging, and use of different methods to obtain prey, do not necessarily lead to differences in diet. A comparison of the size and composition of prey species in the diet of bird species with both similar and different foraging behaviours will indicate the degree to which spatial and behavioural segregation of resources leads to actual dietary differences, if any.

Finally, Ricklefs and Travis (1980) have suggested that the foraging guild structure of a community should be reflected in the morphological guild structure of that community. Morphology has also

been shown to be related to the size and composition of prey species in avian diets. Thus, a comparison of species morphological relationships may be reflected in their dietary and/or feeding relationships.

The object of this study is to determine the structure of the feeding guild of the insectivorous passerine community that breeds on the forested dune ridge at Delta, and to determine if the foraging behaviour of the birds varies with changes in prey availability, time of year and weather. Also, I will determine if the diet and morphology of the species are related to the ecological foraging "niche" as determined by quantitative observations of the birds foraging behaviour.

METHODS

A transect, essentially along the middle of the dune ridge was walked each morning in 1982. When birds were seen foraging, I recorded the species and sex (when known) of the bird, time, date, the plant species on which the bird was foraging, the height of the bird in the plant, the vertical and horizontal locations of the birds in the plant (vertically, the lower, middle or outer third; horizontally, the inner, middle or outer third), the feeding site (alive or dead, foliage, twig, branch, trunk or ground), and the feeding method used by the bird to obtain prey (gleaning, hovering, probing or hawking).

Several nests of each species breeding on the study area were monitored to determine the general stage of nesting of each species at any time. Because the stage of nesting cannot be dissociated from plant phenological changes, the two factors can only be examined together as time. Thus, the results of foraging observations for each species were divided into four periods representing on average, the four stages of nesting. These include prenesting and nest building, egg-laying and incubation, the nestling period and the fledgling period. However, since the individuals that were observed were of unknown breeding status, and since considerable variability exists in breeding schedules between individuals of some species (Goosen & Sealy 1982, Sealy pers. comm.), any changes in behaviour observed between the four periods can only be ascribed to time rather than to breeding activity.

The bird community of the dune ridge contains foliage gleaners both high and low in the canopy, aerial hawking species and ground gleaners and probers. The availability of insects to all these birds must be assessed. Thus, samples must be taken of insects on the vegetation, in the air and on the ground.

Vegetation arthropods were sampled in the morning of every second day using a standard insect sweep net and collecting 8 strokes per sample at two heights. These were ground to one meter and two to four meters (Southwood 1978).

Aerial insects were sampled every second day using window traps at three heights: two m., three m. and six m. Two 66 X 100 cm windows were used at each height, suspended in the canopy of a 100 m. section of the study area. Containers attached to the bottom collected stunned insects in a saturated salt solution. The traps were operated for 12 hours each sample day.

Litter arthropods were sampled by collecting two 20 X 20 X 2 cm litter samples every second day (MacFadyen 1962).

Weather data were obtained from the Environment Canada Weather station at the Field Station. Temperature data were supplemented by recording the temperature when beginning and finishing transects.

The diets and morphology of the birds were determined by collecting individuals of each species on the Bell Estate every 12 days (five sampling periods), measuring the birds, removing the stomach contents and preserving them in alcohol. The skins were prepared as museum skins and deposited in the University of Manitoba Zoology Museum. A total of 270 birds were collected.

Frequency tables and univariate and multivariate statistical methods will be used to analyze the data.

RESULTS

Only the foraging behaviour data have been examined, and the results are preliminary. Sixteen insectivorous passerine species were observed on the study area between May 20 and July 15. A total of 1,201 observations were obtained. The 16 species differed in most aspects of behaviour examined, particularly in the foraging methods they used (Table 1), and in mean plant and bird heights observed (Table 2). Eventually, a discriminant function will be used to separate the species into guilds (Root 1967) of similarly foraging species.

An example of how foraging behaviour changed over time is shown in Table 3 for the Warbling Vireo (Vireo gilvus). As the summer progressed, changes occurred in the use of different tree species, horizontal and vertical locations in the canopy, feeding substrate used and the proportion of use of hovering and gleaning as foraging techniques. The use of Salix interior decreased as summer progressed, vireos fed in the lower and outer parts of the canopy more frequently later in the summer and also increased their use of leaves and branches for feeding. Hovering was used more often as a foraging technique in the middle two periods of the summer. Changes with time have also been determined in other species, including Yellow Warblers (Dendroica petechia), Northern Orioles (Icterus galbula), Catbirds (Dumetella carolinensis) and Least Flycatchers (Empidonax minimus).

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Table 1. Proportion of use of four foraging methods by 16 species of insectivorous birds at Delta and number of observations for each species (N).

Species	Foraging Method				N
	Glean	Probe	Hawk	Hover	
Northern Oriole	99%	1%	0%	0%	205
Yellow Warbler	89	0	2	8	280
Yellow-headed Blackbird	97	0	0	3	61
Brown-headed Cowbird	92	3	0	5	74
Gray Catbird	84	7	1	7	84
Warbling Vireo	88	0	0	13	104
Least Flycatcher	20	0	13	67	126
House Wren	67	33	0	0	38
Red-winged Blackbird	95	0	0	5	63
Veery	44	33	0	22	20
Orchard Oriole	100	0	0	0	20
American Robin	50	50	0	0	16
Eastern Phoebe	14	0	29	57	8
Western Kingbird	50	0	33	17	6
Eastern Wood-Peevee	12	0	12	76	33
Eastern Kingbird	16	0	38	46	63

Table 2. Mean height of foraging (+SE) and mean height of plants used by each species (+SE).

Species	Bird Height (m)	Plant Height (m)
Northern Oriole	9.9 ± 0.6	13.6 ± 0.6
Yellow Warbler	7.2 ± 0.4	11.0 ± 0.4
Yellow-headed Blackbird	11.2 ± 0.9	13.4 ± 0.9
Brown-headed Cowbird	8.5 ± 0.7	12.0 ± 0.8
Gray Catbird	4.2 ± 0.5	8.2 ± 0.7
Warbling Vireo	10.8 ± 0.6	14.4 ± 0.5
Least Flycatcher	6.0 ± 0.4	10.8 ± 0.6
House Wren	2.5 ± 0.6	8.0 ± 1.3
Red-winged Blackbird	8.7 ± 0.7	13.1 ± 0.7
Veery	5.7 ± 0.7	11.5 ± 1.0
Orchard Oriole	8.1 ± 1.5	9.5 ± 1.6
American Robin	5.5 ± 2.7	7.3 ± 3.0
Eastern Phoebe	1.6 ± 0.4	5.8 ± 2.6
Western Kingbird	17.0 ± 3.4	22.0 ± 3.0
Eastern Wood Peewee	9.4 ± 0.7	14.7 ± 0.9
Eastern Kingbird	8.6 ± 0.8	13.6 ± 1.7

Table 3. Changes in tree species use, horizontal and vertical location in trees, foraging substrate and foraging manouever in Warbling Vireos as the summer progresses. Period 1, May 20 - June 1; Period 2, June 2 - 18; Period 3, June 19 - July 2; Period 4, July 3 - July 17.

Period	Tree Species				
	<u>Acer</u>	<u>Fraxinus</u>	<u>Salix interior</u>	<u>Salix amygdaloides</u>	<u>Populus</u>
1	22%	46%	11%	22%	0%
2	22	30	3	46	3
3	23	47	0	24	6
4	12	63	0	25	0

	<u>Vertical</u>			<u>Horizontal</u>		
	<u>Low</u>	<u>Mid</u>	<u>Upper</u>	<u>Inner</u>	<u>Mid</u>	<u>Outer</u>
1	10%	20%	70%	33%	30%	38%
2	24	27	49	27	41	32
3	33	28	39	22	22	56
4	33	44	22	22	22	56

	<u>Feeding site</u>				<u>Manoeuver</u>	
	<u>Branch</u>	<u>Twig</u>	<u>Leaf</u>	<u>Flower</u>	<u>Glean</u>	<u>Hover</u>
1	5%	13%	55%	28%	93%	7%
2	24	5	62	8	84	16
3	33	11	56	0	83	17
4	22	11	67	0	89	11

The Development of Diatom Communities on Natural and Artificial Substrates

Friederike Schneider and Gordon Robinson
Department of Botany, University of Manitoba

INTRODUCTION

The majority of the underwater substrates in the Delta Marsh are subject to colonization by algae. The nature of these periphytic communities is of interest since they can be very productive and provide a readily available food source for aquatic consumers. Diatoms form a major part of these communities, especially in the early stages of colonization. In this study, the development of diatom communities on a variety of natural and artificial substrata was examined. The principle aims were to establish the degree of specificity of diatoms for substrates, the variability of colonization of individual substrates and the influence of initial colonization on the final community structure.

METHOD

Periphytic algae on three species of macrophytes, Ceratophyllum demersum L., Scirpus validus Vahl., and Typha glauca Godr., and on two types of artificial substrata, acetate strips and acrylic rods, were studied. The sampling site, along the southern edge of the Blind Channel, was chosen because all the desired plant species grew in close proximity thus the effects of any local differences in nutrients, depth or current were minimized. Acetate strips and acrylic rods were placed in the vicinity at approximately the same time that the macrophytes emerged. Typha began appearing around May 17, while the substrates were placed in the marsh on May 27, and all substrates were sampled on June 7, June 18, July 7 and July 26.

On each of the sampling dates, three 5-cm segments of each substratum at 5 to 10 cm above the sediment were taken. All algae were scraped off the samples, the surface area of the substratum sample was determined and an aliquot of algal suspension representing a known area of substratum was placed on a coverslip. All organic material was removed by combustion in a muffle furnace at 600°C for 6 minutes. The diatoms were identified and counted at a magnification of X1000 using phase contrast microscopy. 500 cells were counted for each sample. Final numbers of each species were recorded as cells per unit area of substratum.

RESULTS AND DISCUSSION

A preliminary list of the species found is given in Table 1. Although almost 100 species were observed, many of these are uncommon and only a few members of the genera Cyclotella, Cocconeis, Fragilaria,

and Navicula ever composed more than five per cent of the total number of cells present. Further analysis of the cell counts is incomplete but will involve comparisons of cell density and species diversity within and between substrates.

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Table 1: Periphytic diatoms found on natural and artificial substrata in the Blind Channel, Delta Marsh.

<u>Achnanthes lanceolata</u> Bréb.ex Kütz	<u>Navicula tenera</u> Hust.
<u>Achnanthes Lemmermanni</u> * Hust.	<u>Navicula pupula</u> Kütz.
<u>Achnanthes hauckiana</u> Grun.	<u>Navicula pygmaea</u> Kütz.
<u>Diploneis finnica</u> (Ehr.) Cl.	<u>Navicula rhynchocephala</u> Kütz.
<u>Diploneis puella</u> (Schum.) Cl.	<u>Navicula salinarum</u> Grun.
<u>Amphora ovalis</u> (Kütz.) Kütz.	<u>Navicula minuscula</u> Grun.
<u>Amphora perpusilla</u> (Grun.) Grun.	<u>Navicula cincta</u> *(Ehr.) Ralfs.
<u>Anomoeoneis sphaerophora</u> (Ehr.) Pfitz.	<u>Navicula tuscula</u> Ehr.
<u>Caloneis amphisbaena</u> (Bory) Cl.	<u>Navicula accomoda</u> Hust.
<u>Caloneis lewisii</u> Patr.	<u>Navicula pelliculosa</u> (Breb.ex Kütz).
<u>Caloneis limosa</u> (Kütz.) Patr.	Hilse.
<u>Caloneis bacillum</u> (Grun.) Cl.	<u>Navicula cuspidata</u> (Kütz.) Kütz.
<u>Caloneis ventricosa</u> (Ehr.) Meist.	<u>Navicula semen</u> *Ehr.emend.Donk.
<u>Cocconeis placentula</u> Ehr.	<u>Navicula reinhardtii</u> (Grun.) Grun.
<u>Cocconeis disculus</u> (Schum.) Cl.	<u>Navicula gastrum</u> (Ehr.) Kütz.
<u>Cyclotella</u> spp.	<u>Navicula inflexa</u> *(Greg.) Ralfs
<u>Cymatopleura solea</u> (Bréb.) W.Sm.	<u>Navicula protracta</u> *Grun.
<u>Cymbella cistula</u> (Ehr.) Kirchn.	<u>Navicula globulifera</u> Hust.
<u>Cymbella minuta</u> Hilse ex Rabh.	<u>Neidium bisulcatum</u> (Lagerst.) Cl.
<u>Cymbella muelleri</u> Hust.	<u>Nitzschia acicularis</u> W.Sm.
<u>Diatoma tenue</u> Ag.	<u>Nitzschia amphibia</u> Grun.
<u>Diatoma vulgare</u> Bory	<u>Nitzschia filiformis</u> *
<u>Epithemia adnata</u> (Kütz.) Breb.	<u>Nitzschia hungarica</u> *
<u>Epithemia turgida</u> (Ehr.) Kütz.	<u>Nitzschia linearis</u> *
<u>Epithemia sores</u> Kütz.	<u>Nitzschia palea</u> (Kütz.) W.Sm.
<u>Eunotia</u> sp.	<u>Nitzschia apiculata</u> *
<u>Fragilaria brevistriata</u> Grun.	<u>Nitzschia kutzingiana</u> Hilse
<u>Fragilaria capucina</u> Desm.	<u>Nitzschia sigmoidea</u> (Ehr.) W.Sm.
<u>Fragilaria vaucheriae</u> (Kütz.) Peters.	<u>Nitzschia paradoxa</u> *
<u>Fragilaria pinnata</u> Ehr.	<u>Pinnularia brebissonii</u> (Kütz.) Rabh.
<u>Fragilaria construens</u> (Ehr.) Grun.	<u>Pinnularia gentilis</u> (Donk.) Cl.
<u>Fragilaria virescens</u> Ralfs.	<u>Pleurosigma delicatulum</u> W.Sm.
<u>Gomphonema acuminatum</u> Ehr.	<u>Rhopalodia gibba</u> (Ehr.) O.Mull.
<u>Gomphonema gracile</u> Ehr.	<u>Surirella ovalis</u> *
<u>Gomphonema parvulum</u> Kutz.	<u>Synedra acus</u> Kutz.
<u>Gomphonema subclavatum</u> (Grun.) Grun.	<u>Synedra rumpens</u>
<u>Gomphonema grunowii</u> Patr.	<u>Synedra tabulata</u> (Ag.) Kütz.
<u>Gyrosigma spencerii</u> (Quek.) Griff.& Henfr.	<u>Synedra ulna</u> (Nitzsch.) Ehr.
<u>Navicula aurora</u> Sov.	<u>Entomoneis paludosa</u> (W.Sm.) Reim.
<u>Navicula capitata</u> Ehr.	<u>Rhoicosphenia curvata</u> (Kütz.) Grun.
<u>Navicula circumtexta</u> Meist. ex Hust	
<u>Navicula cryptocephala</u> Kütz.	
<u>Navicula halophila</u> (Grun.) Cl.	
<u>Navicula vulpina</u> Kütz.	
<u>Navicula peregrina</u> (Ehr.) Kütz.	
<u>Navicula pseudofrickia</u> Patr.	

*Tentative identification.

Behavioural and Ecological Studies
of Birds on the Forested Dune Ridge, Delta Marsh

Spencer G. Sealy

Department of Zoology
University of Manitoba

The forested dune ridge which separates Lake Manitoba from the Delta Marsh, Manitoba, has been the focus since 1974 of a study of the behavioural and ecological relationships of insectivorous birds and one dove species that nest here in high numbers. This breeding bird community is interesting, and perhaps even unique, because the nesting density of each species is higher than that reported elsewhere in its breeding range, even in other riparian woodlands. First, the linear nature of the habitat, a narrow dune ridge of deciduous trees along the southern shore of Lake Manitoba, provides the birds with a high edge-to-area ratio. Second, the area experiences frequent massive emergences of insects, primarily dipterans, throughout the late spring and summer each year. The inter-relationships among the breeding birds and this abundant food supply and the habitat that is available to them for nesting are being studied in detail over the long term.

Field work of the following projects was initiated, continued, or completed in 1982:

1. My long-term work was continued on the population biology and mating system of the Northern Oriole (Icterus galbula), one of the passerine species that nests densely in the dune-ridge forest.
2. The high nesting densities on the dune ridge promote hostile interactions between and among individuals of some of the breeding species. Studies of these encounters are being continued to elucidate the spacing patterns that the nesting species exhibit on the dune ridge.
3. A 3-year, community-wide study of clutch size and productivity, timing of breeding, cowbird parasitism, nesting density, and nest placement was completed.
4. About 260 nestling Yellow Warblers (Dendroica petechia) were banded in 1982. This is part of an ongoing project that concerns the influence of age and experience of Yellow Warblers on their spring arrival chronology, dispersal, nest-site selection and reproductive success.
5. Weather-mediated territorial behaviour was studied in color-marked, male Cape May Warblers (D. tigrina) during a migratory stopover in mid-May, 1982.

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Post Fire Performance of Phragmites australis
The Second Season After Burning

Jennifer M. Shay

Department of Botany
University of Manitoba

INTRODUCTION

Prescribed burning is potentially a useful tool for the management of marshes. The giant reed Phragmites australis dominates extensive tracts of the Delta Marsh at the south end of Lake Manitoba. Fire has been suggested as a means of managing this species and in 1979 a study was initiated to examine the effects of spring, summer and fall burns on a typical reed community (Thompson 1982).

A Phragmites stand on the west side of the Blind Channel was divided into twenty 20 X 20 m plots (Fig. 1). Using a split plot sampling design, the plots were sampled in August 1979 to assess vegetation uniformity. Four plots were burned later that month, and four in each of October 1979 and May 1980. Of the eight remaining, four served as controls and four were left undisturbed. Post-burn growth was sampled bi-weekly in 1980. The results (Thompson 1981, 1982) showed that summer burning considerably reduced regrowth, while spring and fall burns enhanced it. Such dramatic effects usually diminish after the first year and it was hypothesized that over several seasons the burned plots would become indistinguishable from the controls. This study monitored the second year's regrowth.

METHODS

Three randomly-placed 0.5 m² (71cm X 71cm) quadrats were sampled in each burned plot and the controls on May 25, June 25, August 2, and August 25, 1981. In each quadrat, shoots were clipped at ground level, counted, bagged, and dried to a constant weight at 80°C. Flowering shoot morphology was compared under all treatments on August 2 by randomly choosing five flowering shoots from each of the quadrats. Shoot height to flag leaf, length of inflorescence, shoot basal diameter, leaf number, and longest leaf length were recorded. Below ground biomass was removed on August 20 from a plot 25 X 50 cm in surface area and 30 cm in depth. It was sorted into new rhizomes, buds and roots, old rhizomes and roots, and the 1981 growth of stem bases.

Vegetative and flowering biomass and stem morphological characteristics were compared by analysis of variance across treatments with a randomized complete block design. Duncan's Multiple Range test was employed to compare treatment means. Calculations were made using the S.A.S. (Helwig and Council 1979) statistical package.

RESULTS

Comparison of Means

Analysis of the 1981 data showed that biomass on the controls and summer burns was similar, while that on fall and spring burns was significantly higher (Table 1). Indeed, biomass on the spring burn was twice that on the control. All treatments resulted in a significant increase in density compared with the controls. The greatest increase occurred on fall-burned plots. Fall and spring burns produced taller shoots than the controls while summer shoots were shorter. Although treatments stimulated flowering, the percentage of shoots producing inflorescences remained more or less the same. The mean stem weight decreased on all treatment plots.

ANOVA

In the analysis of variance for shoot biomass in the 1981 growing season, significant effects were found for treatments ($F = 34.10$, $p 0.0001$), blocks ($F = 8.35$, $p 0.0001$) and the treatment by block interaction ($F = 2.85$, $p 0.0069$) (Table 2). The significant block effect indicates an overall positive response of shoot biomass to increasing soil moisture after burn treatments and on the control plots. Flowering shoot biomass paralleled the ANOVA for total biomass.

Total shoot density showed significant differences between treatments ($F = 64.10$, $p 0.0001$) but not between block ($F = 1.68$, $p 0.18$). However, the significant treatment by block interaction indicates a differential response of shoot density to the moisture gradient on the test plots ($F = 3.77$, $p 0.0008$). This differential response did not apply to flowering density because block and block-treatment interactions were significant at the $p = 0.0001$ level.

DISCUSSION

A selection of comparisons with 1980 (Thompson 1981) data are appropriate. In 1980 biomass in the controls was almost 150 g/m^2 greater than in 1981, whereas biomass in all treatments was lower by $100 - 200 \text{ g/m}^2$. The rank ordering for treatments was the same. Shoot density on control plots showed an increase in 1981 but not on the treated plots where it declined. Percent flowering showed less variation than in 1981 as did the mean weight per stem. Other characteristics such as height and weight per stem showed significant differences between treatments, blocks and treatment-block interaction effects (Table 2).

Recovery is clearly complex and influenced by the burn treatment, block, treatment-block interaction, moisture levels, and other factors. In order to elucidate some of these interactions we plan to examine abiotic parameters such as soil characteristics including moisture content in all the plots. The unused plots will be compared with the controls to assess the influence caused by sampling and the same pattern of sampling the burned plots will continue.

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Table 1. Means of selected characters of *P.australis*, the second growing season after burning. The plots were burned in August 1979, October 1979, and May 1980. The August 2nd and 25th sampling periods have been combined.

Characteristic	*TREATMENT MEANS			
	(1) Control	(2) Summer	(3) Fall	(4) Spring
Biomass (grams/m ²)	573.2 ^c	618.6 ^c	867.4 ^b	1033.5 ^a
Density (shoots/m ²)	54.8 ^c	92.2 ^b	119.0 ^a	109.8 ^a
Average height (cm)	207.4 ^c	190.9 ^d	214.0 ^b	220.5 ^a
Maximum height (cm)	234.3 ^b	206.6 ^c	233.8 ^b	292.6 ^a
Density (vegetative shoots/ m ²)	30.7 ^c	52.0 ^b	64.5 ^a	46.0 ^b
Flowering biomass (g/m ²)	366.2 ^c	372.4 ^c	556.6 ^b	755.0 ^a
Density (flowering shoots/ m ²)	24.1 ^d	40.1 ^c	54.5 ^b	63.6 ^a
Mean weight per stem (g)	20.8 ^a	13.4 ^d	15.0 ^c	18.6 ^b
Percent flowering	43.4 ^b	42.4 ^b	46.8 ^b	57.4 ^a

*Means followed by the same letter are not different at $\alpha = .05$, Duncan's Multiple Range Test.

Table 2. Analysis of variance for selected characters of *P.australis*, the second growing season after burning.

Character	Treatment		Block		Treat * Block	
	F ¹	p ²	F	P	F	P
Biomass (g/m ²)	34.10	.0001	8.35	.0001	2.85	.0069
Density (shoots/m ²)	64.10	.0001	1.68	.1796	3.77	.0008
Flowering biomass (g/m ²)	38.25	.0001	19.55	.0001	4.25	.0003
Density (flowering shoots/m ²)	48.87	.0001	23.80	.0001	5.47	.0001
Mean weight per stem (g)	61.87	.0001	14.81	.0001	2.43	.0191
Maximum height (cm)	70.99	.0001	116.44	.0001	18.68	.0001
Average height (cm)	116.43	.0001	256.20	.0001	53.22	.0001
Percent flowering	10.58	.0001	21.46	.0001	4.57	.0001

¹F calculation

²probability > F

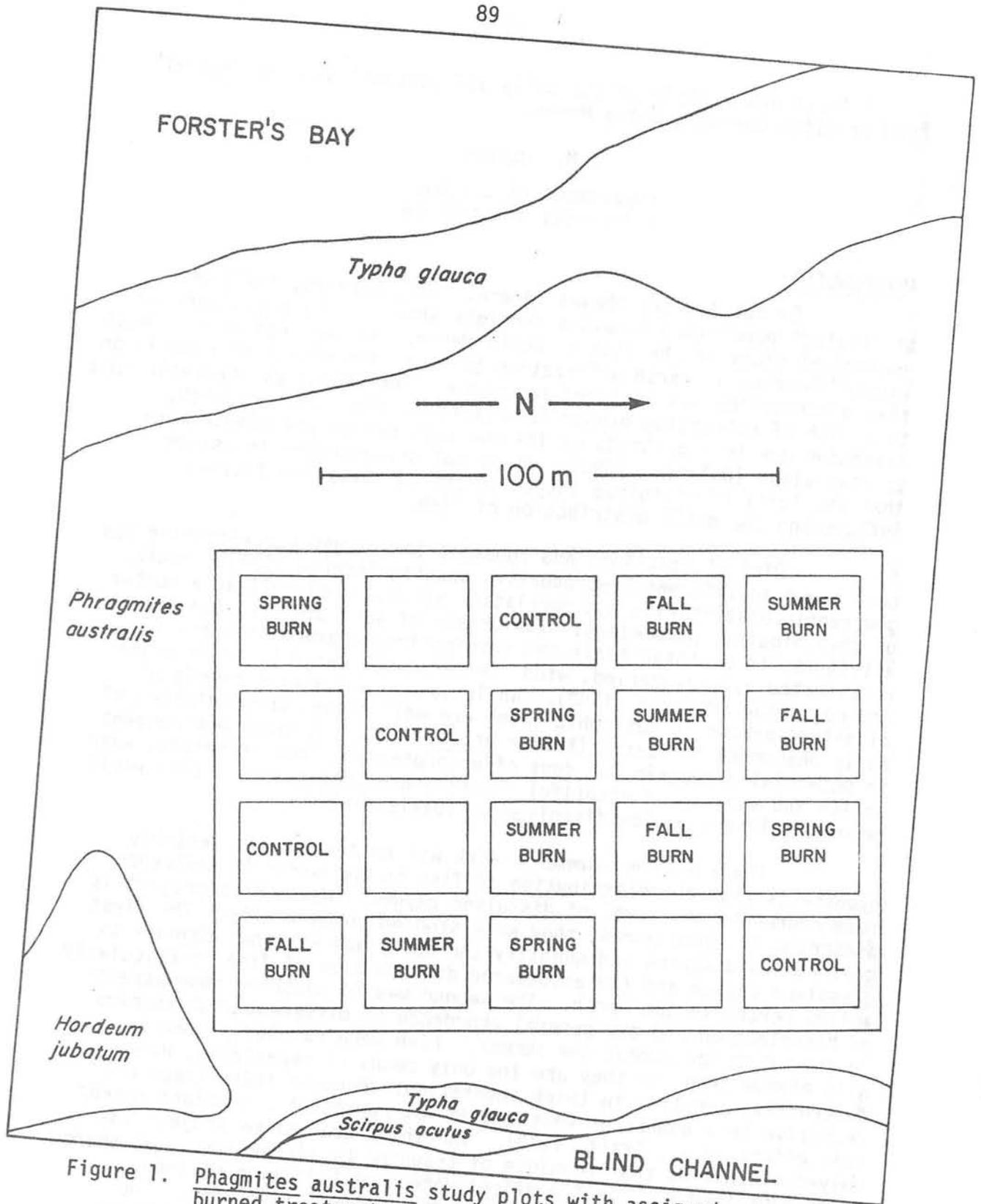


Figure 1. *Phragmites australis* study plots with assigned burned treatments.

A Preliminary Study of the Daily and Seasonal Distribution of Fish in Blind Channel, Delta Marsh.

I.M. Suthers

Department of Zoology
University of Manitoba

INTRODUCTION

Except for two theses (Acere, 1971; Bernard, 1972) on stickleback population dynamics and lake shiners, there has been no ecological study of the fish in Delta Marsh. In the context of a much larger question of marsh utilization by fish, the effect of hypoxia on fish distribution was isolated for study. The potential energetic cost to a fish of extracting oxygen from normoxic water is very high, breathing one to two thirds of its own body weight per minute merely to stay alive (Holeton, 1980). It is not unreasonable to assume that the level of dissolved oxygen is one of the prime factors influencing the daily distribution of fish.

Diel fluctuations and constant low oxygen concentration has been shown to influence reproductive success (Brungs 1971), growth, geographic distribution and population structure as well as a number of physiological parameters. The origin of such diel fluctuations is attributed to photosynthesis and respiration/decomposition but is complicated by photoperiod, wind, temperature, water stratification and pollution (Holeton, 1980). While summer and winter trends of dissolved oxygen in eutrophic lakes are well known, documentation of daily phenomena is scarce (Kramer et al, 1978). A marsh environment is potentially hypoxic but does offer protection from predators, wave action and provides a plentiful invertebrate food resource that would be more tolerant of low dissolved O₂ (Davis, 1975).

The aim of my summer's work was to develop the testable hypothesis that the distribution of fish in the marsh is influenced to some degree by the level of dissolved oxygen. While this project is presented in three parts, they were studied concurrently. The first goal was to describe and quantify the daily and seasonal changes in dissolved oxygen and the associated distribution of fish, particularly yellow perch, in the marsh. The second was to describe some aspects of distribution and the general abundance of different fish species in the marsh throughout the summer. Fish were sampled primarily with minnow traps as they are the only means of repeatable, non-destructive sampling in thick vegetation. However these traps are selective in a number of ways and do not represent a constant catch/unit effort (e.g., Statt, 1970). The third goal of my project involved evaluating the technique of trapping by minnow traps, as there is no published work on the effectiveness of this type of trap, particularly with immature yellow perch (Perca flavescens). The dominant species found in the marsh were yellow perch, the fathead minnow (Pimephales promelas), brown bullhead (Ictalurus nebulasus),

five-spined stickleback (Culaea inconstans), along with spot-tailed shiners (Notropis hudsonius), carp (Cyprinus carpio), pike (Esox lucius) and the nine-spined stickleback (Pungitius pungitius).

MATERIALS AND METHODS

Part I. Fish sampling and oxygen/temperature readings were taken at two sites (A & B) in the Blind Channel (Fig. 1). At each site five transects were established, along each side of a 100 m stretch of channel, perpendicular to the shore (10 transects in total). Each transect was composed of four poles (or stations) (Fig. 3). The sites were selected on the basis of accessibility while the transects were placed 20-30 m apart providing station 1 was in 40 cm water amongst cat-tail vegetation (Typha latifolia). Station 2 was at the boundary between the cat-tail and open water, 3 in approximately 50 cm of water which become thickly vegetated with sago pond-weed (Potamogeton sp.) and 4 in 90 cm deep water approaching the centre of the channel. Each pole supported two minnow traps; one resting on the mud and the other at the surface. For each trap oxygen and temperature were recorded, the fish counted and transported 500 m away before release. Fish found dead in the traps, apparently from hypoxia were not counted. Four out of the 10 transects, selected using a random numbers table were set at morning (4 X 4 X 2 = 32 traps) and evening over a three-day period for site A, and repeated the following week at site B. This whole procedure was done four times during the summer; June 8th - June 18th, July 6th - 16th, July 27th - Aug. 6th, Aug. 17th - Aug. 26th. Only data for the first two sampling periods will be discussed in this report. Sampling times for the first period were 0700 - 0900, and 1900 - 2100 and the remaining three periods 0900 - 1100 and 2100 - 2300. Reasons and the implications of this will be discussed. A fine gauge (12mm) multifilament gill net (50 m length, 50 cm drop) was set close to the cat-tail vegetation at both sites. The net was set for two hours from 0700 - 0900, 1300 - 1500 and 1800 - 2000 hrs. over a three day period. The position of meshed yellow perch with depth was noted, and where possible noting if it was on the inshore or offshore side of the net. A continuous recording temperature and oxygen meter (YSI, Model 56) at both sites provided temporal variation of O_2 at one place.

Part II. Three monitor trap sites were established along Blind Channel (Fig. 1). Two (a and b) were near the transect sites and the third (c) was at the cut between Blind Channel and Forester's Bay. Each site had four poles each with two traps top and bottom. The traps were checked generally every two or three days from late May to September, then approximately every seven days to mid-October. The mean number of fish of each species was calculated as:

$$\frac{\sum_1^4 \ln \left(\frac{T + B}{\# \text{ days}} = 1 \right)}$$

4 (= # of poles) where T = top and B = bottom trap of each pole. In August duplicate seine hauls (20 X 2m)

were made at each site each week for comparison. The relative abundances of fish amongst two emergent vegetation types were quantified by placing 20 traps in scattered patches of Typha and Scirpus in Blind Channel, and checked every 24 hrs. on two, three day periods; June 9 - 11th, July 27 - 29th.

Part III. The difference of day/night captures (with regard to Part I) in an exposed area of cat-tail that did not become hypoxic was examined using 10 traps June 16 - 18 and 20 traps June 22 - 25 in amongst cat-tail vegetation. To test for recapture of fish, 20 traps were placed in cat-tail vegetation and every second day (for 10 days) yellow perch in traps 1 - 5, 16 - 20 were given a caudal fin clip and released on site, while those in traps 6 - 15 were given a pelvic clip and transported to the opposite bank. The rate of capture was examined over 12-hr. periods by placing 10 traps with numbered floats along the edge of the dock ditch and over July 6th and 8th were checked and emptied at 0830 hrs. and 2030 hrs. but at 1200, 1500, 1800, and 2300, 0530 hrs. the contents of the traps were counted only, not releasing any fish. The accumulated catch over three days was examined June 15 - 18th, June 23 - 25th using five wire and five plastic traps in thick stands of cat-tail. The wire vs. plastic comparison was of interest as initially plastic traps were used for monitoring. The contents of the traps were counted and replaced in the original position.

RESULTS

Part I. A composite of typical diel oxygen pulses from each station at site A in early July (Fig. 2) shows a similar range of maxima to minima (8 ppm) for the top trap, but the mean value increases from station one to four. Absolute concentration is expressed in ppm. but due to decreasing solubility of O_2 with increasing temperature, per cent saturation thus increases. At 26°C, 16 ppm represents over 200% saturation, and bubbles of gas at the surface film in mid-afternoon were apparent. The bottom trap O_2 values for station 1, are very close to zero but further away from the vegetation the levels are lower, and mimic the upper trap. Diel temperatures varied from 20 - 25°C, but little between top and bottom traps. During this time the weather was generally fine and sunny and sheltered from the northerly breeze. Note that the sampling times for the transects correspond to minimum (0900 hrs.) and maximum O_2 values (2100 hrs.). Oxygen traces during early June at the same sites show a smaller range of fluctuation (3 ppm), and no trapsite goes below 2 ppm. Conversely, in late summer these trends were more exaggerated with diel ranges of 0.5 - 16 ppm.

The mean values for morning and evening temperature, dissolved oxygen and numbers of yellow perch and fatheads caught for the first two sampling periods are shown in Figs. 3 & 4. This cursory form of analysis does not account for variation between

sites and transects but permits some general conclusions. These data will later be analysed using log-linear discriminant function analysis. Oxygen values were always higher in the evening sample and lower for the bottom traps--increasing further out into the channel. This became more marked in the second sampling period, when the water temperature increased from 14° to 20° C. More fish were caught in all evening samples than morning ones due to the general diurnal activity of fish. Yellow perch were the most abundant in the lower trap amongst the cat-tail stems while fathead minnows were found predominantly in the upper, offshore traps. In the July sampling period (Fig. 4), more yellow perch were caught in the lower, offshore traps and less in the station I trap. The average morning O_2 values in this trap were very low (1.4 ppm) increasing to 3.5 ppm in the evening, correlated with an increase in the numbers of yellow perch caught there. Conversely, at this time fathead minnows were nearly all caught in the upper offshore trap. Fork length measurements were obtained, but not presented here, to document growth and recruitment of young-of-the-year. The fine-mesh gill nets caught very few yellow perch in the morning set compared to the mid-day and evening sets. All yellow perch were caught in the bottom third of the net and approximately equal numbers were caught on either side of the net.

Part II. The three monitor trap sites (Fig. 5, 6 & 7) indicate a trend of large catch per unit effort in June and early July comprising immature (1+) yellow perch, adult 1 and 2 fatheads dropping to low levels from mid-July onwards. Most fish caught in middle-late summer were young-of-the-year. The wide fluctuations in mean log catch/unit effort could not be correlated with any obvious environmental variable, but greater than two days between sampling, particularly in early summer, could have resulted in trap saturation. The ice-free season in the channel was from mid-April to late October. While monitor trapping commenced in late May, preliminary sampling on the 12th - 13th May indicated few fatheads and no yellow perch. The weekly seines in August caught large numbers of spot-tail shiners, fatheads and yellow perch which were absent from minnow traps at the time. Yellow perch showed a definite preference for cat-tail (Typha sp.) compared to the bullrush (Scirpus sp.). Bullhead fry, present in late July appeared to prefer the bullrush.

Part III. The day/night captures of yellow perch in exposed areas of cat-tail that did not become hypoxic indicate a five-fold increase in the evening over the morning captures. Of the 341 fish caught over 10 days, 1.5% were recaptures, one of which was from the opposite shore. The mean rate of capture (Fig. 8) is approximately exponential but indicated by the S.E., there is wide variation between individual traps. Traps already with fish appear to attract more fish. While similar numbers of each species were caught day and night, there appears to be a slightly smaller capture rate during the dark.

For fatheads in particular, there is a rapid capture rate from 0830 - 1200, levelling out in the afternoon. Sticklebacks indicate some ability for escape. Yellow perch caught in wire traps reach saturation levels of about 12 - 15 perch/trap, within a day (Fig. 9 a,b). This figure would most probably vary during the season. Very few fatheads are caught in wire traps, but where present (Fig. 9 b) indicate a preference for plastic traps. More sticklebacks were caught in wire traps, and again show a net loss due to escape.

DISCUSSION

The phenomenon of daily fluctuations in dissolved oxygen in a marsh environment creates vertical and horizontal gradients that vary with time. The daily O_2 maxima and minima diverge during the summer presumably due to the increased growth of sago-pond weed and increased temperature during the day, salting out O_2 because of the decreased solubility. The two dominant species of fish in the marsh, juvenile yellow perch and fathead minnows, occupy different areas, fatheads found in the upper surface water and yellow perch inshore amongst the thick cat-tail vegetation. This distribution of yellow perch is possibly influenced during the night by the development of hypoxic conditions inshore, forcing fish out of this preferred habitat. The small mesh gill nets indicated no net diel movement in and out of the cat-tail. Large mesh gill nets were set close inshore, catching predatory adult bullheads, a few yellow perch and pike but rarely were fish found in the guts. Seasonally, the yellow perch distribution may be influenced partly by cover, with thick growth in mid-summer of sago pond weed offshore (Hall and Werner 1977). In the shallower, station I position, the two traps often overlapped in depths covered, but yellow perch were consistently found in the lower trap.

The sampling times were advanced two hours from 0700 and 2100 in the July sampling to approximate the anticipated half-way point of the oxygen cycle so that the traps would be set over a 'low oxygen period' and a 'high oxygen period'. However this half-way point does not occur until noon and midnight (Fig. 2). Effectively the traps were set over a time of increasing oxygen, and of decreasing oxygen despite this two hour advance of sampling time. Conclusions as to the changes in distribution are still valid, but probably not as dramatic as if sampling was done at 1200 and 2400 hrs.

There is an abrupt drop in the catchability of fish at both sampling sites in mid-July, and very few fish were caught in the remaining two sampling periods. Yellow perch (1+) may leave the marsh for the lake when water temperatures reach 20°C , or activity may be low to conserve energy due to the high metabolic rate in warmer water. For two weeks in August, twelve transects of three traps each were maintained along Blind Channel, but no localised concentrations

of catchable fish were found. At this time 5 - 10% of fatheads sampled displayed a heavy infection of a Myxosporidean protozoan (*Myxosoma* sp.), causing protrusion of the eyes and occluding the mouth and gills. The rise in late summer catch at the cut (Fig. 7) represents emmigrating fish, this being the only channel to the lake (Fig. 1). The early summer figures may be lower than naturally occurring due to the possible trap saturation, particularly for yellow perch (Fig. 9).

Minnow traps appear to catch fish initially by general movements of fish which then attract more in an exponential manner. Consequently such traps catch active fish and activity varies both diurnally and seasonally. Yellow perch are more active during the day (e.g., Alabaster and Robertson 1961) and in the spring, presumably due to high feeding activity. Plastic traps are probably not as preferred due to the thicker mesh inhibiting vision, but were favoured by fatheads as nest sites. Plastic traps (and floats) almost invariably had eggs in early summer, adding another element of selectivity. Prior catches of a predator (juvenile pike or yellow perch) or of prey (fatheads, crayfish), could have influenced the final catch. How these factors affect monitor-trap data is uncertain. Such data may not be an index of absolute fish abundance as indicated by the August seine catches, but do represent the population catchable by minnow traps. Seining may be a suitable index but would not be constant during the summer due to weed growth fouling the net in mid-late summer, and the increased clarity of the water permitting fish escape. While sticklebacks are known to home around trap sites (G.E.R. Moodie, pers. comm.), clipped yellow perch were rarely caught again even when released at the trapsite and thus each trap sample may be regarded as independent. Minnow traps are also size selective and by late summer some yellow perch may have outgrown the catchable size. Analysis of forklength measurements could indicate this.

CONCLUSIONS

Baseline information on the oxygen regime, the abundance of catchable fish, and the effectiveness of minnow traps at Delta Marsh has now been established. Tentative evidence has been presented supporting the hypothesis that the level of dissolved oxygen can influence the daily and seasonal distribution of yellow perch thus achieving the particular aim of the past summer. Laboratory studies are now in preparation to test this hypothesis, and the interaction with other factors such as cover. Next summer will involve using other sampling techniques, and experimental manipulation by bubbling air into hypoxic environments.

ACKNOWLEDGEMENTS

This study is supported by a University of Manitoba graduate fellowship. I would like to thank my supervisor Dr. J.H. Gee for his encouragement and advice and particularly to Barbara Beaver without whom I could not have accomplished half of this study. The support of Jennifer Shay, Robert and Robin Barclay and the staff at the field station is greatly appreciated.

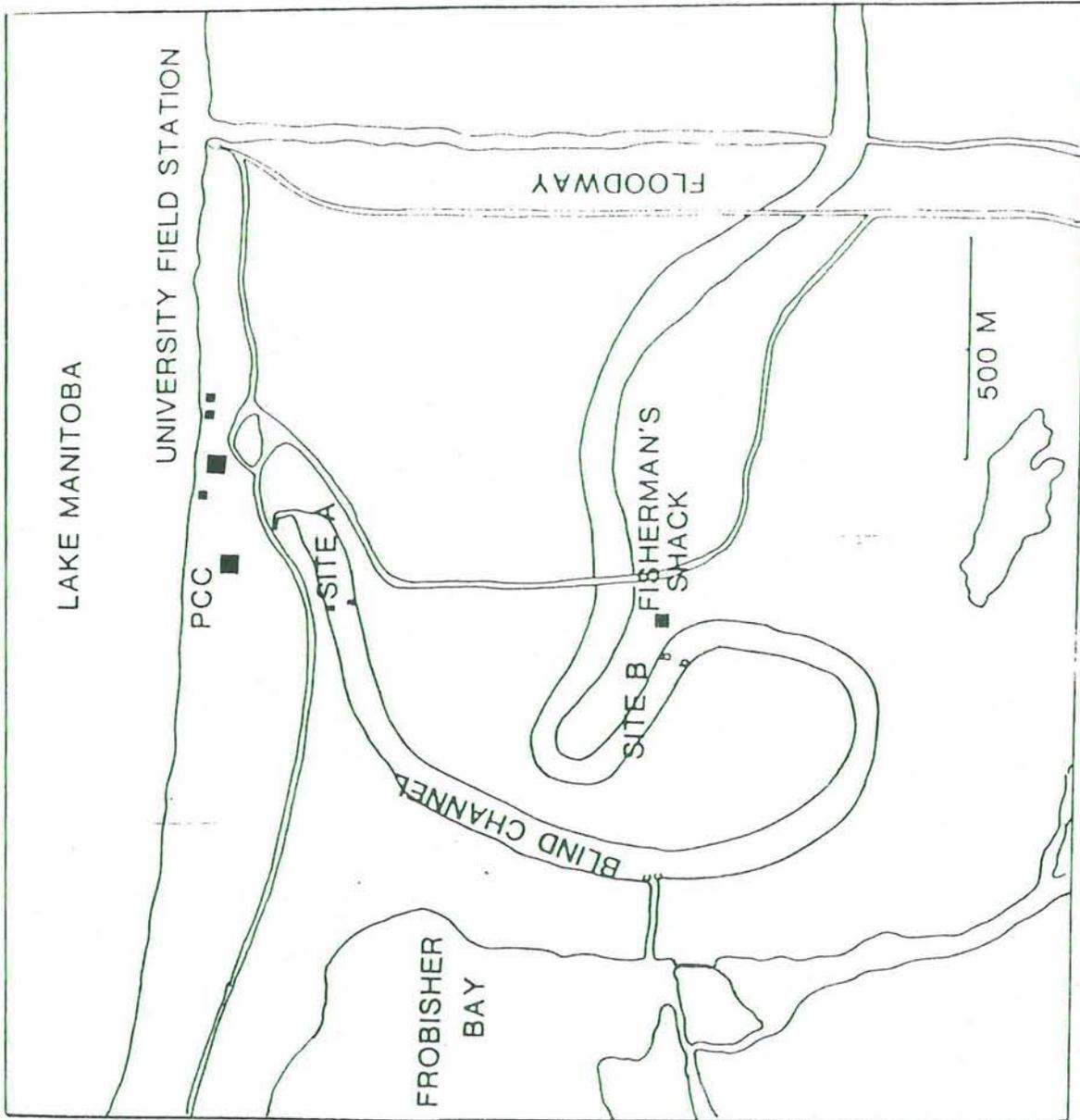


Figure 1. Delta Marsh and location of sampling sites.

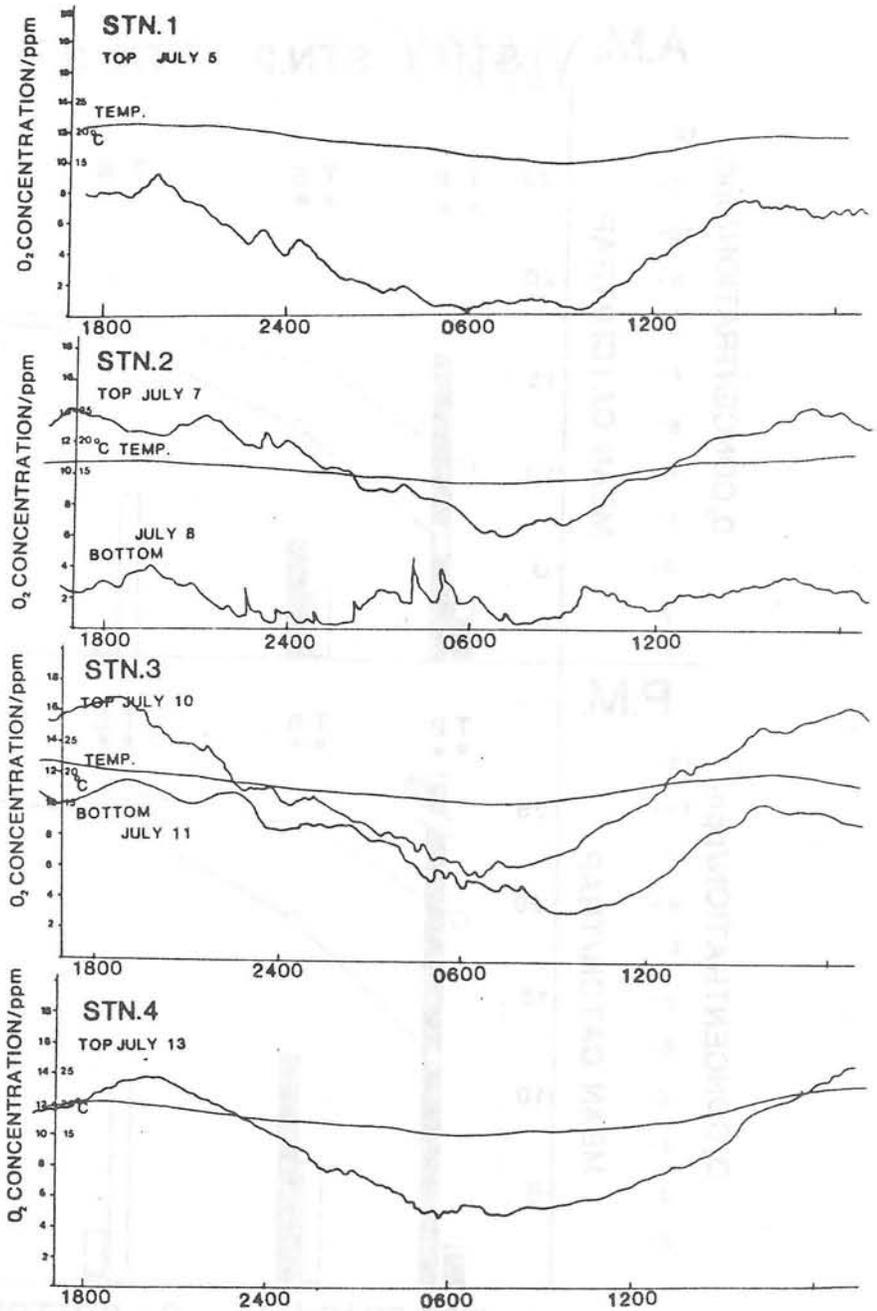


Figure 2. Dissolved O₂ and temperature traces from a continuous recording oxygen meter over 24 hrs. at site A. The temperature trace is for the surface, the bottom being almost identical. 'top' and 'bottom' are 10 cm from the surface and substrate, respectively.

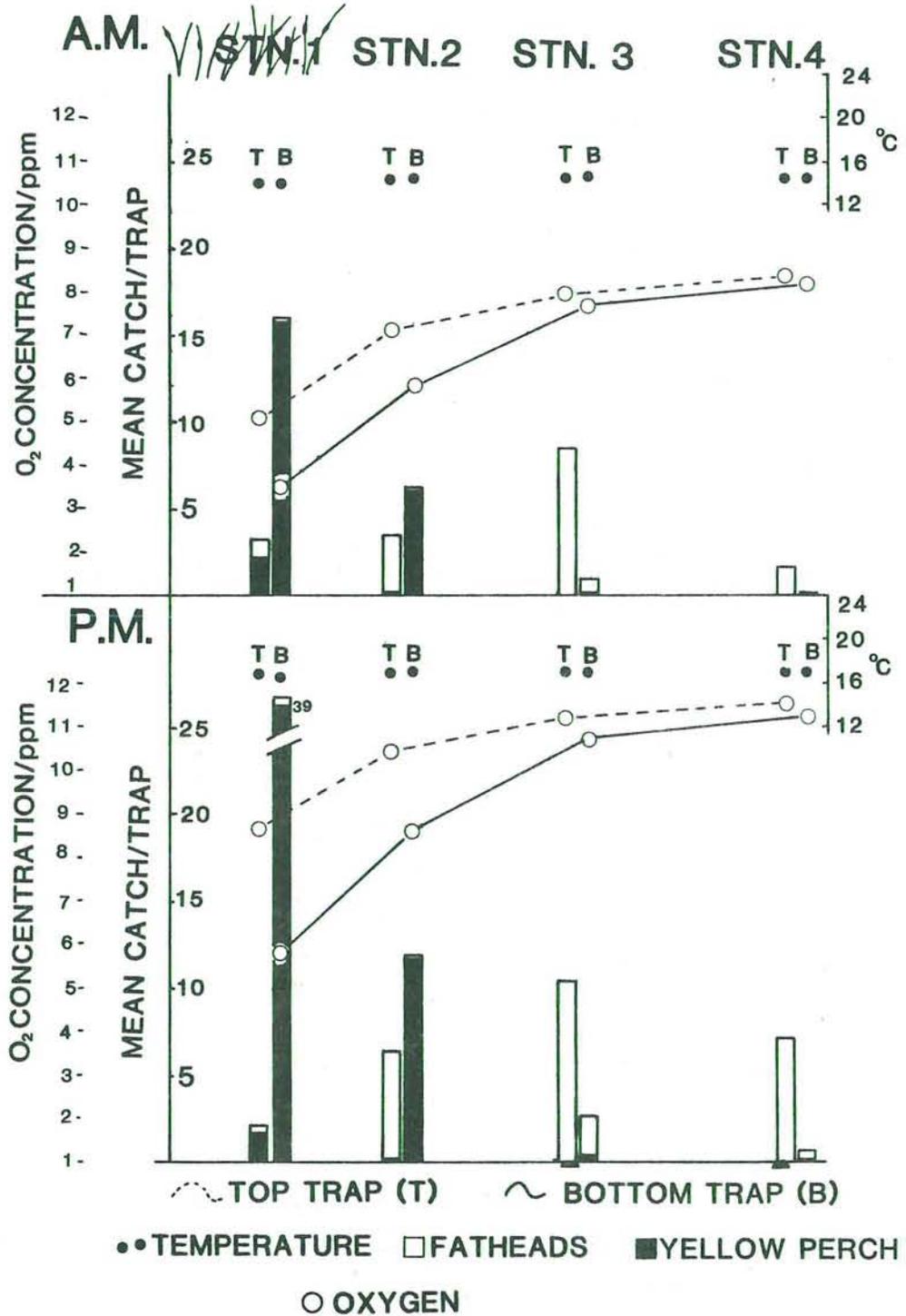


Figure 3. Mean values for all sites and transects at four stations and both depths over June 8th - 18th, in the morning (AM) and evening (PM).

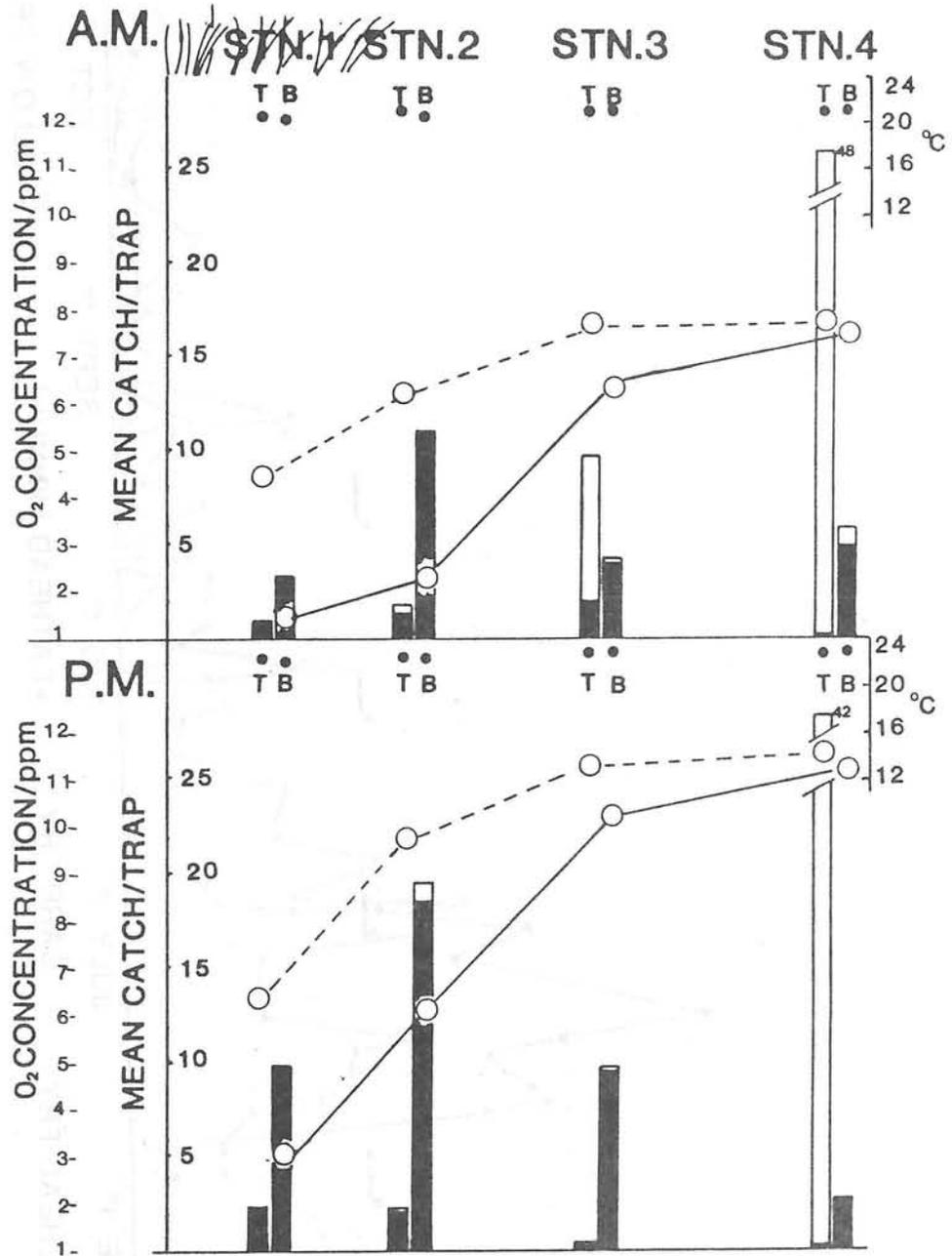


Figure 4. Mean values for all sites and transects at four stations and both depths over July 6th - 16th.

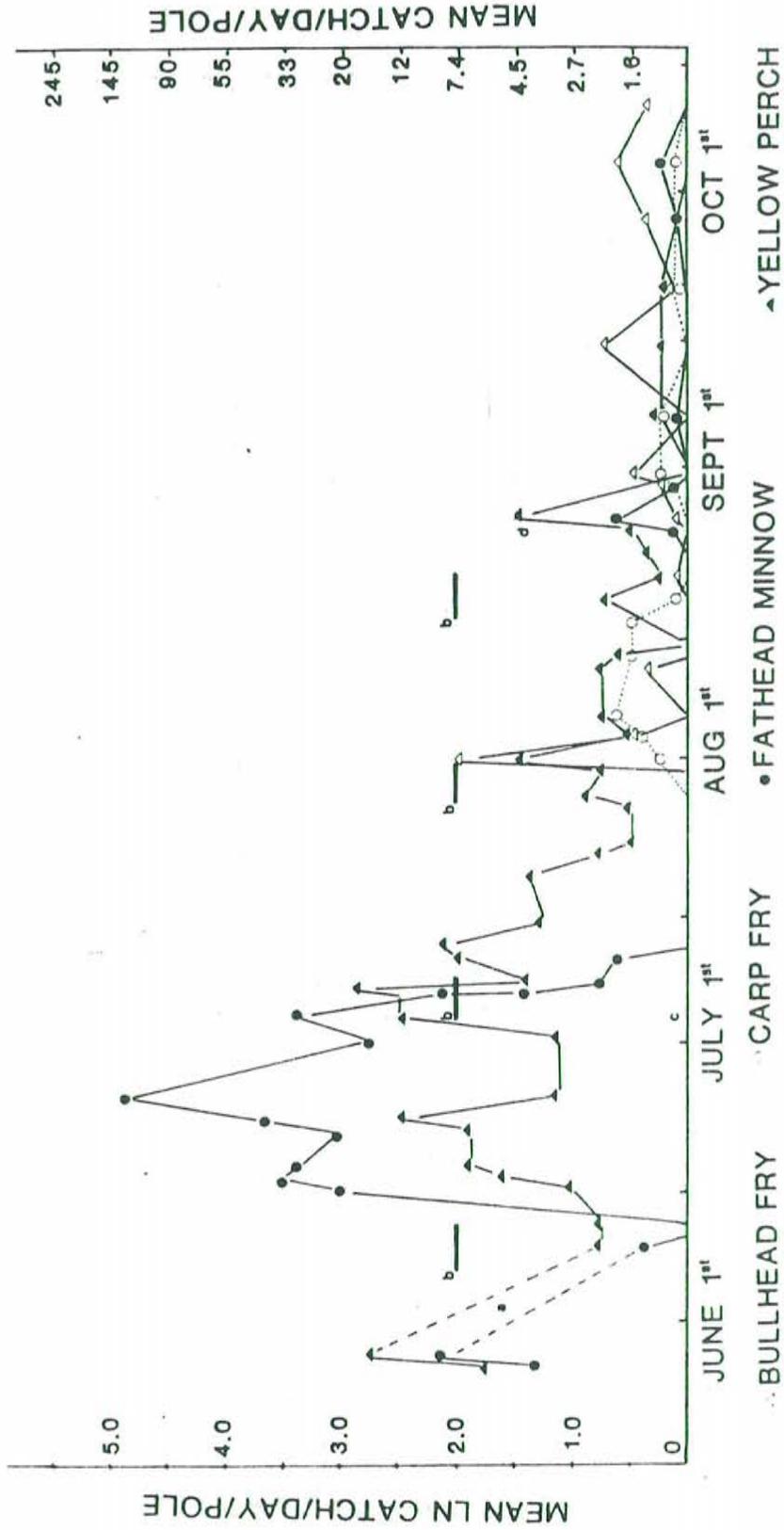


Figure 5. Monitor trap data for site A. notes a; traps not in place, b; transects sampling period, c; change plastic to sire traps, d; mostly 0+ yellow perch.

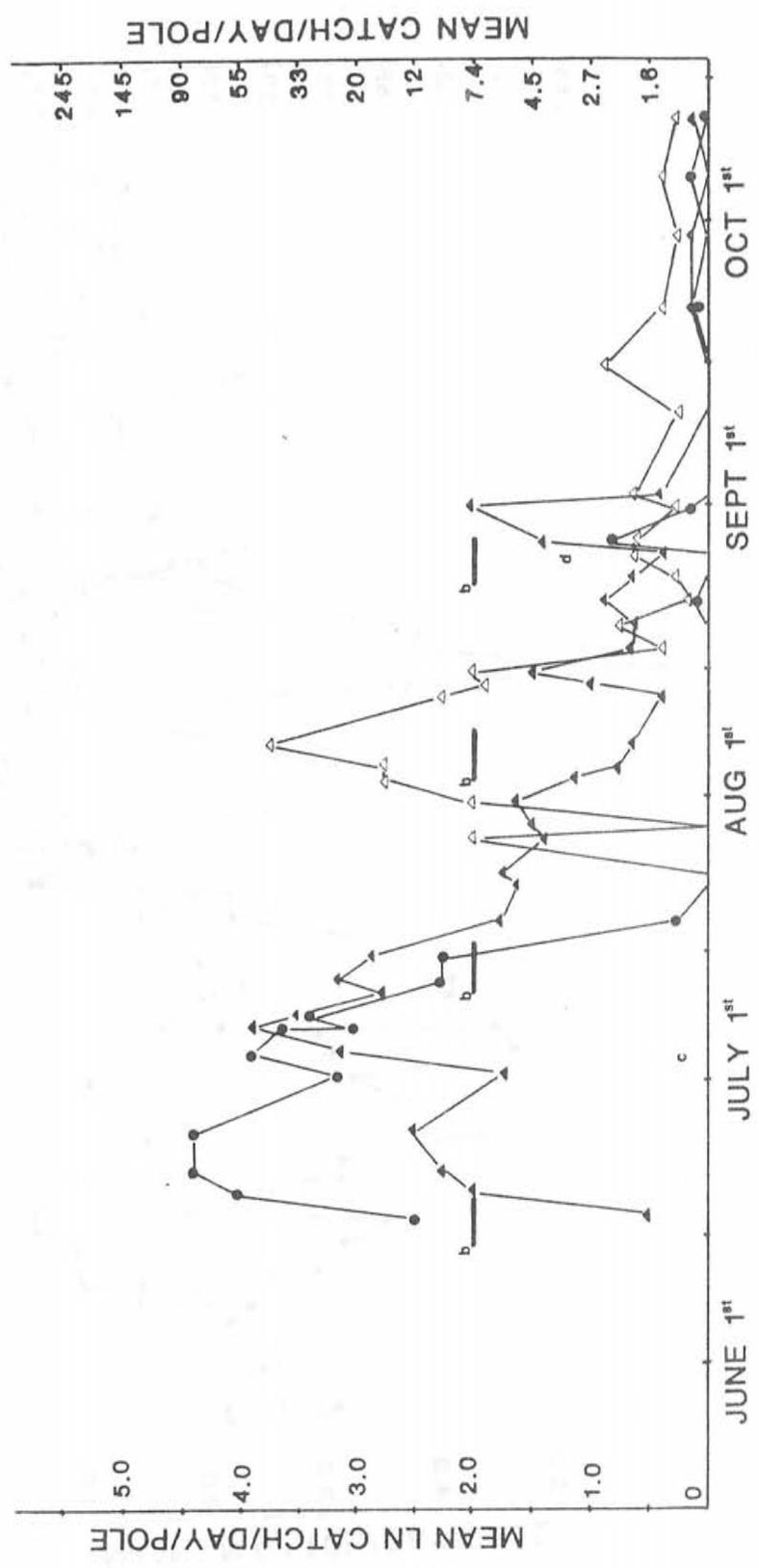


Figure 6. Monitor trap data for site B. Notes as in Fig. 5

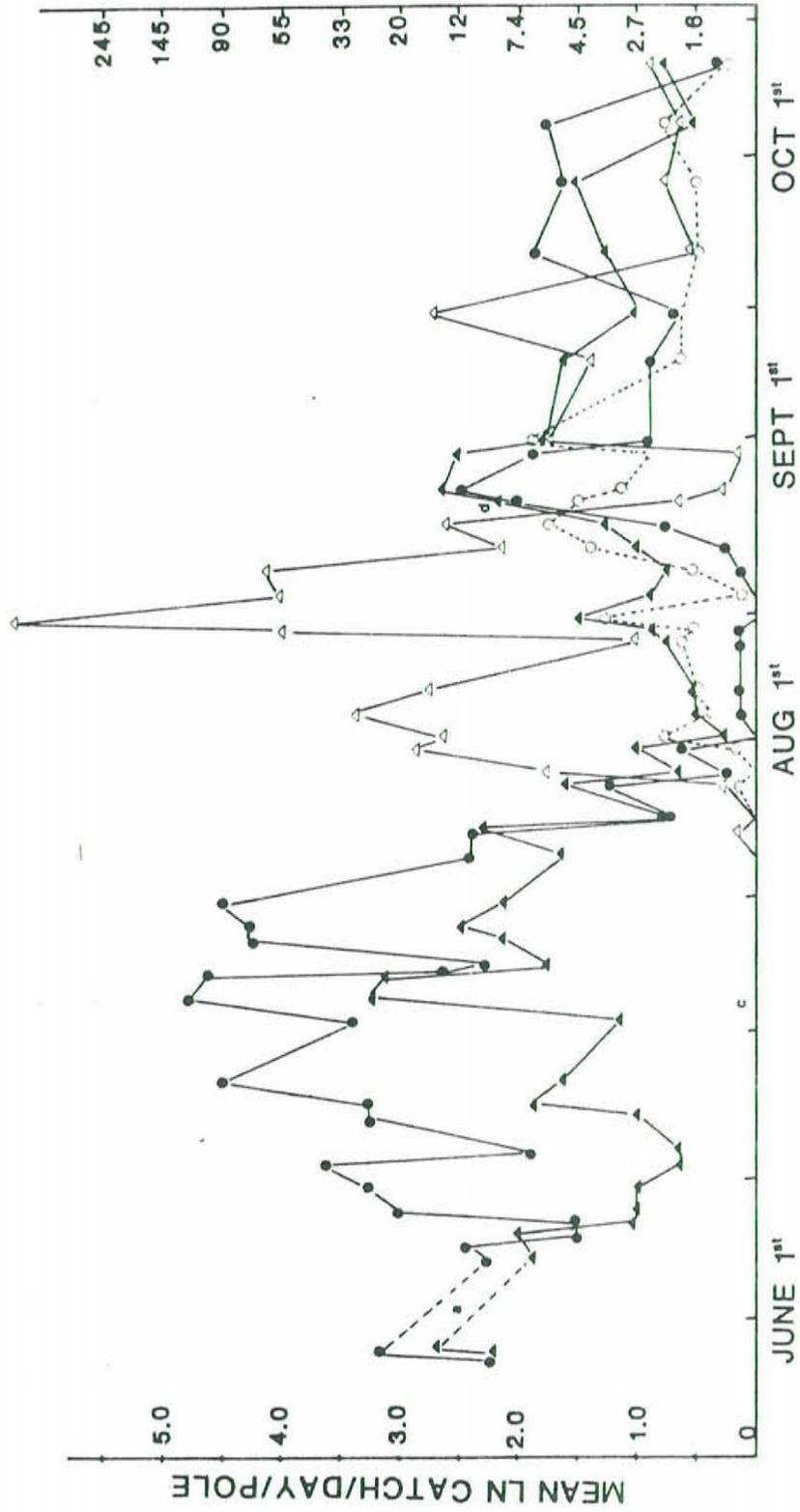


Figure 7. Monitor trap data for the cut (c). Notes as in Fig. 5.

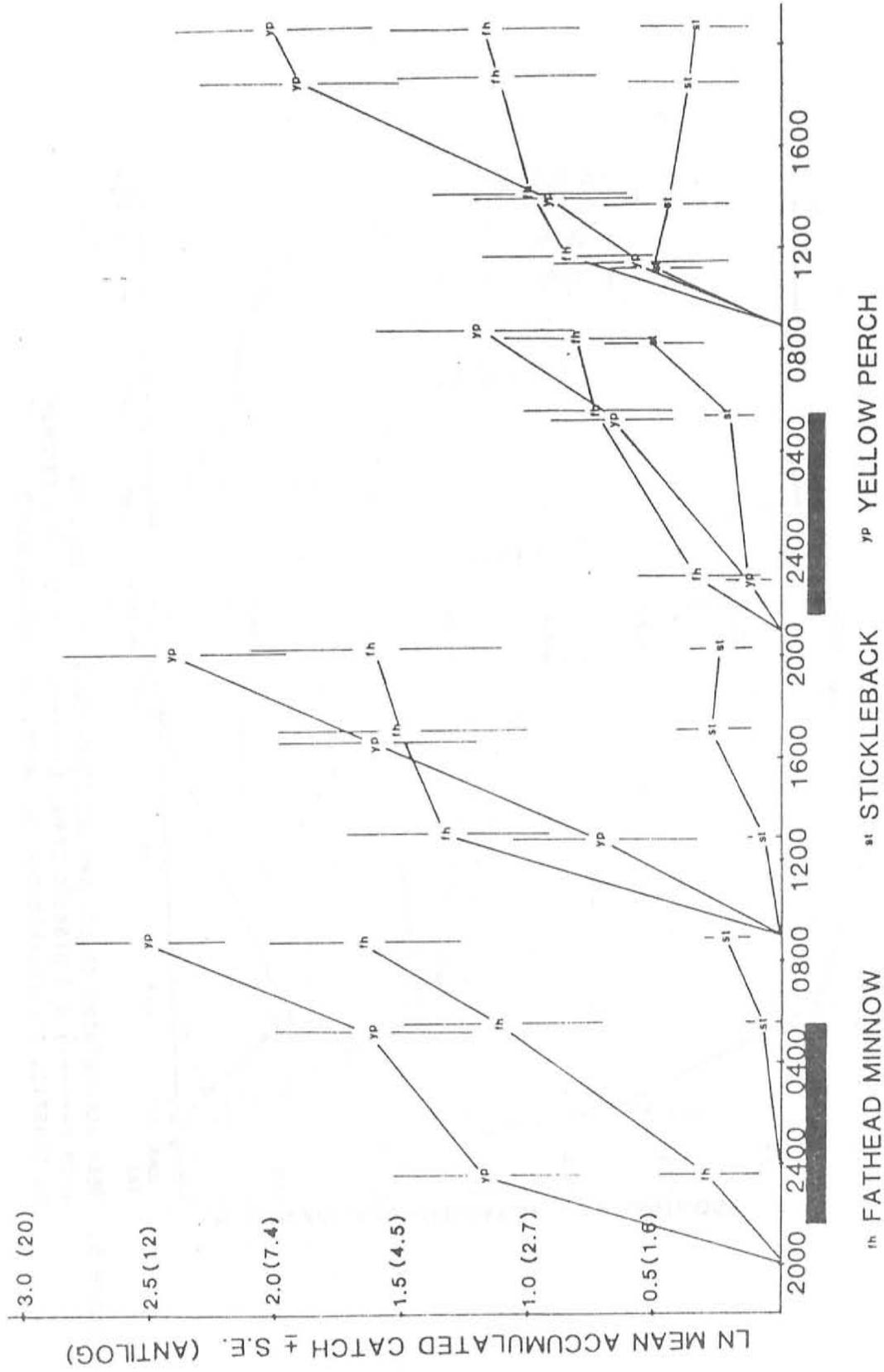


Figure 8. Mean accumulated catch over 12 hour day/night traps. Traps emptied at 0830 and 2030 hrs. (n=10) fh; fatheads, st; stickleback, yp; yellow perch.

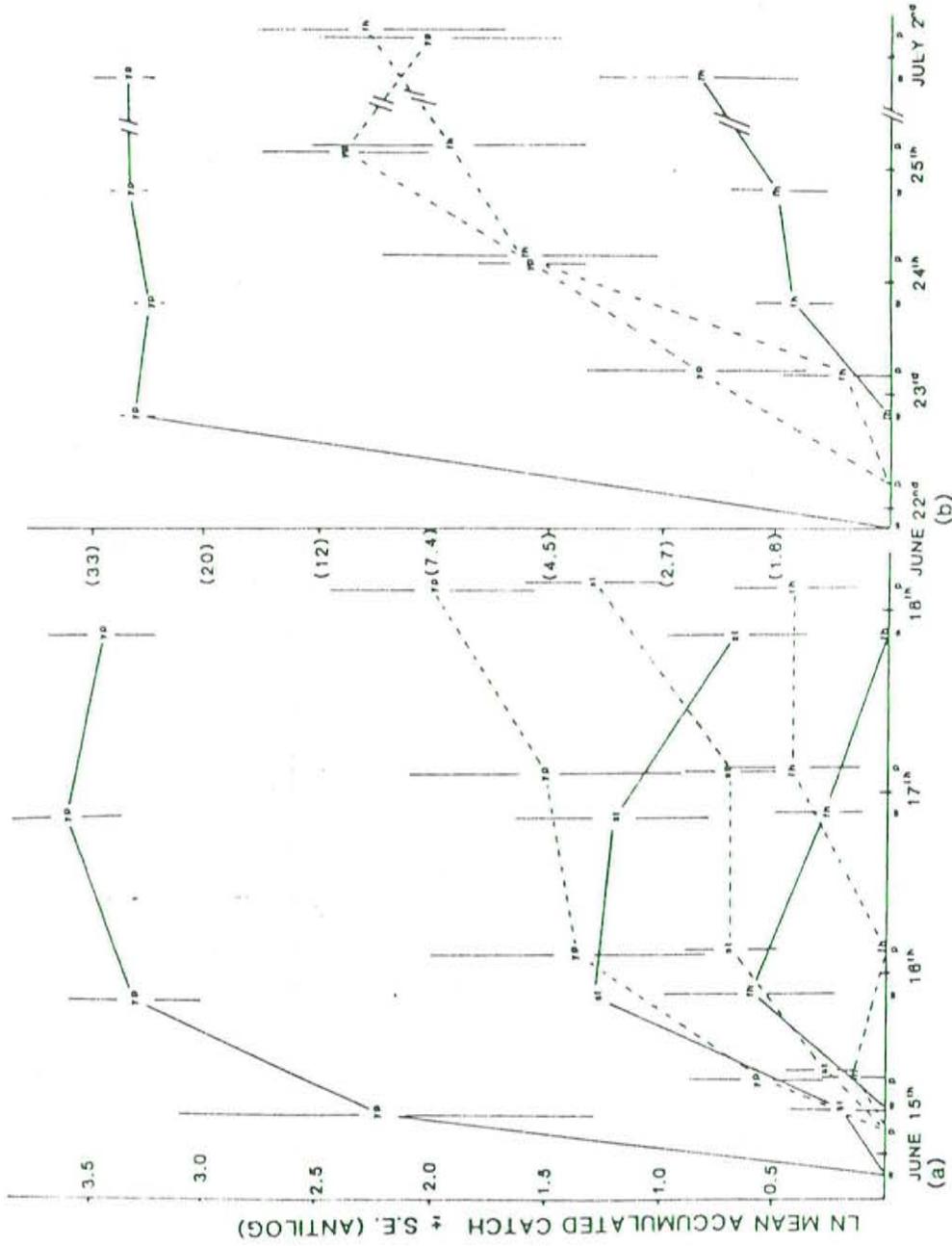


Figure 9. Mean accumulated catch over a) three days b) 10 days in wire (-----) and plastic traps (-----). n = 5. fh; fatheads, p; plastic, st; stickleback, w; wire, yp; yellow perch.

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Nest Selection by the Brownheaded Cowbird, (Molothrus ater):
Habitat Preference

by June Marie Tugwood

Department of Zoology
University of Manitoba

INTRODUCTION

Nest selection by Brown headed Cowbirds (Molothrus ater) may be governed in three general ways: 1) the cowbird may select a particular host species for parasitism, 2) it may select within a species the specific adult pairs which may, through some of their behaviours, reveal that they would be preferred hosts over other individuals, and/or 3) the cowbird may select a general habitat type within which it will concentrate its egg-laying (Lowther 1979, McGeen 1972, Thompson and Gottfried 1981).

This study, initiated in the summer of 1982, endeavours to investigate the importance of two of these three categories of selection. The first category, species selection, is not examined; one host species, the Yellow Warbler (Dendroica petechia), was studied exclusively for cowbird parasitism. This past summer, the study focussed on the habitat; the purpose of the study was to investigate whether Yellow Warbler nests which had been parasitized differed in habitat from nests which had not been parasitized.

METHODS

The breeding of the Yellow Warbler was followed closely, in particular noting when cowbird parasitism was present, and resulting reactions from the host species. Intensive nest searches were conducted throughout the warbler breeding season, with nests checked regularly and the status and outcome of each nest being recorded. The location of these nests on the ridge was noted in the following manners: the nests which were located on the northern side of the ridge, on the slope facing northwards toward Lake Manitoba, were designated as 'north'; those found on the southern side, within stands of pure or nearly-pure Sandbar Willows, were 'southern'; those found in the central region of the ridge were considered 'central'.

When Yellow Warbler nesting was completed, 72 nest sites were examined with several habitat parameters being measured. The specific parameters measured with respect to each nest were: nest height; "nest-tree" height; species of nest-tree; circumference of nest-tree at breast height (CBR); depth of the nest; and width of the nest (distance between outer edges: if $< 5\text{mm}$ difference was found in two perpendicular measures, a single measure was used to represent the diameter of a circle. If a difference of $> 5\text{mm}$ was noted, both measures were recorded). Also, an index of concealment of the nests was devised: from a distance of 15 cm from the nest, the extent of coverage of the nest was estimated. A reading of 0-5 was assigned depending on coverage of the nest: 0=0-5% cover, 1=5-25%, 2=25-50%, 3=50-75%, 4=75-95%, 5=95-100%. Six readings were taken for each nest, from the compass directions and from directly above and directly below the nest.

The nest site was defined as the area encompassed by a circle of radius five metres, with the center being the nest in question. Measurements made with respect to nest site included: species, height and CBR of first and second nearest-neighbour trees; height, species and CBR of ten randomly-selected trees; distance to an open area (defined as an area with a minimum width of three metres, a canopy not less than five metres in height, and being continuous with other open areas ie. not isolated and enclosed); total stem density, subdivided by species; and a qualitative rating of ground cover (plant species present, density, height). Canopy cover was indexed by presence/absence readings at one metre intervals, along the compass points (five per direction = 20 total per site).

Analysis of the nests will involve discriminant analysis on the habitat features, to determine whether the habitat of nest sites with cowbird-parasitized nests differs from nonparasitized nest sites. All previously-mentioned variables will first be grouped using a principle-components analysis, before the discriminant analysis is performed.

RESULTS

All results presented are preliminary; the bulk of the statistical analysis has not been completed at the time of writing. Thus, the results mentioned below should be considered tentative only.

The nesting success of the Yellow Warbler, and the cowbird success within warbler nests are presented in Tables 1 and 2. For the parasitized nests, the percent eggs laid that hatched, the percent eggs that fledged young (42.2, 15.6%) are comparable to Goossen's (1978) findings of 40.4 and 16.6%, respectively. Percent hatched that fledged young is slightly lower in this study (37.0%) than Goossen's finding of 41.1%. In non-parasitized nests, the percent eggs that hatched in this study (50.5%) was lower than Goossen (61.0%); percent hatched that fledged, however, was higher (75.0%) than found previously (66.7%). Percent eggs laid that fledged young were similar for both studies (37.9%, current; 40.2%, Goossen, 1978).

The parasitism rate this summer was 20.3%, which was lower than the rate found by Goossen and Sealy (1982) over three summers (25.5%). However, cowbird success in Yellow Warbler nests - percent eggs laid that hatched, percent hatched that fledged young, and percent eggs laid that fledged young (Table 2), were found to be higher than those reported by Goossen (1975).

Overall, of all warbler nests, 4.8% of the active nests (ie. with at least one warbler egg present) produced a single fledgling cowbird.

From those nests used for habitat analysis, fewer parasitized nests were found on the 'south' side of the ridge (Table 3). No distinct trends were seen in nest-tree species between parasitized and non-parasitized nests (Table 4); the "other" category mentioned is comprised mostly of shrubs, rarely over 1.5 metres in height.

DISCUSSION

In terms of Yellow Warbler and cowbird breeding success, last summer does not appear to have been extraordinary. Fewer nests were parasitized on the south side, which is primarily composed of Sandbar Willow stands, but parasitism is seen in the Sandbar Willow (Table 4). Cowbirds do not lay in this area apparently for reasons other than the fact that nests are in willow trees. The southern area has a dense growth of willow and undergrowth, particularly in the latter part of the breeding season. The cowbirds may prefer an open area, with less tall and dense undergrowth; perhaps the cowbird can more easily observe nesting warblers from a more open area, and may thus search the other portions of the ridge for nests more than the southern area. Another factor which must not be discounted is the presence of host species other than the Yellow Warbler. The central and northern part of the ridge represents a greater variety of habitat types, and it is possible that more host species and host pairs are more easily found if the cowbird searches these areas: if it searched more intensively in the southern edge, it might not find other hosts' nests, and thus might not find the greatest number of host nests possible.

The incorporation of all factors into the principal components/discriminant analysis should reveal what general type of habitat (if any) the cowbird may be selecting, or avoiding, when searching for nests.

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Table I: Yellow Warbler nesting success, 1982.

Parameter	Parasitized Nests	Nonparasitized Nests	Total
# nests	47	185	232
# eggs	147	711	858
# nestlings	62	359	421
# fledglings	23	270	293
% eggs laid that hatched	42.2	50.5	
% eggs hatched that fledged young	37.0	75.0	
% eggs laid that fledged young	15.6	37.9	

Table 2: Cowbird fledging success in Yellow Warbler nests, 1982.

Parameter	
# eggs laid	46
# nestlings	18
# fledglings	11
% eggs laid that hatched	39.1
% eggs hatched that fledged young	61.1
% eggs laid that fledged young	23.9

Table 3: Differences in rate of parasitism (according to the position of the host nests on the Ridge)

	# Parasitized Nests	# Nonparasitized Nests	% Parasitized
North	9	18	33.3
Central	20	38	34.5
South	3	45	6.25

Table 4: Differences in parasitism according to nest-tree species

Tree Species	# Parasitized Nests	# Nonparasitized Nests
Sandbar Willow	5	26
Manitoba Maple	5	9
Green Ash	4	6
Peach-leafed Willow	0	3
Other (shrub)	8	6
Totals	<u>22</u>	<u>50</u>

Taxonomy of Acuarioid Nematodes (Acuarioidea:
Schistorophinae) of Shorebirds (Charadriiformes)

P.L. Wong

Department of Biology
Lakehead University

INTRODUCTION

Nematodes belonging to the superfamily Acuarioidea are found in the lumen of the oesophagus and proventriculus and under the gizzard lining of birds. The superfamily presently consists of three subfamilies: Acuariinae, Seuratinae and Schistorophinae.

In the subfamily Schistorophinae, five genera are recognized: Schistogendra Chabaud and Rousselot, 1956; Schistorophus Railliet, 1916; Sciadiocara Skrjabin, 1916; Viktorocara Guschanskaja, 1950 and Ancyracanthopsis Diesing, 1861. A literature search revealed that most of the 44 species presently assigned to this subfamily have been reported from shorebirds. Unfortunately, many species lack modern descriptions; some of them have not been reported since their original descriptions. For example, Adams and Gibson (1969) reviewed Ancyracanthopsis and listed the original description of A. bilabiata by Molin (1860) as the only report of the species. Furthermore, some authors still employ the one-species-one-host concept when proposing new species (see Mawson, 1968). These reasons have therefore limited our understanding of the distribution and epizootiology of this subfamily of worms in shorebirds.

MATERIALS AND METHODS

Various species of birds belonging to four families, namely, Recurvirostridae, Charadriidae, Scolopacidae and Rallidae were collected at the University of Manitoba Field Station, Delta Marsh (50°11'N89°19W) three km west of Delta, Manitoba. Birds were collected using either mist nets (2.0cm X 2.0cm mesh size) or a 410 shotgun and number six shot.

Individual birds were weighed and skinned. The skins were put in plastic bags and placed in the freezer. Study skins were prepared within 10 days after freezing and subsequently deposited in the ornithological collections at the Department of Biology, Lakehead University, Ontario; Department of Zoology, University of Guelph, Ontario; Department of Zoology, University of Manitoba, Manitoba and its affiliated University Field Station, (Delta Marsh), Delta, Manitoba.

The carcass was opened, the bird sized and the oesophagus, proventriculus and gizzard removed and placed in large petri dishes containing 0.9% saline. These regions of the alimentary tract were opened, the lining of the gizzard peeled and examined for worms using a dissecting microscope. Worms recovered were placed in 0.9% saline in small petri dishes.

Worms for scanning electron microscopy were kept in the refrigerator overnight in saline and subsequently fixed in 2.5% cacodylate buffered glutaraldehyde. They were washed in buffer and post-fixed in 1% osmium tetroxide. Specimens were then dehydrated through an alcohol series, critical dried with CO₂, placed on metal stubs, coated with gold-palladium and scanned with a Cambridge Stereoscan S600 electron scanning microscope. Specimens for light microscopy studies were fixed in hot 70% glycerin-alcohol and stored for later examination in pure glycerin.

In addition to those birds collected at Delta, birds from Oak Lake, Manitoba, and Brooks, Cowoki Lake and Foremost, Alberta, were also examined. These birds collected by Dr. Al Bush, University of Brandon, Brandon, Manitoba, were shot and immediately frozen in dry ice. They were subsequently thawed and the gizzards removed and examined for worms. Worms recovered were preserved in 70% glycerin-alcohol and cleared in pure glycerin for morphologic studies.

RESULTS AND DISCUSSION

A total of seven species of nematodes belonging to the subfamily Schistorophinae were recovered from examination of 200 shorebirds. Through the kind co-operation of museums around the world the types of as many species as possible will be studied in detail and compared with our material from Canada. On this basis, we will provide complete redescriptions of species that are considered valid at this time. In addition, a key to these species will also be provided.

Next year we hope to examine charadriids and scolopacids from May to September. From the field data of this year and next, we hope to determine if transmission of these acuarioids occurs on the breeding ground of these birds. In addition, we also hope to examine the epizootiology of this subfamily of worms in shorebirds.

ACKNOWLEDGEMENTS

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Appendix I

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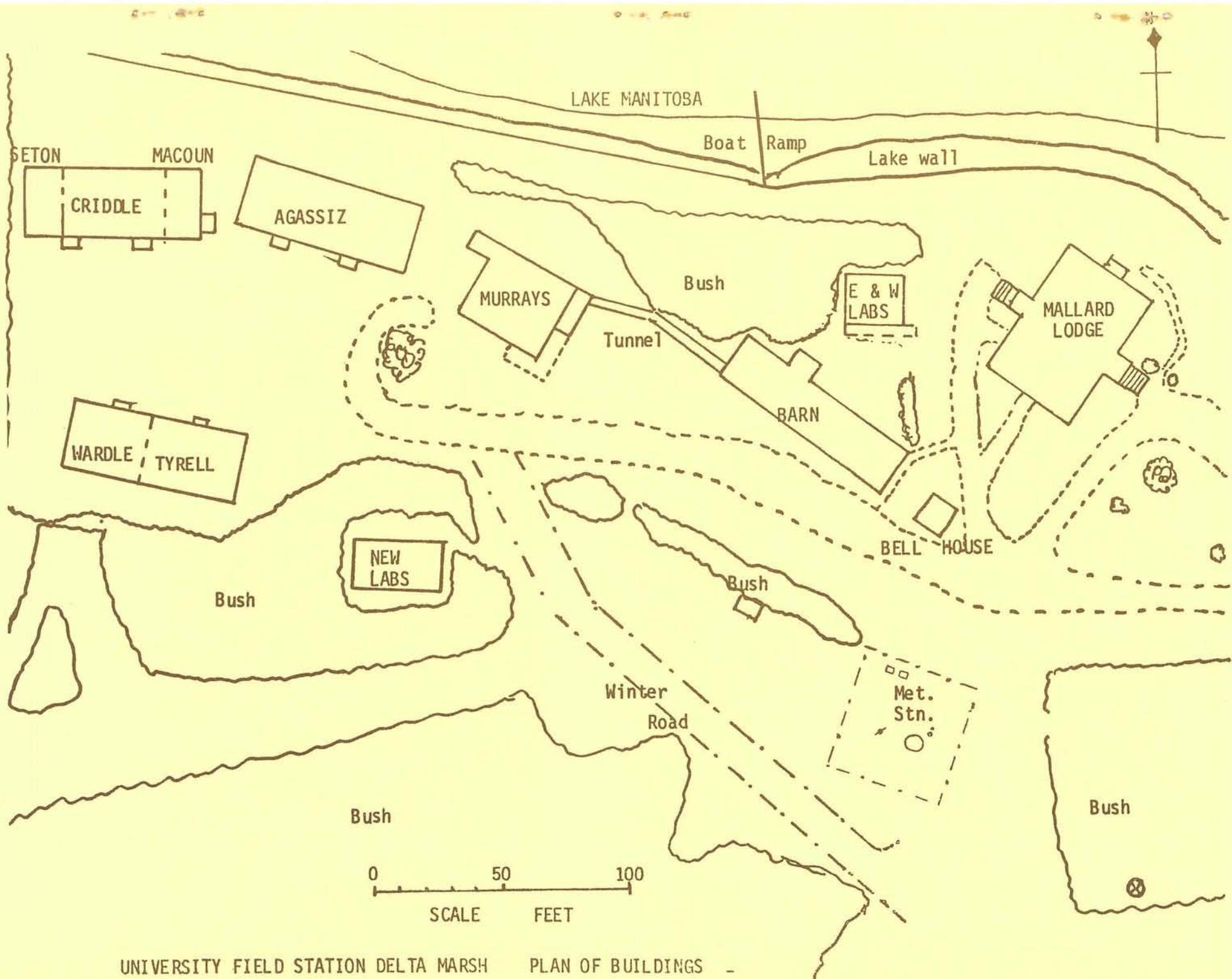
Appendix II

Theses Resulting from Work at
the University Field Station (Delta Marsh)

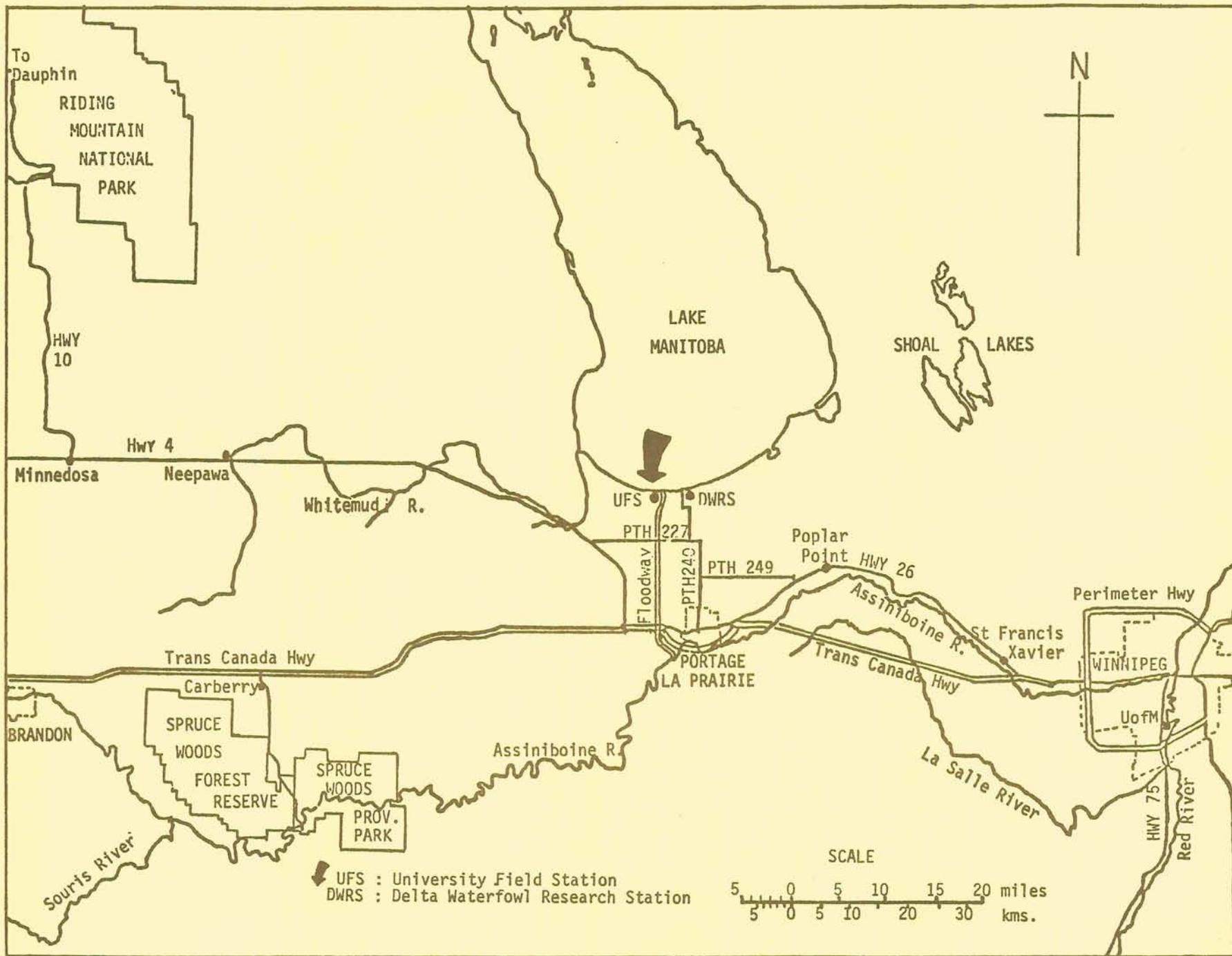
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UNIVERSITY FIELD STATION DELTA MARSH PLAN OF BUILDINGS



UFS : University Field Station
 DWRS : Delta Waterfowl Research Station

