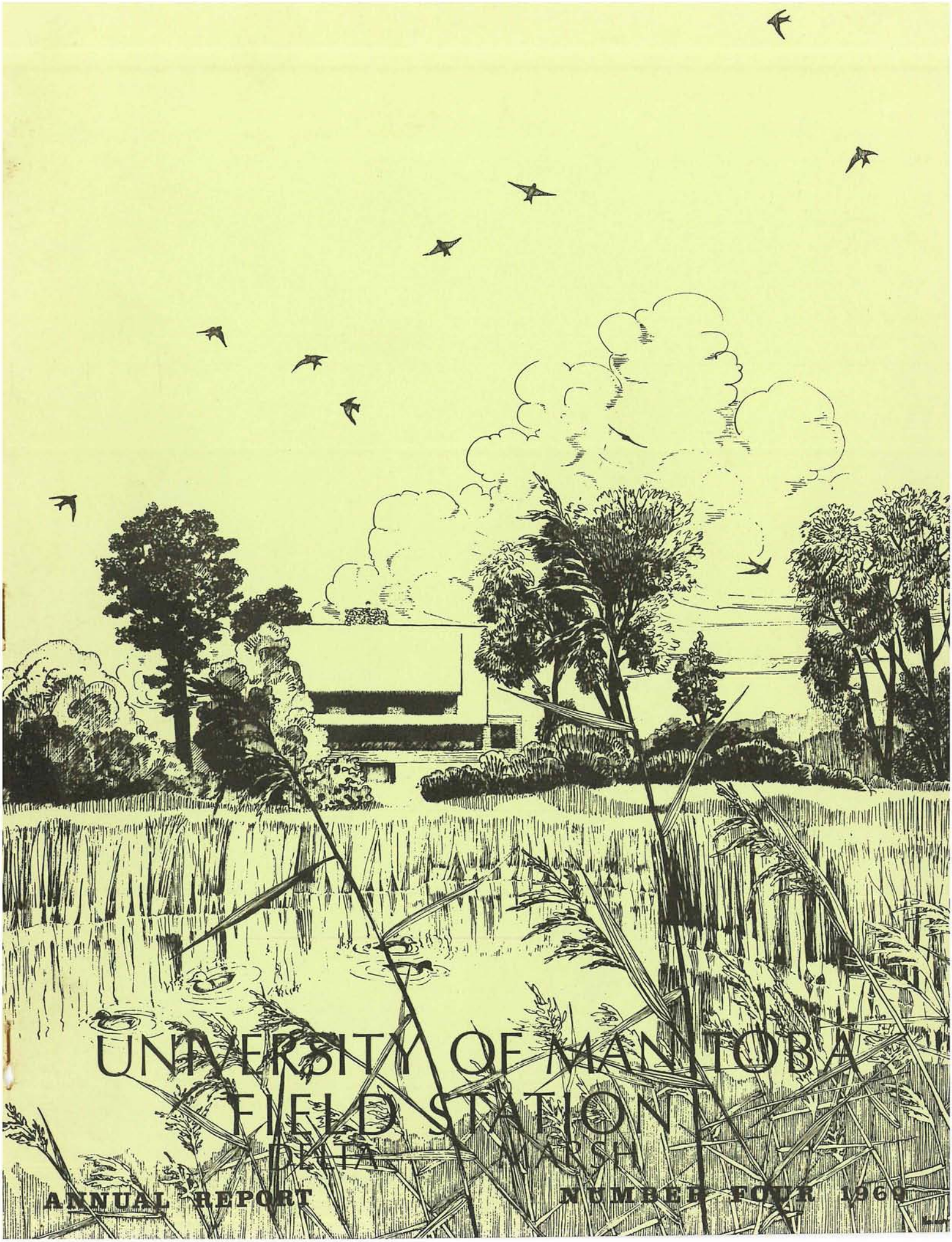

UNIVERSITY OF MANITOBA FIELD STATION

DELTA MARSH

ANNUAL REPORT NUMBER FOUR 1969

UNIVERSITY OF MANITOBA FIELD STATION
(DELTA MARSH)

FOURTH ANNUAL REPORT
1969

DIVISION OF BIOLOGICAL SCIENCES
THE UNIVERSITY OF MANITOBA
WINNIPEG 19, MANITOBA

C O N T E N T S

C O N T E N T S (cont'd)

Director's Report, 1969

The University Field Station had another successful season and fifteen research projects were undertaken during the summer. They included:--population and productivity studies in algae and emergent marsh species; nitrification processes in marsh soils; the relationship between evapotranspiration in Phragmites and water table fluctuations; ecological studies on benthic fauna; factors determining mollusc distribution; population dynamics of Brook Sticklebacks; comparative ecology of two species of Shiner; internal helminths of two amphibian species; reproductive biology of Forster's Tern; territory in the Yellow Warbler, seasonal energy balance in the muskrat; geomorphic, sedimentological and stratigraphic investigations of the area between Portage la Prairie and Lake Manitoba and groundwater studies in the Delta area.

We had the pleasure of visits from a number of distinguished scientists from various parts of the world. The Department of Anthropology held a field course for one month and groups from Botany and Zoology stayed at the Station for shorter periods of time.

The following staff, students and technicians spent all or part of the summer at the Field Station:

FACULTY	GRADUATE STUDENTS	SUMMER ASSISTANTS
J. M. Walker	T.O. Acere (Zoology)	W. Dentry
G. G. C. Robinson	H. Bauer (Psychology)	L. Hendzel
J. Wright	D. Bernard (Zoology)	T. Hochbaum
C. T. Shay	D. Brown (Botany)	J. Leberdensky
R. M. Green	L. Hlynka (Zoology)	P. Lemon
	M. Fenton (Earth Science)	K. Machniak
	D. Lutchman (Earth Science)	R. Moyshenko
	M. McNicholl (Zoology)	T. Sulymko
	F. Phillips (Botany)	G. Vascatto
		J. Yarysz
		C.K. Yeung

The first project started in early April, and from then until mid-September the accommodation was used for 265 resident-weeks with 4,269 meals being served! There are two projects continuing throughout the winter.

Seminars

A weekly programme of seminars and films was held in June July and August, and we were privileged to hear lectures from Dr. L. Rudescu (Roumania), Dr. R. Nero (Manitoba Museum of Man and Nature), Dr. R. Miller (Yale University), Mr. L. Gray (Water Control and Conservation, Department of Mines and Natural Resources), Dr. J. M. Walker (Botany, University of Manitoba), Dr. E. S. Burch (Anthropology, University of Manitoba), Dr. G. G. C. Robinson (Botany, University of Manitoba), Dr. D. Schindler (Fisheries Research Board, Winnipeg), and Dr. G. Brunskill (Fisheries Research Board, Winnipeg). We welcomed the participation of members of the Delta Waterfowl Research Station at these seminars and appreciated their invitation to attend the two-day Seminar on "Spacing Mechanisms in Waterfowl" and their July and August seminar series.

At the 3rd November Seminar fifteen research summaries were presented, including reports from Mr. F. Austin and Mr. P. Ould, graduate students in the Department of Zoology who carried out their work at the Delta Waterfowl Research Station. The seminar attracted about 80 people, promoted discussion and is now well established as an important part of the Field Station programme. Brief summaries of most of these projects form the major part of this Annual Report.

Courses

Anthropology 76.662

A small Archaeological Field School led by Prof. C. T. Shay of the Department of Anthropology was held during the month of July. The class surveyed for archaeological sites in the area and spent two weeks excavating a small campsite on the Bell Estate. The campsite, located on a small beachridge, yielded stone artifacts and pottery dating between 1300-1600 A.D. We would like to extend to Mr. P. Ward our appreciation for permission to excavate this site and for helpful assistance throughout the course.

Comparative Chordate Zoology 22.220 and Plant Kingdom 1.220

Dr. G. Ross and Dr. B. Young respectively spent useful days at the Field Station with their students.

Introductory Ecology (Botany 1.336 and Zoology 22.334)

Three sections each of 3 1/2 days duration were organized by Drs. J. Gee, J. M. Stewart. J. M. Walker and J. F. Wright, assisted by Mr. D. Bernard. Two sections were held in Registration Week and one the following weekend. During the course, the students were introduced to a variety of habitats, sampling techniques and methods of assessing environmental parameters, which give an insight into the structure and functioning of ecosystems.

Plant Ecology 1.452

Drs. J. M. Stewart and J. M. Walker organized a weekend course in Plant Ecology with emphasis upon ordination and sampling techniques as an aid to plant community description.

Advanced Taxonomy 1.442

Dr. R. Longton conducted a weekend course during which intensive collecting of critical groups from a range of habitats was undertaken. The collections were for analysis later in the term.

Marsh Ecology 1.721

The Marsh Ecology course spent a weekend at the Station with Drs. J. M. Stewart and J. M. Walker, and examined the plant communities from the lakeshore to the forested ridge and from the wet meadow to the marsh. Materials were collected for plant and soil analysis, calorific determinations, etc.

Visitors

We had the pleasure of visits from members of a number of other Universities and institutions: Dr. T. Pritchard (Nature Conservancy, U.K.), Dr. D. Bellamy (Durham), Dr. L. Rudescu (Bucharest, Rumania), Dr. K. Patalas (Freshwater Institute), Dr. Bilden (Macdonald College), Dr. D. Pimlott (Toronto), Dr. G. Ross (Southern), the members of the Board of Trustees of the North American Wildlife Foundation, Dr. B. Kendrick (Waterloo), Miss V. Humphreys (National Museum, Ottawa) Miss M. Dwyer (National Parks, Ottawa), Mr. E. Carp (International Wildlife Research Bureau), Dr. A. Johnson (Hendrix College), the members of the 11th Delta Waterfowl Research Station Seminar, Dr. G. MacLachlan (McGill), Dr. J. Burnett (Glasgow), Dr. H. Dale (Guelph).

Special Events

There were three events worthy of special mention. On August 14th, Dr. H. H. Saunderson officially opened the new laboratories at the Station, when we were happy to be joined by friends from the University, Provincial Government and others. A tour of the facilities and displays by graduate students helped to make the day a memorable one.

The Biology Division Picnic in July was the occasion for a gathering of more than eighty for a beach celebration which became the merrier when driven indoors by rain.

Perhaps the marathon social event was a barbeque supper for the 128 participants at the International Coregonid Conference on August 27th, accompanied by suitable musical revelry.

Buildings

During the winter and spring two cottages were built east of Mallard Lodge and Murrays Cottage was renovated. The transformation of the latter was completed with the assistance of graduate students armed with paint brushes and permitted the building to be used for the Archaeology Field Course. The Bell House was converted into a laboratory by Dr. Robinson and Dennis Brown. However, despite this increase in facilities, the basement of the lodge was in constant use as a laboratory. A site plan and survey was prepared during September to enable future expansion to take place on an orderly basis.

I would like to express appreciation for the efforts the Provincial Government made to acquire for the Field Station two housing units from the Macdonald Airfield. These will be brought to Delta during the winter and will provide the laboratory and living accommodation which is essential if an expanding programme of research and teaching is to be carried out at the Field Station.

General

We are grateful for the opportunities afforded to us to use the Bell Estate for various projects and for the friendly co-operation extended to us by the members of the Delta Waterfowl Research Station. Thanks are also due to the Portage Country Club for allowing us to use their property for study purposes.

To all departments of the Provincial Government upon whose jurisdiction we impinge, warm thanks are extended for their many kindnesses.

I would like to thank all the staff for their help during the season and look forward to an even more successful year in 1970.

Jennifer M. Walker

Jennifer M. Walker
Director.

Mark and Recapture Techniques on Culaea inconstans (Brook Stickleback) in Delta Marsh Ditch

T. O. Acere

Department of Zoology

Introduction

The purpose of this project was to assess different techniques for estimating vital statistics such as population numbers in a closed system from time to time. From this knowledge, the following population parameters could be estimated: survival, growth rate, recruitment and mortality during the time of study. After one week's survey of the marsh for a suitable site, it was decided to use the Ditch situated south-east of Mallard Lodge on the southern shore of Lake Manitoba.

Methods

The Ditch was screened with double mosquito net wire gauze and about 3 in. sq. mesh thick wire gauze at the southern end of it thus creating a closed system. The first sampling was carried out on May 7th, 1969, and this yielded unsatisfactory results indicating a very sparse population. Stocking was carried out by transplanting over 1000 Culaea inconstans which were collected with minnow traps at the mouth of the Assiniboine Diversion. This process was facilitated by the migration of some cyprinids and sticklebacks up the Diversion. The migration upstream, which reached a peak on May 13th, 1969, is for spawning purposes, an activity which starts in early June to about mid-July and/or late August.

The samples were collected using a 15 ft. seine-net until mid-July, when a 35 ft. seine-net was made by joining two 10 ft. nets with one of 15 ft. This resultant net was ideal for one person seining a bigger area than before. By the beginning of July, the Ditch was overgrown with hydrophytes and weeding was carried out throughout the Ditch during the remainder of the summer. The clearing of weeds introduced an added mortality factor as there were always fish in the weeds cleared, some of which escaped observation and were thrown out of the Ditch together with the weeds. When the Ditch was overgrown with the hydrophytes, it was impossible to seine.

Seined fish were taken to the laboratory and kept in aquaria containing ditch water. From May to June the fish were weighed on a beam balance, total lengths were measured with a vernier scale and dorsal spines clipped with a pair of scissors. From July onwards, the fish were placed in 1:15,000 solution of M.S. 222 for easier weighing, measuring and clipping.

During the summer, five marking experiments were conducted, for each of which one dorsal spine was clipped in a series of 1st to 5th dorsal spine. When the young of the year appeared in the sample taken on July 2, 1969, staining with "Bismark Brown Y" was attempted. This was unsuccessful due to failure of the stain to last longer than 3 days with solutions of 1:60,000 and high mortality when solutions of a higher concentration were used, irrespective of the time of exposure.

Results

Recaptures of previously marked fish were retained for aging, using the otoliths viz sagittae, the largest of three ear stones. This fish is between 20 mm to 23 mm long and approximately 3 weeks old. The second ring is set when the fish is one year old. There were no fish with more than 2 rings indicating that this species does not survive to live a third summer at Delta.

The following were observed to be predators: kingfisher, terns, Culaea itself on its young and eggs, waterboatman (Corixidae), and waterbugs (Notonectidae and Belostomatidae).

Food included fish eggs, young of Pungitius pungitius, Culaea inconstans, Hyalella, aquatic arthropods, ostracods, algae, hydrophytes, and detritus.

The data in table 1 show that there was a decline in the population of one year olds, the mass mortality occurring after spawning. It also shows a high turn-over of the young of the year and indicates that spawning stopped somewhere around early mid-August.

Date	t	n_t	S_t	m_t	$\hat{\alpha}t$	$\hat{F}_t$	$\hat{M}^o_t$	$\hat{N}_t$	$\hat{\mu}^o_t$	$\hat{\lambda}^o_t$	$\hat{N}^o_t$ **	$\hat{U}^o_t$ **
May 18	1	265	265	-	-	-	-	2783*	0.674	-	-	0.0562
May 21	2	146	133	13	0.08904	0.072520	179	2013	0.439	1.511	233	0.0403
June 10	3	101	91	10	0.09900	0.076140	131	1326	0.307	25.440	158	0.0437
Aug. 20	4	1734	470	11	0.00634	0.168631	65	10288	0.965	1.140	1670	0.1242
Sept. 5	5	530	479	27	0.05094	0.053359	506	9933	0.596	10.350	1388	0.0155
Nov. 25	6	320	0	3	0.00937	0.092664	-	-	-	-	-	-

Table 1: The values of different population parameters and variables from May 18, 1969 to October 25, 1969 of Culaea inconstans in the Project Ditch, Delta Marsh.

* Petersen Estimate.

** Standard error of.

Key to Symbols

t = time when the t^{th} sample was taken.

n = number of fish in the t^{th} sample.

S_t = number of fish in the t^{th} sample that were returned to the ditch after marking.

m_t = number of marked fish recaptured in the t^{th} sample.

$\hat{M}_t$ = total population of marked fish at the moment of capture of the t^{th} sample.

$\hat{N}_t$ = total population at the time of t^{th} sampling.

$\hat{\alpha}_t$ = proportion of marked fish in the population at the moment of t^{th} capture.

$\hat{\mu}_t$ = survival rate, which is the proportion of fish alive at the time of release of the t^{th} sample which survived to the time of (t+1)th sampling.

$\hat{\lambda}t$ = the measure of the proportion of new members in the population.

$\hat{F}_t$ = fraction of the population sampled at the t^{th} sampling.

Territory in the Yellow Warbler, Dendroica petechia: a Report on an Introductory Investigation

Harold R. Bauer

Department of Psychology

"The Yellow Warbler is a bit of feathered sunshine. In his plumes dwells the gold of the sun, in his voice its brightness and good cheer. We have not to seek him in the depths of the forest, the haunt of nearly all his congeners, he comes to us and makes his home near ours." This is the way in which Frank M. Chapman (1907), in part, described the species in the book he authored early in the century on North American Wood Warblers (Parulidae). Warblers have attracted a considerable amount of popular attention, having been the subject of two more recent books; a rather ornate one by Griscon and Sprunt (1957) and a two part volume in Arthur C. Bent's (1953) "Life Histories". Despite the considerable attention that parulids have received, little of it has been focused on behavioral aspects of the family.

Exceptions exist in the dearth of behavioral work, the major one being Charles Kendeigh's (1941) study of the birds of a prairie community; and the comparative ethological studies of wood warblers by Millicent and Robert Ficken (1962; 1965). It was on the latter work that much of the conceptual and terminological basis of this study was founded.

The intention of this study was to introduce the student to territorial behavior in the yellow warbler and problems surrounding its study. The investigation was made during a two and one-half month stay at the University of Manitoba Field Station (Delta Marsh), during the summer of 1969. As the student had not even known what a yellow warbler was six months before, a considerable amount of time initially as spent observing the many species in the Delta Marsh area. In this respect the innumerable hours birding with a trained ornithologist, Martin K. McNicholl, were invaluable to the study and much appreciated. It was also found that the territorial displays could not be reasonably understood without a general understanding of the life history of the yellow warbler To facilitate this an ancillary study of daily nest records was kept on thirty-five yellow warbler nests ranging from the first discovery of a nest under construction on June 3rd until leaving the Field Station on July 20th.

The concept of territory is as old as the science of ornithology, going back to Aristotle (384-322 B.C.) describing eagles defending a territory about their nests ((Lack, 1944; Nice, 1953). Scattered references to territoriality in birds appeared until Johann Bernard Altum (1824-1900) published the ornithological epic Der Vogel und Sein Leben in 1868. Altum noted that males fought for the defense of an area, rather than females, permitting the selection of the healthiest individuals for reproduction (Mayr, 1935).

Henry Eliot Howard's (1873-1940) book Territory in Bird Life was largely responsible for bringing the concept of territory to the attention of English speaking ornithologists and their literature (Nice, 1941; Huxley and Fisher, 1964). Although Emlen (1957) has criticized the definition of territory as putting too much emphasis on the area as the object of defense rather than a local dominance, it is accepted as being defined (e.g. Hinde, 1956) as "any defended area" after Noble (1939).

The Habitat and Methods of Study

As might be expected the habitat dictated the methods of study. The area choosen for study was the tree covered beach ridge beginning at the main lodge of the Field Station and going west for one and one-quarter miles. The sandy ridge goes back from the southern shore of Lake Manitoba approximately one hundred and fifty to two hundred feet at the end of which are fourteen foot high willow stands bordering on the Delta Marsh. The beach was used as an access, as other ridge areas near the Field Station with road accesses were too highly trafficked. This decreased the number of open observation points from elevated areas and was one arguement for constructing an elevated, portable blind.

The eighteen foot high by four foot square blind provided a 360^{o} view of the surrounding area from a collapsible aluminium chair at the fourteen foot elevation. Access was made to the hop-sack enclosed and floored compartment by a wooden-runged rope ladder. Structural rigidity for the four, one inch square, eighteen foot long, tubular aluminium uprights was provided by three, four foot square, three quarter inch, angle iron box frames at different elevations. Internally, eight cross-hatched, wire main stays maintained its rigidity, while four, one-quarter inch lines radiating from the corners kept the blind stationary externally. It stood high winds and rains requiring only semi-daily checking of anchors. It weighed less than one-hundred pounds and was transported from site to site by one person on a yoke.

Other equipment included a pair of 8 x 30 binoculars, which were quite appropriate for the often tight standing willows in not being bulky. Field notes were written and sometimes taped and transcribed. Tape recording of vocal displays were made with poor equipment and played back to incite displays be territorial males. Most behavioral observations were made in the morning beginning at sunrise and nest rounds were made before sunset.

The most apparent interactions between habitat and methodology are seasonal changes. Initially the willows, the prime nesting habitat of the yellow warbler found, were free of leaves and permitted constant visual contact for extended periods. It was not until late June, however, that the blind was completed by which time visual contacts were more sporadic. The extensive growth of under brush also contributed to the metamorphosis of the study area.

Results and Discussion

The male yellow warbler has the main role in territorial defense carrying it out through a variety of aerial and vocal displays

directed against conspecifics. From the first arriving males approximately May 14th, followed by arrival and pairing with females, about five days later, through nest construction, courtship, laying, incubation, care of altricials to feeding of fledgings, the territory is the center of all activity with the exception of occasional extra-territorial food-seeking sorties by the male. This three dimensional compartment served all these major functions in varying degrees through the fourth dimension, time. The three dimensionality of territorial space is apparent in that intrusions into a neighbors air space at elevations of forty to fifty feet from the ground, depending on the cover, did not precipitate an encounter. Such "fly-overs" were infrequent and usually constituted food sorties by the male.

Most intrusions into bordering territories by males precipitated an encounter, a male-to-male territorial interaction. When a gross encroachment was made, aerial "chases" were frequent. The intruding male would either be flown at while perching, or met in mid-air to be followed by a fairly prolonged zig-zagged pursuit until the encroaching male was displaced to its own territory. The pursuer would often then return to a perch just within its own territory. At times chases would be back and forth between each territory, ending in a "draw", as did most all encounters.

"Circling" or "arcing" was a frequent aerial boundary display. It consists of a flight towards the bordering opponent, which may displace him, and an arcing-away return to this home territory in a form ranging from an open arc to a nearly closed circle before re-perching. After turning away from the receiver in mid-arc, "gliding" was sometimes, but rarely, observed. This gliding away from the opponent consisted of wings and tail spread out until returning to a perch.

"Fighting" was sometimes preceded by the rapid wing beat and slow movement of "moth flight". Varying from encounter to encounter when it occurred, fighting was typified by two males flying towards each other and making striking movements towards the opponent. In some cases, contact occurred and in two cases pairs not only locked vertically, pulling apart, and flying up out of the ground cover in a "draw".

In between a series of aerial encounters or immediately following them, always while perched, infrequent displays included "tail-spreading", "wings out", and "sleeked postures". The sleeked posture refers to compression of plumage giving the bird a "slim" appearance.

All the above displays were performed by the male in maintaining his territory. The female, however, has a "nest territory" equivalent. During an interspecific encounter between a female yellow warbler and an eastern Kingbird, within twenty feet of an eighteen foot high nest, a variety of displays were observed. Fluttering of the wings as in "moth flight" occurred while the female moved from perch to perch between the opponent and the nest. Invariably such displays, and modifications of them, were given when the female caught the observer at her nest.

Vocal displays in the male include two principle types of song that are easily differenciated. The "accented ending song" is a series of four low frequency notes ended by three higher ones and is used usually up until the first clutch of eggs is laid. The "unaccented ending song", is found to begin during incubation and is the case after hatching. Muted

songs occur occasionally after encounters. (I never got my ears attuned to the point that I "heard" a muted accented ending song and a muted unaccented ending song as Ficken and Ficken (1965) suggest.

Females emit calls other than localization calls. Alarm calls are given in the immediate nest area when intruders are found. The female can be said to play a role in territorial defense by giving calls, infrequent though it is, when foraging for food near the territory perimeter after discovering a male, conspecific intruder. In at least one case this calling was followed by the mated male being attracted to the area and repulsing the intruder, while the female remained in the area.

Theoretically many functions have been ascribed to territory (Hinde, 1956). In the yellow warbler it has been implicated as a population-regulating mechanism (Ficken and Ficken, 1965b). It was observed that two established territorial males over a period of hours of displaying boxed out a third established territorial male. This third male had few and poor singing perches; a requirement for a territorial site that Kendeigh (1941) noted. The male's displays gradually became less intense and finally terminated with him leaving the area permanently. The determinition of territory as being a limiting factor in the yellow warbler would require a systematic investigation. Such an investigation, to draw conclusive evidence would require either a continual collection of new arrivals or, less drastically, a controlled capture, color banding, holding and release programme. In this manner you could argue whether or not territory acts as a dispersal mechanism. The second problem would be to determine that birds dispersed from the territory went to marginal habitats and suffered in breeding success. In a species with such a wide distribution as the yellow warbler the problems would be many.

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Depth Distribution of the Emerald Shiner, Notropis atherinoides, and the Spottail Shiner, Notropis hudsonius in Lake Manitoba

Don Bernard

Department of Zoology

Introduction

Emerald and Spottail Shiners belong to the largest of recognized fish families, the Cyrinidae. This family is characterized by soft-rayed fishes, having toothless jaws and teeth on the pharyngeal arches.

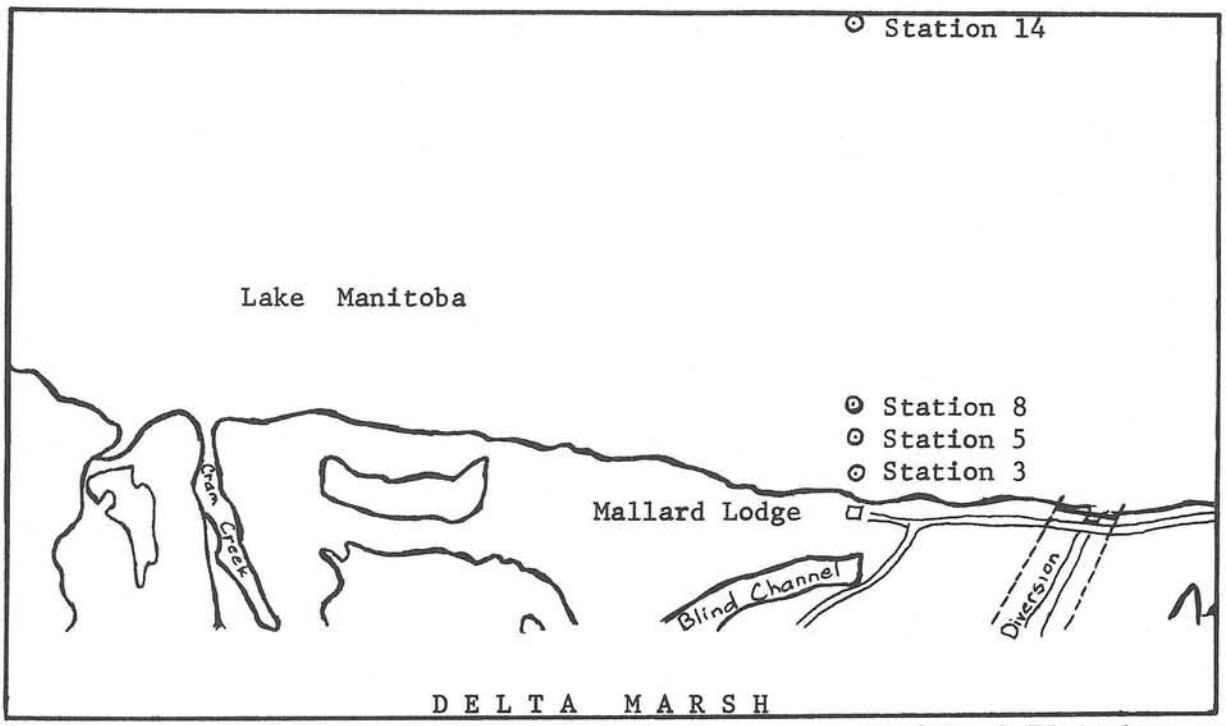
Cyprinids are found in the North Temperate Zone, throughout Africa, south-eastern Asia and China. Spottail and emerald shiners, however, are confined to the Temperate one of North America. Both species are found in lakes and large rivers, and usually reach a size of between 2.5 and 5 in. Both are spring spawners and move inshore to spawn over sandy shoals.

The species are morphologically similar, except that the emerald has a small oblique mouth while the spottail has a small terminal mouth with the upper jaw slightly overhanging the lower jaw. With these differences in mouth structure, it is believed that emerald shiners would be best adapted for a pelagic mode of life, feeding in midwater and surface, while spottail shiners would do better as a bottom-dwelling fish, feeding on bottom organisms. This hypothesis was tested by studying the horizontal and vertical distribution of both species over 24 hour periods at different times of the year.

Most of the summer of 1969 was spent testing various types of gear in order to determine which would catch both species efficiently. It was found that gill nets sampled the adults of both species and the fry were successfully caught with a tow-net.

Sampling Area

Sampling was concentrated along a transect (Fig. 1) extending for 1 mile due north of Mallard Lodge. A gang of monofilament gill nets (gang consisting of two 50 ft. nets, one of 1/2 in. mesh, and the other of 3/4 in. mesh size) was set parallel to shore in 3 ft., 5 ft., 8 ft., and 14 ft. of water to obtain information on horizontal spacing of Shiners. Each gill net was divided into panels 0.5 m. deep to record vertical distribution.



Scale: 3.75 inches per mile

Figure 1: Locations of gill net sampling stations.

Results of Gill Netting

The horizontal and vertical distribution of both species is shown in Figure 2. Day sets from July 3-14 show that spottails were found inshore and at the bottom except at station 8, while emeralds were found throughout the water column and were also abundant inshore. During the night sets, spottails were less abundant than during the day but did not change in distribution. The emerald's position in the water column became more defined, especially at station 14.

July 20-24, the spottails showed no change in vertical distribution, although they were more abundant in the nets at 15:00 hr. and 21:00 hr. emeralds were found at the surface at station 3. At station 5 during daylight they had a general distribution; while at night they were found at the surface. Similarly, at station 8 they frequented the surface and midwater at night.

August 20-24 and September 8-9 showed a considerable reduction in catch of both species. These two sampling periods seem to suggest that emeralds move offshore sooner than the spottails, with the spottails gradually moving offshore in early September. Sampling carried out in October revealed very few fish suggesting either a low period of activity or a movement offshore into deeper water.

Conclusion

In the area sampled, spottails were generally associated with the bottom while the emeralds were dispersed throughout the water column, especially during daylight, but at night they were most abundant in midwater and at the surface. However, the data shows considerable overlap in distribution between the two species. Also, movement offshore in late summer for both species is suggested by the data collected. There are limitations in sampling with gill nets and next summer trawling will be supplemented with gill netting to elucidate the problem. Also factors responsible for their distribution will be examined.

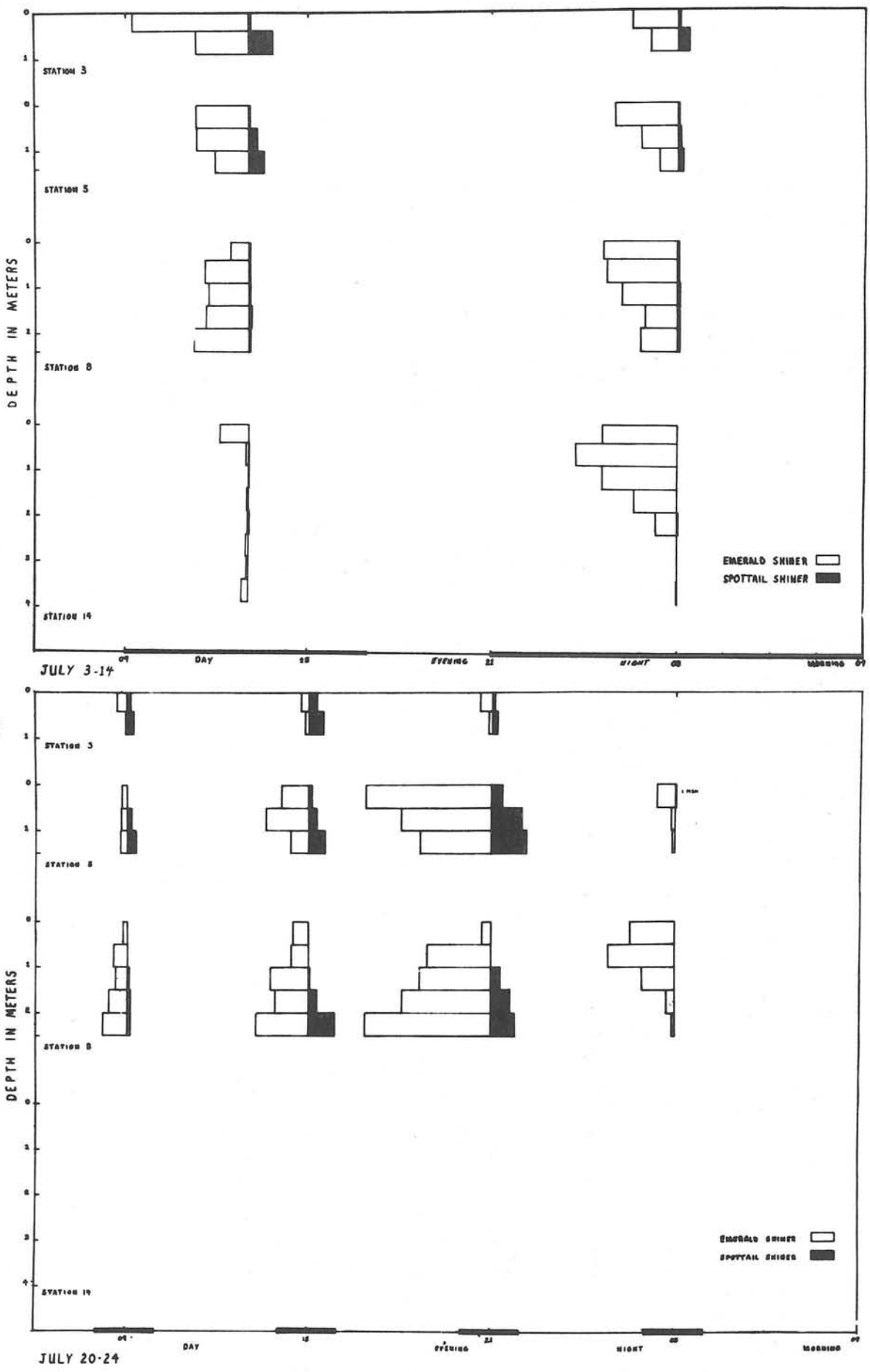
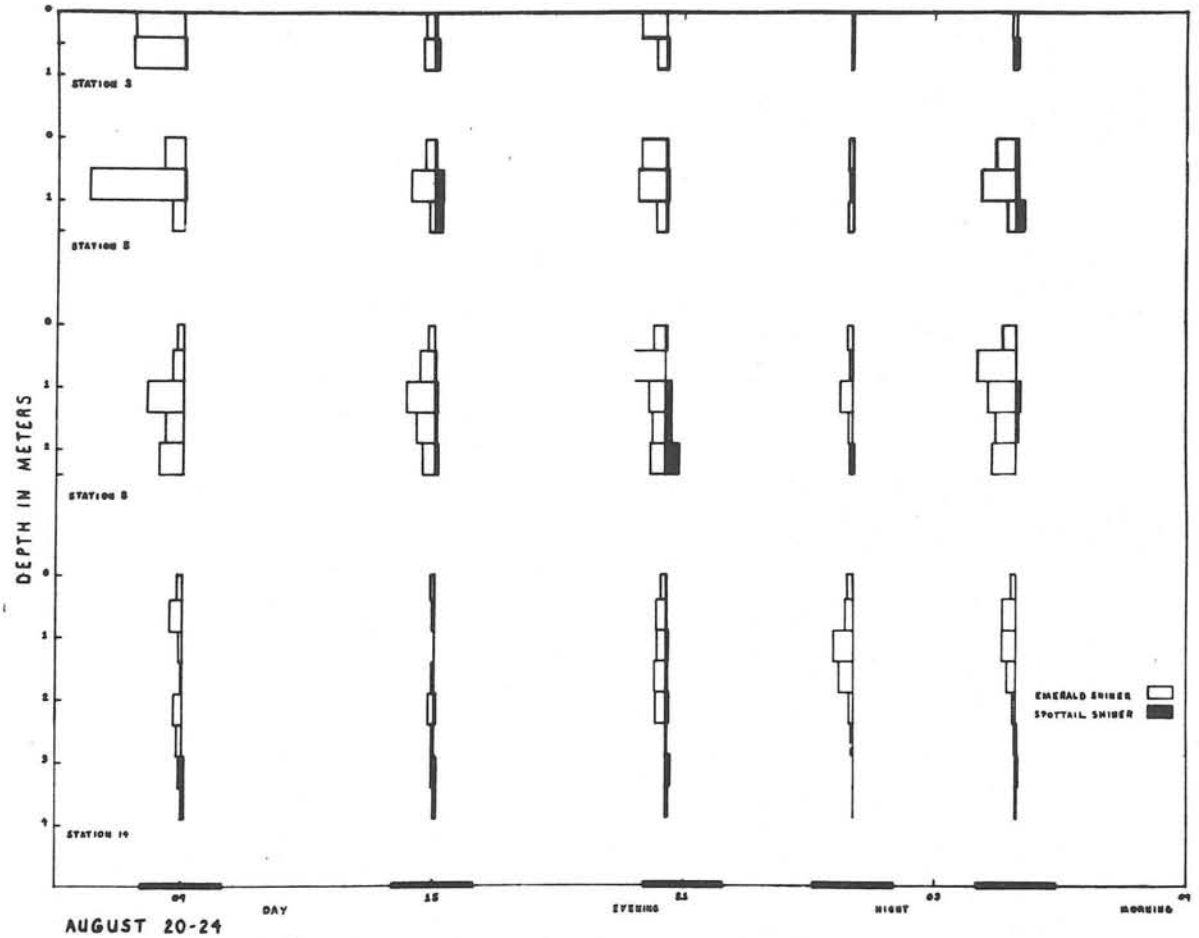


Figure 2: Horizontal and vertical distribution of Emerald and Spottail Shiners. July 3-14 and 20-24.



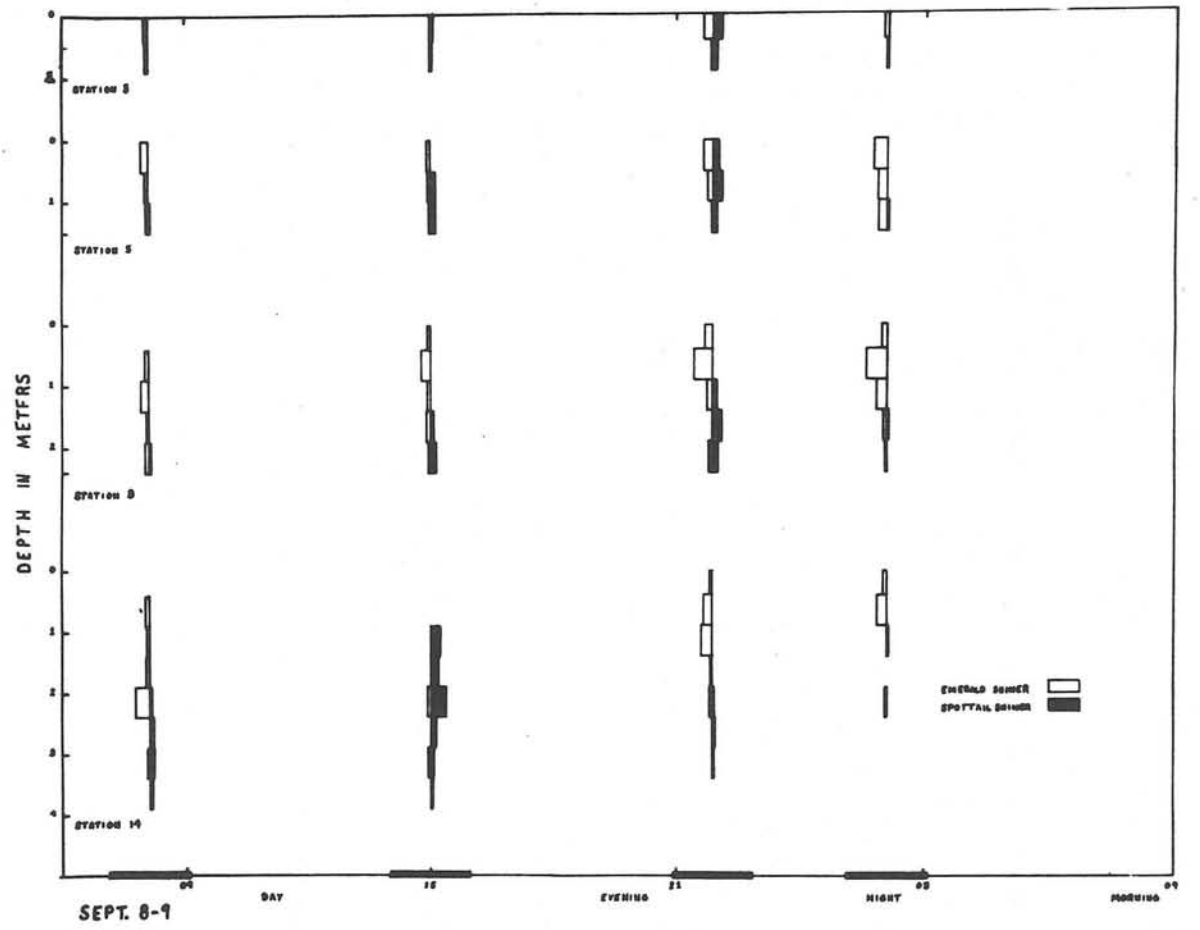


Figure 2: Horizontal and vertical distribution of Emerald and Spottail Shiner. August 20-24 and September 8-9.

Phytoplankton Succession in Cadham Bay

Delta Marsh, Manitoba

Dennis Brown

Department of Botany

Methods

Three sampling areas were studied throughout the period May to September 1969 at regular weekly intervals. Station 1 and 2 were similar in all aspects, although, depending upon wind direction, the number of cells per liter varied. Station 3 was situated in the channel linking Cadham Bay and Simpson Bay and varied somewhat in species composition. The maximum depth of the bay is 180 cm. (Station 1-140 cm.; Station 2-160 cm.; Station 3-180 cm.) In this discussion, only Station 1 will be considered because physical and chemical data is complete. Samples were collected at 0 and 1 m. depths with a Van Dorn sampling bottle. The water was taken to the laboratory where phytoplankton counts and water analysis was undertaken. Phytoplankton samples were concentrated in a centrifuge and counted according to genera in a Sedgewick-Rafter counting cell. Water analysis for total phosphate was undertaken using the Hach chemical analysis technique. Carbohydrate carbon results were determined utilizing an Anthron carbon technique. Nitrate and ammonia were analyzed spectrophotometrically.

Results and Discussion

Analysis of the total phytoplankton cells per liter indicated a close correlation between the 0 and 1 m. depths. Two prominent peaks were evident from the graph, one at the end of June and one at the end of September (Fig. 1).

Two peaks could be attributed to the Cyanophyta (blue-green algae). It was noted that the blue-greens did not become detectable in the samples until mid June. These curves were composed predominantly of the Aphanizomenon flos-aquae (Fig. 2). It is generally found in large numbers, due to the collection of many filaments into large macroscopic aggregations. Reproduction is by akinetes and fragmentation into new filaments.

The chlorophyta (green algae), (Fig. 3), showed an early peak in numbers before that of the Cyanophyta and an increase in cell numbers as the blue greens reach their peak and began to diminish. Crucegenia quadrata was predominantly responsible for the increase in the number of Chlorophyte cells. It occured in flat plates of sixteen cells, having broken to form new colonies.

Fig 1

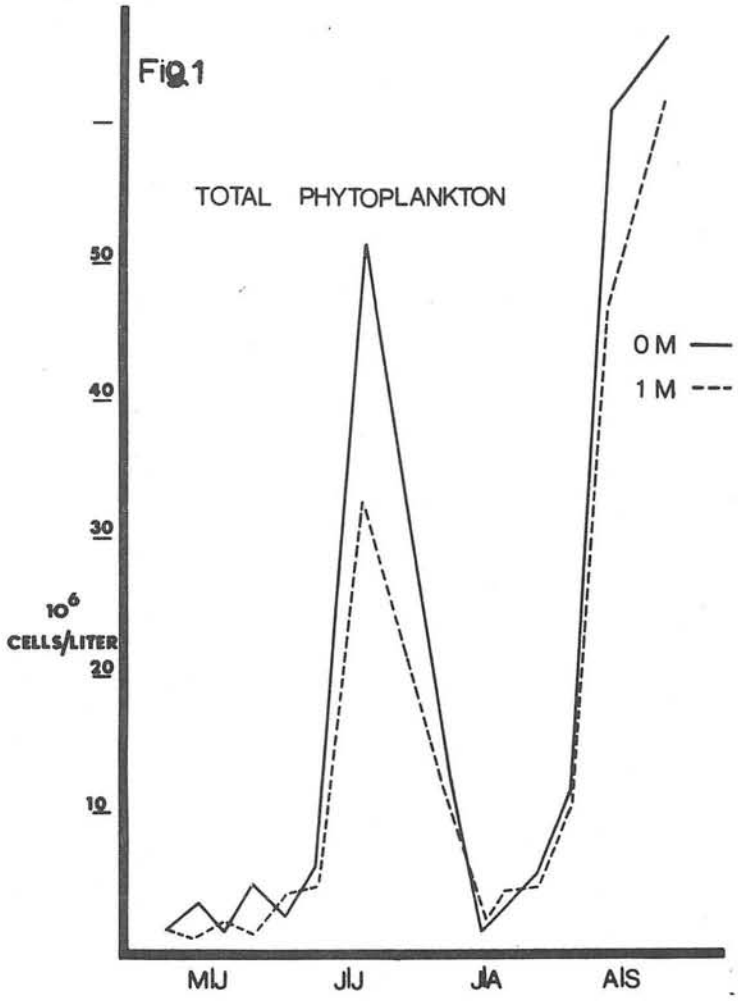


Fig 2

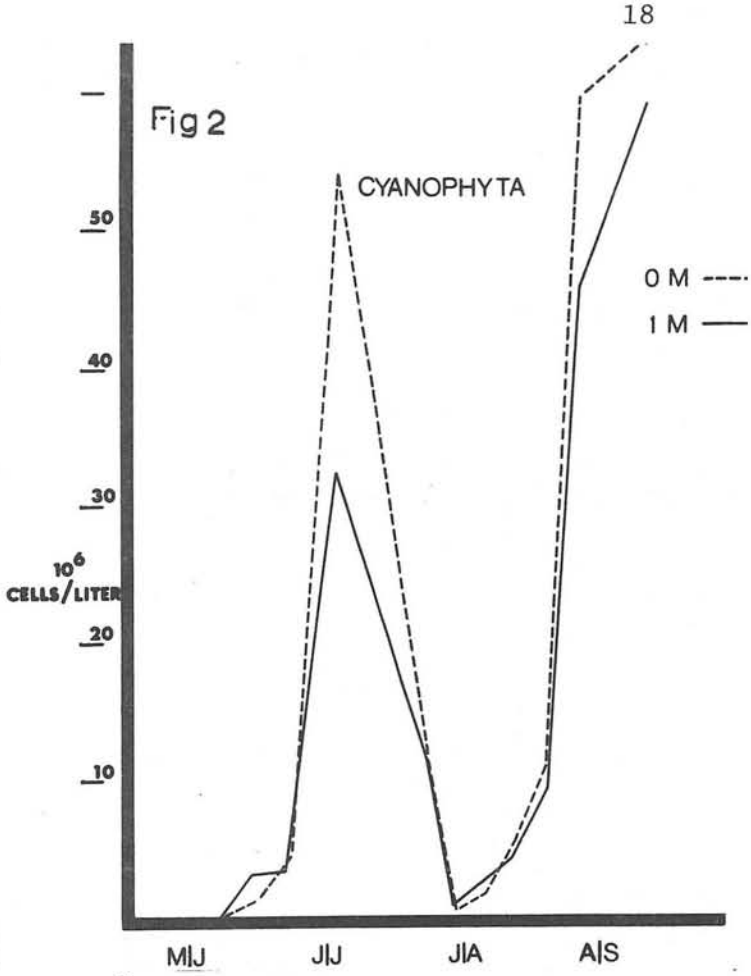


Fig 3.

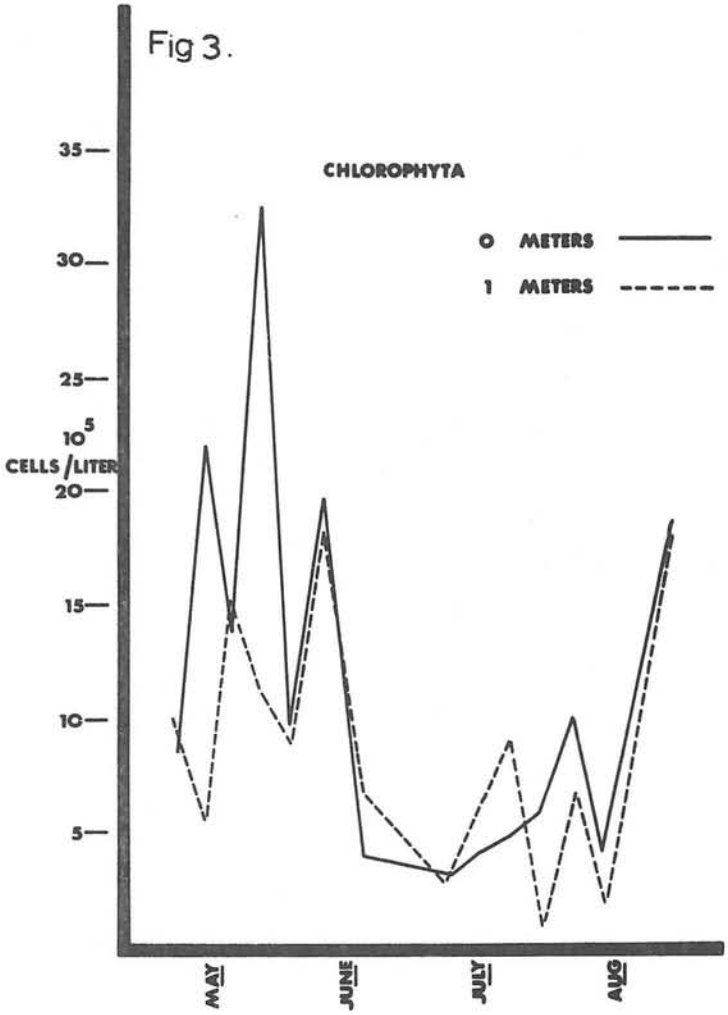
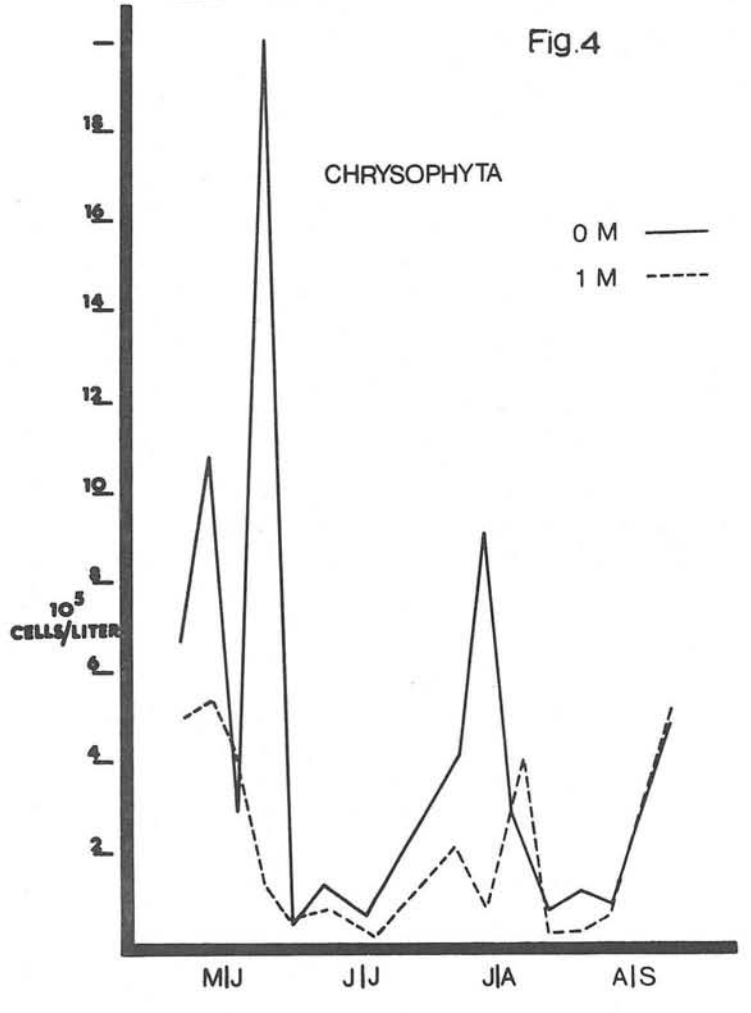


Fig.4



The Chrysophyta (Diatoms) in figure 4 showed an early diatom peak and another midway between the Cyanophyta peaks. Naviculoid diatoms were predominantly responsible for the Chrysophyte increases.

These three phyla of algae; Cyanophyta, Chlorophyta, and Chrysophyta, were responsible for most of the cells per liter at any given time, although the Euglenophyta were represented to a minor extent throughout the sampling period.

Figure 5, portraying total carbohydrate carbon as a function of time, shows a reasonable correlation with the total number of cells per liter. In this context, the total carbohydrate carbon gives an approximate indication of the standing crop of phytoplankton at any given time. A good correlation exists between the 0 and 1 m. depths. An analysis of the nitrogen and phosphorus data seems to show that the nitrate and phosphate ions did not become limiting in Cadham Bay. A good correlation between both the nitrate (Fig. 6) and the ammonia to the total phytoplankton cells per liter was evident. These, as well as the carbohydrate carbon data, give an indication of the standing crop, because the nutrient analysis method includes both the nitrate and ammonia free in the water and that incorporated within the phytoplankton. The good correlation existing between the nitrate, ammonia and carbohydrate carbon to the phytoplankton counts, lends strength to the counting procedure utilized which had a ±20% error under the best counting conditions. Phosphate levels, although determined by the relatively crude Hach analysis method indicated that the phosphate levels dropped with an increase in cell number but did not become a limiting factor to phytoplankton growth (Fig. 7).

Since nutrients do not appear responsible for the decline in total numbers of cells per liter, it is postulated that light was the limiting factor. In a typical shallow lake situation the light does not become a limiting factor, but due to self-shading and extreme turbidity in Cadham Bay, it appears as though light limited the growth of phytoplankton. The extreme turbidity results from the turbulence of wave action, stirring the bottom silt into the upper layers of the water. A light extinction curve for Station 1 was calculated on June 4, before the bloom of blue-greens occured. This data indicated an almost total extinction of light beneath 70 cm. without the introduction of self-shading.

In conclusion it may be stated that Cadham Bay had a seasonal succession similar in composition to that of other north temperate lakes, namely diatoms, greens, blue-greens, diatoms, blue-greens, greens. In most lake situations it is a nutrient deficiency which limits the phytoplankton growth, however, in Cadham Bay light extinction was probably the limiting factor.

Fig. 5

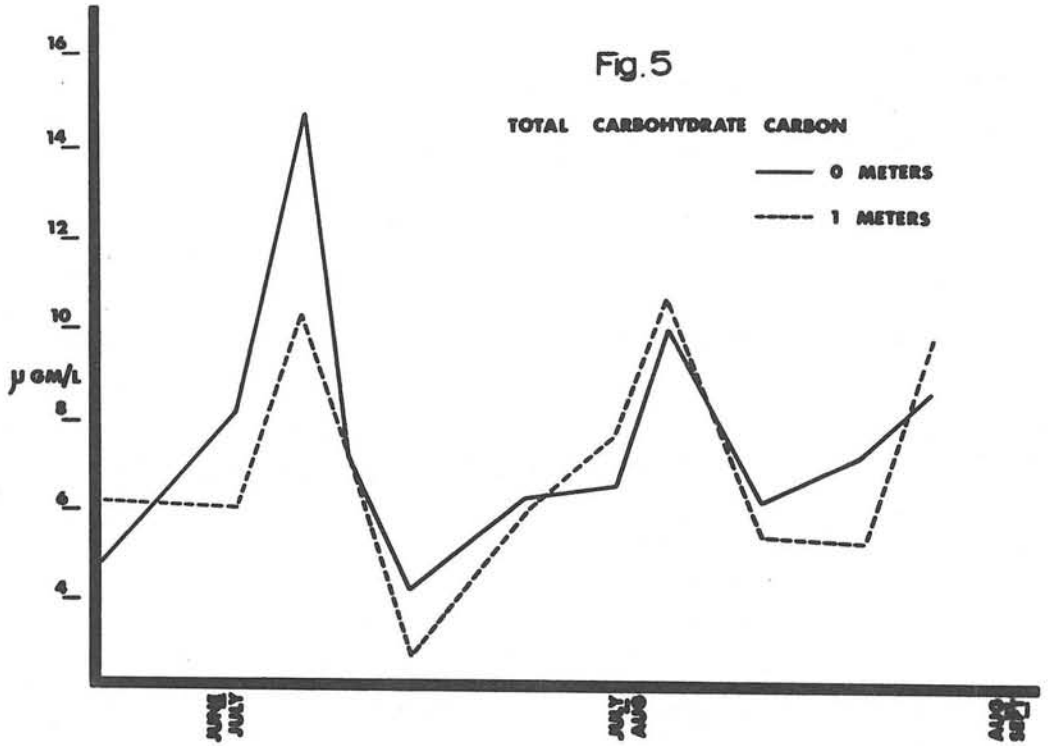


Fig. 6

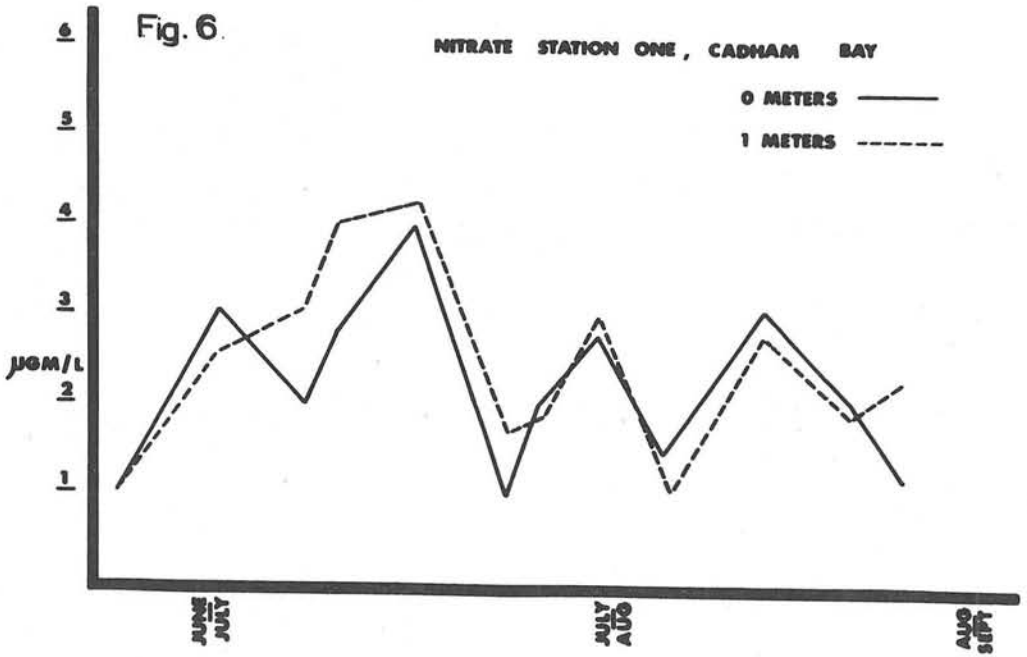
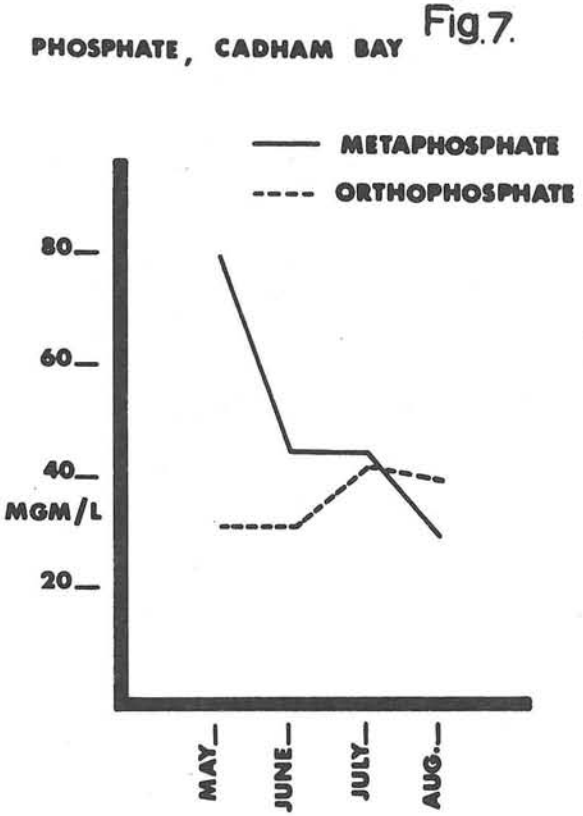


Fig. 7



Flow Patterns and Hydrochemistry of a Shallow Groundwater Regime in the Delta Area, Manitoba

J.A. Cherry and M. Lutchman

Department of Earth Sciences

Introduction

Since 1967 the Department of Earth Sciences has been engaged in a programme of field investigations of shallow groundwater regimes in representative areas of southern Manitoba. This paper summarizes the relationships between the stratigraphy, flow patterns, and hydrochemistry in the area between the Assiniboine River and Lake Manitoba, here referred to as the Delta area (Fig. 1). Basic data for the study was collected during the period of May to October, 1969. The results of this investigation can be used as a basis for interpretation of soil salinity in the area and provides a framework for design of future investigations of the geohydrology of the Delta marsh.

The Delta area is underlain by discontinuous deposits of sandy alluvium and recent beach sediments overlying glacial drift. The overburden thickness ranges between 70 and 250 feet and overlies Jurassic and Devonian limestone and associated sedimentary rocks. The investigation extended into the upper portion of the bedrock, however, most of the subsurface information was obtained from the upper 100 feet of the glacial drift.

Methods of Investigation

Following an inventory of most of the domestic wells in the area of the glacial drift and upper bedrock, test drilling was conducted to define the stratigraphic framework. Except for 8 holes in the Delta area drilled into bedrock using a rotary drill, test holes and piezometer installations were made using a truck-mounted hydraulic drill equipped with solid stem augers. Locations of test holes and piezometer nests are shown in Fig. 2. Each piezometer nest consists of a water-table well and 2 to 4 deeper piezometers. All piezometers are of the standard standpipe design; those in the drift are constructed of 0.8 inch inside-diameter, polyvinylchloride piping with slotted tips, sand packs and grout seals. Two-inch, inside-diameter steel pipe piezometers using a design modified after Lissey (1968) were installed in the bedrock holes in the Delta area.

Each piezometer was flushed and response tested using the Hvorslev (1951) method. Water levels were measured periodically throughout the summer and fall months of 1969, in order to define representative hydrographs for preparation of flow diagrams. Water samples were collected from the bottom few feet of each piezometer and subjected to analysis for major-ion concentrations. Ph measurements were made in the field immediately following sampling using procedures outlined by Barnes (1964). Tests conducted by Cherry et al. (1971) indicate that the values obtained by this procedure are representative of in situ pH and have accuracy and reproducibility

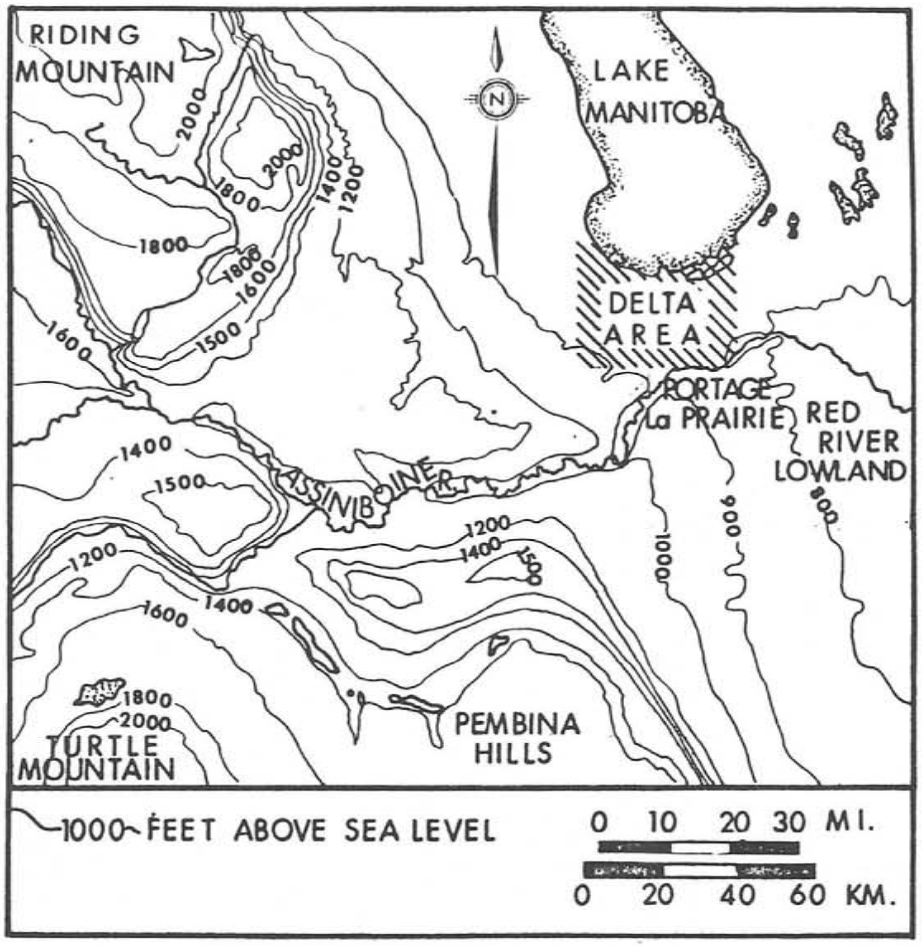
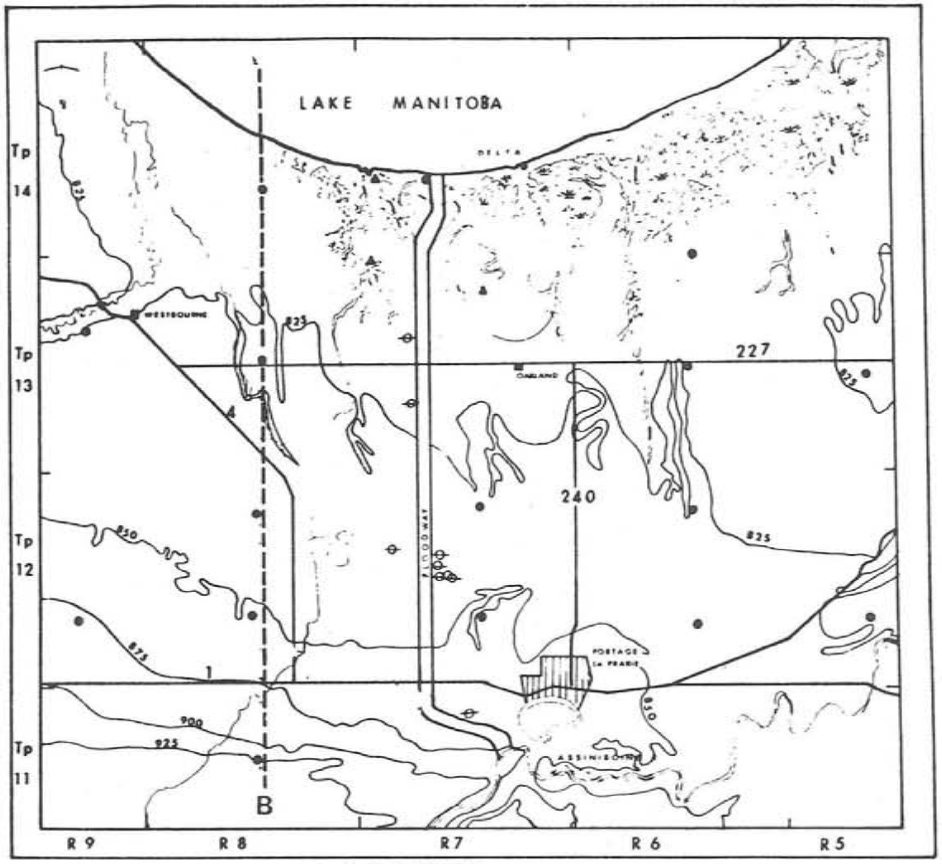


Fig. 1. Regional topography and location of the Delta area.



- Piezometer Nest, UNIV of MANITOBA
- Piezometer Nest CANADA DEPT. ENERGY, MINES, RESOURCES
- OBSERVATION WELL, MANITOBA WATER RESOURCES BRANCH

Fig. 2. Topography and instrumentation in Delta area.

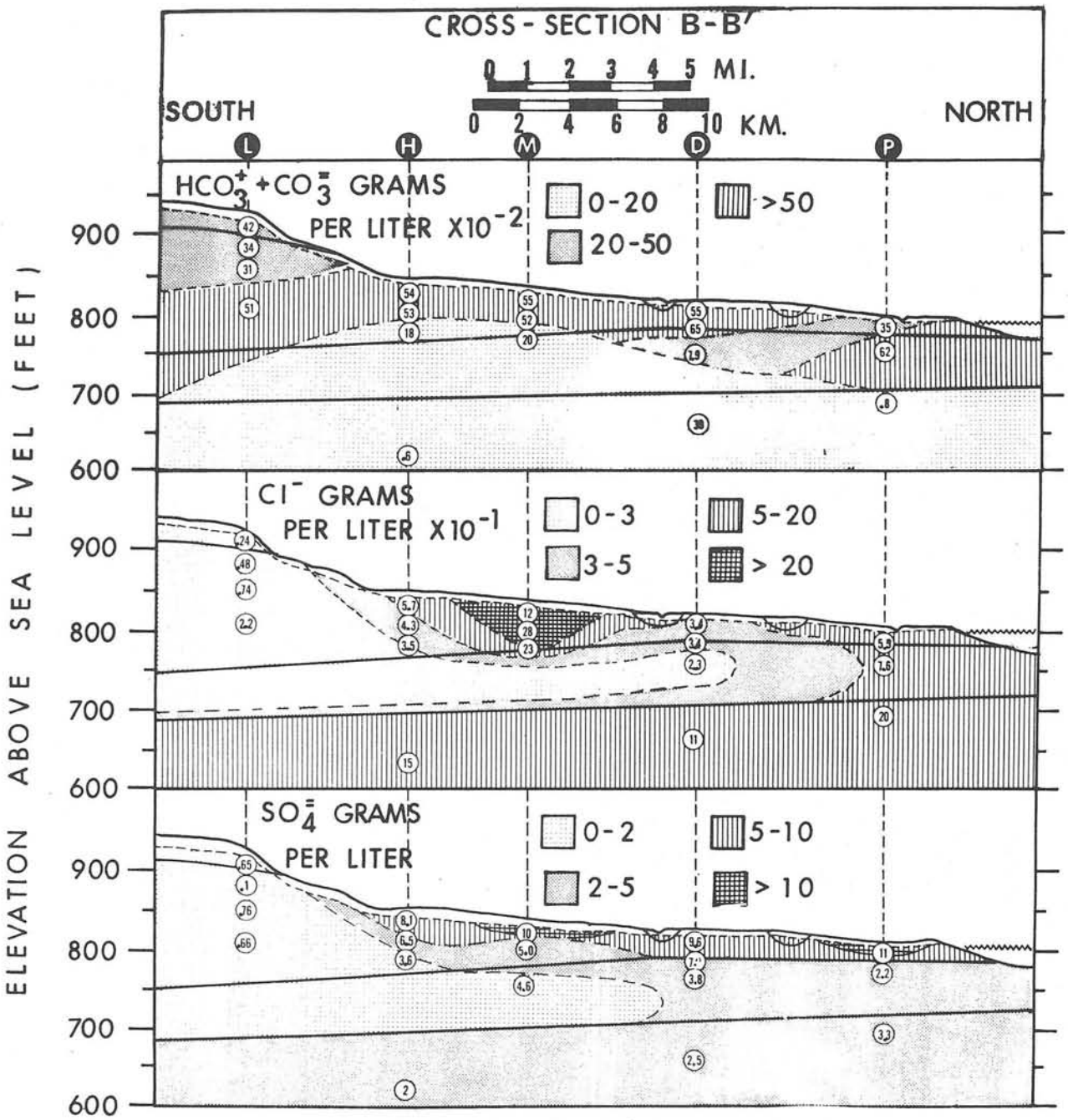


Fig. 5. Distribution of major anions, (a) HCO_3^- + CO_3^{2-}, (b) Cl^- and (c) SO_4^{2-}, along cross-section B-B^1.

to ±0.02 pH units. Concentrations of major cations Na^+, K^+, Ca^{2+}, Mg^{2+}, were determined by atomic adsorption. Accuracy and reproducibility of ±3 per cent are associated with the measured concentrations. The potentiometric titration procedure of Barnes (1964) was used for determination of HCO_3^- and CO_3^{2-}. The Mohr method (Rainwater and Thatcher, 1960) was used for Cl^-. Accuracy and reproducibility of ±5 per cent are associated with the reported HCO_3^-, and Cl^- concentrations. SO_4^{2-} concentrations were determined colorimetrically, with accuracy and reproducibility of ±10 per cent. Electrolytic conductivity at the bottom of selected piezometers was determined periodically using an extended-cable cell and conductance bridge unit. Similarity of repetitive measurements in conjunction with piezometer bailing test were used to insure that samples were representative of formation water.

Hydrostratigraphy

Cross-section B-B^1 exhibits the most distinct relationships between hydrostratigraphy, flow pattern, and major-ion distribution in the Delta area (Fig. 3). The overburden and shallow bedrock stratigraphy are shown in Fig. 3a. The surficial unit comprises discontinuous deposits of sandy alluvium. Beneath the alluvium and outcropping in much of the area is a thick deposit of Lake Agassiz clay which rests on a complex interbedded sequence of clay-loam till and stratified, sandy deposits. The interbedded till unit is underlain by Jurrassic bedrock, which in the area of cross-section B-B^1 is composed primarily of jointed and fractured limestone. The stratigraphy of the Delta area is described in detail by Fenton (1970). Hydraulic conductivities in the Agassiz clay and clay-loam till are very low, and occur within the same range as those obtained in Aggasiz clay and clay-loam till near Pinawa, Manitoba.(Cherry et al., 1970). No piezometers were installed in the coarse-interbeds within the complex till unit, however one would expect relatively high conductivities to be associated with these zones. Hydraulic conductivities in the bedrock are moderated to high and result from a secondary permeability network. Although data are not available for the alluvium, the texture of the deposit suggests that it is characterized by moderate to high conductivities.

Groundwater Flow Pattern

An interpretation of the groundwater flow pattern along cross-section B-B^1 is shown in Fig. 3b. The potential distribution is based on water-level data collected from the piezometer network during November, 1969. Piezometer hydrographs for the period July-December, 1969 indicate that the November data yield representative potential gradients for the summer-fall period and that the gradients vary only slightly due to precipitation. The flow pattern of Fig. 3b was constructed following the methods described in Cherry et al. (1970).

The potential distribution indicates that water moves from the south into the flow region represented by cross-section B-B^1. This

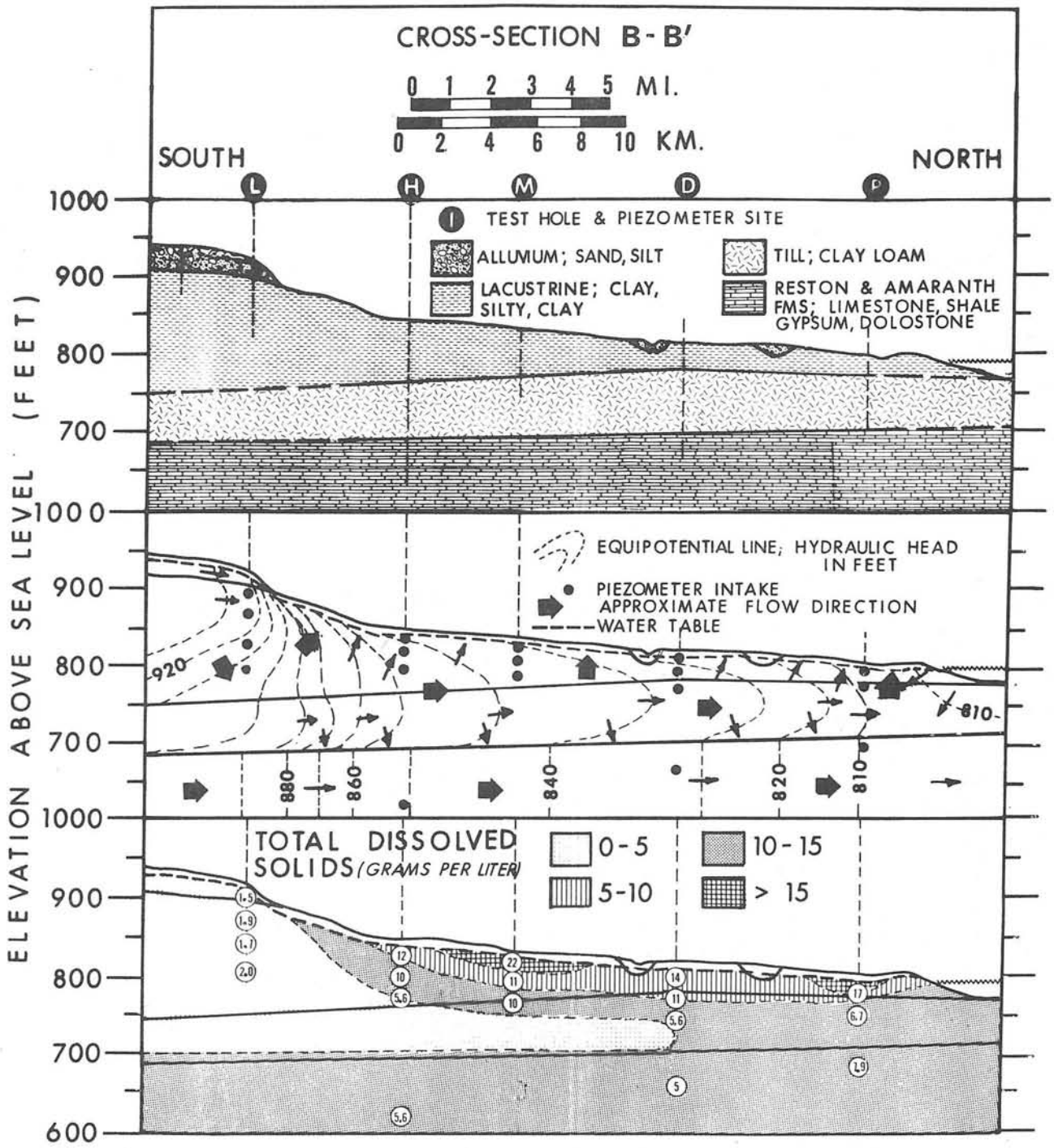


Fig. 3. Comparison of (a) stratigraphy, (b) groundwater flow pattern, and (c) distribution of total dissolved solids along cross-section B-B[1].

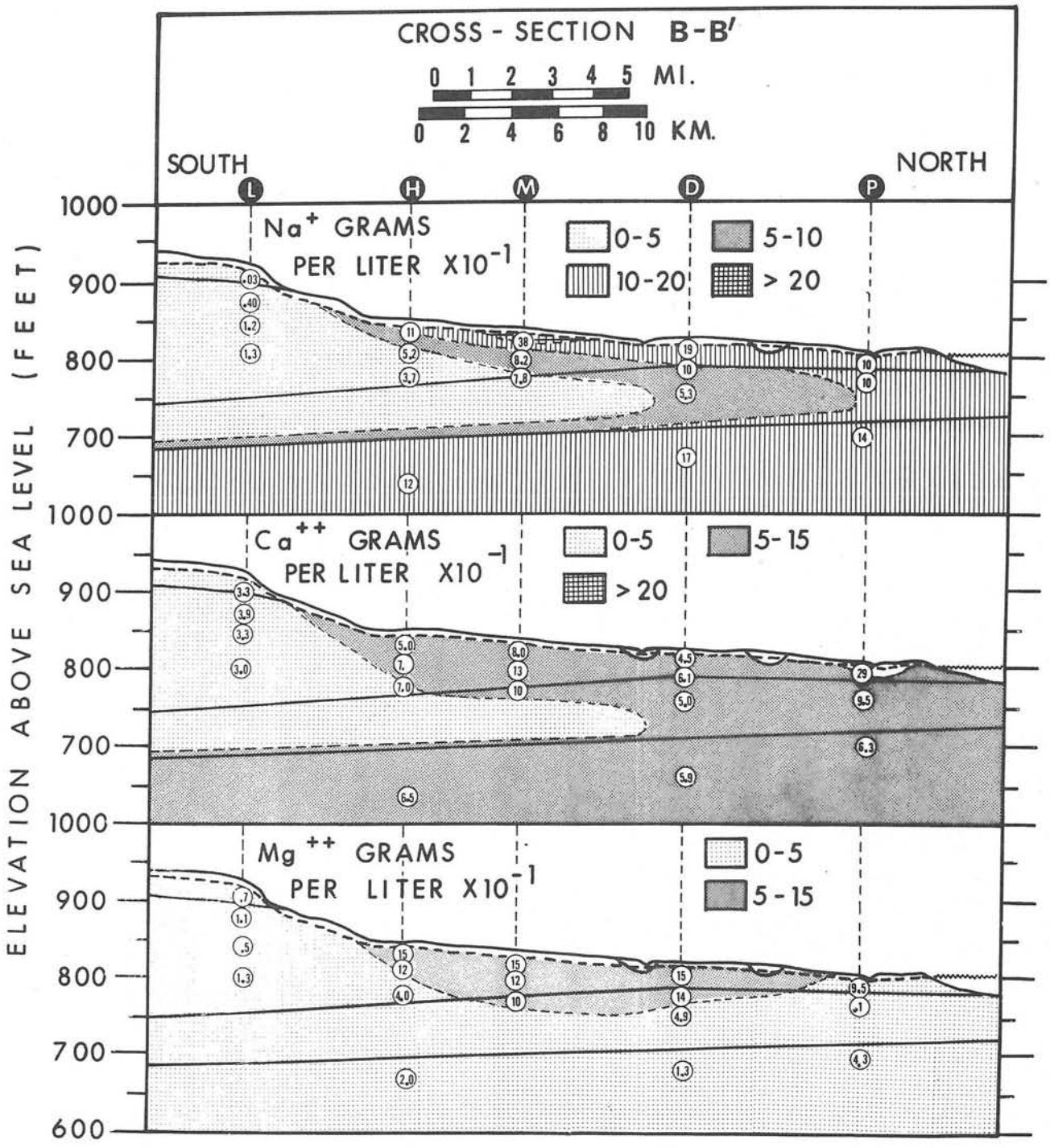


Fig. 4. Distribution of major cations, (a) Na^{+}, (b) Ca^{2+}, and (c) Mg^{2+}, along cross-section B-B'.

influx occurs as lateral northward flow in the bedrock and surficial alluvium, and to a more minor extent in the upper portion of the drift. The upper piezometers in nests D, H, M, and P exhibit well-defined upward gradients indicating that much of the area between the upland in the southwestern portion of the area and the Delta marsh is underlain by a groundwater discharge regime. The maximum upward vertical component is 0.02 ft/ft. Bedrock piezometers beneath this area, however, have potentials lower than in the upper drift and suggest that downward gradients occur in the lower portion of the complex till unit. An interpretation of the flow pattern (Fig. 3b) congruent with these data includes lateral northward flow in the complex till unit with divergence of flow both upward and downward from this zone. It would appear that the lateral flow is induced by the high-permeability sandy interbeds which occur within the till and which discontinue in the northern portion of the area. Although there are no piezometer nests along cross-section B-B^1 in the marsh and shore area near Lake Manitoba, nests in these areas to the east of the cross-section indicate local recharge in the sand dunes back of the beach and local discharge towards the lake and towards the marsh.

It was not possible to represent the flow pattern using mathematical modelling methods because of the complexity of the boundary conditions. However, it is evident from the field data that distinct permeability contrast between several of the hydrostratigraphic units is a major influence on the flow pattern and accounts for the rather unusual situation where both upward and downward gradients are observed in individual piezometer nests.

Hydrochemistry

The distribution of TDS in the area (Fig. 3c) is strongly influenced by mineralogic variations associated with the stratigraphy of the cross-section and the length and position of the flow path which the water has followed to arrive at a particular location. Although not shown on Fig. 3c, water in the sandy alluvium generally contains less than 1.5 gm/l TDS. This relatively low salinity is a result of a low content of soluble minerals and the flushing effect of shallow, predominantly lateral flow regimes which characterize these deposits.

Water in the drift at piezometer nest L is characterized by low TDS and occurs in a transmission zone close to a recharge area in the uplands to the south. There is no distinct increase or decrease of TDS with depth in this nest. This relationship is congruent with the flow pattern in this area which indicates a slight upward potential gradient in the upper two piezometers and a downward component in the lower piezometers. As water moves northward in the drift from the vicinity of nest L and flows beneath the zone of shallow discharge, major increases in TDS occur. As illustrated in nests D, H, M, and P (Fig. 3c) there is a progressive increase in TDS as the water moves upward to the water-table through the upper 100 feet of till and

Agassiz clay. This increase is mainly due to combined individual increases of Na^+, Mg^{2+}, and SO_4^{2-} (Figs. 4a, 4c, and 5c). The other major-ions exhibit much weaker correlations with the flow pattern.

Solution of calcite and dolomite, which are abundant in the surficial sediments, occurs predominantly in the soil moisture zone during infiltration. Abundant $HCO_3^- + CO_3^{2-}$ is therefore present throughout the drift and exhibits no correlation with the flow pattern. Concentrations of Ca^{2+} and Mg^{2+} are considerably higher in the discharge piezometers of nests D, H, M, N, P, than in nest L. The distribution of $HCO_3^- + CO_3^{2-}$ indicates that the Ca^{2+} and Mg^{2+} increases cannot be accounted for by solution of carbonates. Major increases in SO_4^{2-} concentrations along the apparent directions of groundwater movement suggest that solution of sulphate minerals is the mechanism by which the additional Ca^{2+} and Mg^{2+} are introduced into the hydrochemical systems. Minor percentages of gypsum are commonly observed in lacustrine sediments and till in the Agassiz Basin (i.e. Fenton, 1970; McPherson, 1970; Wicks, 1965). Magnesium sulphate is probably present in very small percentages in fine-grained sediments is usually not possible by standard X-ray diffraction methods, therefore little data is available in the literature of this region regarding their presence and distribution.

The influx of Ca^{2+} and Mg^{2+} from non-carbonate sources increases the ino-activity products of the groundwater with respect to calcite and dolomite.

$$IAP_{calcite} + A_{Ca^{2+}} \cdot M_{Ca^{2+}} \cdot A_{CO_3^{2-}} \cdot M_{CO_3^{2-}}$$

and

$$IAP_{dolomite} = A_{Ca^{2+}} \cdot M_{Ca^{2+}} \cdot A_{Mg^{2+}} \cdot M_{Mg^{2+}} \cdot A^2_{CO_3^{2-}} \cdot M^2_{CO_3^{2-}}$$

where 'A' represents activity coefficient and 'M' molality; (see Hanshaw et al., 1966, for detailed development). The common-ion effect appears to account for supersaturation with respect to calcite and dolomite which occurs in much of the flow system (Lutchman, 1970). The precipitation reactions for calcite, aragonite, and dolomite therefore appear to be much slower than the solution of gypsum.

The distribution of Na^+ and Ca^{2+} throughout much of the zone of shallow groundwater discharge suggests that Na^+ is being replaced by Ca^{2+} on the exchange sites of clay particles in the Agassiz clay and till. For example, in nests D, H, and M (Fig. 4) Ca^{2+} exhibits no distinct increase with decreasing depth and yet gypsum is present throughout the drift in this area (Fenton, 1970). Solution of gypsum in addition to magnesium sulphate is necessary to account for the SO_4^{2-} increases. Saturation calculations indicate that supersaturation of the groundwater with respect to gypsum occurs only very rarely in the area. It is likely therefore that gypsum is continually going into solution as the water moves upward through the discharge zone, and that the Ca^{2+} is being replaced in solution

by Na^+. Large increases of Na^+ with decreasing depth are observed at nests D, H, and M (Fig. 4a) and are not accompanied by corresponding increases in Cl^- (Fig. 5b) as would be expected if the Na^+ were being derived from halite which is its usual alternative source of Na^+ in the drift. The cation exchange mechanism, however, does not appear to be effective in the discharge zone at nest P. At this location large increases of Ca^{2+} and SO_4^{2-} occur with decreasing depth and the concentration of Na^+ remains constant.

Considering that the groundwater flow system in the Delta area described in this paper has been in existence since the evolution of the present landscape several thousand years ago, it is somewhat surprising that the cation exchange reaction is still effective. The availability of exchange sites for Ca^{2+} on the clay particles is limited by the tendency of the reaction to approach an equilibrium (Bear, 1964). Equilibrium has apparently not been attained in this area, probably because of very low circulation rates of the groundwater system and because secondary fracture permeability networks have limited the extent to which intergranular pore water volumes are being replaced by circulating water. This would induce cation diffusion which would greatly depress the overall rates and effectiveness of cation exchange reactions.

The distribution of major-ion concentrations in the bedrock does not correlate with the apparent flow directions as well as in the drift. This is probably due to the combined effect of (a) insufficient piezometer density, (b) more heterogeneous mineralogy, and (c) complexity of the flow pattern caused by the irregulatities in the joint-fracture permeability network.

Summary of Conclusions

The groundwater flow system in the Delta area has been delineated using a network of simple, standpipe piezometers. The flow pattern is strongly influenced by permeability contrasts associated with the major stratigraphic units. A major portion of the area is underlain by a zone of shallow groundwater discharge characterized by brackish to saline water. The best individual flow correlation ions are Na^+, Mg^{2+}, and SO_4^{2-} which increase progressively with distance along flow lines within most zones in the drift. The most important geochemical processes influencing the major-ion distributions are:

(a) rapid solution of calcite and dolomite in the soil moisture zones of recharge areas caused by biochemical generation of CO_2,

(b) slow solution of gypsum and magnesium sulphate which occur in minor or trace quantities in the fine-grained drift units,

(c) solution of halite which occurs in trace quantities in the fine-grained drift units,

(d) exchange of Ca^{2+} for Na^{+} on the exchange sites of clay-mineral particles.

The hydrochemical data enable more detailed interpretation of the flow system to be made than would otherwise have been possible. It should be noted, however, that the major-ion distributions would have been somewhat misleading if unaccompanied by relatively detailed stratigraphic and potentiometric information.

Acknowledgements

We are grateful to Mr. J.A. Gilliland of the Inland Waters Branch, Department of Energy, Mines, and Resources, for providing the bedrock piezometers, unpublished data, and assistance during the field investigation. Dr. J.M. Walker kindly arranged for accommodations and laboratory facilities at the University of Manitoba's Field Station (Delta Marsh). The test drilling programme was conducted in co-operation with Mr. M.M. Fenton who also provided geologic cross-sections and data on the surficial sediments in the Delta area prior to publication. Able field assistance was provided by Mr. J. Lebedynski. The diagrams were drafted by Mr. R. Pryhitko.

The study was supported by grant no. A4210 of the National Research Council.

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A Preliminary Report on the Pleistocene Geology of the Portage la Prairie to Lake Manitoba Area

M. M. Fenton

Department of Geology

This report presents an outline and preliminary interpretation of data collected during the months of May to September, 1969.

Location

The location of the study area is shown on the accompanying map (Fig. 1). It includes all or portions of townships 11 to 14 and ranges 5 to 9 W.P.M. and covers approximately 500 square miles.

Methods of Study

The field work was divided into two parts, (1) surface work and (2) subsurface work.

The surface work consisted of an air photo interpretation of the entire area and the drilling of approximately 300 shallow hand auger holes.

The subsurface work consisted of drilling 33 holes from 10 to 275 ft. deep. Three types of drills were used, (1) a Minuteman power auger capable of drilling a three inch hole to thirty ft., (2) a truck mounted auger capable of drilling a six in. hole to one hundred ft., and (3) a truck mounted rotary drill capable of drilling a six inch hole to bedrock - a maximum of 265 feet in the area. Six holes were drilled with the Minuteman, twenty with the truck mounted auger and seven with the rotary drill.

Pleistocene and Recent Geology

For the purpose of this report the geology will be split into surface and subsurface units. It is to be remembered that the interpretations presented here are preliminary and may be subject to later revision.

Surficial Geology

Six surficial geologic units can be distinguished in the study area (Fig. 2). They consist of glacial till, lacustrine deposits, deltaic deposits, alluvial deposits, beach deposits and marsh deposits.

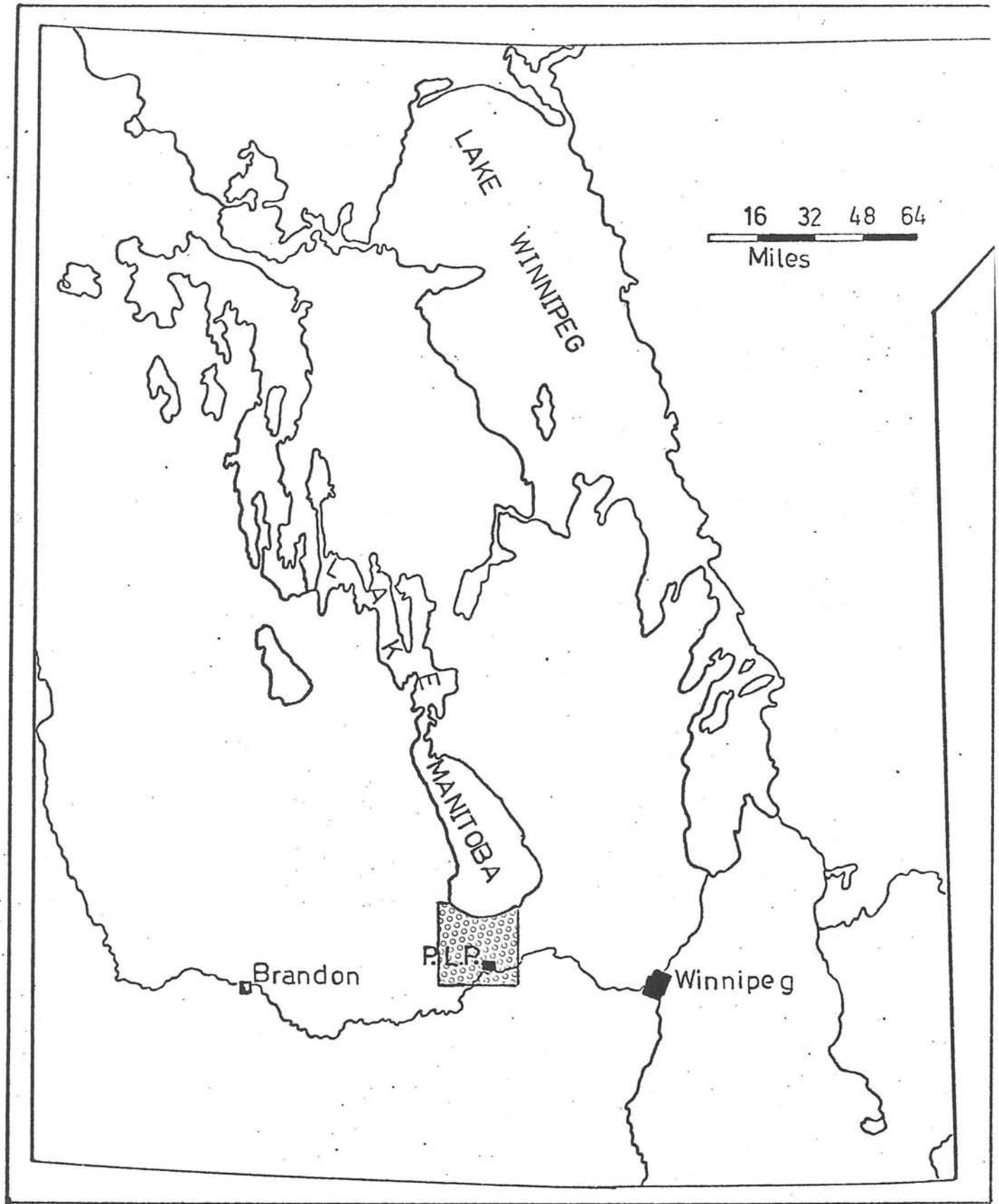

Fig 1 Location of study area

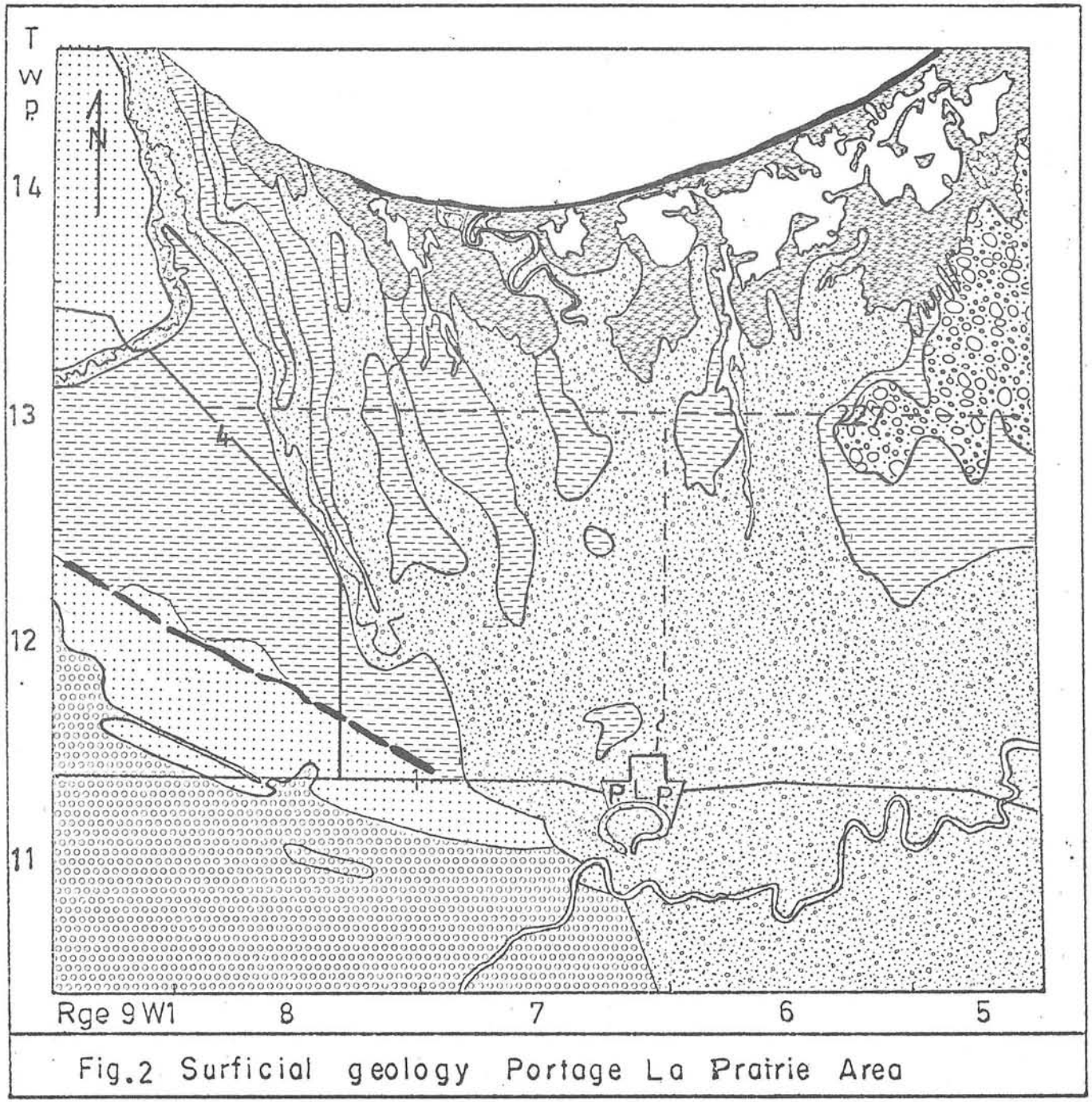

Fig.2 Surficial geology Portage La Prairie Area

LEGEND

AGE DEPOSITS

RECENT

- Beach deposits
- Marsh deposits
- Alluvial deposits

PLEISTOCENE

- Beach deposits
- Lacustrine deposits
  - clay
  - silt
- Deltaic deposit
- Till

0 1 2 3 4 5

Miles

Highway

Road gravel

Glacial Till

Till is the sediment deposited directly by the glacial and is typically very poorly sorted, grain size varying from clay to boulders, and it lacks bedding. The outcrop of the till (unit 1, Fig. 2) is confined mainly to the northeastern corner of the study area. The unit is a grayish brown clayey to slightly sandy till with occasional stones up to boulder size (64 mm.). The most characteristic feature of the till is a well developed northwest southeast lineation. The lineation consists of alternating parallel to subparallel ridges and troughs with the relief on the ridges generally less than 5 ft. and is very obvious on air photographs. The photo pattern is emphasized by groves of trees which tend to grow parallel to the lineations.

Lacustrine Deposits

These deposits (unit 2, Fig. 2) form a low relief plain (10 ft.) in the central and western portion of the area and were laid down in Glacial Lake Agassiz. The deposits vary from clay to silt with the major portion being a grayish brown to olive brown silty clay. The unit contains chunks of till and silt and occasional pebbles with the proportion increasing as the contact with the till is approached.

The photo pattern is characterized by a gray to dark gray blotchy, light and dark, tone; a fine texture and a relatively angular stream pattern. The lighter toned areas may form irregular circular patterns especially in the western portion of the area. The contact between the lacustrine deposits and the till was placed, on the air photos, at the disappearance of the till lineations and, in the field, at the disappearance of the lake clay layering.

Deltaic Deposits

These deposits (unit 3, Fig. 2) consist of the sediment deposited at the mouth of the glacial Assiniboine River which emptied into Glacial Lake Agassiz west of the study area. This unit forms a topographic high in the southeastern corner of the area. The elevation decreases from approximately 925 ft. in the southwestern corner to 850 at the lacustrine deposits. The unit can be divided into a sand and a silt subunit.

The sand subunit is composed of fine to medium grained brown sand and forms a thin veneer over the silt. The upper portion of the sand is pebble free and has been blown into sand dunes, the majority of which have been stabilized by vegetation.

The silt subunit is a grayish brown clayey silt. The deposit is cyclic. Each cycle is approximately one ft. thick and composed of a pure dark grayish brown clay at the base grading upward into thin parallel laminated clayey silts and above this into cross laminated clayey silts. The photo pattern for the unit is a light tone, coarse texture and an irregular vegetation growth.

Alluvial Deposits

The alluvial deposits (unit 4, Fig. 2) include all the material

deposited by the ancient and now generally abandoned rivers in the area. The unit is flat with the only relief being the channels themselves which are less than 10 ft. deep.

These deposits are characterized by their variable lithology. They change from coarse to fine sand in and adjacent to the river channels, to grayish brown to olive brown silts and clays away from the channels. Mollusc and plant fragments appear occasionally in the sandier layers. The photo characteristics of this unit are a smooth, light, photo tone; and the river channels themselves, which are generally the widest in the area, have a well to poorly developed meander pattern.

The contact with the lacustrine sediment is difficult to determine with the alluvium thinning to a "feather edge" away from the channels. The alluvial silty clays were distinguished from the lacustrine silts and clays on the basis of:

1. photo pattern, mentioned previously
2. degree of compaction, the lacustrine sediments being generally firmer
3. the presence of till chunks in the lacustrine sediments
4. the presence of mollusc and plant debris in the alluvium.

Beach Deposits

These deposits (unit 5, Fig. 2) include both Pleistocene and Recent beaches. The Pleistocene beaches occur in the southwestern quarter of the area either at the contact of the lacustrine and deltaic deposits or northeastward on top of the lacustrine deposits. The best developed beach forms an asymmetric ridge approximately 10 ft. high (on the seaward side) and 100 ft. wide trending northwest across the southwest quarter of the area. The sediment is fine to medium grained sand with the occasional pebble.

The Recent beach is situated along the south shore of Lake Manitoba and forms a ridge generally less than 10 ft. high and 100 ft. wide. The sediment consists of fine to medium grained sand showing evidence of considerable aeolian action.

Marsh Deposits

These deposits (unit 6, Fig. 2) occur immediately south of the beach on the southern shore of Lake Manitoba. They form a thin covering of brown to black organic rich sediment over alluvial or lacustrine sediments. The photo characteristics are the light toned marsh vegetation alternating with dark areas of open water.

Subsurface Geology

The subsurface geology is illustrated on the two accompanying geologic cross sections, A-A' and B-B' (Figs. 3, 4 and 5).

The east west cross section A-A' illustrates the subsurface geology in the southern portion of the area. There are two tills with

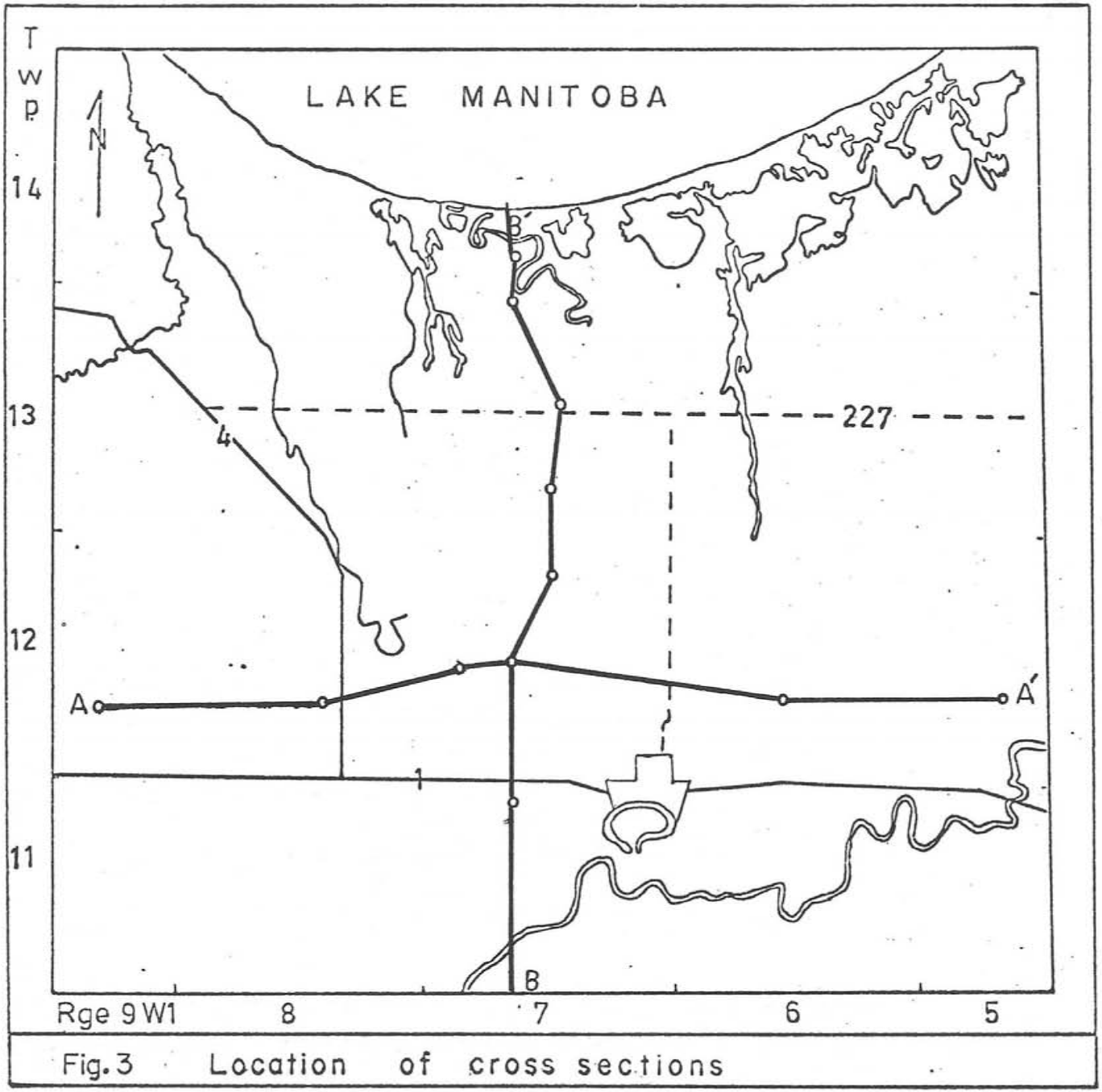

Fig. 3 Location of cross sections

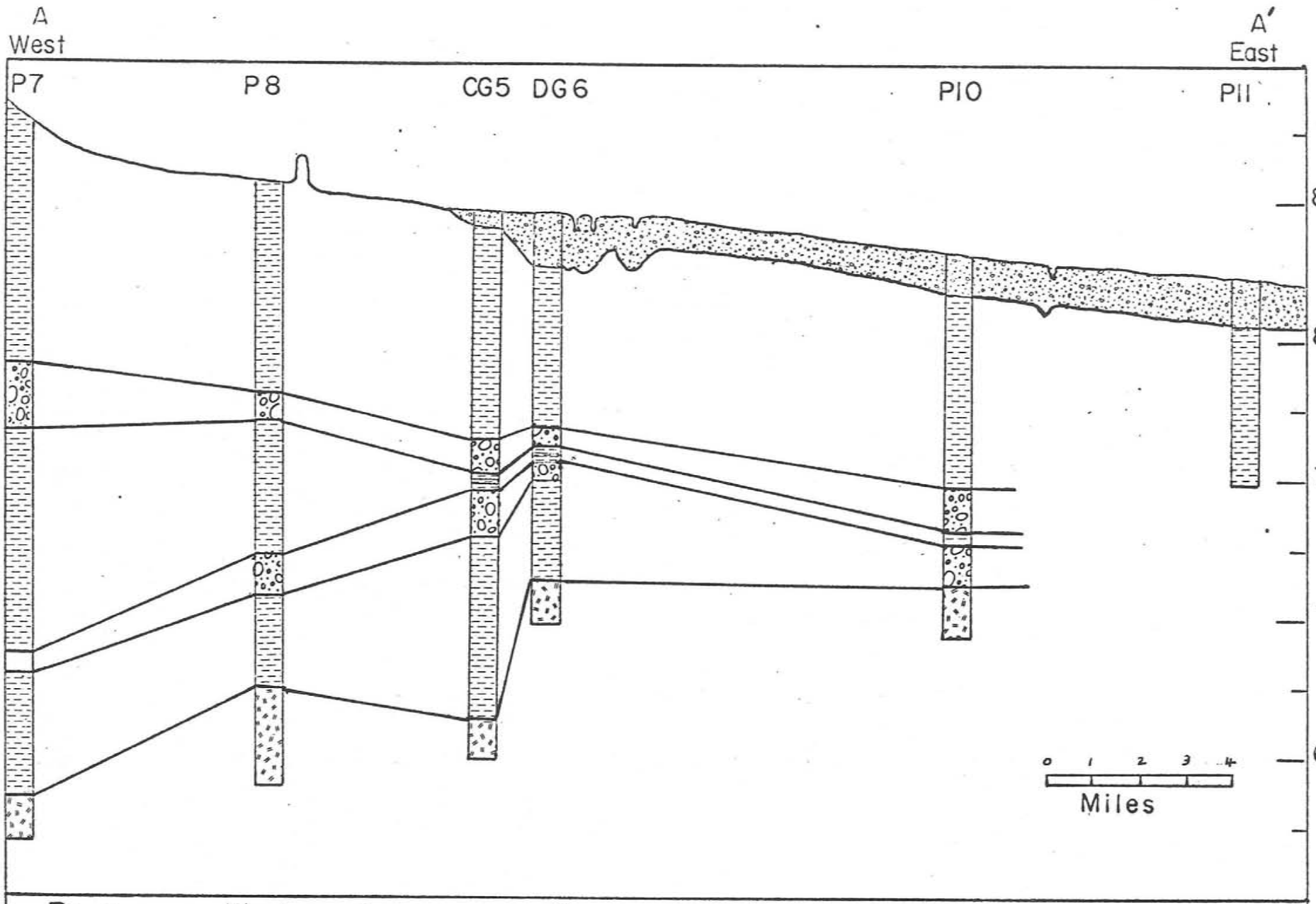

Fig. 4 West east cross section

Alluvium Lake and delta deposits Till Bedrock

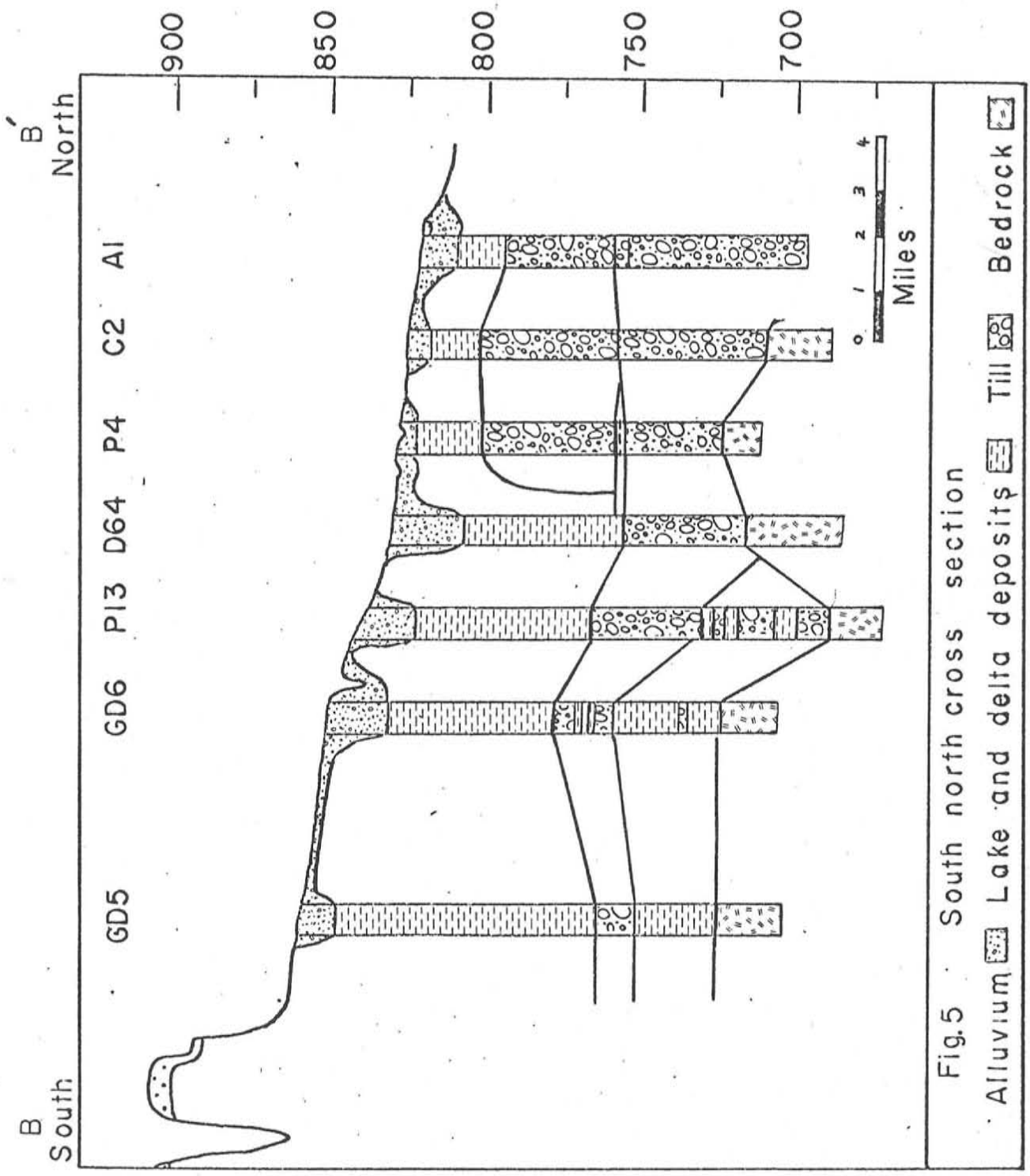

Fig.5 South north cross section

lacustrine and/or deltaic deposits above, between, and below them. The two lowermost lacustrine units thine toward the east.

The north south cross section B-B' reveals a third and uppermost till sheet which is present only in the northern third of the area. This till likely represents an ice frontal position during the later stages of glacial retreat in the region.

Future Research

The future research will include laboratory analysis of the field data and the compilation of the material into a Masters thesis.

The laboratory analysis will be conducted on specimens from selected drill holes. The methods of study will include grain size determination, X-ray analysis of the clay fractions, carbonate content analysis and heavy mineral study on the tills. The object of the studies will be to ascertain the composition and grain size distribution of the different units and to try and determine properties which will allow the correlation of, and the distinction between, the three tills in the region.

Acknowledgements

The author wishes to thank Dr. J. M. Walker, Director of the University of Manitoba Field Station (Delta Marsh), for permitting him to reside there while conducting the summer's field work. Thanks are also extended to Dr. J. Gilliland, Inland Waters Branch, and Dr. B. Bannatyne, Manitoba Mines Branch, for furnishing some of the subsurface data used in this study.

Nitrification Processes in Soils of the Delta Marsh

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Department of Botany

Introduction

Most higher plants obtain their nitrogen in the form of nitrate (NO_3^-) from the soil. Nitrate is formed from ammonia (NH_4^+) a product of decaying vegetation by the soil bacteria Nitrosomonas which oxidizes NH_4^+ to nitrate (NO_2^-) and Nitrobacter which oxidizes NO_2^- to NO_3^-. This 'nitrification' process occurs rapidly in well aerated agricultural soils. However, the reverse process 'denitrification' can occur under certain conditions.

The objective of this study was to determine whether the nitrifying capacity of marsh soils was influenced by different species of vegetation. The preliminary experiments in the summer of 1969 served only to test a new apparatus for the assay of nitrification in marsh soils, but showed that denitrification plays a prominent role.

Materials and Methods

Soils. Soils were obtained form the Cadham Bay area under stands of Phragmites.

Apparatus and Assay. The assay method is based on the aerobic circulation of an ammonium sulphate solution through a column of soil at 25°C. Aliquots of the circulating medium were withdrawn daily to assay for NH_4^+, NO_2^- and NO_3^-.

The glass apparatus holding the soil consisted of a 10 cm x 2.5 cm column constricted at the base and sealed to an 11.5 cm x 5.0 cm reservoir which held the circulating medium. The reservoir has an outlet at the base and a sealed-in glass tube vent at the top which extended to the top of the soil column. The outlet of the reservoir

was connected to a polystaltic pump which pumped the circulating fluid through a three way stopcock to the top of the column of soil closed by a rubber stopper and tube. Between the pump and the stopcock air was pumped into the column of fluid and adjusted so that there were always alternate columns of liquid and air at a flow rate of 3 ml per minute. About 20 cc of a 50-50 mixture of air dried soil and sterile acid washed sand was placed in the column and held in position by glass wool at the constriction. The three-way stopcock was normally in the position for a closed system, but could be opened to withdraw aliquots for assay. The glass apparatus was held in a water bath at 25°.

Ammonium. NH_4^+ was determined by the following of the formation of indophenol blue.

Nitrite. NO_2^- was determined by the sulfanilic acid procedure of Bratton et al (1939).

Nitrate. NO_3^- was determined by the phenoldisulfonic acid procedure of Snell and Snell (1936).

Standard curves were constructed for each ion. Five millilitres of the medium was withdrawn daily for about eight days and aliquots were used for the determinations.

Results and Discussion

The kinetics of nitrification in well-aerated agricultural soils show the typical disappearance of NH_4^+, a transient appearance of NO_2^- and a steady, usually exponential appearance of NO_3^- until all the NH_4^+ and NO_2^- is exhausted.

The results of many experiments indicated that this was not the case with marsh soils. While the results were rather erratic because the methodology was being tested at the same time, there were significant trends in the data. Ammonium generally increased initially due to the elution of this ion from the soil. After two - three days it showed a decrease and remained steady at about the initial level from a minimum feeding of 0.5 µmoles/litre to a maximum of 2.5 µmoles/litre. Nitrate showed an initial rapid increase

and then remained at a steady state concentration and was never oxidized completely. Similarly, nitrate showed an initial increase to a steady state value. In other words, there was never a complete exhaustion of ammonium and the nitrification process was never completed.

The results can be explained on the basis that marsh soils are generally existing under anaerobic conditions and contain large amounts of detritus and carbonaceous matter in various stages of decay. When such soils are assayed for nitrification under the aerobic experimental conditions, there is an initial oxidation NH_4^+ to NO_2^- to NO_3^- or nitrification. However, owing to the high carbonaceous matter and aerobic conditions, the soil bacteria (nitrifiers and other organisms) compete with the available oxygen through respiratory processes and reduce it to H_2O releasing CO_2 in the process. This high bacterial activity depletes the oxygen in the soil and the bacteria must necessarily find electron acceptors other than oxygen to accept their reducing power ($H^+ + e^-$). The most readily available electron acceptors are NO_2^- and NO_3^- and these are in turn reduced to NH_4^+. This process of denitrification would normally occur under the anaerobic conditions of marsh soils.

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The Biology of Rana pipiens Schreber and Bufo hemiophrys Cope in the Delta Marshes

Leo Hlynka

Department of Zoology

A survey of the helminths of Rana pipiens and Bufo hemiophrys revealed five species of trematodes, four of nematodes, and one each of cestodes and acanthocephala. One trematode species was frequently encountered in B. hemiophrys whereas three were common in R. pipiens. Cestodes and Acanthocephala were found only in R. pipiens and B. hemiophrys respectively. Nematodes found in both hosts generally do not require intermediate hosts and are associated with a terrestrial habitat. Trematodes, cestodes, and acanthocephala, however, require aquatic intermediate hosts for their transmission. As R. pipiens, commonly known as the leopard frog, harbours the majority of helminths associated with an aquatic habitat and the helminths of B. hemiophrys are related to a moist terrestrial habitat, it follows that the biology of the hosts is the factor influencing their helminth fauna.

Biology of Rana pipiens (Leopard Frog)

The leopard frog is the most aquatic anuran in the region studied. Its habitat is fully aquatic during hibernation and breeding. Following the breeding period, the leopard frog oscillates between aquatic and moist terrestrial sites, best described as a semi-aquatic habitat. Figure 1 shows the approximate habitat changes in relation to time of year, and activity of the frogs.

Gonads were observed to be fully developed at the time of the frogs' emergence from hibernation. Ova were heavily pigmented at the animal poles and filled most of the abdominal cavity. Testes were large and males could be heard calling from the marsh soon after their emergence from Lake Manitoba. Breeding ensues from the end of April to the end of May. The first spent female was found on May 12, 1969, while regenerated ovaries were first observed on July 10, 1969. Changes in testes size were not as readily observable. The maximum development of testes and ovaries were observed in the periods April to May, and August to September.

Examination of the stomach contents of R. pipiens revealed that frogs in the Delta marshes feed chiefly on arthropods and to a lesser extent on snails and small vertebrates. The major part of the arthropod material was insects. Among the wide variety of insects taken, beetles and flies were most common as food items while hemipterans were next. Predation on any one organism seems to be influenced by the abundance of the organism in the habitat of the frog. For example, during chironomid emergences in June, July and August, when thick mating swarms of midges were evident throughout the sampling area, large numbers of Diptera were found in the stomach contents.

FIG.1 SEASONAL HABITAT CHANGES IN RANA PIPIENS

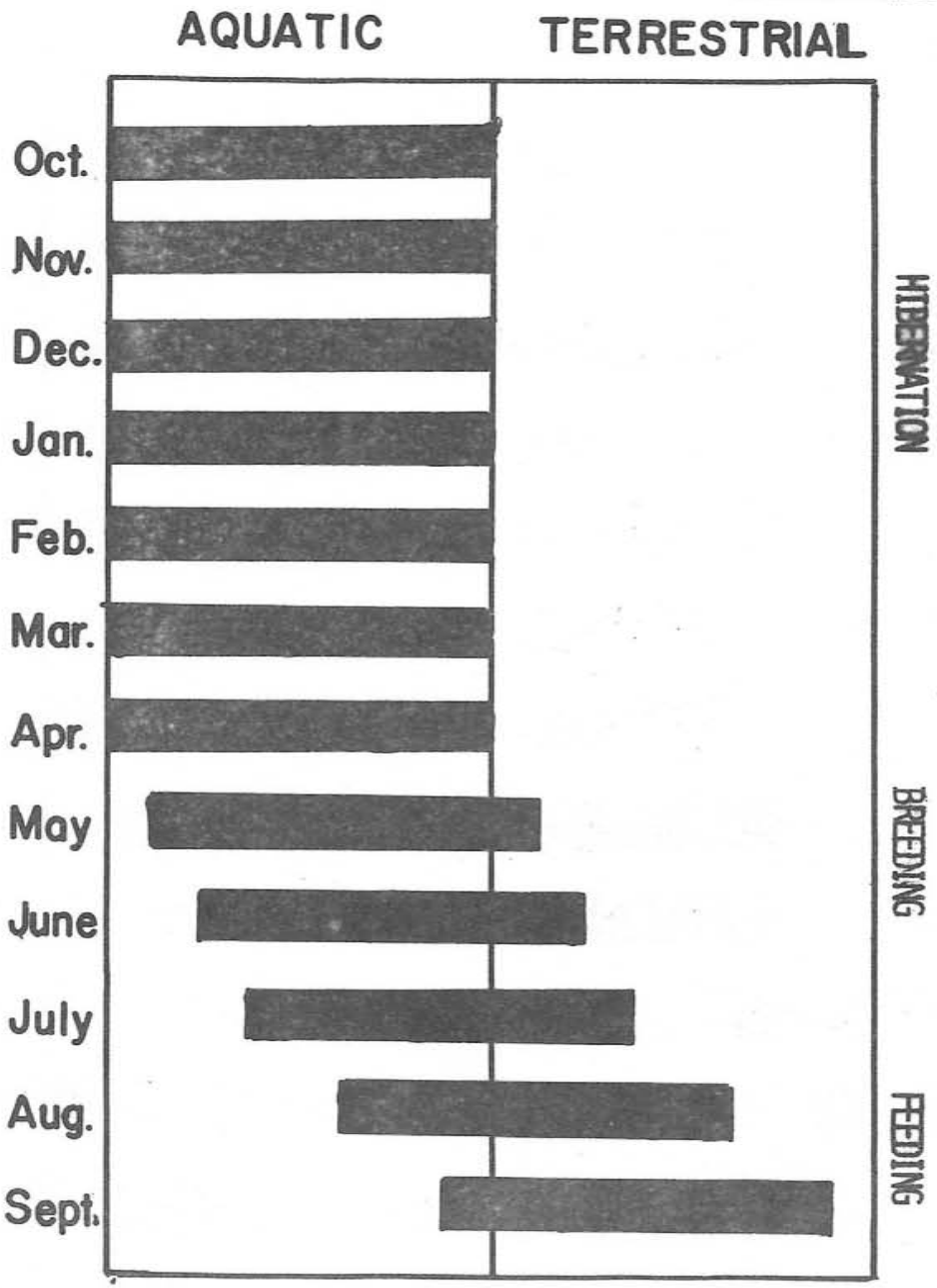
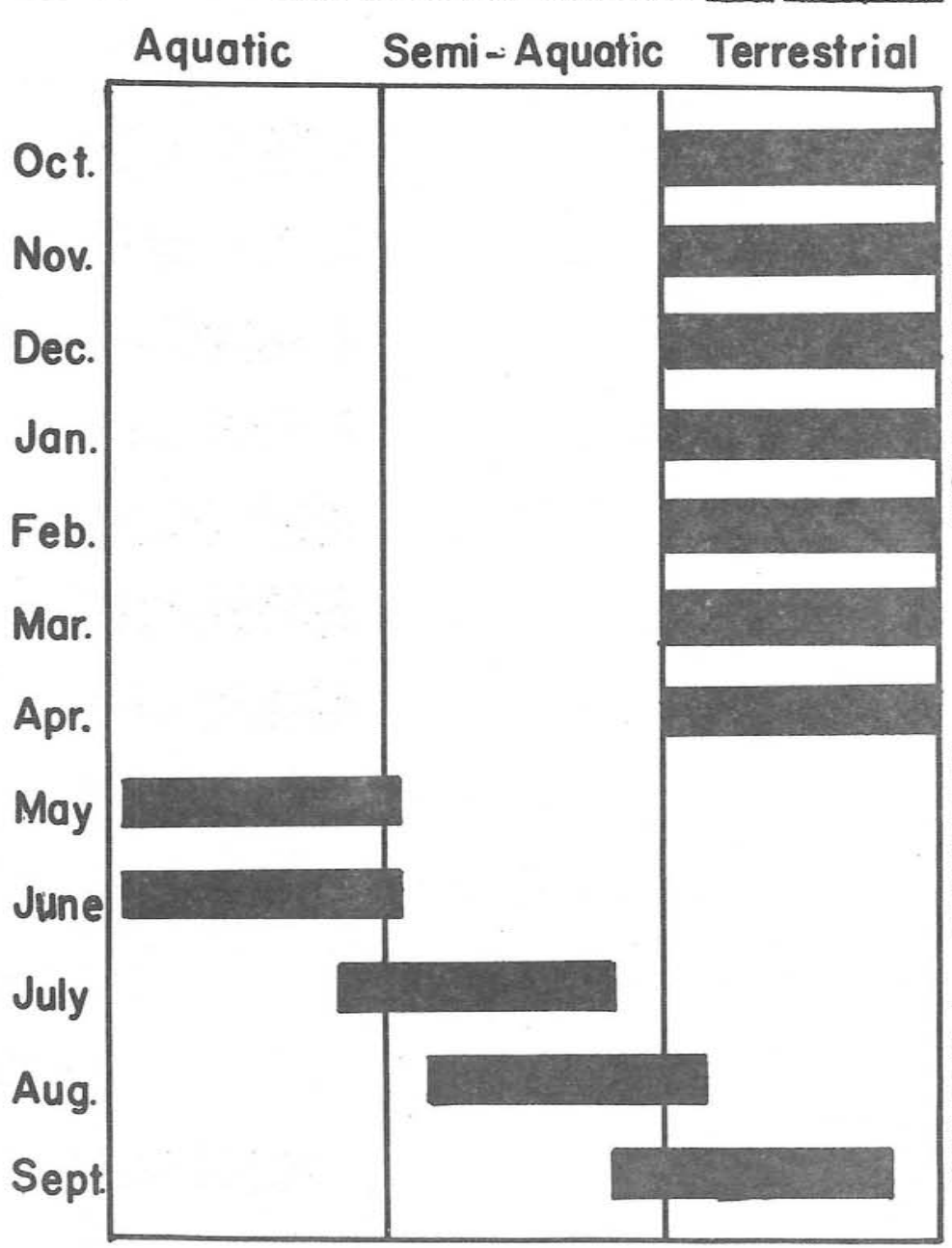


FIG. 2 SEASONAL HABITAT CHANGES IN BUFO HEMIOPHRYS



The percentage of full stomachs containing aquatic organisms (aquatic larvae, nymphs, gastropods, hemipterans or coleopterans) when plotted against time, rapidly decreased from 82% in May to 8% in September. This indicates that the frogs spend less time in an aquatic habitat as the summer progresses.

Biology of Bufo hemiophrys. (Canadian Toad)

The Canadian toad is the most terrestrial anuran of the region. The habitat of the toad was observed to be fully aquatic only during its breeding period. Following the breeding period, B. hemiophrys, frequents both semi-aquatic and terrestrial habitats. Figure 2 illustrates the approximate habitat changes in relation to time of year and activity of the toads.

Gonads were fully developed at the time of the toads' emergence from hibernation. The breeding period was observed from the beginning of May to the end of June in 1969. The first spent female was found on July 1, 1969, and regenerated ovaries were first observed on July 22, 1969. Changes in testes size were too gradual to be graded as to size, however, a maximum size similar to that observed prior to breeding, was attained by the end of August.

An examination of the stomach contents of B. hemiophrys revealed that the toads fed chiefly on arthropods and to a lesser extent on snails. The major part of the arthropod material consisted of insects. Among the wide variety of insects taken, beetles and flies appear to be most common as food while hymenopterans are next. Like frogs, the diet of toads seems to be influenced by the abundance of the available prey.

The percentage of full stomachs containing aquatic organisms when plotted against time increased from 11% in May to 51% in July and then decreased to 28% in September. The increase during the early part of the summer corresponds to the time spent in an aquatic breeding habitat and the decrease relates to the terrestrial habitat frequented by toads during the latter half of the summer.

Conclusions

The greater variety and quantity of helminth parasites found in R. pipiens is a result of the leopard frog's more aquatic habits. This relationship was substantiated by observations of a decrease in trematode infections in the summer months. The fact that few trematodes occur in B. hemiophrys suggests that the more terrestrial habits of the toads are not suitable to successful parasitism by trematodes. The comparatively fewer trematodes in toads during the aquatic breeding period is probably a result of the host's physiology and the life cycles of the parasites.

The Courtship Behaviour of Forster's Tern (Sterna forsteri) in Delta Marsh

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Department of Zoology

Note: This is a summary of the main points brought out in the seminar, and does not necessarily include all of the discussion given, as the seminar was given from slides, which served as an outline of the major points.

Introduction

During the summers of 1968 and 1969, I conducted a study on the biology, behavior, and ecology of Forster's tern (Sterna forsteri) during the breeding season at Delta, as an M.Sc. project under Dr. Roger M. Evans of the Department of Zoology (University of Manitoba). The dearth of literature on this species prompted the study, so that a background for further studies on this species, and for comparisons with other species, could be obtained. The effects of weather on the breeding success of the population were discussed, as far as could be provided by 1968 data, at the 1968 seminar series. This report deals in general terms with some of the findings relating to courtship behaviour in this species. At the time of the seminar all findings are considered preliminary in nature, until time permits sufficient analysis of the data to allow more definite statements to be made.

Study Area

Most of the observations on which the following report is based were made on "Forster's Bay", the first bay south-west of the University of Manitoba Field Station in the Delta Marsh. Most of this bay belongs to the Portage Country Club. Supplementary notes were obtained from Big Lake, further west in Delta Marsh, and from South Lake, Riding Mountain National Park.

Methods

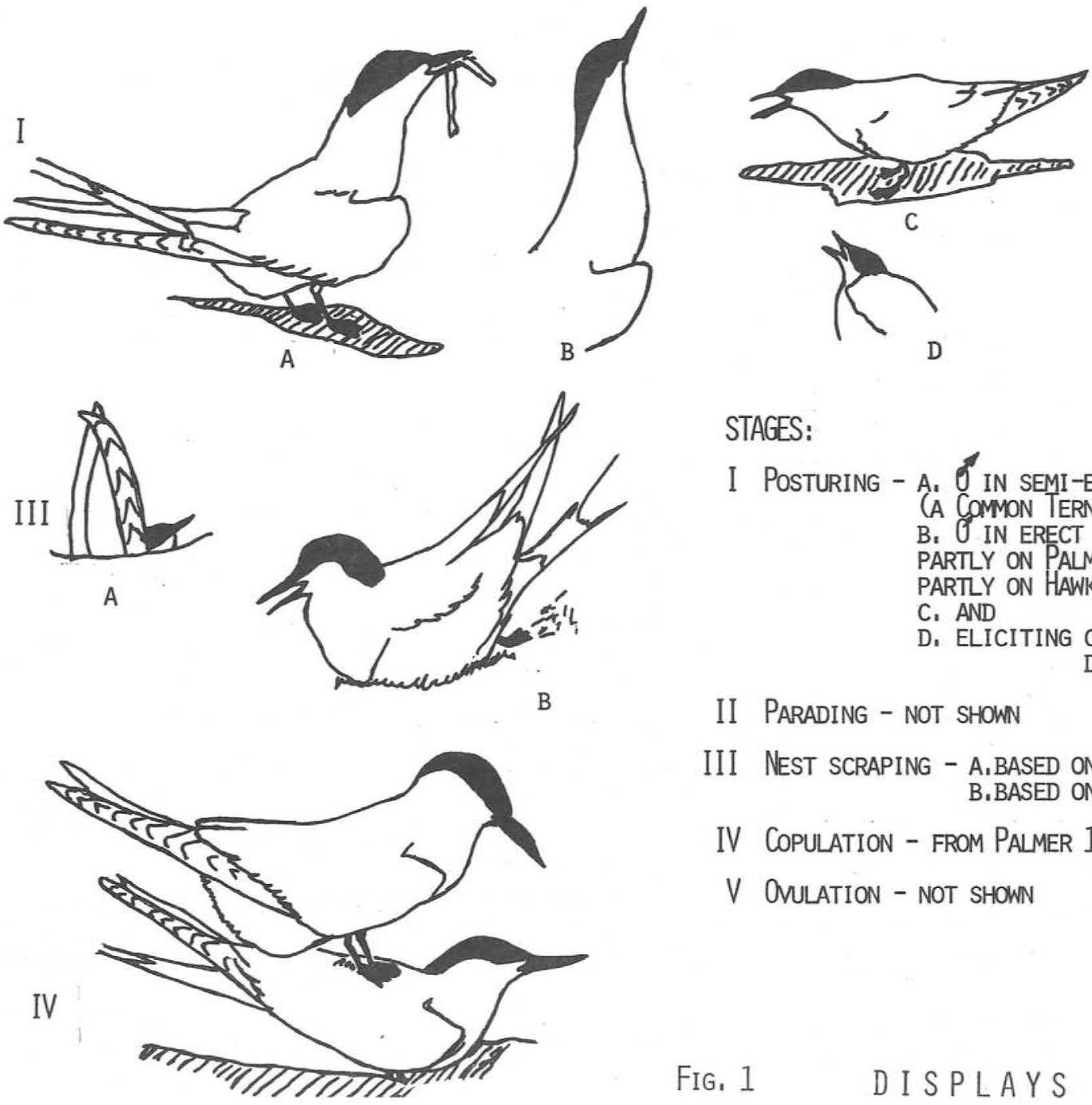
Most observations on courtship behaviour were made from a platform blind situated in one of the "islands" of the Forster's Bay colony. However, a considerable body of data was also obtained while canoeing from one part of the colony to another, and while wading through the "islands" to check nests for other facets of the research. Some photographs and tape recordings were also made.

Courtship

The term courtship is here used loosely to include not only mating behaviour, but also pair-bonding and pair-bond maintenance behaviour. The observations are here divided into three main "types" of courtship behaviour: (1) aerial courtship, (2) muskrat-house courtship, and (3) signpost and water courtship. The first two were the most frequent and probably the most important types.

Courtship on Muskrat Houses

The courtship behaviour involved with the actual mating ceremonies appears always to take place on a hard substrate, in this species usually on muskrat houses. This, of course, does not imply that none of the



STAGES:

I Posturing - A. ♂ in semi-erect posture (A Common Tern-Palmer, 1941)
B. ♂ in erect posture (based partly on Palmer, 1941 and partly on Hawksley, 1950)
C. and
D. eliciting C from Palmer, 1941
D from Southern, 1938

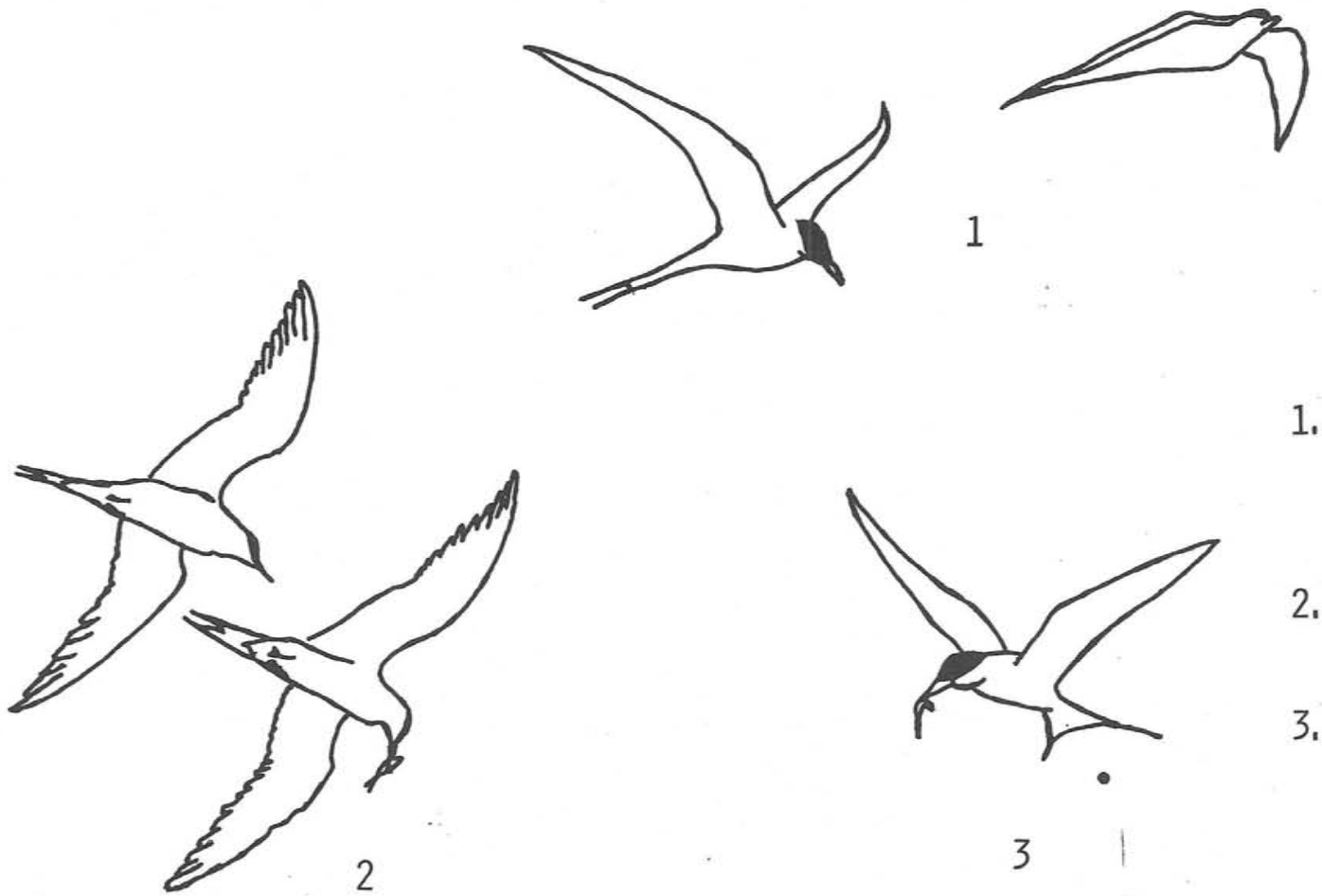
II Parading - not shown

III Nest scraping - A. based on Hawksley, 1950
B. based on Palmer, 1941

IV Copulation - from Palmer 1941

V Ovulation - not shown

Fig. 1 DISPLAYS



1. Pass with bent and straight postures in Arctic Tern (Cullen, 1960)
2. Common Tern in fish flight (Palmer, 1941)
3. Arctic Tern V-flying (Cullen, 1960)

FIG. 2 Aerial Displays

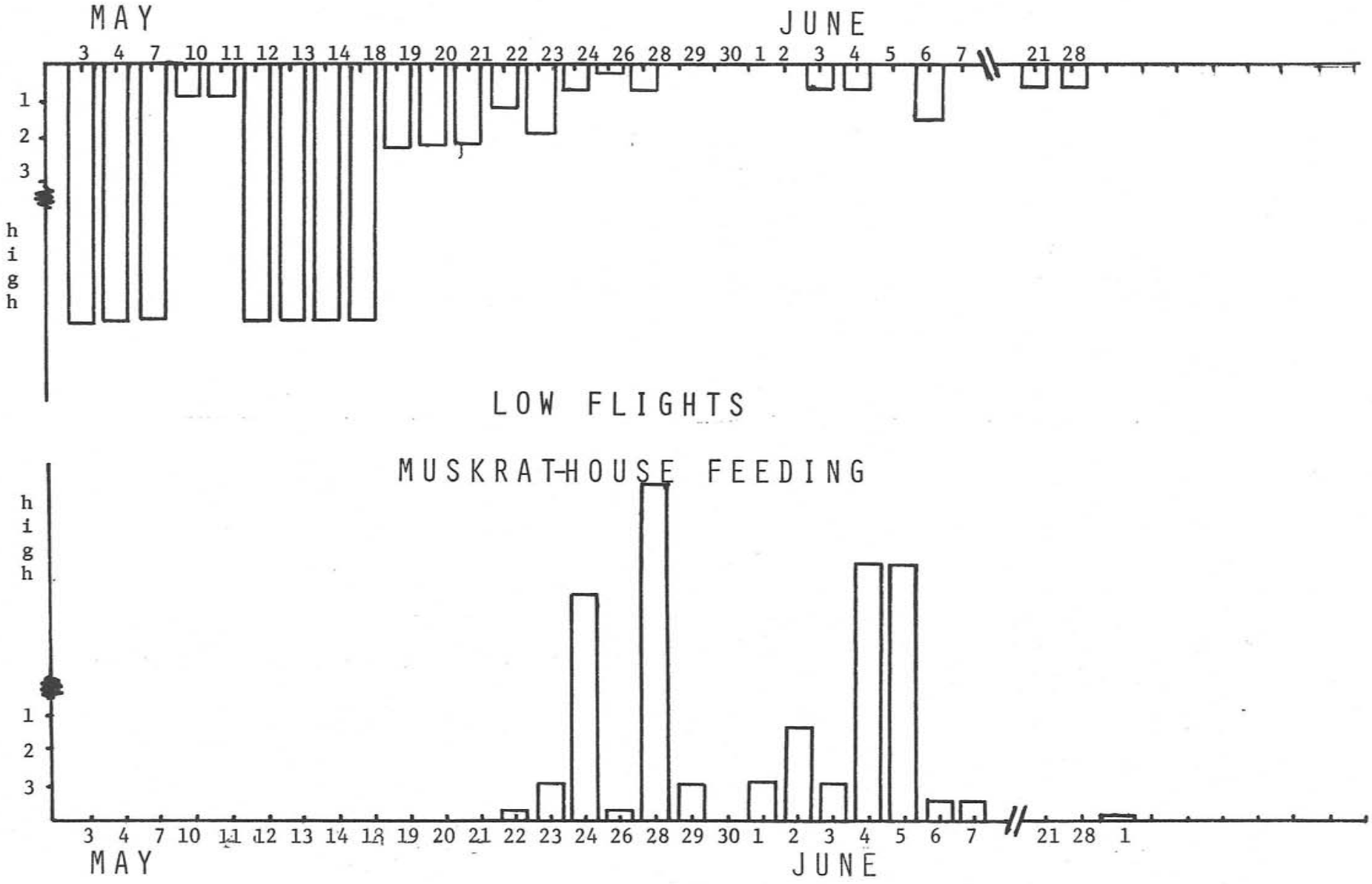


FIG. 3. FREQUENCY OF OCCURRENCE OF LOW FLIGHTS IN COURTSHIP AND MUSKRAT FEEDING.

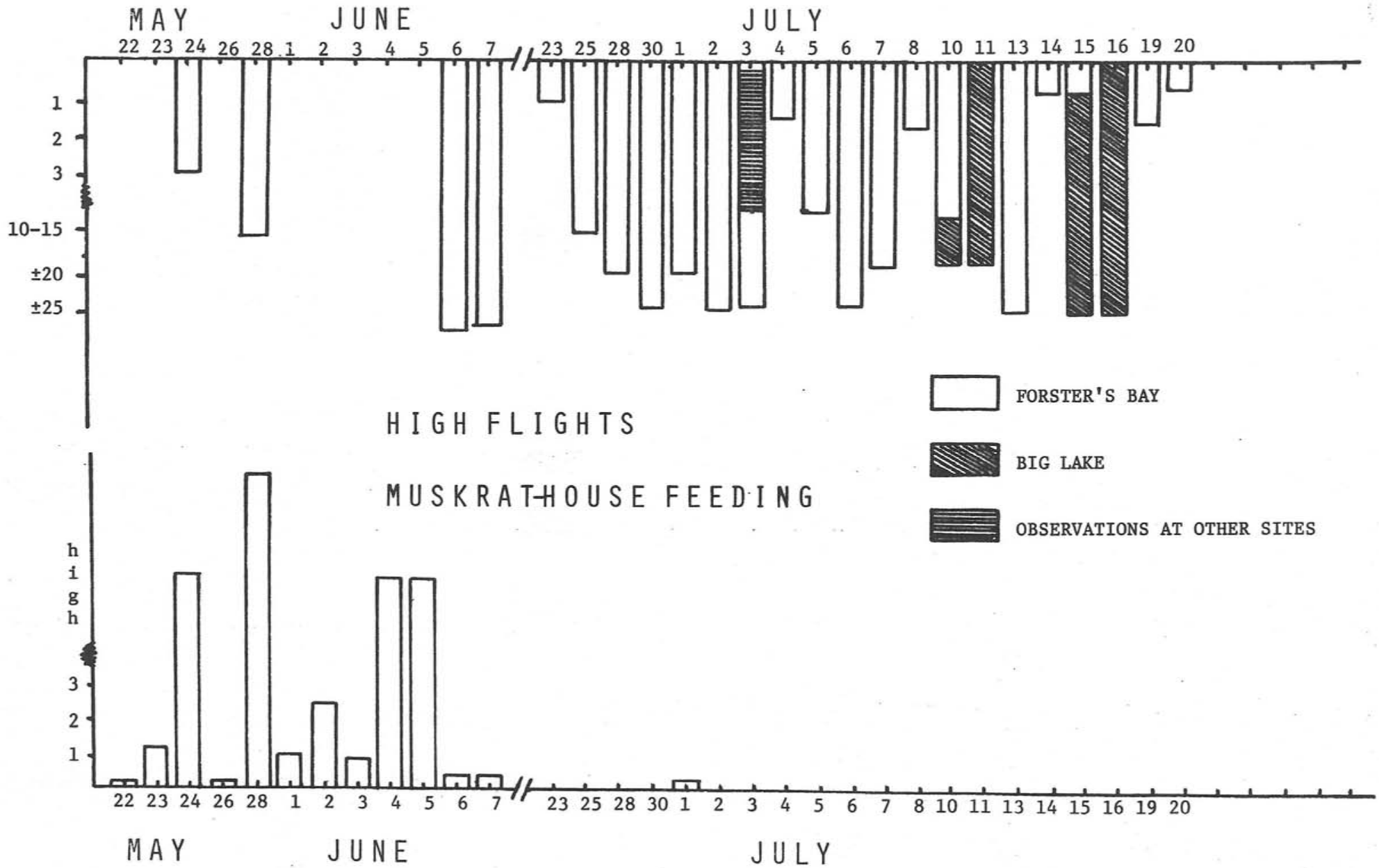


FIG. 4 FREQUENCY OF OCCURENCE OF HIGH FLIGHTS IN COURTSHIP AND MUSKRAT FEEDING.

ceremonies performed on these houses are involved with maintenance of the pair bond. Although steps occur as follows, and as shown in Figure 1 (terminology follows that of Cullen, 1956, Hawksley, 1950, Palmer, 1941, Southern, 1938 and other authors). These steps include:

a) "Posturing" - typically with one bird eliciting, and another coming in to present the first with a fish. However, eliciting may occur without the bird's being fed, and the postures and calls of the bird which usually feeds the fish may appear without the other bird's presence. Occasionally the performance may proceed without a fish, and therefore no actual feeding.
b) "Parading" - in which one bird typically walks around the other, which usually remains in the eliciting type of behaviour.
c) "Incipient Nest-building" or "Scraping" - in which one bird behaves as if creating the depression for a nest. This is often intermingled with "Parading".
d) "Mounting and Copulation" - in which one bird mounts on to the back of the other and copulation may or may not occur.

These steps may all occur together, but usually only one or two of them occur during a particular episode. In comparison to the other steps, fish-feeding is particularly frequent in Forster's tern. If copulation is successful, ovulation and incubation follow. Fish-feeding may continue after incubation has begun, for a few days.

"Signpost Courtship" and Courtship on Water

On several occasions, fish-feedings took place on signposts in the marsh. In these feedings, the bird on the post would elicit, just as would one on a muskrat house normally, and another would feed it from the air. The only basic difference between these feedings and those on houses, was that the bird bringing in the fish did not land, and therefore did not undergo his usual "Posturing" after feeding. On one occasion this occurred also on a muskrat house. At first, this behaviour occurred rarely on days of plenty of other courtship activity or commonly on days on which, for reasons of weather, other courtship activities were almost non-existent. However, it also occurred quite frequently later in the season when muskrat house courtship was almost completely over. Thus, it seemed to be a low-key version of "Posturing". Another type of courtship which does not seem to have been noted in other species, was a feeding which on a few occasions late in the season took place on the water. These two unusual types of courtship activity may be a reflection on the marsh-nesting habits of this species. The similarity of courtship feeding and feeding of the young has been noted by several authors in many bird species. In the Forster's tern, the young leave the nest within a few days after hatching, and are then fed by their parents in one of two ways: from the air, or by landing on the water and then passing over the food. These two methods would seem to correspond to the two "unusual" methods of courtship found in this species.

Aerial Courtship

In Aerial Courtship there appear to be two basic kinds of display which Cullen (1960) has termed "Low Flight" and High Flight" Both involve a "Pass" in which one bird changes positions with the other on one or more occasion(s). There are several differences in the two flights, but the most diagnostic feature is that the "High Flight" includes an ascent followed by a spectacular "Glide", which is absent in the "Low Flight" (Figure 2).

"Low Flights" are most frequent early in the season, tending to

fall off in frequency of occurrence at about the time muskrat house courtship begins (Figure 3), and these flights are thought to function mainly in the initial stages of acquiring a mate. "High Flights", on the other hand, first appear about the time that courtship beings on muskrat houses, and continue throughout the breeding season (Figure 4). These flights are thought to function more in maintenance of the pair-bond, and possibly later in stimulating adults to feed young. Normally only two birds participate in aerial displays, but occasionally three are involved in the "High Flight".

Concluding Remarks

As mentioned above, it is often difficult to distinguish courtship behaviour as such (i.e. mating) from pair-bonding and pair-bond maintenance behaviour. Further analysis of the data and comparisons with other species as reported in the literature should help to sort out some of these elements, but further long-term studies on many species in several habitat situations are necessary to clarify the situation. The above is only a summary of the main points involved in the courtship of Forster's terns. Further analysis should help to show how these various features of courtship behaviour are related to each other, to other behaviour such as incubation and feeding of the young, and to other influences in the environment, such as weather and other species of animals. A comparison of the behaviour of Forster's tern with that of other species, should help to reveal how each has modified its behaviour to suit its environment.

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A Preliminary Investigation of Water Fluctuations in the Delta Marsh

Floyd Phillips

Department of Botany

Introduction

Everyone is familiar with the need for adequate water supplies in order to sustain life on this planet. One interesting aspect of the water levels in Delta Marsh, is the relationship between ground water and its use by a dominant species in the marsh, Phragmites communis, Trin., the common reed.

Following a proposal that flood water of the Assiniboine River be diverted into Lake Manitoba, the Inland Waters Branch of the Department of Energy, Mines and Resources, (Ottawa) in co-operation with Water Control Branch of the Department of Mines and Natural Resources of Manitoba began a survey of ground water and soil permeability in the area of the proposed Diversion channel. In conducting this investigation they installed a number of shallow observation wells equipped with Stevens recorders in order to measure the ground water table. While analyzing the records, a diurnal fluctuation in the water table was observed in regions covered by marsh vegetation. Mr. John Gilliland. co-ordinator of the survey, asked Dr. E. R. Waygood and Dr. J. M. Walker if the marsh plants, especially Phragmites communis could be using enough water to cause this fluctuation.

The present study was undertaken to investigate the possible relationship between water used by the marsh plants and the shallow water table fluctuations. The hypothesis is that the flow rate of water through the soil--to replace losses by transpiration during the day--is insufficient to maintain the saturated zone in the soil. This causes a drop in the water table during the day. At night, the plants lose little water by evapotranspiration and water movement through the soil is able to restore the water table.

Methods

In the last two decades, a considerable amount of evapotranspiration research has been undertaken using cultivated crops such as corn and alfalfa. Various formulae have been developed to estimate potential evapotranspiration. In the present investigation, the energy balance formula by Penman (1963) has been used, incorporating the amount of water lost from an evaporation pan and environmental measurements of wind speed, net radiation, air temperature and humidity. All these factors are being monitored in the present study.

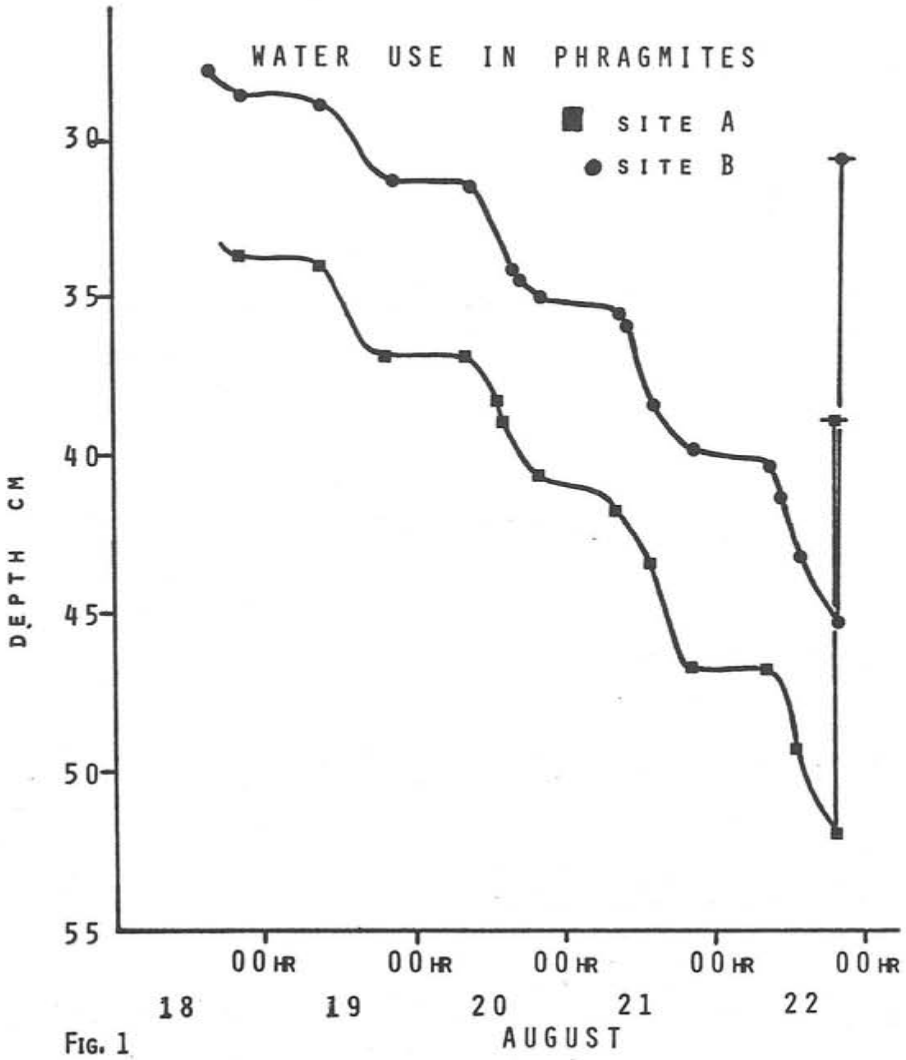
WATER USE IN PHRAGMITES
SITE A
SITE B
DEPTH CM
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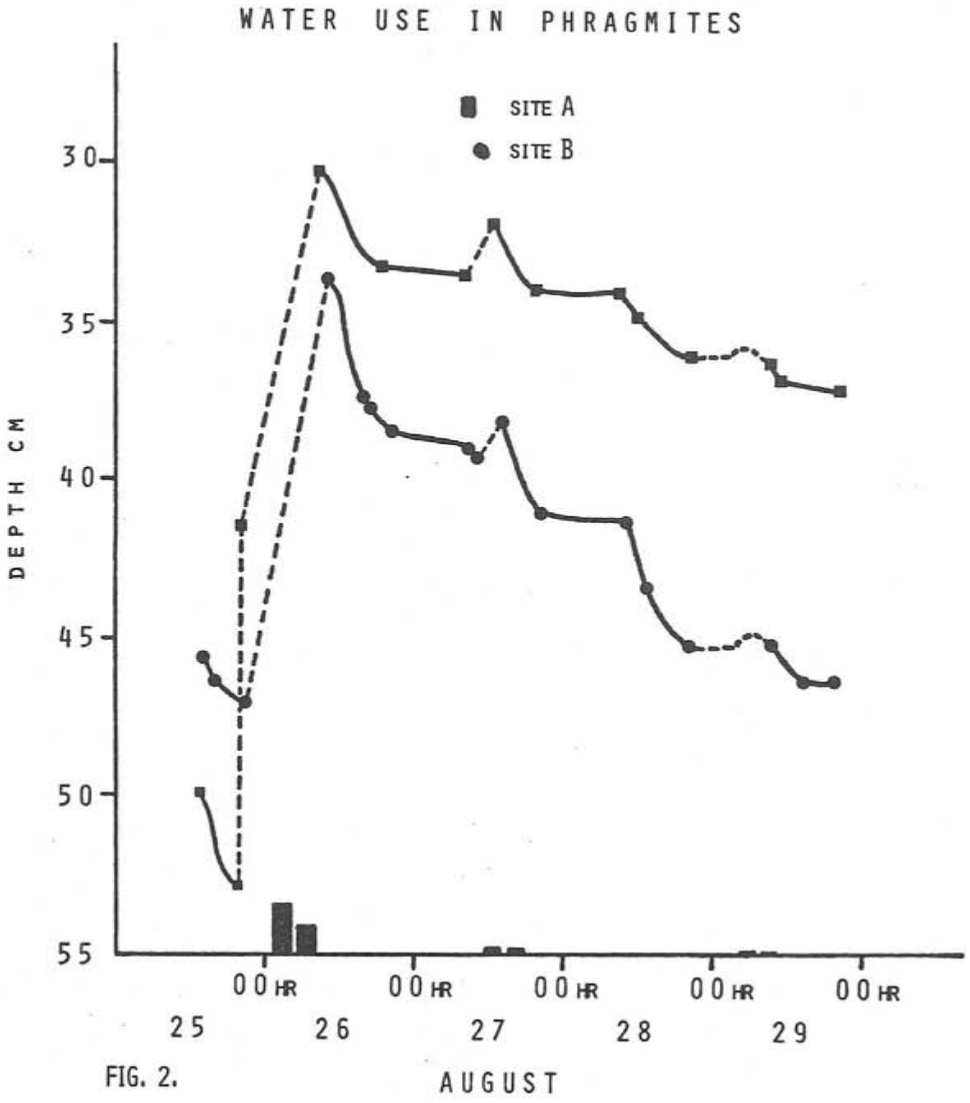
Fig. 1


WATER USE IN PHRAGMITES
SITE A
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DEPTH CM
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AUGUST

FIG. 2.

DATA FROM *PHRAGMITES* PLANTS IN LYSIMETER AND ADJACENT STAND

SITE B

	ADJACENT STAND	LYSIMETER
MEAN HEIGHT CM	218.3	228.6
NUMBER LEAVES/PLANT	15.1	14.2
PERCENT INFLORESCENCES	62.5%	54.4*%

*THIS FIGURE HAS BEEN CORRECTED FOR INFLORESCENCE DAMAGE DURING PREPARATION OF LYSIMETERS. THE ACTUAL FIGURE WAS 36.4%.

FIG. 3.

The development of the lysimeter has enabled investigators to directly measure the amount of water lost by evapotranspiration per unit of time. Other studies have involved weighing lysimeters which use the loss of weight of the lysimeter as a measure of the amount of water lost. A water table was maintained in the lysimeters set up during the summer of 1969. Using a small peizometer and a length of wire as a dipstick, the reduction in this water table was measured. The reduction in water table level was then used as a measure of the water lost from plants and from the soil surface. The lysimeter mentioned above consisted of an undisturbed block of soil supported by a plywood box set in a water tight metal tank. It was 50 cm.^{2} and 60 cm. deep. This depth was chosen because it encompassed the maximum rooting depth of the plants.

Two contrasting sites were chosen in the marsh, both with Phragmites stands. Site A had a higher water table than Site B, but Site B has a purer stand of Phragmites.

Results

Figure 1 shows the water use by Phragmites in 2 sites over a 5-day period in August, indicating a rapid fall in the water table of the lysimeters during the daylight hours. Figure 2 shows water use by Phragmites for another 5-day period. 5 l. of water was added to Lysimeter A at the left hand side of the graph. Rainfall also increased the water table level in the lysimeters. The rainfall on August 26th at Site A was 1.67 cm. and at Site B was 1.04 cm. The amount of water used by these plants ranged from 0.9 to 1.8 litres per day per 1/4 m.^{2} of ground. This compares very well with the 1.5 litres per day value published by Hobbs for an alfalfa stand.

The table in figure 3 shows a comparison between naturally growing Phragmites and those growing in the lysimeter. It is important to the study that the plants in the lysimeter are growing as well as those in the natural situation. The differences noted here in stem height, leaf numbers and percentage of inflorescences are insignificant. Next summer less variation should occur because the lysimeters will be installed in early May before plant growth is initiated.

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Archaeological Work in the Southern Lake Manitoba Area - 1969

Report of the Summer School Course Archaeological Techniques 76.661

C. T. Shay

Department of Anthropology

Introduction

Past surface collections and limited excavations in the area south of Lake Manitoba indicate that it has been occupied by a variety of cultures since at least 1,000 B.C. With the aim of learning more about these past cultures and their adjustments to the local environment, a field school from the University of Manitoba conducted archaeological reconnaissance and excavation during July, 1969. Student participants included Damon Chevier, Dan Hilderman and Gay and Bill Merry. Anthropology Graduate students Burke and Nancy Penny directed the school during the last week in July. Mrs. Maria Graham and her son from Portage also participated in the work for several days.

Fieldwork

The area involved is a roughly 15 x 6 mile area (90 sq. mi.) south of Lake Manitoba. The northern half is covered by Delta Marsh hh (50 sq. mi.), the remainder is part of the Portage Plain. Relief in the area is slight, allowing marsh water-level fluctuations to innundate or expose large areas. Elevated areas include low ridges adjacent to former drainage channels that flowed into Lake Manitoba from the Assiniboine River. Soils vary from heavy clays of the lake plain to sands of the ridges and modern beaches of Lake Manitoba. Principal vegetation types are deciduous forest on the modern beach ridge, aquatic grasses and sedges of the marsh, and, prior to recent cultivation, prairie with aspen groves on the Portage Plain.

Field survey was carried out from July 8-14 and excavation from July 14 to August lst. Sites recorded by two previous surveys (Boyd Wettlauffer and the Lake Agassiz Survey) were revisited and collections made from them. Five additional sites were located, and private collections were also noted and photographed. Collections included projectile points, other stone artifacts, stone chipping debris and small amounts of pottery. Among the sites visited were two circular earthworks reportedly built by a band of Dakota Indians when they were escaping from the Ojibwa in the late 19th century. One of these was overgrown with shrubs and could not be precisely located; the other near Clandeboye Bay was clearly delimited.

Another area of interest is the beach adjacent to the University of Manitoba Field Station, which has yielded considerable numbers of points, bison bone and a few pottery sherds, all apparently eroded from deposits underlying the beach. Test excavations conducted by the Lake Agassiz survey in 1967 proved unrewarding and the parent deposit of the materials remains unknown. Further investigations is warranted because these finds may relate to the development of the modern beach ridge.

Field Methods

The site selected for excavation (LAS 348) is located on a former beach ridge 400 meters south of the main ridge on the Bell estate, 1 ½ miles east of the Delta Waterfowl Research Station.

First, several 1 x 2 m test trenches were dug in and adjacent to a road leading from the ridge to the marsh. Most of these produced small amounts of bone fragments, waste flakes and pottery. Following these tests, efforts were concentrated on the ridge about 50 meters east of the trenches excavated by the Lake Agassiz survey in 1967. A backhoe cleared the shrub cover from an area of about 68 sq. m and a survey grid was established. Pits measuring 1 x 2 m were laid out within the cleared area and dug in 10 cm intervals. At the end of excavation, 28 sq. m had been opened up and a total of 17 cu. m removed.

Cultural material occurred from the surface to a depth of nearly 1 m although it was concentrated in two zones. The upper zone was near the original surface, the second was associated with a dark band, probably a former soil horizon. Materials recovered included mollusk shells, carbonized plant remains, bones, stone artifacts and chips and pottery.

Laboratory Analysis

Upon returning to Winnipeg the students worked in the Anthropology laboratory, processing the material collected. Finds were numbered, sorted into categories (bone, shell, etc.) counted and weighed. Artifacts and pottery were described, categorized and photographed. Analysis of the materials together with those collected by the Lake Agassiz Survey is still in progress.

Results and Provisional Interpretations

Early in the survey it became apparent that the majority of sites were located on the low ridges described above. These apparently served as camping areas and access routes to the lake. Although less valuable during periods of low water, they have been in use since about 1,000 B.C. judging from the point styles found on them.

Unfortunately, time did not permit a systematic survey of the ridges but one should be productive.

Because of its locations and relatively undisturbed condition, the Bell site provides a key to the late prehistoric occupation of the area. Pottery and projectile points are typical of the Late Woodland period (ca. 1000-1700 A.D.). The pottery includes types from the Laurel, Lockport, Manitoba and Winnipeg River wares defined by MacNeish (1958) for Southeastern Manitoba. Most of these types occur throughout the levels indicating either post-depositional mixing and/or contemporaneous deposition of several different types. The site may have been intermittantly occupied during much of Late Woodland times but more precise dating must await C-14 analysis. Stone artifacts included points, scrapers, knives and utilized flakes, most of them manufactured from locally-obtained chert. A few were of a non-local brown chalcedony (Knife River Flint).

Historic Indian groups in the region were primarily buffalo hunters although other mammals, fish, and some plant products were included in their diet. Inferences about the Late Woodland human ecology can be conveniently grouped under the following categories:

1. Resource patterns - the distribution in time and space of economically important plants, animals and other resources.
2. Exploitive patterns - the technology used in obtaining resources.
3. Settlement patterns - the way in which groups distribute themselves over the landscape through time.
4. Community patterns - the social organization of the groups involved.

Although evidence is as yet scanty, the environment of the area appears to have been more or less uniform for the past 1,000 years. Lake water levels probably fluctuated about as much as they have in recent decades, alternately flooding and exposing large areas of the marsh. Similarly, the seasonal distribution of major resources probably paralleled that of historic times. Bison would be available on the ridges and margins of the marsh during the spring and summer but may have sought shelter in aspen groves to the south in winter. Beaver and muskrat could be captured during all seasons, birds would be especially numerous during spring and fall migration and fish could be most easily obtained during spring spawning.

Plant and animal remains identified so far show that the inhabitants used a fairly wide range of natural resources but probably not all during the same season. These included hazelnuts, berries, bison, moose?, elk?, muskrat, beaver, fish, and birds. Several canine bones, possibly dog, were recovered but it is not known that these represent food remains. Bison and other game were probably killed with bows and arrows judging by the size and shape of the points recovered. Birds may have been killed with arrows or captured from blinds. Net impressions on some of the pottery suggest that nets may also have been used in fishing.

Because of the differences in seasonal availability of important resources, the Late Woodland inhabitants of the area were seasonally nomadic, gathering in larger groups when there was abundant food, splitting into smaller groups when food was scarce. The Bell site seems ideally situated for such groups to gather and exploit the resources of both the marsh and the lake. It was probably occupied during two seasons of the year; late summer or early fall for hunting and plant collecting, and spring for hunting and fishing. Other camps on the ridges leading to the marsh would also have been occupied during the warm months of the year. The people spent the winter in the shelter of aspen groves.

During their visits, the occupants carried out the normal range of domestic activities including butchering and food preparation, wood and bone working and stone tool manufacturing. It is not certain whether pottery was made at the site. These activities apparently overlapped in area because food refuse, stone and pottery were evenly distributed over the site. Repeated occupation, however, would probably destroy such spatial patterns.

Although it can be inferred that the site was occupied by family groups there is little to indicate the kinship composition or residence rules of these groups. One clue to such social patterns is the variable and often distinctive designs applied to pottery vessels before they are fired. It is safe to assume that women were the potters in Late Woodland times as they were among historic Canadian Indians. These designs together with their techniques of application would be passed on from mother to daughter (or grandmother to granddaughter) much as sewing skills are today. If women moved from their natal group at marriage, pottery decoration would be thereby dispersed, with women from different groups each making the styles learned in their original group. If, on the other hand, men joined their wife's group at marriage, decoration would be less variable within than between groups. Decorative variation within sites compared to that between sites should thus reflect post-marital residence and the degree of wife/husband exchange between groups.

The Bell site pottery is quite variable, representing types from four different ceramic wares. Several types appear to have been deposited at the same time, possibly by the same group. Corresponding ceramic variety involving the same pottery types occurs in upper levels of several southeastern Manitoba sites (MacNeish 1958). If this variety was produced by single groups, then within-site variation is greater than between-site variation suggesting that female potters left their groups at marriage. Furthermore, the distribution of some pottery types over much of Manitoba indicates a wide network of social interchange. Another indication of intergroup contacts is the occurrence of Knife River Flint at the Bell site and elsewhere in southern Manitoba (Leonoff 1970). This material is derived from deposits in central North Dakota although some can also be found in river gravels near Souris, Manitoba. Trade with the south was probably the means used to obtain it.

Summary

In July, 1969 a Field School from the University of Manitoba investigated the archaeological resources of the southern Lake Manitoba area through reconnaissance and excavation. The sites recorded by the school and previous surveys were mainly on low ridges adjacent to former drainage channels that flowed from the Portage Plain to Lake Manitoba. These ridges have served as camping areas and access routes to the lake since at least 1,000 BC. One site (LAS 348) on a former beach ridge behind the modern lake beach was excavated. It produced animal bone, plant remains, stone artifacts and chips and pottery associated with a buried soil horizon. The projectile points and pottery found are characteristic of the Late Woodland period (ca.1,000-1700 AD). Analysis of this material together with that collected in 1967 is now in progress.

The site represents a spring and fall encampment of one or more groups over several hundred years. The environment during occupation was probably not very different from recent times. Resources exploited included hazelnuts, berries, bison, moose?, elk?, beaver, muskrat, fish and birds. A variety of domestic activities were carried out including butchering, food processing, and work in stone, bone and wood. The variability of pottery decoration is evidence that women changed groups at marriage. The similarities of pottery from this site and sites elsewhere in Manitoba is suggestive of a wide range of group contacts. Further evidence of these contacts comes from the occurence of Knife River Flint probably obtained through trade from the south.

Acknowledgements

I would like to thank the following individuals and institutions for their interest and support. Operating funds were provided by the Dean of Arts and the Department of Anthropology which also furnished equipment. Much appreciation is due Dr. Jennifer Walker, Director of the University Field Station, where we stayed. She and her staff helped create a pleasant and stimulating environment for the crew. Mr. Peter Ward, manager of the Bell estate, provided the backhoe and other assistance to the project. Dr. George Lammers, Manitoba Museum of Man and Nature, is aiding in the identification of animal bone. I wish to acknowledge the assistance in analysis given by the Field School students, especially Dan Hilderman who has worked on all phases. Several graduate students also contributed: Gary Dickson (ceramic decoration) Les Leonoff (stone identification) and George Wenzel (wear patterns of stone tools).

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A Summary of Benthic Investigations at Delta Beach

Gian Vascatto

Department of Zoology

Introduction

In the summer of 1969, the Assiniboine River Diversion between Portage la Prairie and the southern shore of Lake Manitoba was nearing completion. The purpose of the diversion will be to conduct some of the Assiniboine River spring floodwaters into Lake Manitoba. The diversion channel is designed to carry a flow of up to 25,000 cubic feet per second, is scheduled to open in the spring of 1970, and each spring thereafter for the short flood periods.

It is realised that a considerable silt load, together with suspended nutrients, will be carried by the spring waters into the now semi-sterile sandy shores of the Delta area. As changes will doubtless occur in the present aquatic ecosystem, a superficial survey of the benthic fauna present was attempted in the summer of 1969.

Materials and Methods

Between the period of July 22 and August 1 a series of ten stations were established on the transect running north of the diversion outlet. These stations represented the following distances from the shore line: 1, 50, 100, 200, 300, 400, 550, 650, 750, and 1000 m.They varied in depth from 0.20m. to 4.00 m.

At each station the depth was measured and three Ekman samples were obtained, except for the 200, 300, 650, 750 m. stations where only two samples were taken, by means of a 15 cm x 15 cm Ekman dredge. The samples were washed through a #30 metal screen in a sieving bucket, and the organisms were hand-sorted into various groups.

At 1, 50, 100, 200, and 750 m. from shore sediment samples were collected with the Ekman dredge and immediately frozen. Later the samples were run through a standard set of nesting sieves to determine the percent dry weight composition of the sediment in the various particle size ranges. A sample of the sediment was oven-dried at 97^{o}C for 24 hours, and then ignited for one hour at 525^{o}C. Thus the percent loss on ignition was determined and the result was used as an index of organic carbon present in the sediment.

Results

The total number of organisms found increased with depth. The organisms did not appear in significant numbers in water shallower than 2 m., and increased steadily with depth showing a slight decline at the four m. depth. The range of the numbers per two or three samples was quite constant, the exception being the 4 m. samples. The low range is assumed as indicating a homogenous distribution of organisms at the sampling station. The sediment analysis indicated that the organic content increased with depth, while the mean particle size decreased. This would be expected since the inshore waters are constantly affected by wave action.

Discussion

By July 23, the majority of the benthic insects were reported to have emerged, so that it can be assumed that most of the organisms present in the samples would be overwintering in the lake. The greatest contributions to the number present was made by the genus Chironomus (Diptera), which increased steadily with depth, resulting in densities as high as 92 per sample. The other groups of Chironomids numerically contributed little and were represented by at least three species. Their distribution can not be commented upon until further study takes place.

Gastropods, Cincinnatia sp. and Valvata sp. also increased with depth, and represented the second largest numerical contributors.

The Pelecypoda represented by the family Spaeriidae, was present from the 1.75 m. depth onward. A few were found near the shore at 0.2 m. but these are believed to have been washed up by the waves. This is supported by the collection of several recently dead specimens.

The depression in numbers in the 1000m. samples is puzzling, and may be the result of increase aggregations of the Chironomids, or because the deeper water species which are known to emerge later, would have been present in early instars which would have easily washed through the mesh used.

This sampling programme should be continued in the future to determine if any marked change in composition has occurred after the opening of the Diversion; and to see whether the anticipated increase in nutrients causes an increase in the number of Oligochaetes and a depression of the Chironomid fauna.

A Quantitative Survey of the Benthos and Phytomacrofauna of an Isolated Body of Water in the Delta Marsh

Dr. John Wright

University Field Station (Delta Marsh)

Introduction

The Delta Marsh is characterised by very extensive areas of shallow water. This makes it an ideal habitat for a wide variety of aquatic invertebrates which reproduce during the summer months when the water temperature is high. The productivity of these aquatic invertebrates must be very considerable and far outweigh the total production of vertebrate life, including the fish, waterfowl and muskrats which are of more immediate importance to man. It therefore makes sense to devote some attention to the aquatic invertebrates in an attempt to understand their role in the marsh ecosystem. To date this has been an almost totally ignored field of research. It is uncertain whether this vast production is drawn upon to any significant extent by species important to man or whether it is a relatively untapped energy source from man's viewpoint. Whatever the answer, aquatic invertebrates are without doubt important in maintaining diversity and stability in the marsh ecosystem. Clearly, these questions cannot be examined in depth by individuals, but before investigating a more limited objective it is necessary to obtain a working knowledge of the structure and functioning of the marsh ecosystem.

For this reason a quantitative survey of the benthos and phytomacrofauna of an isolated body of water was undertaken on a year-round basis. Benthos refers to those animals which live in or on the substratum, while phytomacrofauna includes the species living in association with the submerged aquatic vegetation. In origin, the survey area was a short section of a channel which had previously meandered through the marsh before reaching Lake Manitoba. Infilling at both ends of this section of the channel produced an isolated body of water which is subsequently refered to as "The Crescent". Since The Crescent was isolated, it was not subject to large daily water-level fluctuations as were the majority of bays which have connections with Lake Manitoba by way of creeks. The total size was approximately 600 by 150 m. but littoral vegetation, which grew to a depth of about 40 cm., limited the area of open water to just over 8 hectares (fig. 1). A survey carried out at the end of May indicated that the deepest point was 1.12 m. This meant that the bay did not dry out or choke with aquatic vegetation during the summer, but at the same time was not so deep as to make quantitative sampling of the submerged vegetation difficult. During the course of the summer a drop in water-level of 26 cm. occured although rain periodically reversed the general trend temporarily.

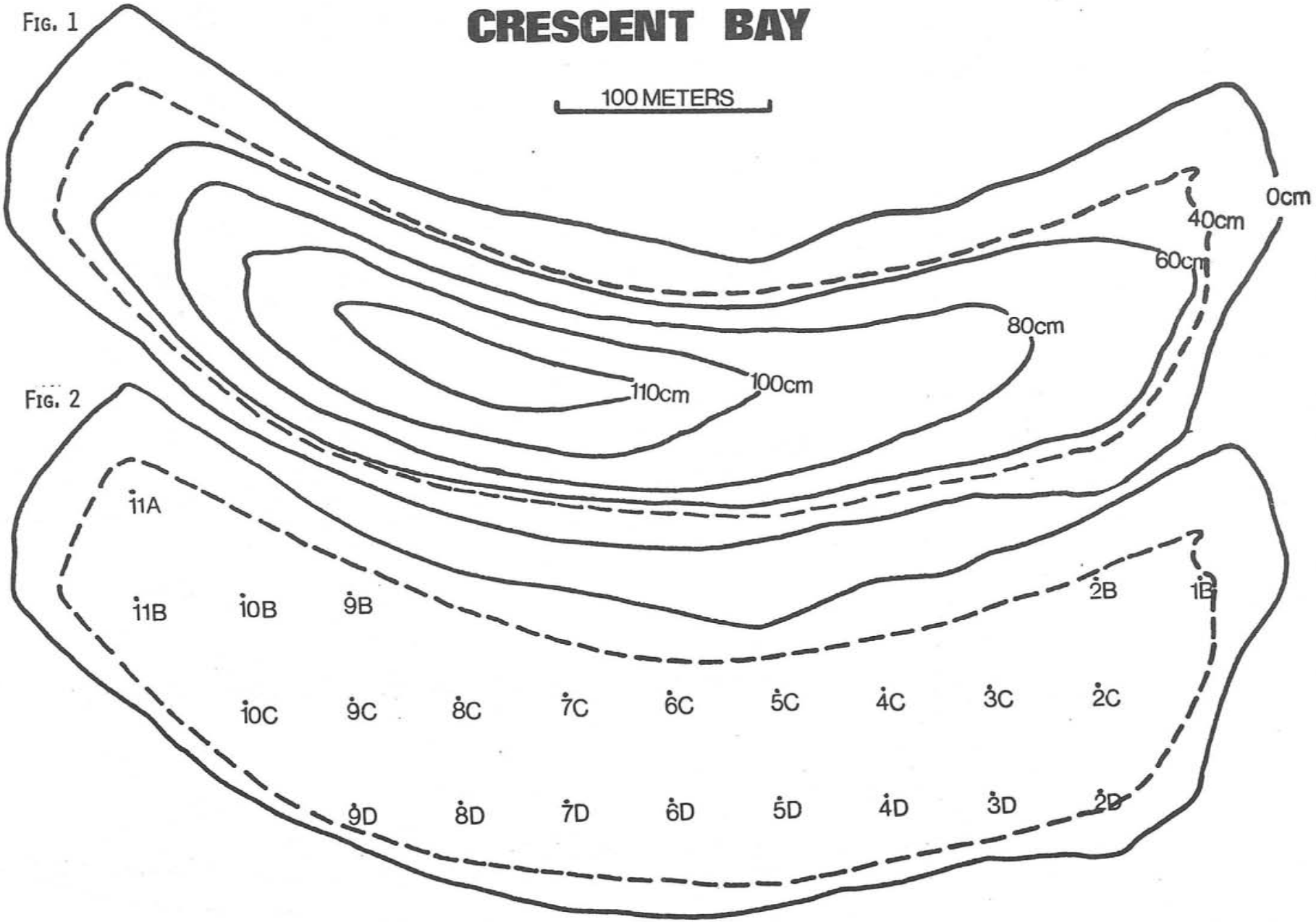

FIG. 1

FIG. 2

FIGURE 1: DEPTH CONTOURS FOR THE CRESCENT. THE DASHED LINE INDICATES THE DIVISION BETWEEN LITTORAL VEGETATION AND OPEN WATER.

FIGURE 2: SAMPLING STATIONS.

The substratum was composed of soft muck, having a high proportion of organic debris mixed in with clay and silt. Three species of submerged aquatics Myriophyllum sp., Potamogeton pectinatus, and Potamogeton friesii were recorded and growth of all three species was slow at first, but after mid-July became quite spectacular. Myriophyllum sp. dominated the deeper areas but P. pectinatus predominated in shallower areas. Nevertheless, all three species were found throughout the bay although growth was meagre at depths in excess of 1 m.

Methods

During the initial surveying, a 50 m. grid system was staked out over the entire bay. This gave 23 sampling stations, all of which were used during the June and July sampling (fig. 2). Four samples were taken at each station with a tall 6 x 6 in. Ekman dredge mounted on a 6 ft. pole. Screening of each sample was carried out at the side of the bay using a 30-mesh wash-bucket and after the operation one to two pints of debris usually remained. This was preserved in alcohol on return to the laboratory. Handsorting of this debris to remove the fauna proved too laborious since each sample took between 1 1/2 and 2 hours. A flotation method was therefore employed in which a sucrose solution of specific gravity 1.12 was added to the sample, which was then stirred. Silt, clay and most debris sank to the bottom but the animals floated. They were scooped from the surface and the process of stirring and scooping repeated until great difficulty was encountered in finding further animals (30 minutes).

With the sudden upsurge of vegetation in mid-July, the Ekman dredge became inappropriate for sampling the vegetation and substratum. A Gerking-type box sampler was therefore employed for the August and September samples. This apparatus sampled the submerged aquatic vegetation covering 1 sq. ft. of substratum before an Ekman dredge was used to sample the substratum immediately below the vegetation. The samples of aquatic vegetation with their associated animals obtained from the Gerking-type sampler were preserved prior to handsorting to remove the animals. Ekman samples were treated as previously outlined. Fourteen of the original 23 sampling stations were used during August and September and in 4 of these, vegetation was so poorly developed that the Ekman dredge only was required.

Work on the sorting, identification, counting and measuring of the animals in approximately 300 Ekman samples and 80 Gerking samples obtained during the summer is currently in progress. For the purposes of this discussion many species have been brought together and placed into major groups so that one or two of the most important trends can be illustrated.

CRESCENT BAY 1969 STATION 3C

NUMBER OF ANIMALS PER SQUARE METRE

	June	July	August	September
HIRUDINEA	-	76	73	36
CRUSTACEA	54	65	1,987	2,808
TRICHOPTERA	32	-	162	97
ZYGOPTERA	11	-	8	16
HEMIPTERA	43	-	383	203
COLEOPTERA	184	183	157	35
DIPTERA	5,432	4,590	135	3
MOLLUSCA	-	22	32	1,350

TABLE I

CRESCENT BAY 1969 STATION 1B

NUMBER OF ANIMALS PER SQUARE METRE

	June	July	August	September
HIRUDINEA	-	76	478	27
CRUSTACEA	32	356	1,847	754
TRICHOPTERA	-	140	92	32
ZYGOPTERA	-	-	27	86
HEMIPTERA	22	54	475	135
COLEOPTERA	87	183	146	95
DIPTERA	12,074	8,294	194	95
MOLLUSCA	-	22	111	513

TABLE 2

CRESCENT BAY 1969 STATION 7C

NUMBER OF ANIMALS PER SQUARE METRE

	June	July	August	September
HIRUDINEA	-	86	-	22
CRUSTACEA	-	400	2,722	9,796
TRICHOPTERA	65	54	140	65
ZYGOPTERA	43	11	-	-
HEMIPTERA	11	43	11	43
COLEOPTERA	194	367	162	96
DIPTERA	3,618	3,488	605	1,123
MOLLUSCA	-	76	54	335

TABLE 3

CRESCENT BAY 1969 STATION 3C

	BOX SAMPLES				EKMAN SAMPLES			
DRY WT. VEGETATION GMS.	9.2	7.6	7.9	10.7				
HIRUDINEA	4	-	-	1	-	8	-	-
CRUSTACEA	333	154	121	164	76	80	56	56
TRICHOPTERA	8	14	5	3	-	4	-	4
ZYGOPTERA	1	2	1	2	-	-	-	-
HEMIPTERA	32	9	8	17	-	-	-	-
COLEOPTERA	4	6	2	1	-	-	-	-
DIPTERA	13	4	8	8	-	-	-	-
MOLLUSCA	194	60	120	77	4	32	8	4

TABLE 4

Results

Table 1 presents data collected at station 3C where Myriophyllum sp. was dominant. High numbers of dipteran larvae, almost all Tendipedidae, were present during the early summer. Their low numbers in the fall indicated winter growth within the muck bottom or rapid growth in the spring. Zygoptera (damselflies) in addition to many species of dipterans emerged during the early part of the summer and both groups provided an important source of food for nesting birds in the area. Although densities of the Hirudinea, Crustacea and Molluscs were high in the fall, their very low spring densities indicated considerable winter mortality. The benthic Crustacea, represented by Hyalella azteca were prolific breeders throughout the summer. Physella sp. and Placobdella sp. the most important gastropod molluscs and leech species, reproduced in June and size structure data indicated that the young of the year were themselves breeding by August.

Table 2 presents data collected at station 1B where P. pectinatus was dominant but the dry weight of vegetation was similar to station 3C. Again, densities of Tendipedidae were very high during the early summer. The Coleoptera included larvae of both herbivores and a wide variety of carnivorous species. The carnivorous larvae (Dytiscidae) were notable for the succession of species which occupied a predominant position during each successive monthly collection. The drop in density of Hirudinea and Crustacea in September poses an interesting problem, but the cause of mortality, whether predation or some other factor(s) is not known.

Near the centre of the Bay (Table 3, station 7C) where there was very little vegetation, there were nevertheless high populations of Hyalella azteca and Physella sp. It is thought that both species were utilizing animal and plant debris which had accumulated on the substratum. In Table 4 data for station 3C for the month of September is presented to show the relative numbers of these two species found in association with the plants and the substratum. It appears that both species prefered vegetation, when available, although at least part of the population was on the substratum. Most other groups were confined to the vegetation.

Summarizing, the major food sources available to predators appeared to be diptera in early summer and Hyalella azteca and Physella sp. in late summer and fall. The Hirudinea, Crustacea (excepting the zooplankton) and Mollusca were each dominated by a single species which underwent remarkable increase under very favourable conditions from low population densities in spring. In contrast, the diptera were represented by a considerable number of species, including detritus feeders, herbivores and predators.

In conclusion, this survey indicates that there are a large number of fascinating problems awaiting attention in this field of marsh ecology.

PUBLICATIONS

UNIVERSITY FIELD STATION (DELTA MARSH)

1. Walker, J.M. and E.R. Waygood, Ecology of Phragmites communis Trin. I. Net photosynthesis of a single shoot in situ. Can. J. Botany, 46, 549 May, 1968.

2. Evans, R.M. and R.W. Nero. Sight record of Green Heron at Delta, Manitoba, The Blue Jay, vol. XXV, (4) December, 1967.

3. Tamplin, M. The Glacial Lake Agassiz Survey. Preliminary Report, University of Manitoba, September, 1966.

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8. Watts, C.H.S. The Larvae of Dytiscidae (Coleoptera) from Delta, Manitoba. The Can. Entomologist, vol. 102 (6), June, 1970.

9. McNicholl, M. The Knot as a migrant in Southern Manitoba, The Blue Jay, vol. XXVII (1), March, 1969.

10. McNicholl, M. Further note on Knot records for Manitoba, The Blue Jay, vol. XXVII (2), June, 1969.

11. Hominick, W. Synchronization of Life Cycles of Three New Mermithids (Nematoda) with their Chironomic (Diptera) Hosts and some observations on the Pathology of the Infections, 101 pps. M.Sc. Thesis, University of Manitoba. 1969.

THE UNIVERSITY OF MANITOBA
WINNIPEG, CANADA

UNIVERSITY FIELD STATION (DELTA MARSH)

THIRD UNIVERSITY FIELD STATION SEMINAR

SATURDAY, NOVEMBER 22nd, 1969 ROOM 527 BULLER BUILDING

9:00 A.M.

A presentation of papers by members of the University of Manitoba who worked at the University Field Station (Delta Marsh) and the Delta Waterfowl Research Station during the past summer.

P R O G R A M M E

Approximate Time

9:00 - 9:15 Preliminary Report on the Pleistocene Geology of the Area Between Portage la Prairie and Lake Manitoba.
- Mr. Mark Fenton, Department of Geology.

9:20 - 9:35 Hydrogeology and Hydrogeochemistry of the Delta Area.
- Mr. Dave Lutchman, Dept. of Geology.

9:40 - 9:55 Preliminary Investigations on Water Level Fluctuations in the Delta Marsh.
- Mr. Floyd Phillips, Dept. of Botany.

10:00-10:15 Nitrification Processes of Marsh Soils.
- Mr. Len Hendzel, Dept. of Botany.

C O F F E E

10:35-10:50 Phytoplankton Succession in Cadham Bay.
- Mr. Dennis Brown, Dept. of Botany

10:55-11:10 A Quantitative Survey of the Benthos and Phytomacrofauna of an Isolated Marsh Bay.
- Dr. John Wright, University Field Station

11:15-11:30 Notes on the Macrobenthos and Sediment of Delta Beach.
- Mr. Gian Vascatto, Dept. of Zoology.

11:35-11:50 Internal Helminthes of Rana pipiens and Bufo hemiophrys from the Delta Marsh.
- Mr. Leo Hlynka, Dept. of Zoology

L U N C H - will be available in Pembina Hall

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PROGRAMME : THIRD UNIVERSITY FIELD STATION SEMINAR

1:30 - 1:45 Archaeology of the Southern Lake Manitoba Area.
- Professor Tom Shay, Dept. of Anthropology

1:50 - 2:05 Biology, Pathology and Occurence of Echinuria uncinata at Delta, Manitoba.
- Mr. Fred Austin, Dept. of Zoology

2:10 - 2:25 The Effect of Stress on Parasitism in Mallards.
- Mr. Phil Ould, Dept. of Zoology

2:30 - 2:45 Population Dynamics of the Brook Stickleback.
- Mr. T.O. Acere, Dept. of Zoology

C O F F E E

3:05 - 3:20 Depth Distribution of the Emerald Shiner (Notropis atherinoides) and Spottail Shiner, in Lake Manitoba.
- Mr. Don Bernard, Dept. of Zoology

3:25 - 3:40 Seasonal Bioenergetics in the Muskrat.
- Dr. M. Alexsiuk, Dept. of Zoology

3:45 - 4:00 Territory in the Yellow Warbler (Dendroica petechia): A Report on an Introductory Investigation.
- Mr. Harold Bauer, Dept. of Psychology.

4:05 - 4:20 The Courtship Behaviour of Forster's Terns (Sterna forsteri) in Delta Marsh.
- Mr. Martin McNicholl, Dept. of Zoology.

APPENDIX A

The Biology, Pathology and Occurrence of *Echinuria uncinata* at Delta, Manitoba

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Echinuria uncinata is a parasite of waterfowl the world over. Most reports of this parasite have dealt with outbreaks in large, domestic flocks in Europe and Asia, where extensive control and chemotherapy programs are carried out. However, virtually nothing has been done on this parasite in North America. Cornwell (1963) reported an outbreak of echinuriasis which killed 30% of the ducks on a pond at the Delta Waterfowl Research Station. This Field Station has excellent research facilities, making this an ideal place to study the biology and pathology of this nematode in Manitoba.

Observations

A. Biology

1. Eggs of *E. uncinata* perished when frozen for 85 days at -5°C. but survived the same period dried on filter paper and stored at a relative humidity above 80%.

2. To ascertain what species of invertebrates could vector this parasite, several invertebrates collected at Delta were exposed to the eggs of this parasite. The following species became infected with juvenile worms:

a)	Cladocera	*Daphnia pulex*
		D. magna
		Simocephalus vetulus
		Ceriodaphnia reticulata
		C. acanthina
		Miona macrocopa
		Eurycercus lamellatus
b)	Amphipoda	*Gammarus lacustris*
		Hyalella azteca
c)	Anostraca	*Chirocephalopsis bundyi*
d)	Conchostraca	*Lynceus brachyura*

Dipteran, Coleopteran and Hemipteran larvae; Copepods; Ostracoda; and the Cladocerans *Alona retangula* and *Scapherolebris kingi* did not become infected.

3. Development of *E. uncinata* juveniles in *Daphnia*. At 20-24°C., 10 days are required for the worms to become infective (third stage), while at 15°C., thirty or more days are required.

4. Development of E. uncinata in Delta mallards.

a) 10 day infections- all worms were 4th stage juveniles.
b) 20 day infections- most worms found moniting to adults. The start of sexual development was evident.
c) 30 day infections- adult male worms were sexually mature while females were gravid but not ovipositing.
d) 40 day infections- adult females ovipositing.
e) 50 day infections- females 10-11mm. long ; males 8mm. long.

Growth increased exponentially up to forty days, when growth rate decreased sharply. Maximum growth coincided with maximum gonadal development.

5. E. uncinata infections in different aged Delta mallards.

Age host when innoculated	Percent survival worms	Body Length (mm.) Female	Male
One week	42%	10.5	8.5
One month	32%	8.3	7.9
Two months	14%	4.7	6.2
Three months	12%	6.9	6.3

6. E. uncinata infections of different intensities.

Number of granulomas correlated well with the number of parasites recovered from each duck, but no correlations existed between size and numbers of parasites.

7. E. uncinata infections in different species of waterfowl.

a) Good hosts (all showed evidence of infection): gadwall, pintail, common eider, lesser scaup and domestic goose.
b) Poor hosts (showed evidence of resistance to infection): redhead , ruddy duck , shovellers, blue-winged teal and coot .

8. Longevity of E. uncinata in the Delta Mallard.

Most early mortality of the parasites started in 30 days of infection. Very few infections were found over 6 months, although a few were known to last one year.

B. Pathology

1. Little or no pathological effects on the intermediate host. As many as 81 juveniles were recovered from only 10 Daphnia magna.

2. In the definitive host:

a) 10 days- slight inflamation of mucosal layer on isthmus. Small lesions evident in surrounding areas.
b) 20 days - parasites confined to larger inflamations on isthmus, these swellings becoming fibrotic.
c) 30 days - swellings now true granulomas, hardened fibrotic and with a central cavity containing the parasites.
d) 40 days - 50 days - granulomas larger and more prominent and often contained necrotic "plugs".
e) 1 year - granulomas large, thin walled sacs distended with parasites and fluids.

3. Pathology in different intensities of infection. Granuloma number correlated with parasite number found but not with innoculation dose. In the heavier infections, the granulomas coalesced to form bands of fibrotic tissue, with many cavities along the isthmus.

4. In different species of waterfowl. In all birds, granulomas were almost exclusively found along the isthmus except the domestic geese, where granulomas were occasionally found at the junction of the proventriculus and oesophagus. In resistant duck species, small scars were often found along the isthmus. Coots had no nodules, but instead, a necrotic band occurred along the isthmus.

C. Occurrence

E. uncinata was found in:

a) Breeding stock (Wild mallards).
b) Resident birds (Trumpeter swan, Delta mallards).
c) Wild mallards and pintails (Crichton, 1969).
d) Gammarus lacustris collected from the Blind Channel west of the Delta Waterfowl Research Station in March, 1969.
e) Daphnia pulex and D. magna from the Swan pond and Bain's pen.
f) From D. pulex and D. magna and Simocephalus vetulus from the Field Station pond in 1968 and 1969 summers.

References

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Cornwell, G. W. 1966. An ecological reconnaissance of helminth popululations in the canvasback Aythya valisinerai. Ph.D. Thesis. Univ. of Michigan, Ann Arbour.

Crichton, Vincent, F. J. 1969. The helminths in the digestive tract of the mallard and pintail in southern Manitoba. M.Sc. Thesis. Univ. of Manitoba.

Stress and Parasitism in Mallard Ducks, Delta, 1969

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A preliminary study was made at the Delta Waterfowl Research Station on the effects of stress on ducks and their susceptibility to the parasitic nematode Echinuria uncinata.

In each experiment stressed and control birds were inoculated with equal numbers of infective E. uncinata juveniles. As the nematodes usually require 40 days to become sexually mature in mallards (Austin, 1969) experimental birds were left 45 days before autopsy. The long term of the experiments required the use of stressor agents which could be applied over a long period of time without fatal effect on the ducks. Consequently crowding, deficient diet, heat exposure, lead shot ingestion and cortisone injection were chosen as stressors.

Symptoms of Selye's Stress Syndrome were used to determine the degree of stress to which the ducks were subjected. Selye noted that a general response was common to all stressors (1950). The major characteristics of the syndrome are: adrenocortical enlargement accompanied by an increased production of the adrenocorticoids, involution of the thymicolymphatic apparatus and gastrointestinal ulcers (only in mammals).

In waterfowl, therefore, the degeneration of the thymus, bursa of Fabricius and other lymphatic structures, as well as the hypertrophy of the adrenal glands would indicate that the ducks were under stress.

Experiments on Stress

1. Crowding experiment: Ten control birds were maintained in a 10 ft. x 10 ft. enclosure with a 5 ft. x 5 ft. pond. Ten stressed birds were held in a 2 ft. x 4 ft. enclosure. Three factors apparently acted as stressors in this experiment: social interaction between the ducks due to crowding, confinement in a small space and the wetting effect of the faeces on the feathers of the ducks.

2. Protein deficient diet: Control birds were fed a diet similar to all birds in our care and containing 16% protein. Stressed ducks were fed corn meal containing approximately 8% protein. Ducklings require a diet containing at least 16% protein to develop normally.

3. Heat exposure: Control ducks were maintained at normal seasonal ambient temperatures. Stressed birds were held throughout the experiment in an enclosure heated by brooder lamps at temperatures ranging from 95° to 110°F.

4. Lead shot ingestion: Stressed birds were administered a total of 17 pellets each over a period of 49 days.

5. Cortisone injection: Stressed birds were injected with a 1 cc. dosage of 25 mg. of cortisone per kilogram body weight twice weekly for the duration of the experiment. Controls were injected with 1 cc. of physiological saline twice a week.

Expected Results

A stressed bird would have theoretically a smaller bursa and thymus, larger adrenal glands, and a smaller weight gain. If stress and parasitism are directly correlated, then a greater number of larger worms would occur in the stressed than in the unstressed or "control" bird.

Observed Results

Of the data already analyzed it was found in every experiment that the mean weights of bursa and thymus were lower and that the mean number of worms was greater in stressed than control birds. The weight gain was less in stressed than in control birds with the exception of the birds in the cortisone experiments.

The results of these preliminary experiments indicate that a definite relationship may exist between stress and parasite load in the mallard duck.

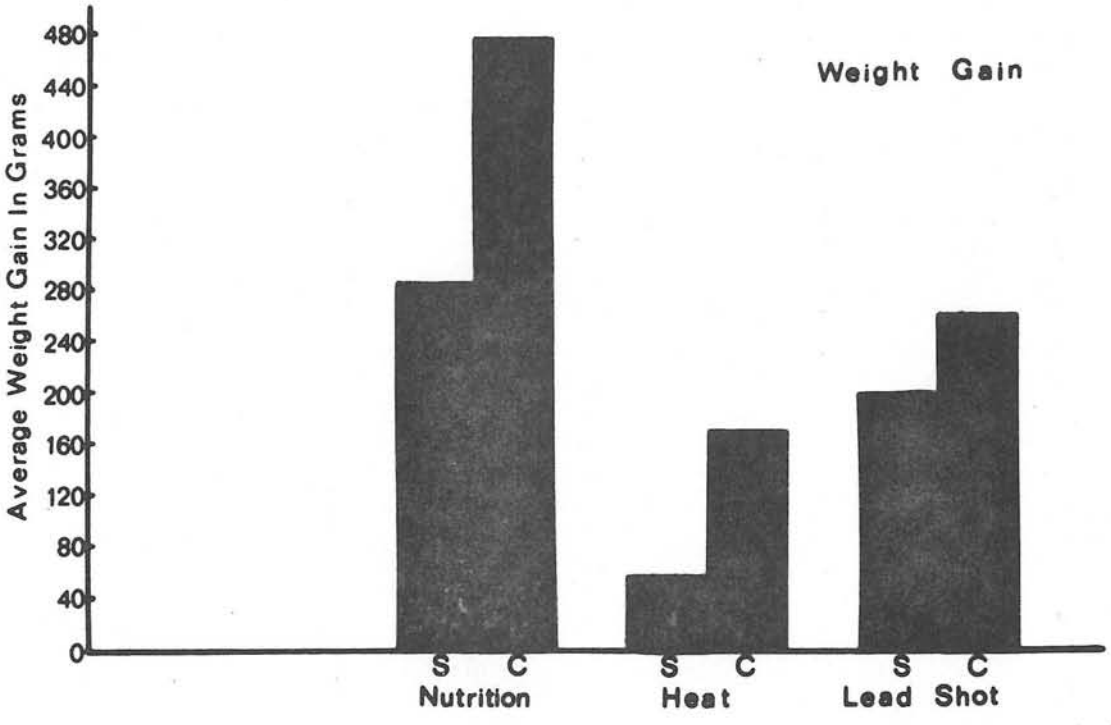

Figure 1: Mean weight gain of stressed and control ducklings during experimental period.

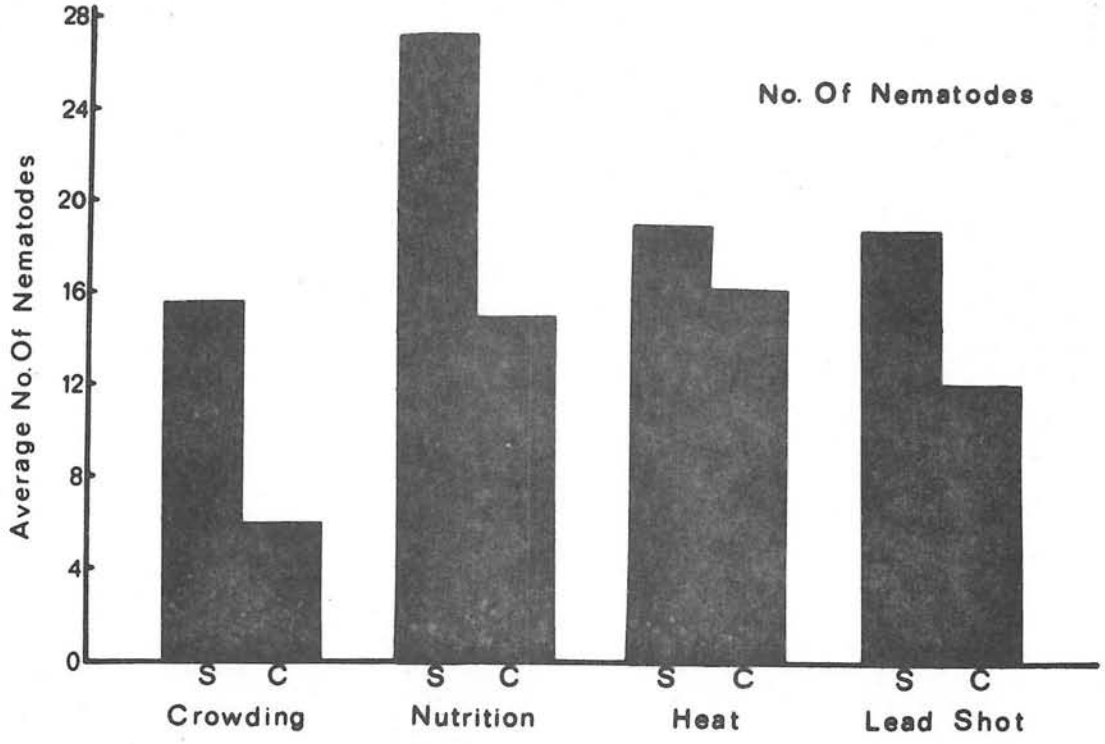

Figure 2: Mean number of nematodes retained by stressed and control ducklings in crowding stress, deficient diet, heat exposure, and lead shot ingestion experiments.

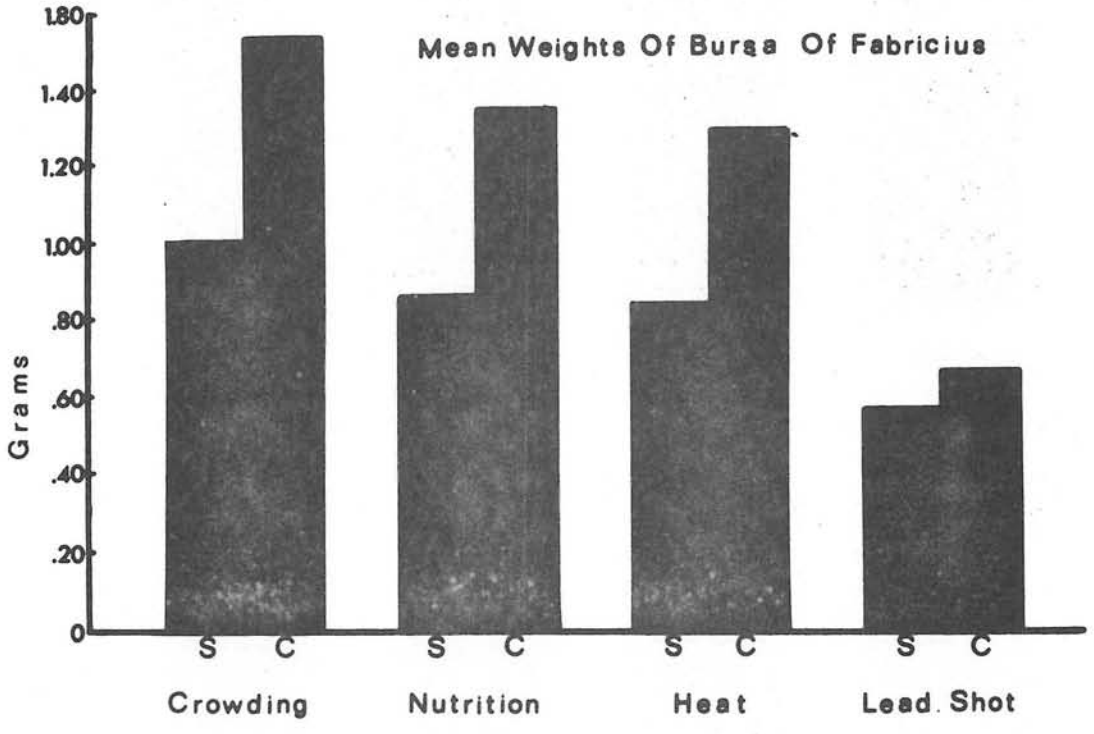

Figure 3: Mean weights of bursae of Fabricius of stressed and control ducklings in crowding stress, deficient diet, heat exposure and lead shot ingestion experiments.

References

Austin, Frederick. 1970. The biology, pathogenicity and occurence of Echinuria uncinata (Rudolphi, 1819) Solviev, 1912 (Spirurida, nematoda) at Delta, Manitoba. M.Sc. Thesis. University of Manitoba.

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