THE SPRING AND SUMMER FOODS OF THE COMMON MALLARD (*ANAS PLATYRHYNCHOS PLATYRHYNCHOS* L.) IN SOUTH CENTRAL MANITOBA

by

Nolan G. Perret
B.A., University of British Columbia, 1950

A THESIS SUBMITTED IN PARTIAL FULFILMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in the Department
of
Zoology

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

APRIL, 1962

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the Head of my Department or by his representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Zoology

The University of British Columbia,
Vancouver 8, Canada.

April 9, 1962

ABSTRACT

The mallard is the most important species of North American waterfowl; its breeding range has been reduced and is in danger of a further reduction due to agricultural and drainage practices. To maintain mallard populations at the present level, it will be necessary to control and manage sufficient habitat to provide for their needs. In such a program, the knowledge of the food habits of waterfowl is an essential tool. The objectives of this study were: to determine the spring and summer foods of the mallard, and to determine the relationship between utilization and availability of the various foods.

A study of the spring and summer food habits of mallards was conducted from 1957 to 1959 on a 100 square mile study area in south central Manitoba. 211 adult and 135 young mallards were collected for analyses of stomach contents. At the same time, ponds were randomly selected from the study area for examination and analyses of faunal and vegetative characteristics.

In the determination of food habits, the gullet contents proved superior to the gizzard contents. The animal foods found in the gizzard were partially digested and could not be measured accurately. There was also the possibility that the hard seeds of aquatic plants persist in the gizzard for a long period of time.

The spring and summer foods of adult mallards consisted of 45.7% plant material and 54.3% animal material. The young mallards, on the other hand, consumed 9.0% plant and 91.0% animal foods. In both adult and young birds the Class Insecta provided the main source of animal foods, and in both cases, the majority of the insect foods were obtained from the orders Trichoptera and

Diptera. In adult mallards the important plant foods were obtained from the Gramineae and Chenopodiaceae families.

A difference in the feeding habits of adult male and female mallards was found. The male birds consumed more plant foods and less animal foods than did the female birds.

Pond fauna increased in abundance until a peak was reached in midsummer then decreased in numbers. On the other hand, seeds increased in abundance in late summer and decreased the following spring as germination took place. The proportion of plant and animal foods consumed by adult mallards varied with the availability of these foods; the importance of plant foods in their diet decreased during the summer, whereas, the importance of animal foods increased.

Considerable variations in water levels, from flood to drought conditions, were experienced during the study. As a result of the change in water levels, the amount of emergent vegetation decreased. The food of young mallards reflected this change in habitat; the ratio of plant to animal foods consumed decreased from 1957 to 1959.

The animal protein intake of the mallard is variable and the variations in the consumption of animal and plant foods depend upon their availability. The relative proportions of the various foods eaten may not be of primary importance; mallards appear to be able to balance their diets with widely different kinds of food.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

Page

LIST OF PLATES

LIST OF FIGURES

Following
Page

INTRODUCTION

North American waterfowl are a renewable natural resource with economic and recreational values of far reaching importance. Tangible evidence of the economic importance of the resource was provided by a survey carried out by the U.S. Department of the Interior (USDI, 1956). The sport of waterfowling alone was valued highly enough by some two million Americans that they spent 115 million dollars pursuing the sport in 1955. No comparable survey has been conducted in Canada, but it is safe to assume that the recreational habits of Canadians are similar to those of Americans and that expenditures were also in the order of several millions of dollars.

The economic and aesthetic values of waterfowl in relation to other recreations such as photography and nature study are difficult to assess. The aesthetic values are recognized as having an important place in modern living but cannot be compared with those contributing directly to man's survival. Considering all interests, the value of the waterfowl resource is high and is important not only to the nation's economy but also to the well being of her people.

The mallard (*Anas platyrhynchos platyrhynchos* L.) is the most important species of waterfowl in North America. The indicated waterfowl breeding population in 1960 was close to 20.5 million birds, of which the mallard made up 35% (USDI, 1960a). The mallard also ranks high in recreation. During the 1959-1960 hunting season the estimated kill of mallards in the United States was 2,856,030 or 40% of all ducks killed (USDI, 1960b).

The waterfowl population is an important natural resource which is renewable only if a sufficient number of birds can find the proper habitat for reproduction. Mallards have always been widely distributed in the northern portions of the Northern Hemisphere, however, in North America the population size and breeding range has diminished in recent years. Historically the American breeding range of the mallard covered most of the continent west of the Hudson Bay, south to Northern Virginia, Central Missouri, Southern New Mexico and Lower California, west to the Pacific coast of the United States and Canada and north to the Arctic Coast (Bent, 1923). The present breeding range is now confined mainly to Western Canada and the northern border states of the central plains (Mississippi Flyway Council, 1958).

Despite the loss of habitat and the reduction in numbers of waterfowl, the popularity of the resource has continued to grow. In the United States, a federal license, or duck stamp, is required by all persons engaged in waterfowl hunting. When the first stamps were issued in 1934, 635,001 were sold (Day, 1949). By 1949, the number of hunters had increased to 1,675,400 (USDI, 1951). In 1958, 1,979,266 stamps were sold to waterfowl hunters (USDI, 1959) and in 1959, 1,477,661 were sold (USDI, 1960a). Thus the main problems facing waterfowl management today is a growing demand for the resource and a shrinking of breeding habitat which controls the waterfowl supply.

The Mississippi Flyway Council (op. cit.) states that their main objective is to maintain a widely distributed population of waterfowl at a sufficiently high level so that both hunters and non-hunters can enjoy and fully utilize the resource now and in the future. In order to accomplish this objective it will be necessary; to build up and hold waterfowl populations at a high level; to develop and enforce regulations which will ensure a carry-over of adequate breeding stock, and to control sufficient habitat to provide for the needs of waterfowl. The primary objectives in the control of habitat are the maintenance of existing wetland habitat and the creation of additional wetlands. In such programs, food and cover are of primary importance.

The scientific study of food habits is a most essential tool of waterfowl management. There is a need for a better understanding of not only what ducks eat during all months of the year but also what they eat in relation to the foods available to them. There is also a need for a better understanding of the nutritional requirements of ducks.

Through the years of food habits studies much has been learned about the fall and winter foods of ducks but little has been learned about their food habits during the critical breeding and brood raising period. This is especially true in the case of the common mallard on the Canadian breeding grounds. Therefore, the objectives of this study were; to determine the spring and summer food of the mallard, and to determine the relationship between the foods utilized and the availability of them.

HISTORICAL REVIEW

The study of food habits of wildlife had its beginning in North America in the latter part of the nineteenth century. With the founding of the United States Bureau of Biological Survey in 1885 began the intensive professional work on the food habits of birds. The early work stressed the economic relationship between birds and man and it was not until after the start of the twentieth century that food studies were carried out for purely biological interest.

Work on the study of waterfowl food habits began after the turn of the century and the names of Mabbot, McAtee, Wetmore and Oberholser are prominent among the early workers. The basis for much of the food habits research in later years has been the data collected by the Bureau of Biological Survey. Duck stomachs collected since 1901 have been analyzed and the data summarized by A. C. Martin and F. M. Uhler (1939), who based their study on 7,998 stomachs, and by Clarence Cottam (1939). The data resulting from a great many food studies were brought together and published by A. C. Martin, H. S. Zim and A. L. Nelson (1951) in their book "American Wildlife and Plants".

Literature on the food of waterfowl is extensive, and at once reveals astonishing similarities in the techniques used to evaluate the food materials. The gizzard contents as an indication of food habits of ducks have been used almost exclusively. McAtee (1918) in his paper on the food habits of mallards states: "A total of 1,725 gizzards of the mallard, many of them accompanied by well filled gullets, have been examined". Other workers made little or no use of the gullet contents or attempted to compare them with the contents of gizzards (Mabbot, 1920, Martin and Uhler, 1939, Cottam, 1939). Pirnie (1935) recognized the importance of using the gullet contents and suggested that greater use should be made of the gullets and less attention paid to the contents of the gizzards.

In many studies of the food of ducks, the adequacy of sampling was often far from satisfactory, too often the investigator examined such material as happened to come his way and all too rarely is there any evidence that he actually supervised the collection of material. Most of the duck stomachs examined were obtained from sportsmen during the hunting season, while collections from other seasons of the year were incidental. Summer collections in particular, are very sparse due to reluctance of biologists to kill or supervise the killing of birds during the breeding season.

STUDY AREA

General Description

Location

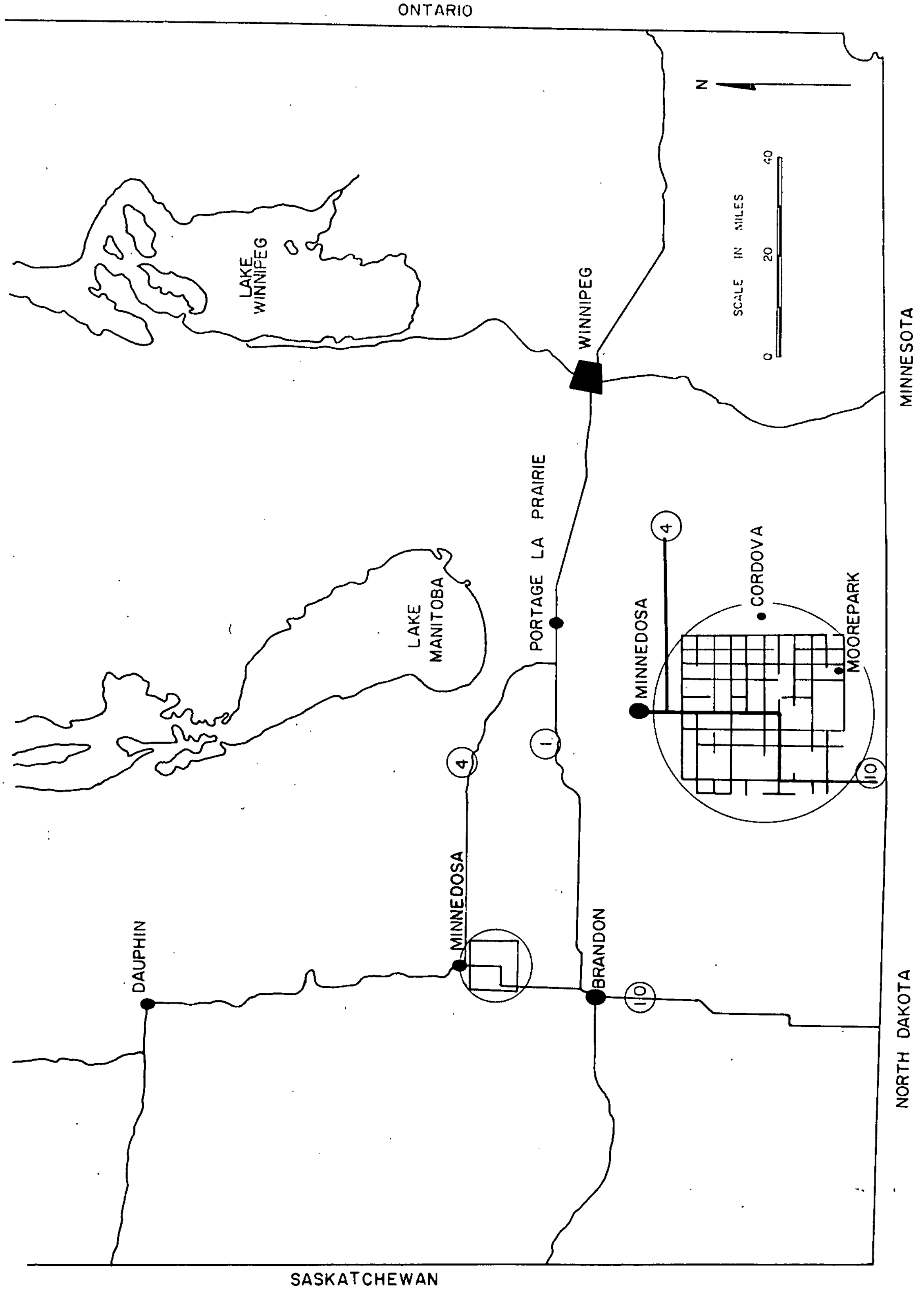
This report describes the work of three summers. A preliminary year, 1956, was spent studying ponds on a one and one half square mile study block of farmland in south central Manitoba. For the three years of investigations, 1957 to 1959, the study area was enlarged to 100 square miles. The area started two miles south of Minnedosa, Manitoba and extended south for ten miles. The east and west boundaries were five miles on each side of Provincial Highway No. 10. Plate I shows the location of the study area.

The general region was chosen because the history of waterfowl use of the area was known from previous investigations. The study block used in 1956 was the center of investigations for many years by Evans (1951) and Dzubin (1954).

Geology

The region is from 1475 to 1825 feet above sea level with the contours running from the northeast to the southwest. Ellis (1938) describes the region as overlain with a thick layer of glacial till derived from the granites of the Laurentian shield and limestone from the Lake Manitoba district. The land surface is rolling, the uplands are usually well drained with the main drainage to the southeast. Most of the depressions are filled with water from melting snows and runoff from the heavy spring rains. Thus, water areas are formed which vary in size from temporary puddles to ponds of ten or more acres. The soils are the northern black earths, predominately heavy clay loams, formed under the tall grass prairie and aspen groves.

PLATE I. LOCATION OF MINNEDOSA STUDY AREA



Land Use

The land use in the study area was mainly for the production of cereal grains of which wheat, barley and oats were the important crops. In addition, most farmers raised small herds of dairy or beef cattle. On the one and one half square mile study area Evans (op. cit.) found in 1949 that 57% was under cultivation, 14% used as permanent pasture, 17% was not cultivated and consisted of fence rows, road allowances, aspen groves and field borders, and the remaining 12% consisted of water or wet areas. This breakdown probably holds true for the whole study area, although no attempt was made to determine the actual acreages involved.

Upland Cover

The vegetation of the study block varied considerably due to the effects of land use and to the influence of the slope on temperature and soil moisture. The following description is based to a large extent on information from Bird (1930) and Evans (op. cit.) with some modifications.

Woody growth consisted mainly of aspen (*Populus tremuloides* Michx.), while burr oak (*Quercus macrocarpa* Michx.) was found on the drier sites with a southerly exposure. The aspen groves were generally surrounded by a shrub zone made up of one or more of the following shrubs; snowberry (*Symphoricarpos albus* (L.) Blake), choke-cherry (*Prunus virginiana* L.), saskatoon (*Amelanchier* sp.), and cranberry (*Viburnum trilobum* Marsh.). On the ungrazed, wet sites, between the aspens and the emergent vegetation, there was either a border of grasses, rushes (*Juncus balticus* Willd.) and sedges (*Carex* sp.) or a zone of willows (*Salix* sp.). Bird (op. cit.) states that the willow zone is present where there is no concentration of alkaline salts, but where such salts are present the succession is directly from marsh to prairie.

Drought conditions during the summers of 1958 and 1959 resulted in the formation of large areas of dried mud flats around most of the exposed water areas. First to colonize the open flats was the marsh ragwort (Senecio congestus (R. Br.) DC var. palustris (L.) Fern.). The ragwort was first found on the study area in 1958 and by 1959 it had become the dominant plant along the borders of drying ponds.

Water Areas

The rolling terrain of the Minnedosa region is ideally suited for the natural creation of small ponds. From aerial photographs taken of the region by the United States Fish and Wildlife Service in the spring of 1959 it was estimated that there were some 10,000 water areas in the 100 square mile study block. Because of the amount of equipment used in the study of the ponds, only the roadside water areas, accessible by car, were used. Out of a total of 220 miles of road allowances in the study area, 161 miles were passable by car; an estimated 2200 ponds were located along these. It was from this population of water areas that the samples were chosen.

The size and shape of the ponds was extremely variable and depended upon the contours of the land. Water depth was also variable and was not only dependent upon the contours but also upon the gain or loss of water during the season. In natural areas the maximum depth encountered was eight feet whereas in artificial areas maximum depths of eighteen feet were common. The mean depth of all ponds studied was 1.3 feet.

Extreme variation in water levels from abnormally high waters in 1955 to drought conditions in 1959, had a profound effect on the pond vegetation.

Areas with thick stands of emergent plants were denuded by flood conditions. The plant communities were unable to recolonize the ponds when the waters receded, with the result that the ponds in 1959 were mostly free of emergent plants and were surrounded by large mud flats. The emergent vegetation of the ponds was varied and in some ponds, whole communities changed during the study. However, in general, the dominant species were whitetop (*Scolochloa festucacea* (Willd.) Link) sedges (*Carex* sp.), cattail (*Typha latifolia* L.), bulrush (*Scirpus acutus* Muhl., S. *paludosus* Nels., S. *Validus* Vahl.) and reedgrass (*Phragmites communis* Trin.).

The ponds supported a variety of floating and submerged plants of which the following were the most common; duck weeds (*Lemna trisulca* L., L. *minor* L.); milfoil, (*Myriophyllum exalbescens* Fern.); White water-crowfoot, (*Ranunculus subrigidus* W. B. Drew); hornwort, *Ceratophyllum demersum* L.); mare's tail, (*Hippuris vulgaris* L.); pond-weeds, (*Potamogeton* sp.); bladderwort, (*Utricularia vulgaris* L.). The large green algae, *Chara* sp. and a smaller, filamentous green algae were also important members of the pond communities.

METHODS

Pond Studies

A study of the faunal characteristics of small prairie ponds was initiated in 1956 to determine the changes that occur during the summer months. Two ponds were chosen for weekly and four for bi-weekly studies. In 1957 a one hundred square mile study area was established. Four of the ponds sampled in 1956 were again sampled weekly in both 1957 and 1958, and in addition, ponds randomly selected from the study area, were examined once. In 1959 all of the ponds examined were randomly selected from the study area. Table 1 summarizes the ponds studied during the four years of the investigation.

Table 1. Ponds studied in the Minnedosa study area, 1956 to 1959

Year	Number of different ponds studied			Total pond samples
	Weekly	Bi-weekly	By random selection	
1956	2	4	0	44
1957	4	0	7	53
1958	4	0	19	76
1959	0	0	43	43
TOTAL	4	4	69	216

The random selection of study ponds was facilitated by the use of four figure random number groups. The study area was on an established one mile grid and the perimeter of each block was divided into eight, one half mile sections. A four number group, taken from a table of random numbers, referred to a precise location along the perimeter of a section of land. The first two numbers of the group indicated the square mile block; the third number, the section of the perimeter; and the last number, the distance to the nearest corner. Water areas accessible by car, in the locations indicated by random numbers, were used as the study ponds.

Methods used in the study of ponds fell into two categories;

determination of the composition of vegetation in and around the water area and determination of the composition of the fauna.

Vegetation

Several techniques for surveying the emergent and shoreline vegetation were tried in 1956 and 1957. The method that appeared most suitable and used during the balance of the study was essentially the line-point method described by Dasmann (1951). Transects were run at right angles to the shore and extended from the edge of the open water to a point ten feet above the spring high water mark. The frequency of transects depended to a large extent upon the length of the shoreline and the variability of the plant community. Normally the transects were run at no less than fifty foot and no more than two hundred foot intervals around the edge of the water area. This technique varied in ponds with vegetation throughout, in which cases, the transects were continued through the areas. Points were located one foot apart and the dominant plant, or class of cover directly under the foot mark, was recorded. Submerged vegetation was not surveyed because of the lack of an adequate technique, however, the species of submerged plants were recorded for each pond.

Fauna

The macroscopic animals which live on the bottom and those which live in association with plants were sampled with the aid of a six inch Ekman dredge. Dredgings were taken in multiples of four from the shallow waters along the shore and from the deeper waters near the centers of ponds. Each group of four dredgings was combined to form a sample equivalent to one square foot of bottom. The samples were washed through a 30 x 28 mesh screen and the organisms were sorted, identified, counted and preserved for further study in the laboratory. To facilitate the sorting of the animals from the debris, the washed samples were immersed in a sugar solution with a specific gravity of 1.110, the organisms floated to the surface and were screened off for identification. With this method it was possible to recover as many as 95% of the organisms, whereas, in hand picking only 79% were recovered (Dobie, 1958).

Food Studies

Sampling Statistics

To establish the food habits of mallards, the number of stomachs needed for analysis is a problem which must be overcome before the sampling is completed. Where the ducks are eating several foods, a different size sample is required for each item of food. In this study, therefore, the emphasis was placed on the use of two major foods, animal and plant.

Cochran (1956) suggests the following formula for estimating the size of sample required:

$$n = \frac{4s^2}{L^2}$$

Where n is the sample size, s is the standard deviation of the amount of one food consumed by the population and L the allowable error. From the sample of 41 adult mallards collected in 1957, the standard deviation for both plant and animal foods utilized was 43.2%; the allowable error of the estimate was arbitrarily set at 10%. Based on these data the sample size required was estimated at 74 ducks with food in their gullets. The allowable error would have to be increased if a smaller sample is used or if the sample is subdivided.

Waterfowl Collections

The information on food habits of mallards is based on 346 birds collected during the spring and summer months over a three year period, 1957 to 1959. Most of the birds were shot, some were caught by hand and others were obtained from banding operations in the study area. During the first year, birds were taken whenever possible, however, it was evident that the number of birds with food in their gullet diminished during the midday. Therefore in the following years, collections were made mainly in early morning and evening. The roads in the study area were driven and an attempt was made to shoot the mallards encountered. In all cases, where pairs were found an attempt was made to obtain both. Similarily, when groups were found an attempt was made to obtain two from the group. Table 2 summarizes the collections of mallards during the three year period.

Table 2. Mallards collected on Minnedosa study area, 1957 to 1959

Year	Ducks collected with food in gullets			Total ducks collected		
	Adults	Young	Total	Adults	Young	Total
1957	41	14	55	89	31	120
1958	4	31	35	17	70	87
1959	51	17	68	105	34	139
TOTAL	96	62	158	211	135	346

In 1957 and 1958 the stomachs were not removed from the birds until after the hunting was finished, usually anywhere up to three hours later. In examining the stomachs it was found that in some, deterioration of the gullet contents, especially the soft bodied animals, had taken place. During the last year of collecting, the stomachs were removed and fixed in 35% isopropyl alcohol as soon as the birds were killed.

In this study, foods found in the two anterior regions of the alimentary canal were used to determine feeding habits. The muscular grinding chamber of the canal is termed the gizzard and the region anterior to the gizzard, is termed the gullet. The gullet includes the mouth cavity, oesophagus and proventriculus (Henderson, 1939).

In the laboratory examination of stomachs, the foods found in the gullet were kept separate from the foods found in the gizzard. The gullet foods were sorted, identified, enumerated and the volumes measured by displacement of water. The proportions of the food items were then determined for each individual. The gullet was considered empty only when there was less than 0.2 milliliters of food present. The gizzard contents, on the other hand, were sorted and identified only.

An effort was made to identify each item of the organic contents regardless of the amount found. Where possible, the items of plant foods were identified to species. Most of the seeds were identified by the Plant Products Division of the Canada Department of Agriculture. The technical names were taken from Gray's Manual of Botany (Fernald, 1950). Animal foods were identified by myself to class and order, or in the case of some insects, to family. The technical names used were taken from "Fresh-water Invertebrates of the United States" (Pennak, 1953) and "An Introduction to Entomology" (Comstock, 1950).

A McBee Keysort card was made out for each bird collected. On the card the relevant collection data and stomach contents were recorded and coded. In cases where food was found in both the gullet and gizzard, duplicate cards were made out, one with the gullet contents coded and the other with the gizzard contents coded.

RESULTS

Characteristics of Vegetation

The ponds encountered in the study area were of two general types; those constructed by man and those formed in the shallow depressions by rains and melting snows. The artificial ponds or dugouts, were constructed mainly during the drought years of the 1930's to serve for stock watering purposes. Since then, many of the dugouts have overflowed at the ends so that at least two of their sides are no longer steep and support a dense growth of vegetation.

The natural ponds were in the various stages of succession, progressing from an open water habitat to a grassland or a wooded habitat. The change in vegetation is the normal hydrarch succession described by Weaver and Clements (1938) in which the submerged plants are replaced by floating plants and emergent vegetation in the shallow waters, these in turn give way to the sedge meadow types along the moist shoreline. Any stage, and usually all, can be found in a single natural pond. The stages appear to be arranged in more or less parallel zones radiating from the margins. The artificial ponds or dugouts were also undergoing successional changes, although it was more evident in some dugouts, which were older or filling more rapidly due to erosion, than in others.

The successional stages and even the direction in which they are proceeding may be affected by land use and water levels. During the long drought period in the 1930's most of the ponds in the Minnedosa area were used as a source of hay for cattle, while some of them were cultivated and planted. Even during years of normal water levels, cultivation almost to the water's edge and shoreline grazing by cattle has a marked affect on the plant communities. Water levels in the ponds can vary considerably over a short period of time and may be an important factor in determining the successional stage or the direction of the succession.

The successional changes affect the animal communities as well. Indeed, the whole biotic community undergoes a gradual change which arises from an interaction within the biotic community, from physical changes outside the community, or from a combination of the two. Allee, et al. (1949) state that the result of the community succession is a gradual alteration of the community through time, and the appearance of species populations better adjusted to the changed conditions.

Pond Classification

From work in the Minnedosa area, Evans (op. cit.) suggested a method for classifying water areas by the permanence of the water and by the plant community. The ponds were divided into ten classes consisting of four major groups as shown in Table 3. The two groups which contained emergent vegetation were further divided according to their plant community. This classification, which was based on normal water levels, is used for comparative purposes. Areas which were classified as semi-permanent during normal years became indistinguishable from permanent areas during the wet cycle (Plates II to VI). Similarily, some permanent areas were dry in 1959 whereas, some of the semi-permanent ponds contained an abundance of water.

Table 3. Types of ponds found in the Minnedosa study area (from Evans, 1951)

A. Permanent ponds
   1. Whitetop-sedge
   2. Cattail
   3. Bulrush
   4. Mixed emergents or denuded

B. Semi-permanent ponds
   1. Whitetop-sedge
   2. Cattail
   3. Bulrush
   4. Mixed emergents or denuded

C. Temporary ponds

D. Dugouts without flooded ends

On a one and one half square mile block in the middle of the Minnedosa study area, Evans (op. cit.) recorded 127 ponds. Of these, 33% were classified permanent, 41% semi-permanent, 24% temporary and 2% dugouts. He did not record the number of ponds that went dry but presumably 65%, the temporary and semi-permanent ponds, would have been dry by the end of summer. Ponds in the study area were counted in August 1957 and none were dry. An early August count in 1958 showed 66% of the ponds dry and in 1959 the number had reached 80%. The number of ponds did not vary appreciably from spring to spring because there was enough runoff each year to at least partially refill the water areas.

When it became apparent in 1957 that a vast change in vegetation was taking place, a sample of ponds was chosen and classified according to the vegetation type. Table 4 summarizes the yearly samples as compared to the findings of Evans in 1949.

Table 4. Classification of ponds in Minnedosa study area

Year	Percentage of ponds in each classification			
	Whitetop-sedge	Cattail	Bulrush	Mixed or denuded
1949	67	13	8	12
1957	44	15	15	26
1958	47	16	11	26
1959	19	4	7	70

It was not until 1959 that the whitetop-sedge associations were noticeably affected and reduced in number. What the sample does not show are the densities of the plants within the associations, this was not measured in a large enough sample to be of any value. The stands of emergent vegetation, particularly whitetop and sedge, were considerably thinner during the period of unstable water conditions than they were during the period of normal or relatively stable water levels.

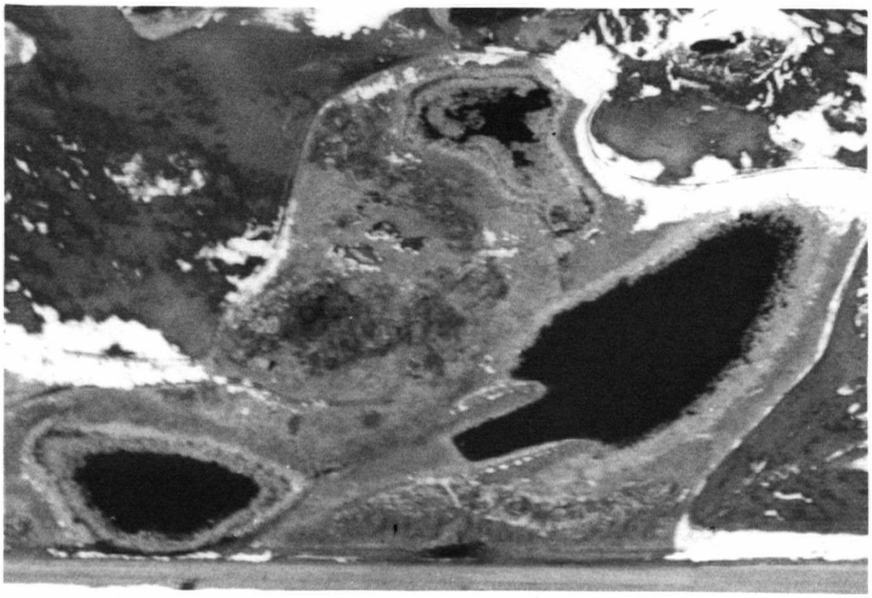
Factors Affecting Plant Communities

During the study the most important factor affecting the plant communities was the fluctuation in water levels. Under normal conditions, with water levels receding as much as twelve inches during the summer, dense stands of vegetation form in the water and along the shores of ponds. The sudden increase in water levels in 1955, flooded beyond the normal high water mark and into the upland cover. With prolonged flood conditions the upland plants gradually died out and were replaced by species better adapted to the wet site. An increase in water level may also affect both emergent and submergent vegetation, either directly, or indirectly by an increase in wave action or turbidity.

The vegetative character and thus the classification of a pond, changes with prolonged periods of high water levels. For example, a cattail pond with an outer zone of whitetop grasses and sedges can change to a whitetop-sedge pond if the cattail zone is killed by an increase in water level. A prolonged period of high water may continue to alter the vegetation to a mixed or denuded classification. Plates II to VI illustrate changes that occurred from 1954 to 1960, in the plant associations of three ponds.

Plate II shows one semi-permanent and two permanent cattail ponds as they appeared under normal conditions in the spring of 1954. The inner band of emergent vegetation, along the open water, was a cattail association. Mixing with the cattails and merging with upland cover above the shore was a whitetop-sedge association. The flooded end of the dugout supported a dense growth of sago pondweed (Potamogeton pectinatus L.) in the open water. Increased water levels in 1955 (Plate III), resulted in the three ponds joining to form a single water area. The cattails were surrounded with water and began to show signs of dying out, while the shoreline association of whitetop and sedge flourished under the new conditions. High waters continued; in 1956 the cattails disappeared as the dominant emergent plants and were replaced by the shoreline zone of whitetop-sedge. The sago pondweed

PLATE II



May 1954. Three cattail ponds during a period of normal water levels. The upper is a semi-permanent pond and the lower two are permanent ponds. The pond in the lower right is a flooded dugout.

PLATE III

July 1955. During the first year of flood conditions the three ponds joined and the cattail association showed signs of dying out.

bed was reduced to only a few small clumps. By the spring of 1958 (Plate IV) all emergent vegetation had disappeared and only a narrow band of whitetop and sedge remained along the shore. The waters began to recede and by late summer, the exposed mud flats were covered with the seedlings of grasses and sedges. Spring runoff was light in 1959 and water levels continued to recede. By midsummer (Plate V) the three ponds were again separate with one dry. The sedge and grass seedlings of 1958, were replaced by a band of marsh ragwort (Senecio congestus var. palustris), better suited to the high soil alkalinity. At the end of the summer of 1959, only the flooded dugout contained water and the newly bared mud flats were covered with sedge, whitetop and cattail seedlings. A high spring runoff in 1960 refilled all three ponds to the 1954 level. The vegetation growing on mud flats thrived under the new water conditions and by early summer (Plate VI) formed a dense zone around the shore. In late summer the three ponds again resembled the 1954 condition; the cattails, however, had not fully recovered and were not as abundant.

Seed Production and Availability

In food studies it is not enough to determine seed production without considering the availability of the seeds. This is particularly true in the study of spring and summer foods of ducks where the seeds produced in the fall must be available in the spring to be of any value. No satisfactory method was found for determining the relative availability of seeds in the spring, therefore, no quantitative data are presented.

The availability of seeds depends on when they are shed from the parent plant and the nature of the understory on which they fall. Whitetop and sedges produce and shed large quantities of seeds in late summer. The parent

PLATE IV

May 1958. After three years of high water levels the cattail association completely disappeared leaving a whitetop-sedge association along the shore.

PLATE V

July 1959. By midsummer of the first year of drought conditions the upper pond was dry and the two lower ponds were surrounded by large areas of bare mud.

PLATE VI

May 1960. With the return of normal water conditions the three water areas assumed separate identities as whitetop-sedge ponds.

plants on land, for the most part, remain standing until the new growth takes over in the spring. The understory, therefore is usually quite sparse and the seeds are readily available in early spring. Seeds shed by whitetop and sedge in water may or may not be available the following spring depending on water depth and nature of the bottom. The seeds of bulrush and spikerush mature in late summer but most remain on the dead plant until spring when they are readily available to the ducks. The availability of the seeds of the submerged plants, like those of emergent plants, is dependent upon the water depth and the nature of the bottom.

Under certain conditions, some upland plants produce vast quantities of seeds which are available to the ducks. Lamb's quarters (*Chenopodium album* L.), which sheds its seeds in the spring, was very abundant in the roadside ditches and shallow ponds that were dry in 1958. When these areas were partially refilled by the 1959 runoff, the waters and shores were covered with seeds. Thus, lamb's quarters was probably the most abundant of the available, non-cultivated seeds in 1959.

Waste cereal grains were usually available throughout the season. They were available in the fields before spring cultivation was complete and along the roads after the fields were worked. The roadsides were probably the best source of seeds, not only because they supplied an almost constant source of cereal grains but also, because they supplied most of the gravel required by the ducks.

Characteristics of Fauna

The animals which were collected by dredge are referred to as bottom fauna and are divided into two categories; center fauna are those which were taken from the center of ponds or in water of more than two feet in depth and edge fauna are those which were taken from the shallow waters along the edges of ponds. The habitat of the two sampling areas was different; the center habitat consisted mainly of submergent vegetation growing in silt and plant debris in an advanced stage of decomposition. The shoreline habitat, on the other hand, consisted mainly of emergent vegetation growing in an area usually covered with dead plant materials in early stages of decomposition.

Differences in Center and Edge Samples

There was no apparent difference in the total number of center and edge fauna collected from ponds in 1957 and 1958 but there was a significant difference in 1959. However, considering all bottom samples collected during the study, a significant difference in abundance of center and edge organisms is indicated. The calculated value of "t" is 2.75 as compared to the table value of 1.96 at the 0.05 level (Snedecor, 1956). Table 5 summarizes the

Table 5. Comparison of the abundance of organisms in center and edge samples collected from ponds in 1957, 1958 and 1959

Year	Center samples			Edge samples			Value of "t"
	Number of organisms	Limits of confidence 0.05 level	n	Number of organisms	Limits of confidence 0.05 level	n	
1957	275.7	96.8	53	192.8	54.5	43	1.40
1958	317.5	86.0	76	274.8	103.9	76	0.62
1959	404.4	145.9	43	125.6	75.4	43	3.86
Mean	326.3	59.4	172	213.4	53.7	162	2.75

statistics of the bottom fauna samples taken from the center and edge locations during the period of study.

The difference in habitat between the shore and center of the ponds is reflected in both the relative abundance and the variety of organisms found in the two locations. Table 6 summarizes the bottom fauna collections made on ponds in 1957, 1958 and 1959. Although all groups of organisms were represented in both the center and shoreline samples, they were found in

Table 6. Summary of bottom fauna collections from 161 ponds in 1957, 1958 and 1959

Organism	Number of organisms per square foot of bottom			
	Center samples		Edge samples	
	Mean	Per cent	Mean	Per cent
ANNELIDA				
Hirudinea	1.8	0.6	1.8	0.8
ARTHROPODA				
Crustacea				
Amphiopoda	45.9	14.1	85.5	40.1
Arachnoidea				
Hydracarina	0.5	0.1	0.5	0.2
Insecta				
Ephemeroptera	3.9	1.2	0.9	0.4
Odonata	1.6	0.5	1.2	0.6
Hemiptera	0.4	0.1	1.5	0.7
Trichoptera	8.4	2.6	4.1	1.9
Coleoptera	1.3	0.4	7.0	3.3
Diptera	255.0	78.2	100.2	47.0
MOLLUSCA				
Gastropoda	7.5	2.3	10.7	5.0
TOTAL NUMBER OF ORGANISMS	326.3		213.4	

different proportions. Tendepedidae (Diptera) larvae composed 78.2% of the center fauna but only 47.0% of the edge organisms. Trichoptera larvae, while usually found in association with plants, were more abundant in the center samples. They were found to overlap the two zones and generally appeared in greatest numbers on the open water side of the emergent vegetation. The Amphiopoda obtained in bottom sampling was represented almost entirely by a single species, Hyalella azteca (Saussure). It was a common animal in the ponds and made up 40.1% of the edge fauna. One pond in 1957 had an extremely high population of Hyalella, as many as 5600 individuals were removed from a one square foot sample.

Annual Changes

The changes in water levels during the study had less affect on the abundance of bottom fauna than one would expect. The only significant difference (0.05 level) in numbers of organisms, occurred in the edge samples

Table 7. Students' "t" values of bottom fauna abundance in ponds in 1957-1958, 1957-1959 and 1958-1959

Year	Center samples		Edge samples		Total	
	Value of "t"	n	Value of "t"	n	Value of "t"	n
1957-1958	0.63	129	1.12	119	1.20	248
1957-1959	1.64	96	1.57	86	0.54	182
1958-1959	1.02	119	2.01	119	0.61	238

between the years 1958 and 1959. The results of Students' "t" test to determine if significant changes in bottom fauna occurred between the years are summarized in Table 7.

Although the pond habitat changed noticeably as a result of variations in water levels, the overall abundance of bottom fauna did not change. Certain individual groups of organisms however, were affected by the change in habitat. For instance, Odonata, which depend upon emergent vegetation, decreased in numbers along the pond edges and Coleoptera increased as their habitat of dead

Table 8. Bottom fauna collected from centers and edges of ponds in 1957, 1958 and 1959

Organism	Number of organisms per square foot of bottom							
	Center samples				Edge samples			
	1957	1958	1959	Mean	1957	1958	1959	Mean
ANNELIDA								
Hirudinea	1.8	2.5	0.4	1.8	3.0	1.9	0.3	1.8
ARTHROPODA								
Crustacea								
Amphiopoda	10.2	85.7	19.6	45.9	37.8	135.4	45.1	85.5
Arachnoidea								
Hydracarina	0.2	0.6	0.6	0.5	0.9	0.3	0.5	0.5
Insecta								
Ephemeroptera	0.7	8.1	0.5	3.9	0.3	1.7	tr	0.9
Odonata	1.7	2.1	1.0	1.6	2.5	0.9	0.2	1.2
Hemiptera	0.1	0.3	0.4	0.4	2.6	1.4	0.6	1.5
Trichoptera	5.4	7.5	13.8	8.4	9.2	2.7	1.5	4.1
Coleoptera	0.8	1.3	1.9	1.3	7.3	5.0	11.0	7.0
Diptera	246.2	203.8	356.5	255.0	101.4	120.7	62.5	100.2
MOLLUSCA								
Gastropoda	8.7	5.7	9.4	7.5	27.8	5.2	3.6	10.7
TOTAL NUMBER OF ORGANISMS	275.7	317.5	404.4	326.3	192.8	274.8	125.6	213.4

plant material improved. Table 8 summarizes the bottom fauna collection data for the three years of study.

Seasonal Changes

Throughout the spring and summer season marked changes in the abundance of fauna were noted. The precise timing of the periods of abundance is characteristic of each pond but the pattern of changes are similar. Following the departure of ice cover in April there was a gradual increase in the bottom fauna to a peak in the latter part of May. The spring peak was followed by a slight depression in abundance then a marked increase until a summer peak was reached in mid August. The number of organisms then gradually decreased until the ponds became frozen in the fall. The seasonal changes are best illustrated in the following graphs: Figure 1 shows the changes in center samples; Figure 2 the changes in edge samples and Figure 3 is a composite picture of the changes that occurred in center and edge samples in 1957, 1958 and 1959. The data from which these graphs were drawn are presented in Appendices 1, 2 and 3.

Availability of Bottom Fauna

The availability of bottom fauna depends not only on the abundance of the organisms, but also, on the distribution of the fauna in the ponds and the water depth at which they occur. The center samples were taken in water of usually more than two feet in depth and edge samples, from less than two feet. Because the mallards obtain their food from the shallow waters, the edge organisms were considered to be the most important source of animal foods.

The distribution of the edge fauna was variable in the study area; all

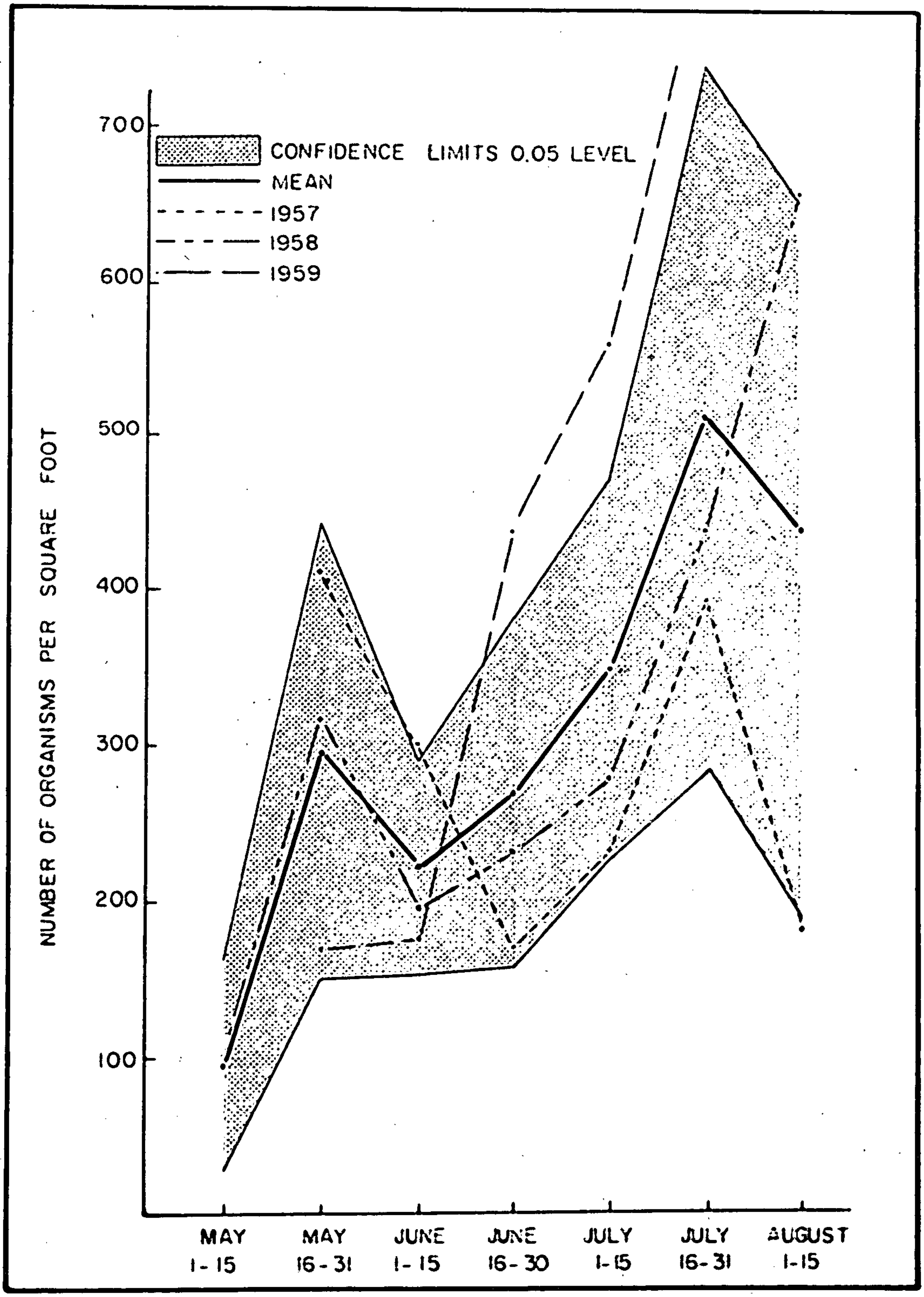


FIGURE I. BIWEEKLY CHANGES IN THE NUMBER OF BOTTOM ORGANISMS PER SQUARE FOOT, CENTER SAMPLES 1957, 1958 & 1959.

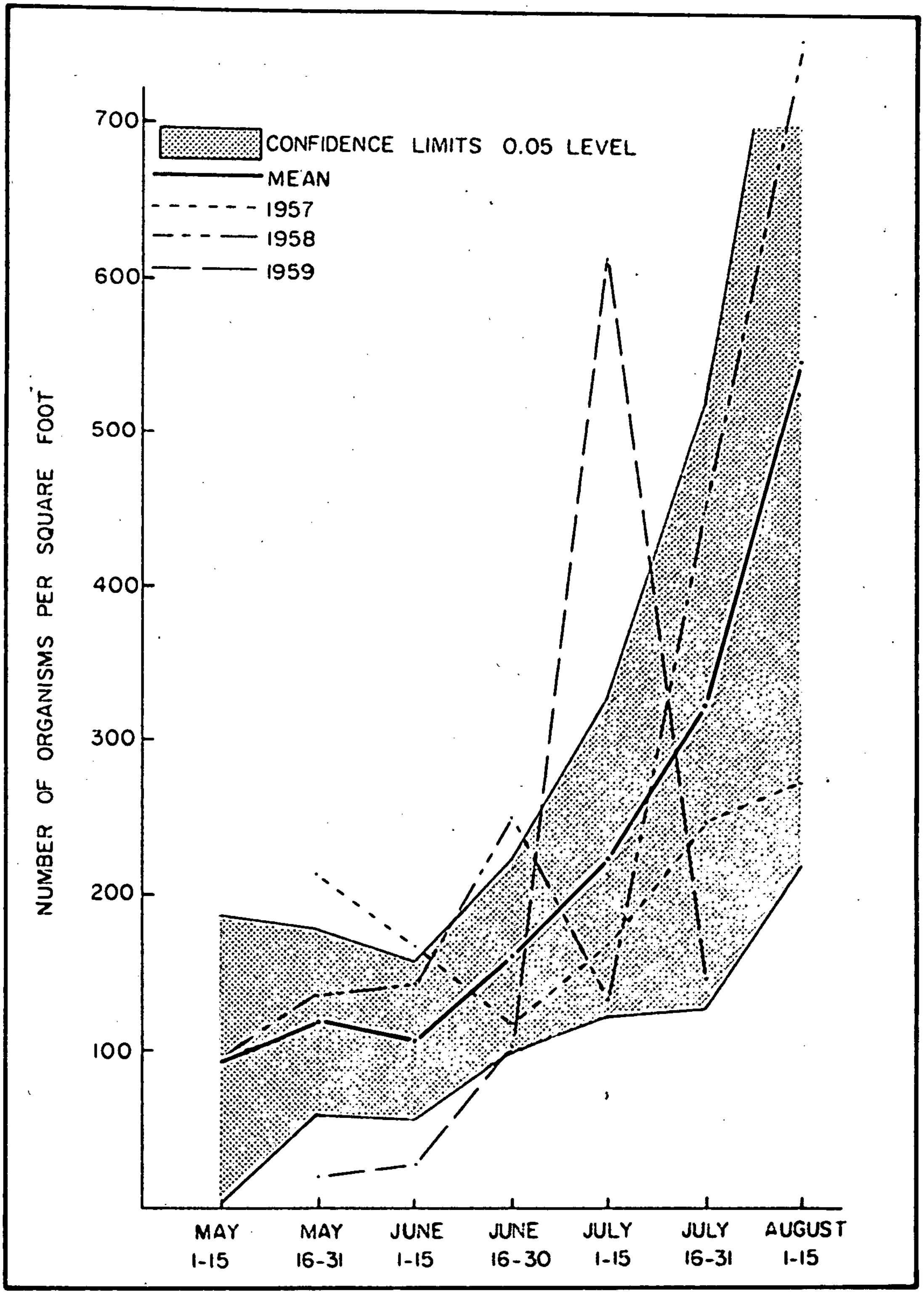


FIGURE 2. BIWEEKLY CHANGES IN THE NUMBER OF BOTTOM ORGANISMS PER SQUARE FOOT, EDGE SAMPLES 1957, 1958 & 1959.

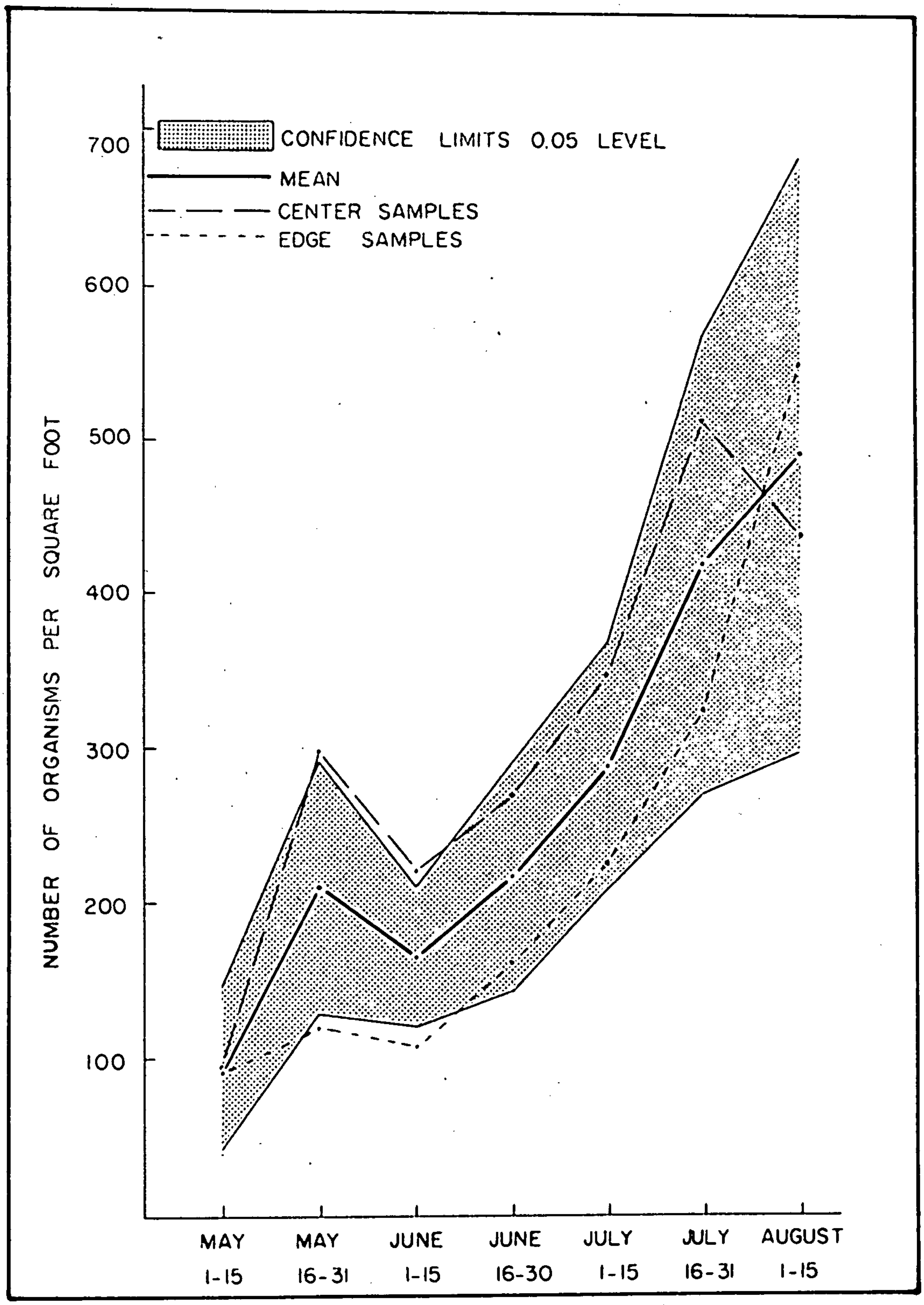


FIGURE 3. BIWEEKLY CHANGES IN THE NUMBER OF BOTTOM ORGANISMS PER SQUARE FOOT IN THE CENTER AND EDGE SAMPLES OF 1957, 1958 & 1959.

groups of organisms were not represented in each pond and the variations were even more marked as habitat conditions changed. One would expect such changes in distribution to take place as the ponds changed from heavy emergent plant cover in 1957 to open water in 1959. The organisms which were dependant upon emergent vegetation became less widely distributed during the study. For instance, the Odonata were found in 51.0% of the ponds in 1957 and only 16.3% of the ponds in 1959. Hemiptera and Trichoptera apparently underwent a similar change, but as they were less dependant upon emergent vegetation than were Odonata, the change was not as marked. Organisms such as Diptera and Coleoptera were affected less by the change in habitat than were the other organisms. Figure 4 illustrates the changes in distribution of edge fauna from 1957 to 1959. The data from which Figure 4 was drawn are presented in Appendix 4.

Use of Study Area by Waterfowl

Populations

Breeding pairs - The Minnedosa area has been the scene of waterfowl research for many years but there are no comparable annual estimates of waterfowl populations in the general area. Each research worker carried out population counts to suit his own needs and the results are not, in most cases, comparable. As a result, one has to depend upon the aerial surveys carried out by the U.S. Fish and Wildlife Service for population indices. Although the population data for pothole habitat are drawn from a sample of the 10,368 square miles of pothole habitat in Manitoba, the indices do give an indication of population trends on the study area. The population indices for the

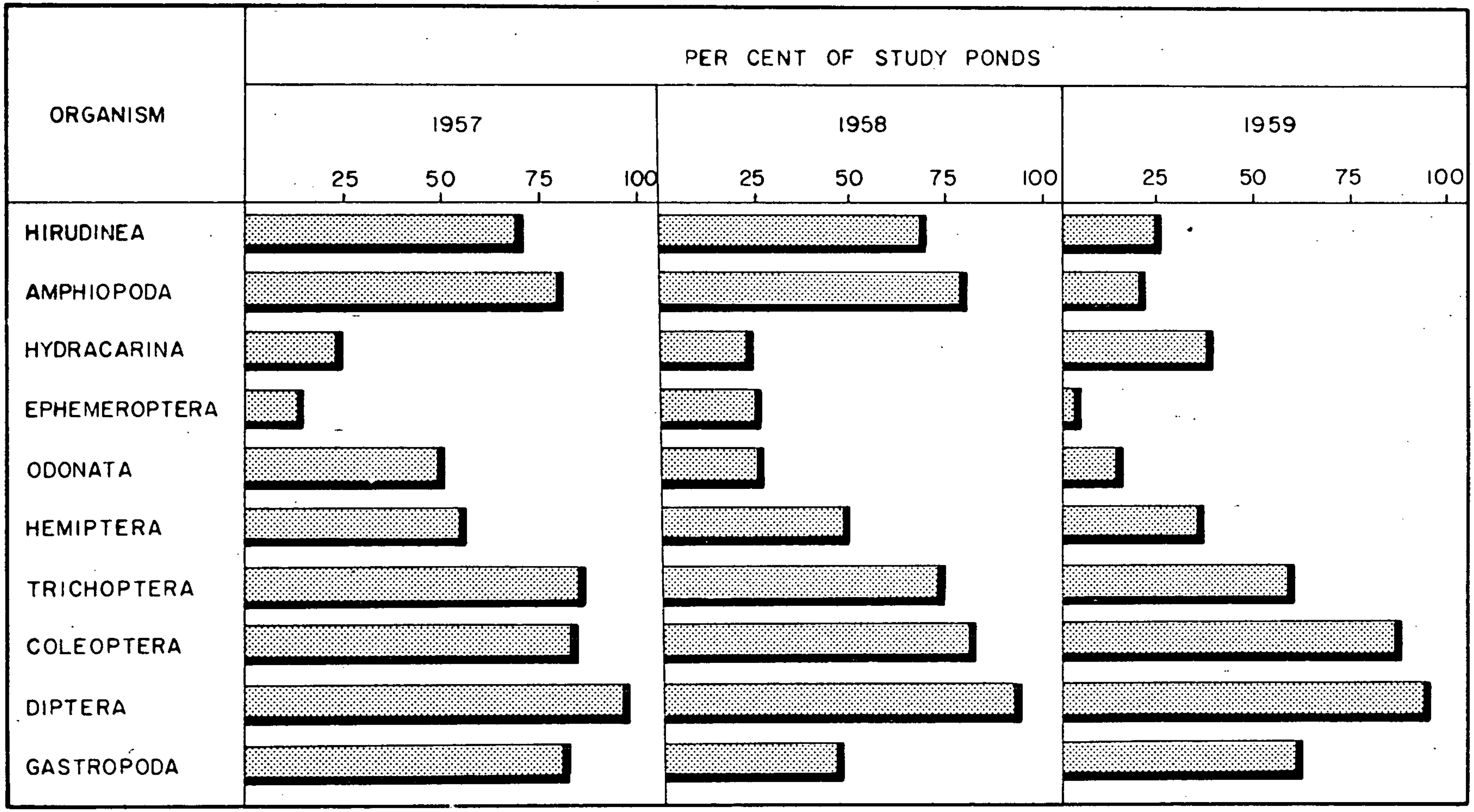


FIGURE 4. OCCURRENCE OF EDGE FAUNA IN STUDY PONDS IN 1957, 1958 & 1959.

pothole habitat (Stratum A) of Manitoba and the sources of the data are summarized in Table 9.

Table 9. Summary of aerial survey data for pothole habitat (Stratum A) in Manitoba

Year	Pairs per square mile		Authority
	All species	Mallards	
1954-1956 Mean	36.6	14.9	Evans 1956 Hanson 1957
1957	40.5	21.7	Hanson 1958
1958	54.2	27.2	Evans 1959
1959	33.7	15.2	Evans 1960

Aerial survey data provide an index to the population and not the true population; the proportion of the population that is seen from the air is unknown and no doubt varies considerably with habitat types. Providing the habitat does not change drastically from year to year, the proportion seen from the air should remain the same. In pothole habitat the main features limiting the visibility of aerial survey crews are the wooded areas around the ponds. As these did not change in 1959 the proportion of the population seen is comparable to previous years.

Ground waterfowl surveys were carried out on the $1\frac{1}{2}$ square mile study area from 1952 to 1956 and data from these provide a better picture of waterfowl populations. Ground surveys, like aerial surveys, do not provide complete population figures but the proportion of birds seen from the ground is higher. Table 10 (Cram, 1956) summarizes the surveys from 1954 to 1956.

Table 10. Summary of ground survey data for $1\frac{1}{2}$ square mile Roseneath study area

Year	Pairs per square mile	
	All species	Mallards
1954	97.8	27.3
1955	73.7	22.0
1956	104.1	24.7
1954-1956 Mean	91.9	24.7

It is apparent from Table 9 that neither the total duck population nor the mallard population changed appreciably during the study. As the aerial surveys are designed to measure population fluctuations of 20% or greater the only significant change in mallard numbers from the 1954-1956 mean, occurred in 1958. The ground survey data indicate a mean population of 24.7 mallard pairs (Table 10) per square mile during the 1954-1956 period. Therefore, assuming that the Roseneath study area is representative of the 100 square mile area, the minimum mallard population on the area in 1957 and 1959 was 24.7 breeding pairs per square mile and probably almost double that figure in 1958.

Broods - Population indices for waterfowl broods in the Minnedosa area are, like breeding pairs, available from aerial surveys of Manitoba and from ground counts made in the Roseneath study area. Table 11 shows the brood indices for the years 1954 to 1959. The period 1954 to 1956, taken from Cram (1956), covers ground surveys in the Roseneath study area, whereas the period 1957-1959, taken from Evans (1960), covers aerial surveys of pothole habitat in Manitoba.

Table 11. Summary of waterfowl brood surveys in Manitoba 1954 to 1959

Year	Broods per square mile		Authority
	All species	Mallards	
1954	30.7	6.0	Cram 1956
1955	43.4	11.3	Cram 1956
1956	50.7	12.0	Cram 1956
1954-1956 Mean	41.6	9.3	Cram 1956
1954-1956 Mean	4.5 x	xx	Evans 1957
1957	5.4		Evans 1959
1958	9.2		Evans 1959
1959	4.8		Evans 1960

x these indices are the sum of the brood and late nesting indices
xx data not available for individual species

Examination of Table 11 indicates that there was a gradual increase in the number of broods in the Roseneath area from 1954 to 1956. This increase probably carried into 1958 when a peak was reached, then dropped sharply in 1959. Evans (1959) felt that the apparent increase in 1958 was due in part to increased visibility as a result of the lack of emergent vegetation. However there was an increase in broods in 1958 but it was not as high as the figures show. Another indication of an increase in production in 1958 was the number of ducklings that reached the Class II and III stages. The average size of Class II and III broods was 5.6 ducklings in 1957, 6.6 in 1958 and 5.4 in 1959. The average brood size for the three years was 5.7 ducklings.

In summary, one could say that in both breeding pairs and production of young, there was an increase from 1957 to 1958 and a decline in 1959. The increase in 1958 was probably caused by a movement of waterfowl from the drought areas to the more stable pothole habitat. By 1959 the pothole habitat was also affected by drought and although the influx of waterfowl was high, the habitat was not able to accommodate as many birds as during the previous year.

Movement of Waterfowl

Adults - During a normal spring in the pothole region of Manitoba the first mallards arrive at the beginning of April; the main flight is in the area three weeks later. The return of waterfowl does not herald the end of winter, indeed, the ponds may still be frozen with open water occurring on the ice or in fields. The ponds normally open by mid April and are ice free when the main flight of waterfowl arrives on the breeding grounds.

However, a normal season in the Minnedosa area is unusual and was not experienced during this study. In all three years the first and main flights of mallards arrived at approximately the same time, March 28-30 and April 15-20, but the arrival of spring was entirely different. An early spring occurred in 1957; the ponds were open and stayed open before the main flight of mallards arrived. In 1958 the ponds opened early but became completely ice covered at the end of April during almost a week of blizzard conditions and near zero temperatures. In 1959 the water areas were slow to open and were not entirely free of ice until the end of April.

By the time the mallards reached the Minnedosa region most of them were in breeding pairs. The birds arrived as small mixed flocks of mallards and pintails (*Anas acuta*) and congregated, sometimes in large concentrations, on the flooded or wet stubble fields. The flocks were well dispersed by the end of April as the individual pairs established their home ranges and nesting territories.

The breeding home range was described by Sowls (1955) as the area in which a bird spends its period of isolation between breakup of spring gregariousness and reformation of fall gregariousness. In general this was true in the Minnedosa area but there were periods of reversion to gregariousness such as when hens which lost their nests joined groups of loafing waterfowl between nesting attempts. The males also returned to a gregarious behavior during the summer; as the hens began to incubate the males formed groups and later joined large concentrations of mixed waterfowl on moulting areas.

The size of the home range of mallard pairs is quite variable and is utilized by other waterfowl as well as other mallard pairs. The defended portion of the home range, or nesting territory, is also variable; it may include only a small area around a single pond or an area almost equal to the home range. Until the pair bond is broken both male and female live and feed within their home range. The range of a pair of mallards is generally smaller than that of the drake alone; Dzubin (1955) described a home range of a pair of mallards on the Roseneath study area and showed that the area covered by the drake alone was in excess of seven hundred acres, almost double that of the pair.

The grouped birds, until their departure for the moulting ponds were not restricted in their movements over the study area. Their flight patterns appeared to be random movements between feeding and loafing areas. In 1959 an unusual condition existed, more grouped birds were noted than was the normal condition and the groups stayed on the study area well into the brood season. These birds were similar to the early spring concentrations, in that they consisted of what appeared to be breeding pairs as well as males. The apparent breeding pairs in the summer concentration were probably birds that had moved into the area from the grasslands where more severe drought conditions existed.

Thus there appeared to be two basic patterns of mallard flight behavior on the Minnedosa study area. The movements of the breeding pairs were restricted to their home range; within each pair there appeared to be a sexual difference in the range of flight. The males covered more territory than did the females and in one case at least (Dzubin 1955), we know that the male's range of travel was almost double that of the female. The non breeding groups of mallards on the other hand, appeared to have more random flight patterns. They were not restricted to a limited home range but travelled freely throughout the study area.

Broods - There is a lack of information concerning the habits and requirements of mallard broods. They are known to travel long distances overland from ponds which are drying up to ones which are more permanent. Hochbaum (1944) cites several instances of overland travel by mallard broods in the Delta marsh of Manitoba and the procedure of constructing permanent brood waters by Ducks Unlimited is based on the assumption broods will travel two to three miles to reach permanent water. Mallard broods are also known to travel shorter distances between ponds, for no apparent reason. Evans (1951) conducted a study of the movements of waterfowl broods on the Roseneath study area and made some interesting observations and conclusions.

Evans determined that the average distance travelled by mallard broods was 0.013 miles per day and knew of no mallard brood which occupied a single pothole for more than twenty days. He found that the influence of the spacing of potholes on brood mobility was quite marked. Those broods which occupied the region of high pond density were almost twice as mobile as those in the low density region. From Evans' data it appears that the pattern of brood movement and direction is completely random and since no motherless broods were known to move from pond to pond, overland travel is initiated by the hen.

Apparently overland journeys of mallard broods continue throughout the season. The reasons for this continual travel are either random nomadic movements or responses by the hen, to changes in the environment. The latter is probably the case since the young alone are not known to move. The female, aware of the conditions in her home range, is probably continually seeking better cover and food conditions in which to rear her young. It makes one wonder however, when a hen leads her brood from one pond to another that is essentially similar in cover type and abundance of food, what factor in the environment has induced her to move.

Analysis of Gullet Contents

Adult Mallards

For the determination of summer food of adult mallards, 211 stomachs were available from birds collected from late March to early August. However, only 96, 50 males and 46 females, had sufficient food in their gullets to be used in the determinations. Although the adult mallards depended upon the plant kingdom for a large part of their summer diet, the majority of the foods were derived from the animal kingdom. In the 96 gullets examined, the food consisted of 45.7% plant and 54.3% animal materials. Table 12 lists the foods by volume and mean proportion.

Table 12. Volume and mean proportion of foods found in the gullets of 96 adult mallards collected in the summer months of 1957, 1958 and 1959

Kind of food	Total volume (milliliters)	Per cent volume	Proportion of food
PLANT FOODS	331.5	63.9	45.7
Gramineae	252.9	48.2	24.6
Cyperaceae	1.2	0.2	0.5
Lemnaceae	tr	tr	tr
Polygonaceae	0.7	0.1	0.1
Chenopodiaceae	76.4	14.7	20.0
Ceratophyllaceae	0.1	tr	tr
Rosaceae	0.1	tr	0.2
Leguminosae	tr	tr	tr
Haloragaceae	0.1	tr	0.1
Compositae	tr	tr	tr
ANIMAL FOODS	187.1	36.1	54.3
Annelida			
Hirudinea	5.0	1.0	0.7
Arthropoda			
Crustacea	0.9	0.2	1.0
Arachnoidea	tr	tr	tr
Insecta	179.5	34.6	51.4
Mollusca			
Gastropoda	1.7	0.3	1.2

Plant foods - The present study showed that less than one half of the summer diet of adult mallards was derived from the plant kingdom. Plants made up 45.7% ± 9.5% (0.05 level) of the foods consumed. They were found in 59 of the 96 gullets examined and varied in volume from a trace to 49.0 milliliters. All of the plant foods examined were in the form of seeds with the exception of duckweeds (Lemna sp.), which appeared as traces of debris in only five gullets. The individual plants found in the gullets are listed in Appendix 5.

Examination of Table 12 shows that the two most important sources of plant foods were the Gramineae and Chenopodiaceae families. The Gramineae family, represented by three main species, barley (Hordeum vulgare L.), wheat (Triticum aestivum L.) and barnyard grass (Echinochloa crusgalli (L.) Beauv.) contributed over one half (53.8%) of the plant foods and 24.6% of the summer diet. The other important family, Chenopodiaceae, represented by a single species, lamb's quarters (Chenopodium album), supplied 43.8% of the plant foods and 20.0% of the summer diet.

In the two years, 1957 and 1959, that the sample of gullets was large enough for comparison (Table 1) there was a difference in feeding habits. In 1957, plant foods made up 33.7% ± 13.6 (0.05 level) of the diet whereas, in 1959, they made up 58.9% ± 13.5 (0.05 level). Application of Students' "t" test to these data indicate that the proportion of plants consumed in 1957 and 1959 was significantly different. The calculated value of "t" was 2.62 as compared to 1.986, the table value of "t" at the 0.05 level.

Table 13 lists the plant foods examined in gullets of 92 mallards collected in 1957 and 1959. In 1958 only four full gullets were available, none of which contained plant foods. The Gramineae family showed a pronounced drop in use from 1957 to 1959; it provided 33.4% of the food in 1957 and 19.5% in 1959. More important however, was the fact that the Gramineae supplied 99.1% of the plant foods in 1957 and only 33.1% in 1959. The plants of the waste areas, such as dry roadside ditches and pond edges, were the ones that received the increased use in 1959. Barnyard grass (Echinochloa crusgalli) increased in use from 2.0% in 1957 to 3.8% in 1959, while lamb's quarters (Chenopodium album) increased from only a trace in 1957 to 37.8% in 1959 and supplied 64.2% of the plant foods.

Table 13. Plant foods found in the gullets of adult mallards collected in 1957 and 1959

Plant food	Proportion of food		
	1957	1959	Mean
Gramineae	33.4	19.5	24.6
Hordeum vulgare	12.6	8.0	12.0
Triticum aestivum	18.8	7.5	9.6
Echinochloa crusgalli	2.0	3.8	2.9
Other grasses		0.2	0.1
Chenopodiaceae	tr	37.8	20.0
Chenopodium album	tr	37.8	20.0
Other plants	0.3	1.6	1.1
TOTAL PLANTS	33.7	58.9	45.7
Number of gullets	41	51	96

Animal foods - Animals were the major source of spring and summer foods of adult mallards in the Minnedosa area. They were found in 71 gullets and made up 54.3% ± 9.5% (0.05 level) of the foods consumed. Appendix 6 lists the groups of animals, both by total volume and mean proportion, found in the gullets. The Class Insecta alone supplied more than one half (51.4%) of the total animal foods, whereas Annelida, Mollusca and Crustacea played only a minor role and supplied 2.9% of the total food and 5.3% of the animals. The order Diptera, represented mainly by larval stages of the family Tendipedidae, was the most important insect order and provided 24.6% of the diet of adult mallards. Almost as important a source of food was the order Trichoptera which supplied 17.8% followed by Odonata (5.5%) and Coleoptera (3.3%).

There was a decrease in the proportion of animal foods consumed from 1957 to 1959. In 1957, 66.3% ± 13.6% (0.05 level) of the total foods was of animal origin while in 1959, 41.1% ±13.5% (0.05 level) of the foods were animal. The calculated value of Students' "t", 2.62, compared to the table value 1.986 at the 0.05 level, indicates that the difference between the two years was significant. The proportions of animal foods consumed in 1957, 1958 and 1959 are listed in Table 14. The data from 1958 are included in the table but are too few to use for comparison with the other two years.

Table 14. Animal foods found in the gullets of adult mallards collected in 1957, 1958 and 1959

Animal food	Proportion of food			
	1957	1958	1959	Mean
Hirudinea		16.6	0.3	0.7
Crustacea	0.9	12.5	0.1	1.0
Insecta	63.7	73.4	39.8	51.4
Odonata	9.6	9.3	0.1	5.5
Hemiptera	0.2		0.1	0.2
Trichoptera	17.9	17.9	19.6	17.8
Coleoptera	2.7	12.5	3.1	3.3
Diptera	33.3	33.7	16.9	24.6
Gastropoda	1.7		0.9	1.2
TOTAL ANIMALS	66.3	100.0	41.1	54.3
Number of gullets	41	4	51	96

Like other animal foods the Class Insecta showed a marked decrease in use from 1957 to 1959; it provided 63.7% of the food in 1957 and 39.8% in 1959. However, the relative use of Insecta remained almost the same; the class made up 96.1% of the animals in 1957 and 96.8% in 1959. Not all insect orders were affected to the same degree, some increased in importance while others declined. Odonata showed the most marked decrease from supplying 9.6% of all foods and 14.5% of the insects in 1957 to 0.1% and 0.2% in 1959. The Diptera also declined to almost one half from 33.3% to 16.9% but still provided a large share of the insect material; Diptera provided 50.2% of animal materials in 1957 and 41.1% in 1959. Trichoptera and Coleoptera showed a slight increase in use from 17.9% and 2.7% in 1957 to 19.6% and 3.1% in 1959. However, both almost doubled in value as animal foods: Trichoptera supplied only 27.0% of the animal foods in 1957 as compared to 47.7% in 1959 and Coleoptera increased from 4.1% to 7.5%. Table 15 shows the changes which occurred in the animal foods from 1957 to 1958.

Table 15. Per cent composition of the animal foods found in adult mallards in 1957 and 1959

Animal	Per cent composition	
	1957	1959
Hirudinea		0.7
Crustacea	1.3	0.2
Insecta	96.1	96.8
Odonata	14.5	0.2
Hemiptera	0.3	0.2
Trichoptera	27.0	47.7
Coleoptera	4.1	7.5
Diptera	50.2	41.1
Gastropoda	2.6	2.2

<u>Sexual difference in gullet contents</u> - Examination of gullet contents showed

an apparent difference in the foods consumed by male and female mallards. Males consumed 54.1% plant and 45.9% animal foods with confidence limits of ± 13.2% (0.05 level), whereas, females consumed 36.5% plant and 63.5% animal foods with confidence limits of ± 13.5% (0.05 level). Students' "t" test applied to the data indicated that at the 0.10 level of confidence a significant difference existed between the gullet contents of males and females. The calculated value of "t" for both plants and animals, was 1.84 compared to the table value of 1.66 at 0.10 level (Snedecor, 1956). Table 16 summarizes the proportion and composition of foods found in the gullets of 50 males and 46 females collected in 1957, 1958 and 1959.

Table 16. Proportion and per cent composition of major foods found in the gullets of 50 male and 46 female mallards collected in 1957, 1958 and 1959

Foods	Proportion of food		Per cent composition of food	
	Male	Female	Male	Female
TOTAL PLANTS	54.1	36.5	100	100
Gramineae	35.0	13.4	64.7	36.7
Cyperaceae	0.1	0.9	0.2	2.5
Chenopodiaceae	18.7	21.6	34.6	59.2
Other plants	0.3	0.6	0.5	1.6
TOTAL ANIMALS	45.9	63.5	100	100
Insecta	43.5	60.0	94.8	94.5
Other animals	2.4	3.5	5.2	5.5

Table 16 shows an interesting comparison of the role played by the plants normally found in cultivated fields with those found in the waste or wet areas. There was almost a complete reversal of the relative importance of Gramineae, Chenopodiaceae and Cyperaceae in the diets of male and female mallards. In the male, 64.7% of the plants consumed were from the Gramineae and 34.8% from the Chenopodiaceae and Cyperaceae families, whereas in the female, 36.7% of the plants were from the Gramineae and 61.7% from the Chenopodiaceae and Cyperaceae families. In the animal foods the relative importance of the groups was about the same for male and female mallards.

Juvenile Mallards

For the determination of the food of juvenile mallards, 135 stomachs were available, of which 62 contained food materials in the gullets. All age classes of young, from Class I to Flying, (Gollop and Marshall, 1954) were collected during the months of June, July and August. Table 17 lists, by age class, the young mallards obtained for the study.

Table 17. Young mallards collected for food habits studies during the summer months of 1957, 1958 and 1959

	Number of young mallards				Total
	Age class				
	I	II	III	Flying	
Gullets empty	18	27	17	11	73
Gullets with some food	19	20	15	8	62
Total	37	47	32	19	135

The young mallards showed a different pattern of feeding habits than that of the adults. Whereas the adults consumed almost equal parts of plant and animal foods during the summer, the young mallards depended upon the animal kingdom for the majority of their foods; plants accounted for 9.0% and animals 91.0% of the food. Table 18 shows the volume and mean proportion of foods found in the gullets of young mallards.

Table 18. Volume and mean proportion of foods found in the gullets of 62 juvenile mallards collected in 1957, 1958 and 1959

Kind of food	Total volume (milliliters)	Per cent volume	Proportion of food
PLANT FOODS	30.0	11.9	9.0
Unidentified plants	0.5	0.2	0.4
Sparganiaceae	tr	tr	tr
Zosteraceae	0.3	0.1	0.9
Gramineae	15.8	6.3	2.7
Cyperaceae	12.4	4.9	4.7
Lemnaceae	0.5	0.2	0.1
Polygonaceae	0.1	tr	tr
Chenopodiaceae	0.1	tr	tr
Leguminosae	tr	tr	tr
Haloragaceae	0.2	tr	0.1
Labiatae	0.1	tr	tr
ANIMAL FOODS	221.8	88.1	91.0
Bryozoa			
Plumatellidae	51.2	20.3	3.7
Annelida			
Hirundinea	4.9	1.9	1.2
Arthropoda			
Crustacea	6.2	2.5	2.8
Arachnoidea	0.1	tr	tr
Insecta	121.7	48.3	71.6
Mollusca			
Gastropoda	36.0	14.3	11.2
Chordata			
Pisces	1.7	0.7	0.5

Plant foods - Plant parts, mainly seeds, made up 9.0% ± 5.6% (0.05 Level) of the food of 62 juvenile mallards. Examination of Table 18 shows that three families, Cyperaceae, Gramineae and Zosteraceae were the main contributors (92.2%) of plant foods. The proportions of individual plants found in the gullets of young mallards collected in 1957, 1958 and 1959 are presented in Appendix 7.

Table 19. Students' "t" values of plant and animal foods consumed by juvenile mallards in 1957-1958, 1957-1959 and 1958-1959

Year	Calculated "t"	n	Table "t" (0.05 level)
1957-1958	2.05	45	2.01
1957-1959	2.54	31	2.04
1958-1959	1.13	48	2.00

There was a significant change in feeding habits during the study; the young mallards ate progressively more animal and less plant foods from 1957 to 1959. Table 19 summarizes the Students' "t" test values for plant and animal foods consumed. The proportions of plant food eaten during each of the three years are presented in Table 20. The Cyperaceae family was the most important contributor of plant foods; it provided 46.8% of the plant foods in 1957, 63.6% in 1958 and 41.7% in 1959. The Gramineae was important in 1957 when it supplied 45.1% of the plant foods but it decreased sharply to 10.6% in 1958 and only a trace in 1959.

Animal foods - The animal kingdom provided 91.0% ± 5.6% (0.05 level) of the food of juvenile mallards. Animal foods were found in all but two of the 62 gullets examined. The Class Insecta was the most important single source of food of young mallards; it contributed 71.6% of the food (Table 18). Also important was the Gastropoda which contributed 11.2% of the food. The animal groups which were found in the gullets of juvenile mallards are summarized in Appendix 8.

Table 20. Proportion of plant foods found in the gullets of 62 young mallards in 1957, 1958 and 1959

Plant	Proportion of food		
	1957	1958	1959
Zosteraceae		1.5	0.3
Gramineae	10.6	0.7	
Cyperaceae	11.0	4.2	0.5
Other plants	1.9	0.2	0.4
TOTAL PLANTS	23.5	6.6	1.2
Confidence limits 0.05 level	19.9%	6.9%	2.1%
Number of gullets	14	31	17

A significant increase occurred in the use made of animal foods from 1957 to 1959 (Table 19). Animals increased from 76.5% of the diet in 1957 to 98.8% of the diet in 1959. The actual changes that took place are summarized in Table 21. This table shows the proportion of the major items of animal foods consumed in 1957, 1958 and 1959.

Examination of Table 21 reveals there was little change in the composition of the animal foods in the three years. The Gastropoda probably

Table 21. Proportion of animal foods found in the gullets of 62 young mallards in 1957, 1958 and 1959

Animal	Proportion of food		
	1957	1958	1959
Plumatellidae		7.4	
Hirudinea	0.8	1.3	1.3
Crustacea	1.6	4.5	0.5
Arachnoidea			0.2
Insecta	67.0	63.2	90.9
Unidentified	0.6		11.4
Ephemeroptera			0.1
Odonata	0.3	8.2	6.6
Hemiptera	0.5	1.6	6.5
Trichoptera	25.3	21.3	22.9
Coleoptera	2.9	4.6	8.9
Diptera	36.8	27.5	33.9
Hymenoptera	0.6		0.6
Gastropoda	7.1	15.9	5.9
Pisces		1.0	
TOTAL ANIMALS	76.5	93.4	98.8
Confidence limits 0.05 level	19.9%	6.9%	2.1%
Number of gullets	14	31	17

varied the most, they supplied 9.3% of the animal foods in 1957, 17.0% in 1958 and 6.0% in 1959. The Insecta showed a drop in 1958 when it contributed only 67.7% of the animal foods as compared to 87.6% in 1957 and 92.0% in 1959, however, in all years, the Insecta was the major source of foods. A single species from the Phyllum Bryozoa, <u>Plumatella repens</u> L., appears as a relatively important source of food, but since it was found in only three stomachs in 1958, I do not think it was an important food source.

Analysis of Gizzard Contents

The gizzard contents of adult and young mallards could not be accurately measured; apparently, secretions in the proventriculus soften and partially prepare foods for digestion. Seeds with a hard pericarp and insects with sclerotized skeletal parts appeared to resist the softening process, whereas soft seeds and animals were partially digested. Since it was impossible to determine from insect remains, the actual number of animals involved, estimates of the proportions of animal foods consumed were not obtained. Individual plants and animals identified in gizzards of adult and young mallards are listed in Appendices 9 and 10.

Adult Mallards

Items of food found in 211 mallard gizzards examined are listed in Table 22. Examination of the table shows that hard seeds of the Cyperaceae, Sparganiaceae and Haloragaceae families, were the most common plant foods; they were found in 84.4%, 10.9% and 20.4% respectively, of the gizzards examined and made up 30.5% of total occurrences. Soft seeds of the Gramineae and Chenopodiaceae families were found in 34.6% and 20.4% of the gizzards and contributed 14.5% of the total occurrences.

Animals with a hard covering or exoskeleton, appeared to be more important than soft bodied animals. Insecta with sclerotized skeletal parts, were easily recognized; Trichoptera appeared in 47.4%, Coleoptera in 41.7% and Diptera in 37.9% of the gizzards and made up 33.5% of the total occurrences.

Table 22. Occurrence of foods found in the gizzards of 211 adult mallards collected during the summers of 1957, 1958 and 1959

Kind of food	Occurrence in gizzards		
	Number of times used	Per cent times used	Per cent of birds
TOTAL PLANTS	431	53.7	94.8
Unidentified plants	3	0.4	1.4
Sparganiaceae	23	2.9	10.9
Zosteraceae	5	0.6	2.4
Gramineae	73	9.1	34.6
Cyperaceae	178	22.2	84.4
Lemnaceae	8	1.0	3.8
Liliaceae	2	0.2	0.9
Polygonaceae	23	2.9	10.9
Chenopodiaceae	35	4.4	16.6
Cruciferae	1	0.1	0.5
Caryophyllaceae	1	0.1	0.5
Ceratophyllaceae	10	1.2	4.7
Rosaceae	3	0.4	1.4
Leguminosae	8	1.0	3.8
Haloragaceae	43	5.4	20.4
Hippuridaceae	2	0.2	0.9
Umbelliferae	1	0.1	0.5
Cornaceae	1	0.1	0.5
Polemoniaceae	1	0.1	0.5
Verbenaceae	1	0.1	0.5
Labiatae	6	0.7	2.8
Plantaginaceae	2	0.2	0.9
Caprifoliaceae	1	0.1	0.5
TOTAL ANIMALS	372	46.3	85.8
Hirudinea	1	0.1	0.5
Crustacea	4	0.5	1.9
Arachnoidea	2	0.2	0.9
Insecta	358	45.0	85.8
Unidentified insects	53	6.6	25.1
Ephemeroptera	1	0.1	0.5
Odonata	20	2.5	9.5
Hemiptera	16	2.0	7.6
Trichoptera	100	12.5	47.4
Coleoptera	88	11.0	41.7
Diptera	80	10.0	37.9
Gastropoda	7	0.9	3.3
TOTAL OCCURRENCE	803		

Table 23. Occurrence of foods found in the gizzards of 135 juvenile mallards collected in 1957, 1958 and 1959

Kind of food	Occurrence in gizzards		
	Number of times used	Per cent times used	Per cent of birds
TOTAL PLANTS	245	45.2	85.2
Unidentified plants	1	0.1	0.7
Sparganiaceae	13	2.4	9.6
Zosteraceae	16	3.0	11.9
Gramineae	21	3.9	15.6
Cyperaceae	110	20.3	81.5
Lemnaceae	4	0.7	3.0
Polygonaceae	10	1.8	7.4
Chenopodiaceae	5	0.9	3.7
Cruciferae	2	0.4	1.5
Ceratophyllaceae	8	1.5	5.9
Rosaceae	2	0.4	1.5
Leguminosae	3	0.6	2.2
Haloragaceae	34	6.3	25.2
Umbelliferae	2	0.4	1.5
Labiatae	13	2.4	9.6
Compositae	1	0.1	0.7
TOTAL ANIMALS	297	54.8	94.8
Plumatellidae	2	0.4	1.5
Hirudinea	2	0.4	1.5
Crustacea	4	0.7	3.0
Arachnoidea	2	0.4	1.5
Insecta	274	50.6	94.8
Unidentified insects	43	7.9	31.9
Odonata	9	1.7	6.7
Hemiptera	32	5.9	23.7
Trichoptera	70	12.9	51.9
Coleoptera	58	10.7	43.0
Diptera	61	11.3	45.2
Hymenoptera	1	0.1	0.7
Gastropoda	13	2.4	9.6
TOTAL OCCURRENCE	542		

Soft bodied animals were rarely recognized and thus appeared to be relatively unused by mallards.

Juvenile Mallards

Gizzards from 135 juvenile mallards of all age classes were available for study. The food items found are presented in Table 23. Hard seeds of aquatic forms of Cyperaceae and Haloragaceae were the most abundant plant foods recorded. Cyperaceae were found in 81.5% and Haloragaceae in 25.2% of the gizzards; both accounted for over one half (44.9% and 13.9%) of the total plant occurrences. Other aquatic plants such as members of the Zosteraceae, Sparganiaceae and Gramineae were also well represented in the gizzards examined.

In animal foods, the Class Insecta was represented in 94.8% of the gizzards and accounted for 50.6% of the total occurrence of food. The insect groups most commonly found, were the easily recognized Hemiptera, Trichoptera, Coleoptera and Diptera, all of which have sclerotized sketetal parts. Soft bodied animals represented only 4.2% of the gizzard food.

DISCUSSION

Feeding Behavior of Mallards

Mallards belong to the subfamily Anatinae, which is commonly referred to as dabbling or surface feeding ducks. One of the characteristics of this group is that they feed by tipping and dabbling along the edges of lakes, ponds and smaller bodies of water. Kortright (1943) in describing the feeding habits of the Anatinae says: "River and pond ducks, or surface feeding ducks, feed, as their name implies, either at the surface, where they skim the water at the edges of the shores and banks, or by "tipping", tail up, in the shallow places, reaching down to obtain their sustenance from the bottom. Many of the ducks of this subfamily graze on land as do the geese, and some wander into the woods in search of nuts, berries and land insects."

Methods used by mallards to obtain food are variable. Not only do they use the methods described by Kortright but also they dive for food, catch flying insects and strain water through their beak to take small organisms and plants. The actual movements involved in securing foods are innate and are fully developed at the time of hatching (Weidmann, 1956). Weidmann (op. cit.) contends that the different ways of taking foods is activated by the degree of hunger, however, he points out that isolated movements such as idle straining of water and snapping at flying insects is independent of the feeding drive.

The question arises whether selection of individual items of food is an innate behavior pattern or whether mallards learn to recognize food. I believe it is probably a combination of both; I have seen newly hatched mallard ducklings feed on insects after leaving the nest on their way to water and Geyr von Schweppenburg (1959) reports two to three day old mallards actively feeding on ground barley. In one case the ducklings displayed innate behavior in taking insects and in the other case, an ability to rapidly learn edible articles in their environment. No doubt their knowledge of which foods are edible is acquired on a trial and error basis. One must assume that mallards pick their food by visual means but are they able to do this while feeding under water? The ability of a duck to see under water has never been demonstrated, therefore I would suspect that most underwater feeding is a random, searching process. Under good light and water conditions mallards can probably see food items near the surface or even on the bottom and go after them, but under poor light and water conditions this would not be possible.

Comparison of Gullet and Gizzard Contents

In determining the food habits of mallards, gullet materials proved superior to gizzard materials because the amount of animal foods found in gizzards could not be accurately measured. Koersveld (1950) in studying the food habits of jackdaws (*Corvus monedula spermologus* (Vieill)), found that digestion of soft bodied animals was already far advanced in birds killed twenty minutes after feeding. In birds killed twenty minutes after taking food but kept for three days before examining the stomach contents, Koersveld found that soft bodied animals had completely disappeared whereas the sclerotized remains of insects were still visible and cereal grains were unaffected.

During the spring and summer months, when mallards have access to Trichoptera larvae, another source of error may be added to gizzard analyses. Certain families of Trichoptera, such as Limnephilidae, construct their larval cases from a variety of materials. In the Minnedosa area many of the cases were constructed almost entirely of sedge seeds (*Carex* sp.). Other seeds were also used, as were empty shells of Mollusca, particularly the family Planorbidae. Plate VII illustrates some of the types of larval cases constructed by members of the order Trichoptera. Larval cases are recognizable in the gullet and in the gizzard after a recent feeding, however, in the

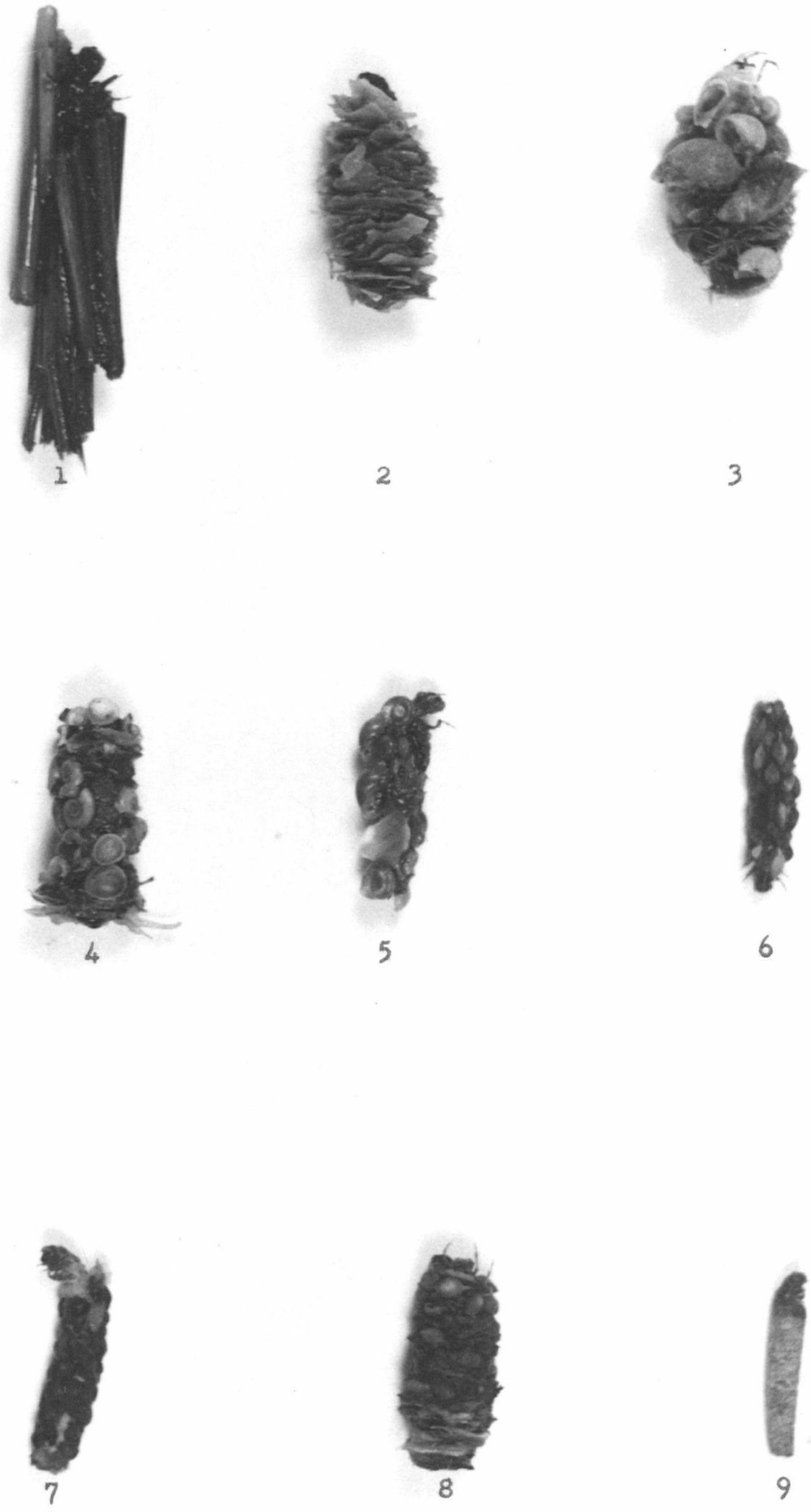
PLATE VII

Family Limnephilidae showing the variety of materials used in the construction of larval cases.

(magnification X2.2)

1. case made of dried plant stems, mostly rushes
2. case made of duckweed (Lemna trisulca)
3. case of duckweed and the shells of snails (Gastropoda)
4. case of snail shells, small clam shells (Pelecypoda) and duckweed
5. case of snails, duckweed and seeds
6. case made almost entirely of sedge seeds (Carex sp.)
7. case made almost entirely of bulrush (Scirpus sp.) seeds
8. case made of duckweed, the seeds of bur-reed (Sparganium sp.) and sedges
9. case made of fine grains of sand

PLATE VII



gizzard, larval cases from a previous feeding, may be reduced to their component parts.

The use of gizzards in the study of waterfowl food habits is an established procedure. Many waterfowl workers however, have questioned the method and have pointed out that gizzard analysis may exaggerate the value of certain hard foods (Pirnie, 1935, and Cottam, 1939). Surprisingly, this did not result in a change of methods even by the ones who doubted them. A search of the literature reveals that it was not until 1959 (Dillon, 1959) that an attempt was made to show and explain the difference between gizzard and gullet analysis.

Dillon (op. cit.) worked with the stomachs of mallards shot during the winter. The birds were living almost entirely on plant materials, and Dillon was able to measure gizzard contents and compare them with gullet contents. Briefly, he found that gizzard analyses tend to give a low rating to easily digested rice field seeds in favor of hard marsh seeds that persisted in the gizzard. For example, Junglerice (Echinochloa colonum (L.) Link) made up 20.7% of the gullet foods and only 11.0% of the gizzard foods. On the other hand, spike sedge (Eleocharis quadrangulata (Michx.) R. & S.) was 0.2% of the volume of gullet contents as compared to 8.4% of the volume of the gizzard contents.

In the present study volumes of food in gizzards were not measured, the contents of gizzards and gullets are compared on the basis of occurrence of various foods. Table 24 summarizes the occurrence of main foods found in gullets and gizzards taken from the same mallards.

Examination of Table 24 shows a discrepancy between gullet and gizzard foods from the same birds. In both adult and young mallards, plant foods received a higher rating in gizzards than they did in gullets. Hard seeds of the marsh plants, Cyperaceae, Polygonaceae and Haloragaceae, appear to be more important than soft seeds of Gramineae and Chenopodiaceae, whereas, the reverse is true in gullet contents. The reason for the higher rating of seeds of aquatic plants is their tough pericarp; this enables the seeds to withstand the grinding action of the gizzard for a longer period of time than can the soft seeds. Although Cyperaceae appeared as only slightly more than 20.0% of

Table 24. Major plant and animal foods found in the gullets and gizzards of 96 adult and 62 young mallards collected in 1957, 1958 and 1959

Kind of food	Per cent times used			
	Adult		Young	
	Gullet	Gizzard	Gullet	Gizzard
PLANT FOOD	35.6	56.8	22.4	43.9
Gramineae	12.5	12.7	5.2	4.7
Cyperaceae	7.5	20.2	8.2	20.4
Polygonaceae	2.7	3.7	0.9	1.1
Chenopodiaceae	7.5	6.4	1.3	2.0
Haloragaceae	1.6	4.0	1.3	4.3
Other plants	3.8	9.8	5.5	11.4
ANIMAL FOOD	64.4	43.2	77.6	56.1
Hirudinea	1.3	0.3	3.0	0.4
Insecta				
Hemiptera	2.4	1.4	10.8	7.1
Trichoptera	14.6	10.4	15.1	13.7
Coleoptera	12.2	10.4	8.2	11.4
Diptera	18.0	11.2	19.8	13.7
Other Insecta	7.8	6.6	7.8	2.7
Gastropoda	4.7	1.7	8.6	5.1
Other animals	3.4	1.2	4.3	2.0
TOTAL OCCURRENCE	295	347	232	255

the times used in both adult and young, seeds of this group were found in 72.9% of the gizzards of adults and 83.9% of the gizzards of young.

In the animal foods, soft bodied animals received a lower rating than did animals with a hard exoskeleton. Sclerotized parts of Coleoptera, Trichoptera and Hemiptera were easily recognized in gizzard debris, although in many cases, they were not identified to order.

Seasonal Variation of Foods

During early spring on the study area it was common to find flocks of mallards feeding in grain stubble fields, but as the breeding season progressed and pairs became established on nesting territories, field feeding flights diminished. However, mallard pairs and later young birds, continued to venture from ponds and into surrounding upland cover in the search for food. With such a pattern of feeding, a great variety of foods may make up the summer diet of mallards.

Little information has been published on feeding habits of mallards while on the breeding grounds. McAtee (1918) examined 1725 gizzards, but only 25 were from birds obtained during summer and the results were not reported on. Stoudt (1944) systematically collected mallards for stomach analysis during August and September and found that during the late summer period the food consisted of 96.5% plant materials. During other seasons of the year, Anderson (1959) found that corn (Zea mays L.) was the principal food of mallards in Illinois; McAtee (op. cit.) considered sedges (Cyperaceae) and grasses (Gramineae) the most important; and Martin, et al. (1951) ranked pondweeds (Potamogeton sp.) and bulrush (Scirpus sp.) top of the preferred foods in the west. The apparent difference in preference of food by black ducks (Anas rubripes Brewster) was explained by Mendall (1949). He stated that many foods are important largely because they are abundant and easily obtained and not necessarily because black ducks exhibit a particular fondness for them. I think this is equally true for mallards.

I believe that preference plays only a minor role in choice of foods; the main reason that a mallard used a particular food is because it is readily available. A food, to be available to mallards, must be abundant, it must be located where birds can use the food and it must be within the normal travel range of the birds. From first arrival in spring until the end of the summer moult, mallards become increasingly more dependent upon ponds and pond edges for their food supply. During this time, although they may not be as abundant as equally desirable foods in a more distant location, only those foods which are found in, or close to water areas, are available. In mid and late summer, as young birds learn to fly and as adults regain their powers of flight after the summer moult, they are less dependent upon ponds; they become very active flyers, often travelling many miles between marsh and feeding area. Because of this increased mobility, vast crops of seeds, both wild and domestic, are available to the birds.

Seasonal variations in food habits appear to be due in part to a decrease or an increase in mobility of mallards. A certain food may be as abundant in summer as it was in spring, but because the range of travel of birds is smaller, the food is less available. On the other hand, a food may be more available to adult males than it is to adult females because the home range of the male is larger than that of the female. Within the pond itself, certain foods may be more available to one age class than to another; young birds are limited to feeding in very shallow areas or in areas of vegetation, whereas, adults can feed by tipping in areas with water depth up to 18 inches (Phillips, 1923, Olney, 1960).

During this study the only plant foods that were available in spring were cereal grains and seeds which carried over the winter either on the plant or on the ground. As the season progressed seeds became less available because of germination and new growth of plants in the understory. Cereal grains were available during most of the season, in fields during spring and to a lesser extent along roadsides during summer. All plant foods became very abundant again in late summer as seed crops matured. Animal foods, on the other hand, increased in abundance during spring and summer months and declined in late summer (Figures 1, 2 and 3).

Seasonal variations of foods used by both adult and young mallards show a trend similar to changes in availability of foods. Figure 5 shows changes, on a bi-weekly basis, in the proportion of plant and animal foods consumed during spring and summer months. Foods consumed by both adult and young mallards were used in drawing the graph, however, most of the adult birds were taken before June 15 and most of the young birds after. The data from which this figure is drawn are summarized in Appendix 11.

When the first mallard stomach samples were taken in the latter part of April, the foods consisted mainly of plant materials (67.4%). It was during this period that seeds from the previous season were abundant and available, whereas the ponds had just become ice free and bottom fauna were not numerous. As bottom organisms increased and seeds decreased in abundance there was a change in diet from predominantly plant to predominantly animal materials. The low in plant utilization was reached in the last two weeks of July and showed signs of recovery in early August as new crops of seeds began to

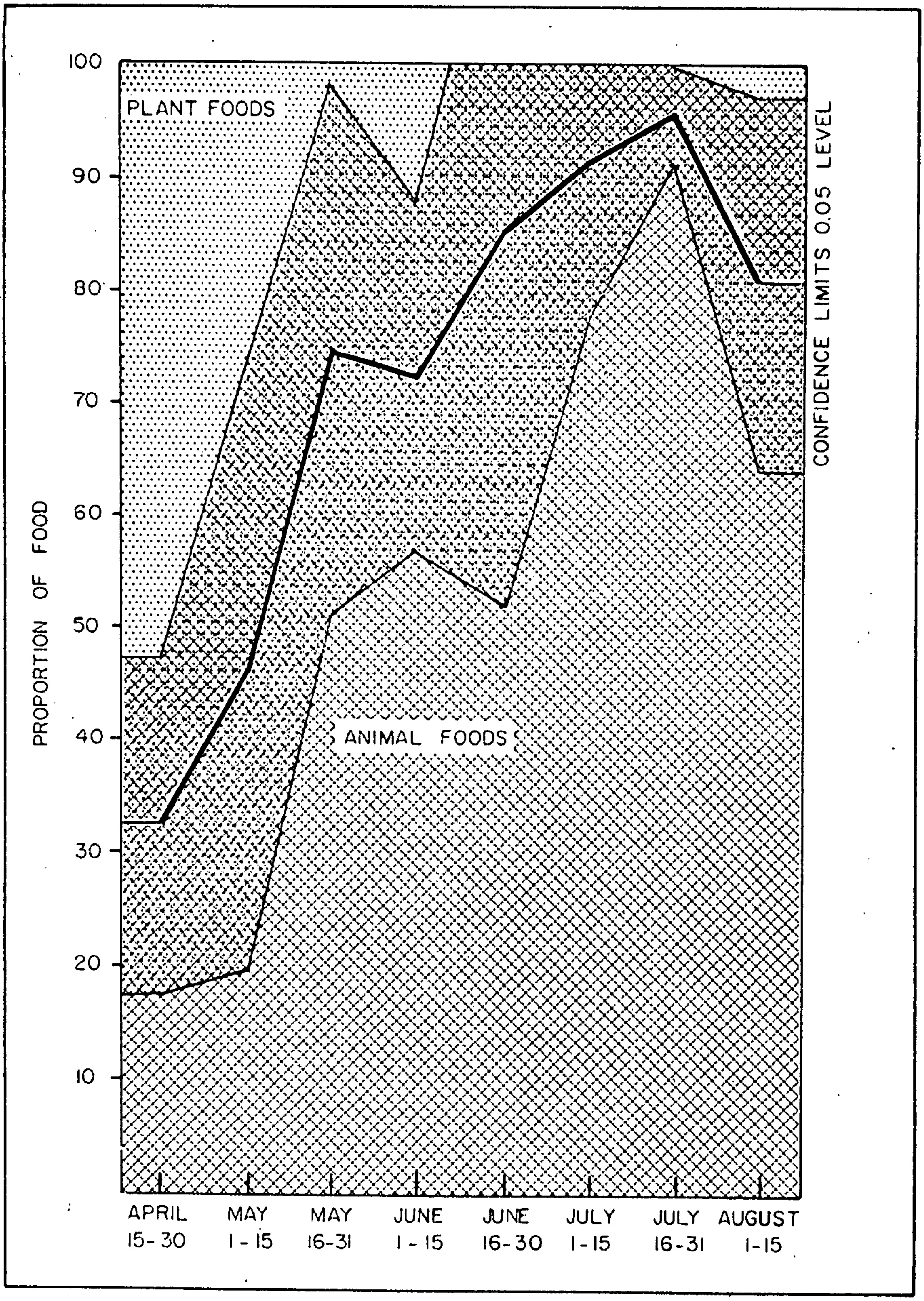


FIGURE 5. PROPORTION OF PLANT AND ANIMAL FOODS CONSUMED BY ADULT AND YOUNG MALLARDS, 1957, 1958 AND 1959.

mature. Had sampling of stomachs been carried on during late August and September the complete change from an animal to a plant diet would probably have been demonstrated. Undoubtedly, as shown by other food studies, mallards remain on a predominantly plant diet until they return to the breeding grounds in the spring.

Comparison of Foods of Adult and Young Mallards

Because the majority of adult mallards were collected before June 15, one would expect plant materials to be the important source of food. One would also expect the food of adults to be different from the food of the ducklings collected later in the summer. The data show this to be the case; 45.7% ± 9.5% (0.05 level) adult foods and 9.0% ± 5.6% (0.05 level) of duckling foods were derived from the plant kingdom, Students' "t" test indicates a significant difference ($t = 5.71$) at the 0.05 level.

When both adult and young mallards are collected during the same period one would expect their food habits to be similar. However, Chura (1961) thought there was a difference in that ducklings ate more animal foods than did females but by the time they were Class III, their food was similar to that of adults. I do not believe there was a difference in proportions of plant and animal foods used by adults and young in late summer in Minnedosa. The individual items that constitute the plant and animal foods may be different, due to a difference in ability to feed in varying water depths, but the total foods should be the same. The sample of adults taken in late June and July was not large enough to statistically compare with young, but the few samples taken tend to substantiate my belief. The food of 7 adults collected from June 16 to August 15 consisted of 85.6% animal materials whereas, foods of young taken from the same period were 90.3% animal origin.

Food of Adult Mallards

Annual Variations

The data presented in Tables 6 and 7 show that the only significant change in overall abundance of edge organisms occurred between 1958 and 1959. However, because the majority of adult mallards were collected prior to June 15, the abundance of edge organisms during this period must be used for comparison; these data are presented in Table 25. The comparison of foods consumed by adults (Tables 13 and 14) with abundance of edge organisms (Table 25) is illustrated in Figure 6.

Table 25. Edge fauna collected from ponds during the period May 1 to June 15 in 1957, 1958 and 1959

Year	Organisms per square foot	Confidence limits 0.05 level	Sample size
1957	187.1	98.0	14
1958	126.3	51.7	31
1959	24.5	6.9	19

There was a significant decrease ($t = 4.00$) in abundance of edge organisms from 1957 to 1959, but this alone was not enough to cause the change in food habits. The relative availability of plant and animal materials played an important part in determining the food selected. In the Minnedosa area, the most commonly grown crops were barley (<u>Hordeum vulgare</u>) and wheat (<u>Triticum aestivum</u>) both of which supplied the majority of plant foods in

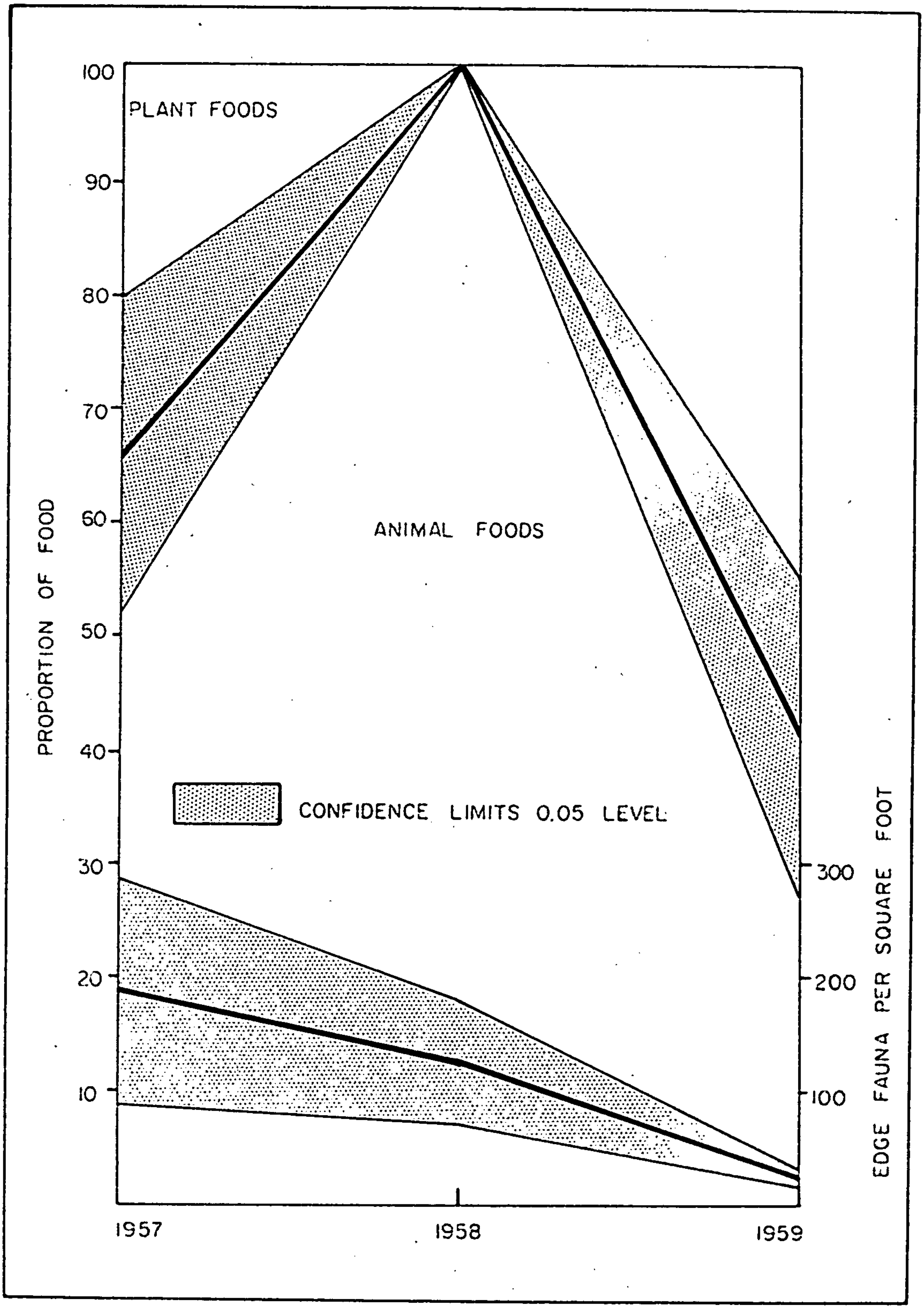


FIGURE 6. COMPARISON OF PLANT AND ANIMAL FOODS OF ADULT MALLARDS AND NUMBER OF EDGE FAUNA PER SQUARE FOOT, 1957, 1958 AND 1959.

1957. The abundance of these grains did not change during the study but use that was made of them decreased in 1959. At the beginning of drought conditions in 1958, many roadside ditches and shallow ponds went dry and created ideal seed beds; one of the main species to colonize these areas was the common weed, lamb's quarters (Chenopodium album). In 1958, lamb's quarters was very common in dried ditches and pond edges and under these ideal conditions produced a heavy crop of seeds. With the temporary return of water to ponds and ditches the following spring, lamb's quarters seeds were shed in the water and were very numerous; in some areas, they formed windrows along the shores. Although they were probably not as abundant as cereal grains in stubble fields, they were more readily available to birds and received a higher use in 1959 than did cereal grains.

The relative availability of animal versus plant foods cannot be measured therefore one must assume that plants, particularly lamb's quarters, were more readily available in 1959 than were pond organisms which decreased in numbers that year. Even if animals had not decreased, lamb's quarters would probably have still been an important source of food because the seeds could be obtained by skimming the water surface without the necessity of dabbling or diving. In 1957 on the other hand, fields with waste cereal grains were the major source of plant foods, however, because they were removed from ponds, plant foods received less use than did pond animals.

The relative availability of various pond organisms is difficult to assess, however, if underwater feeding is a random process availability of bottom dwellers must be closely related to the abundance of them in shallow waters. Availability of pond organisms living in association with vegetation, either submergent or emergent, must also be closely related to abundance as well as to density of plant cover. Although larvae of Trichoptera were more abundant in center samples than they were in edge samples, they were found along the edge of the emergent vegetation zone or just outside the area used in edge sampling. Trichoptera increased in center samples from 1957 to 1959 and with the decrease in water levels, it is possible that they were available in 1959 to mallards feeding by dabbling and diving. The increased use that was made of Trichoptera in 1959 indicates that this was the case. Odonata nymphs, which live in close association with vegetation decreased both in abundance and in value as a food source in 1959. Other pond organisms showed little change in use from 1957 to 1959 (Table 15).

Sexual Differences

Foods utilized by adult male and female mallards were significantly different at the 0.10 level of probability ($t = 1.84$); males consumed a higher proportion of plant foods (54.1%) than did females (36.5%). Examination of Table 16 shows the majority of plant foods consumed by females were those usually associated with water and waste areas; the Chenopodiaceae and Cyperaceae families made up 61.7% of the plant foods. Of plant foods utilized by males, 64.7% were obtained from the Gramineae family found in cultivated fields. Another comparison that can be made is between utilization of both plant and animal foods found in or near ponds and utilization of essentially field foods. Female mallards obtained 86.6% of their food from ponds or pond edges and 13.4% from fields, whereas, males obtained only 64.7% of their food from ponds and 35.3% from fields.

There was a difference in feeding habits of adult male and female mallards during the breeding and nesting seasons. Males were extremely mobile over a large home range where a wide variety of foods were available. On the other hand, females were less mobile; their main feeding activities were restricted to a few water areas within a small home range where the variety of available foods was limited.

Food of Juvenile Mallards

Age Differences

A recent study of food habits of mallards was made by Chura (1961) in the Bear River Migratory Bird Refuge in Utah. He conducted an extensive research program designed to determine availability and preferences of food of juvenile mallards. Little other detailed information is available in the literature; unfortunately, most food habits research has been of a very general nature.

Chura (op. cit.) found a marked change in feeding habits from Class I to Class III ducklings. He states that Class Ia ducklings consumed animal foods almost exclusively; 90% animal foods were consumed by Ib and 75% by Ic. He considered Class II ducklings to be at the "threshold of maturity". At this stage Class IIa consumed 50% animal foods; IIb, 30% and IIc, 11% animal foods. The change over in diet was complete in Class III where the diet was less than 1% animal material. Of equal interest is the fact that almost all animals consumed by Class I young were terrestrial insects, whereas, almost all animals used by Class II were aquatic forms. He states that "this rather instantaneous switch to aquatic forms may be caused by a sudden maturing in feeding behavior involving the head submersion and tip-up feeding of the adults". Chura contends that the change from animal diet at hatching to plant diet at maturity is directly correlated with age and related body requirements.

The proportions of animal foods consumed by juvenile mallards on the

Minnedosa study area are shown in Table 26. Examination of the table shows 94.0% ± 4.3% (0.05 level) of the diet of flightless ducklings was animal foods. Chi square value of 0.57 with 2 degrees of freedom, indicates there was no significant difference in the diets of the three age classes of non flying young. There was however, a significant difference ($t = 2.75$) in the proportion of animals in the diets of non flying and flying young. The food of flying young consisted of 71.1% ± 36.5% (0.05 level) animals and 28.9% ± 36.5% plants.

Table 26. Proportion of animal foods consumed by young mallards in 1957, 1958 and 1959

Age class	Proportion of animal foods	Confidence limits 0.05 level	Sample size
I	98.8	2.5	19
II	89.4	10.8	20
III	93.9	5.5	15
Total non flying	94.0	4.3	54
Flying	71.1	36.5	8

With flying young, one would expect a shift in diet from animal to plant foods. Young mallards with their newly acquired powers of flight, are extremely mobile and are not limited to a home range as were the adults during the breeding season. The small sample of flying young obtained for this study were collected in early August and did not exhibit the complete change over to a plant diet. Pond fauna were still the most abundant source of food; aquatic and field plants were beginning to reach maturity and harvesting of early cereal grains was just starting. An adequate sample of birds taken in late August would probably have revealed they were living almost exclusively on farmers' crops.

I believe that the difference in food habits of Bear River ducklings (Chura, op. cit.) and Minnedosa ducklings was due to a difference in relative availability of plant and animal foods. Chura admits that although many different varieties of potential foods were present in the marsh, few were abundant, whereas, the Minnedosa ponds produced large crops of fauna. The almost exclusive use of terrestrial fauna by Class I mallards on the Bear River marshes indicates a paucity of available aquatic organisms. The fact that Geyr von Schweppenburg (1959) reported two to three day old mallards actively feeding on ground barley further suggests that young mallards are able to survive on many types of food, the main consideration being an abundant supply, regardless of source.

Annual Variations

In the section dealing with faunal characteristics of ponds, only overall annual changes in abundance of center and edge organisms were considered. However, since the majority of mallard ducklings obtained for study were collected between June 16 and August 15 edge fauna sampled during this period must be considered separately. Table 27 shows the abundance of edge fauna during the period June 16 to August 15 in 1957, 1958 and 1959. The comparison of foods consumed by young (Tables 20 and 21) with abundance of edge fauna (Table 27) is illustrated in Figure 7. Examination of Figure 7 shows that there was no significant difference in abundance of bottom fauna between 1957 and 1959 but there was a significant increase ($t = 1.67$) in 1958. The use

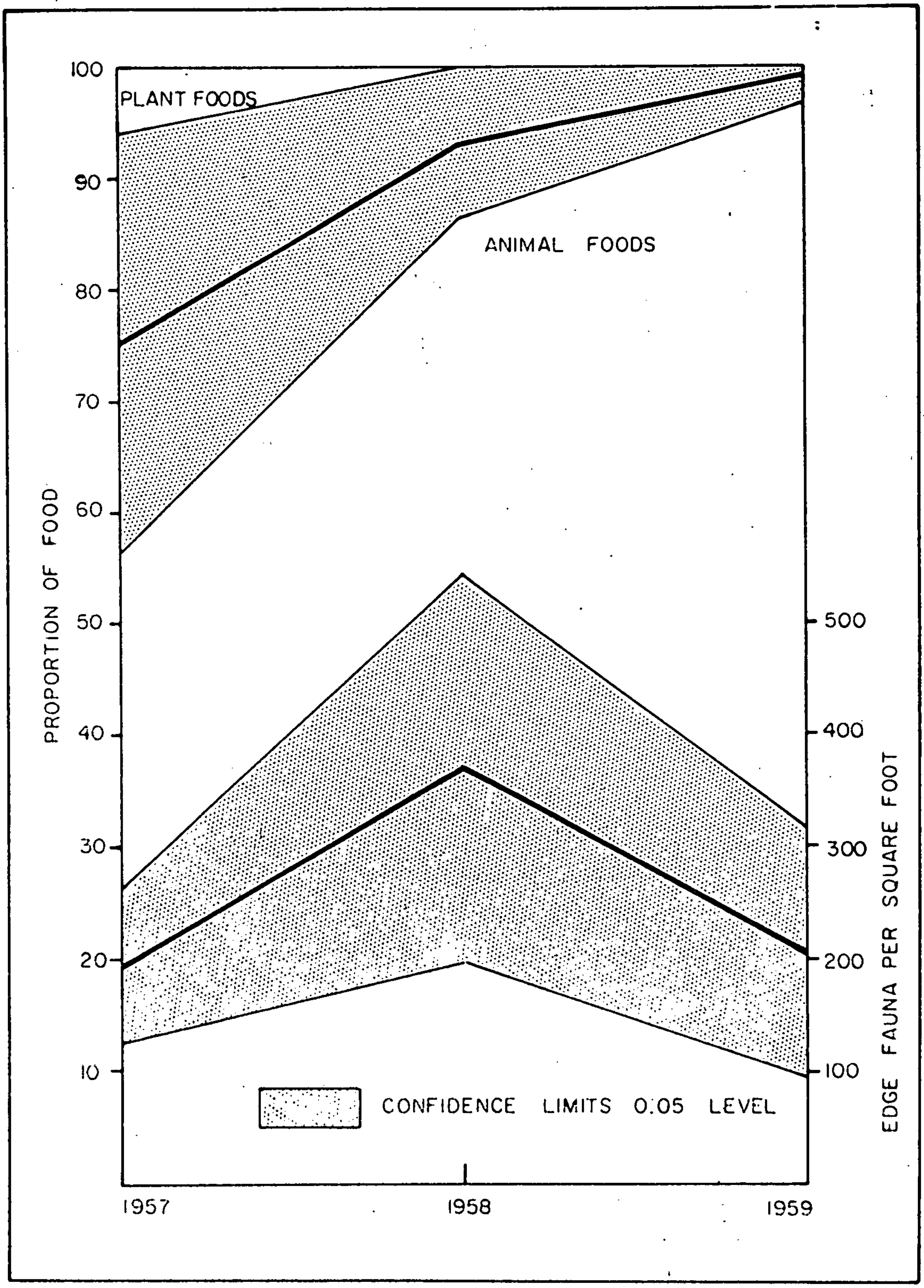


FIGURE 7. COMPARISON OF PLANT AND ANIMAL FOODS OF YOUNG MALLARDS AND NUMBER OF EDGE FAUNA PER SQUARE FOOT, 1957, 1958 AND 1959.

Table 27. Edge fauna collected from ponds during the period June 16 to August 15 in 1957, 1958 and 1959

Year	Organisms per square foot	Confidence limits 0.05 level	Sample size
1957	195.5	69.7	29
1958	377.2	168.2	45
1959	205.5	109.4	24

that was made of bottom fauna by ducklings increased significantly from 1957 to 1958 ($t = 2.05$) and from 1957 to 1959 ($t = 2.54$).

In 1957, when water levels in the ponds were high, emergent vegetation was abundant along the shallow edges. Early maturing plants such as whitetop grass (Scolochloa festucacea), sedges (Carex sp.) and spikerush (Eleocharis palustris (L.) R. & S.) were utilized as a food source. With the onset of drought conditions in 1958, emergent vegetation began to decline and by the brood season of 1959 was almost non-existent. Although there was very little change in abundance of pond fauna between 1957 and 1959, the relative availability of the bottom organisms increased as emergent and shoreline vegetation died out. Thus the importance of plant foods decreased as young changed to an almost exclusive animal diet.

The importance of animal foods increased during the study but the change could not be attributed to a specific animal. Gastropoda showed the greatest change in use; they supplied 9.3% of the animal foods in 1957, 17.0% in 1958 and 6.0% in 1959. Hemiptera and Odonata decreased in bottom samples (Table 8) but increased in use from 1957 to 1959 (Table 21), a change which was probably brought about by an increase in availability as the water levels receded. The change in abundance and availability of Coleoptera was reflected in their increased use as a food source. Trichoptera and Diptera decreased both in the ponds and in utilization by mallard ducklings.

Relationship of Food Use to Availability

Availability of various foods is difficult to assess because so many factors must be considered. As was pointed out in previous sections, food availability is a relative factor dependent upon many conditions; it is determined by abundance of the food, location on land or in water, mobility of the birds and proximity of other food sources. Other factors, such as the stage of development of the food organism and density of the cover in which the food is found, must also be considered.

Any single factor or combination of factors plays an important role in determining utilization of a food source; relative availability of a food is not fixed, it varies from area to area and from season to season. For instance, lamb's quarters (*Chenopodium album*) was more available in 1959 than in the previous two years because it was more abundant in the ponds. Lamb's quarters had a higher use by females than did the more distant field seeds, whereas, in the case of the more mobile male, the reverse was true.

Hyalella azteca (Amphiopoda) comprising 40.1% of the edge fauna (Table 8) was almost unused by mallards, supplying only 3.1% of the animal diet of young (Table 18) and 1.8% of adults (Table 14). *Hyalella* was relatively safe from feeding ducks because of the protection afforded them by the dense beds of filamentous green algae in the Minnedosa ponds. Hemiptera and Coleoptera were not as abundant as the amphiopod but received more use because their habitat was not as dense and did not provide the same protective cover. In ponds with dense algae beds, Hemiptera and Coleoptera frequented the edges whereas, Hyalella was most abundant within the beds.

The stage of development of certain organisms played an important part in determining their relative availability. Larval stages of Tendipedidae, which inhabited the deep areas of the ponds, were not as available to young mallards as they were to adults, but the pupae, as they came to the surface, were equally available. It was common to see ducklings actively skimming the surface of ponds feeding on pupae during a Tendipedidae hatch. Most of the Tendipedidae found in the gullets of young were pupae whereas, larvae predominated in the adults; unfortunately, adult stomachs were not taken at this period for comparison.

Data collected in the Minnedosa study area and in other parts of the mallard range, show that the feeding habits of mallards are variable. The utilization of a food or group of foods appears to be determined by its relative availability.

CONCLUSIONS

1. Emergent and pond shoreline vegetation was almost eliminated by the change in water levels from flood conditions in 1957 to drought conditions in 1959.

2. Availability of seeds during spring and summer is dependent upon the date of maturity of the seeds, the time of the year they are shed and the understory on which they fall. Availability decreases in spring as germination and plant growth takes place and increases in late summer as new crops of seeds mature.

3. There was no significant annual change in abundance of bottom fauna during the study but there was a general seasonal increase in the spring until a peak was reached in May, this was followed by a slight depression and another increase to a much higher peak of abundance in mid August.

4. Gizzard analysis is not a reliable method of determining mallard food habits; initial digestion in the proventriculus and subsequent grinding action of the gizzard renders soft foods unrecognizable.

5. Animals, particularly aquatic insects, were the most important source of the spring and summer foods of mallards in the Minnedosa area. Animals contributed 54.3% of the food of adults and 91.0% of the food of ducklings.

6. The food habits of mallards changed during the spring and summer season due to a change in the relative availability of the plant and animal foods. Plant foods decreased and animal foods increased in abundance during the season.

7. There was a significant change in the diet of adult and young mallards from 1957 to 1959. Utilization of animal foods by adults decreased from 66.3% of the diet in 1957 to 41.1% in 1959. Animal foods consumed by young mallards increased from 76.5% in 1957 to 98.8% in 1959.

8. There was a significant difference in the food of breeding and nesting adults and the food of ducklings; the majority of adult birds were collected prior to June 15 whereas, the majority of ducklings were collected after this date.

9. During the breeding and nesting seasons, there was a significant

difference in the proportion of plant and animal foods consumed by male and female mallards. The males travelled freely over a large home range where a wide variety of foods were available. The females were less mobile; their feeding was restricted to a small home range where the variety of available foods was limited.

10. There was no significant difference in foods consumed by the three age classes of non flying ducklings but there was a difference in the foods of non flying and flying young. When juvenile mallards learn to fly they are more mobile and have a wider variety of foods from which to choose.

11. Utilization of plant and animal foods appears to be determined by abundance and location of the food source in the environment, the proximity of other foods, stage of development of the food organism, density of cover in which a food is found and by the mobility of the bird using the food.

12. The relative proportions of plant and animal foods consumed by waterfowl may not be of primary importance; mallards appear to be able to balance their diets with many different kinds of food.

LITERATURE CITED

Allee, W. C., A. E. Emerson, O. Park, T. Park and K. P. Schmidt. 1949. Principles of animal ecology. W. B. Saunders Co., Philadelphia. 837 p.

American Ornithologists' Union. 1957. Check-list of North American birds. American Ornithologists' Union. 5th ed. 691 p.

Anderson, H. G. 1959. Food habits of migratory ducks in Illinois. Ill. Nat. Hist. Surv. Bull. 27(4):287-344.

Bent, A. C. 1923. Life histories of North American wild fowl. U.S. Natl. Mus. Bull. 126.

Bird, R. D. 1930. Biotic communities of the aspen parkland of central Canada. Ecol. 11:356-443.

Chura, N. J. 1961. Food availability and preferences of juvenile mallards. Trans. 26th N. Am. Wildl. Conf. 121-134.

Cochran, William G. 1956. Design and analysis of sampling. p. 489-523. In G. W. Snedecor, Statistical methods. 5th ed. Iowa State College Press, Ames, Iowa.

Comstock, John H. 1950. An introduction to entomology. 9th ed. rev. Comstock Publishing Co., Inc., New York. 1064p.

Cottam, Clarence. 1939. Food habits of North American diving ducks. U.S. Dept. Agr., Tech. Bull. 643. 139 p.

Cram, B. M. 1956. Waterfowl populations and production on the Roseneath study area, Southern Manitoba, 1956. Can. Wildl. Serv. Mimeo. 5 p.

Dasmann, William P. 1951. Some deer range survey methods. Calif. Fish and Game 37(1):43-52.

Day, Albert M. 1949. North American waterfowl. Stackpole and Heck, Inc., New York. 329 p.

Dillon, Olan W., Jr. 1959. Food habits of wild mallard ducks in three Louisiana parishes. Trans. 24th N. Am. Wildl. Conf. 374-382.

Dobie, John. 1958. Personal correspondence. Minnesota Dept. Conserv. Apr. 5th, 1958.

Dzubin, Alexander. 1954. The intensive study of waterfowl populations on a small block of agricultural land, Minnedosa, Manitoba. M.A. Thesis. Univ. British Columbia, April, 1954.

Dzubin, Alexander. 1955. Some evidences of home range in waterfowl. Trans. 20th N. Am. Wildl. Conf. 278-298.

Ellis, J. H. 1938. The soils of Manitoba. Manitoba Economic Survey Board, Winnipeg, Manitoba.

Evans, Charles D. 1951. A study of the movements of waterfowl broods in Manitoba. M. Sc. Thesis, Univ. Minnesota, April, 1951.

Evans, Charles D. 1955. Waterfowl breeding ground survey in southern Manitoba, 1955. p. 77-88. Waterfowl populations and breeding conditions, summer 1955. USDI and Can. Wildl. Serv., Spec. Sci. Rep., Wildl. No. 30.

Evans, Charles D. 1959. Progress report, Breeding ground surveys in Manitoba, 1958. Mimeo. 37 p. U.S. Dept. of the Interior, 1959.

Evans, Charles D. 1960. Progress report, Breeding ground surveys in Manitoba, 1959. Mimeo. 54 p. U.S. Dept. of the Interior, 1960.

Fernald, Merritt L. 1950. Gray's manual of botany. 8th ed. American Book Co., New York. 1632 p.

Geyr von Schweppenburg, H. Frhr. 1959. On the behaviour of the mallard. J. Ornithol. 100 (4):497-403

Gollop, J. B. and W. H. Marshall. 1954. A guide for aging duck broods in the field. Mississippi Flyway Council Tech. Section. 14 p.

Hanson, R. C. 1957. Progress report, Waterfowl breeding ground aerial surveys in Southern Manitoba, 1956. Mimeo. 25 p., U.S. Dept. of the Interior, 1957.

Hanson, R. C. 1958. Progress report, Waterfowl breeding ground aerial surveys in Southern Manitoba, 1957. Mimeo. 20 p., U.S. Dept. of the Interior, 1958.

Henderson, I. F. and J. H. Henderson. 1939. A dictionary of scientific terms. 3rd ed. Oliver and Boyd, Edinburgh. 383 p.

Hochbaum, H. A. 1944. The canvasback on a prairie marsh. The Am. Wildl. Inst., Washington, D.C. 201 p.

Holm, Earl R. and M. L. Scott. 1954. Studies on the nutrition of wild waterfowl. N.Y. Fish and Game J. 1(2):171-187.

Koersveld, E. van. 1950. Difficulties in stomach analysis. Xth Intern. Ornith. Congr., Uppsala, June, 1950.

Kortright, F. H. 1943. The ducks, geese and swans of North America. The Am. Wildl. Inst., Washington, D.C. 473 p.

Mabbot, Douglas C. 1920. Food habits of seven species of American shoal-water ducks. U.S. Dept. Agr., Bull. 862. 67 p.

Martin, A. C. and F. M. Uhler. 1939. Food of game ducks in the United States and Canada. U. S. Dept. Agr., Tech. Bull. 634. 157 p.

Martin, A. C., H. S. Zim and A. L. Nelson. 1951. American wildlife and plants. McGraw-Hill Book Co., Inc., New York. 500 p.

McAtee, W. L. 1918. Food habits of the mallard ducks of the United States. U.S. Dept. Agr., Bull. 720. 36 p.

Mendall, Howard L. 1949. Food habits in relation to black duck management in Maine. J. Wildl. Mgmt. 13(1):64-101.

Mississippi Flyway Council. 1958. A guide to Mississippi Flyway waterfowl management. March, 1958.

Moyle, J. B. 1961. Aquatic invertebrates as related to larger aquatic plants and waterfowl. Minnesota Dept. of Conservation. Investigational report No. 233. Mimeo. 24 p.

Olney, P. J. S. 1960. Lead poisoning in wildfowl, Part II. Bull. Brit. Ornith. Club 80(3):53-59

Pennak, Robert W. 1953. Fresh-water invertebrates of the United States. The Ronald Press Co., New York. 769 p.

Phillips, J. C. 1923. A natural history of the ducks, p. 21. Houghton Mifflin Co., Boston. Vol. II.

Pirnie, Miles D. 1935. Michigan waterfowl management. Mich. Dept. Cons., Lansing, Mich. 328 p.

Snedecor, George W. 1956. Statistical methods. 5th ed. Iowa State College Press, Ames, Iowa. 534 p.

Sowls, Lyle K. 1955. Prairie ducks. The Stackpole Co., Harrisburg, Pa. and Wildl. Mgmt. Inst., Washington, D.C. 193 p.

Stoudt, Jerome H. 1944. Food preferences of mallards on the Chippewa National Forest, Minnesota. J. Wildl. Mgmt. 8(2):100-112.

United States Department of the Interior. 1951. 1951 Status report of waterfowl. Fish and Wildlife Service, Washington. 39 p.

United States Department of the Interior. 1956. National survey of fishing and hunting. 1955. Fish and Wildlife Service Circ. 44.

United States Department of the Interior. 1959. 1959 Status report of waterfowl. USDI Spec. Sci. Rep., Wildl. No. 45. Washington.

United States Department of the Interior. 1960a. Waterfowl status report, 1960. USDI Spec. Sci. Rep., Wildl. No. 51. Washington.

United States Department of the Interior. 1960b. Waterfowl harvest in the United States 1959-1960 hunting season. USDI Spec. Sci. Rep. No. 52. Washington.

Weaver, John E. and Frederic E. Clements. 1938. Plant ecology. McGraw-Hill Book Co., Inc., New York. 601 p.

Weidmann, Uli. 1956. Verhaltangsstudien an der Stockente. 1. Das Aktionssystem. Zeitschr. Tierpsych. 13(2):208-268.

Appendix 1. Bi-weekly changes in the number of organisms per square foot sample found in the centers of ponds studied in 1957, 1958 and 1959

Date		Center samples					
		1957		1958		1959	
		Number of organisms	Sample size	Number of organisms	Sample size	Number of organisms	Sample size
May	1-15			95.0	8		
	16-31	408.6	7	314.8	13	168.4	8
June	1-15	299.5	10	193.4	10	173.7	11
	16-30	178.3	12	228.7	11	435.2	9
July	1-15	229.2	8	276.1	11	558.6	8
	16-31	392.4	9	435.9	15	820.6	7
Aug.	1-15	178.9	7	656.5	8		

Appendix 2. Bi-weekly changes in the number of organisms per square foot sample found in the edges of ponds studied in 1957, 1958 and 1959

Date		Edge samples					
		1957		1958		1959	
		Number of organisms	Sample size	Number of organisms	Sample size	Number of organisms	Sample size
May	1-15			93.5	8		
	16-31	213.8	6	133.6	13	21.0	8
June	1-15	167.1	8	143.0	10	27.2	11
	16-30	117.7	9	250.7	11	101.8	9
July	1-15	168.5	6	132.2	11	616.5	8
	16-31	245.8	8	448.2	15	146.0	7
Aug.	1-15	272.2	6	754.6	8		

Appendix 3. Bi-weekly changes in the number of organisms per square foot sample found in the centers and edges of ponds studied in 1957, 1958 and 1959

Date	Center		Edge		Mean Edge and center	
	Number of organisms	Limits 0.05 level	Number of organisms	Limits 0.05 level	Number of organisms	Limits 0.05 level
May 1-15	95.0	67.8	93.5	93.9	94.3	51.5
16-31	296.4	145.6	118.1	60.3	208.7	81.2
June 1-15	220.6	68.6	105.7	51.1	165.1	44.6
16-30	267.9	111.5	160.0	62.0	216.6	74.2
July 1-15	345.9	122.1	223.8	101.8	287.2	79.3
16-31	510.1	227.7	322.2	195.2	417.7	148.0
Aug. 1-15	433.6	248.3	547.9	327.8	488.8	192.4

Appendix 4. Occurrence of edge fauna in the study ponds in 1957, 1958 and 1959

Organism	Occurrence of fauna					
	1957		1958		1959	
	Number of ponds	Per cent	Number of ponds	Per cent	Number of ponds	Per cent
Hirudinea	37	69.8	53	69.7	11	25.6
Amphiopoda	43	81.1	61	80.3	9	20.9
Hydracarina	13	24.5	19	25.0	17	39.5
Ephemeroptera	8	15.1	24	31.6	2	4.7
Odonata	27	51.0	21	27.6	7	16.3
Hemiptera	30	56.6	38	50.0	16	37.2
Trichoptera	46	86.8	57	75.0	26	60.5
Coleoptera	45	84.9	63	82.9	38	88.4
Diptera	52	98.1	72	94.7	41	95.4
Gastropoda	44	83.0	37	48.7	27	62.8
Total	53		76		43	

Appendix 5. Volume and mean proportion of plant foods found in the gullets of 96 adult mallards collected in 1957, 1958 and 1959

Plant	Volume of food (milliliters)		Mean proportion of food (per cent)	
Sparganiaceae	tr		tr	
Sparganium sp.				
Gramineae	252.9		24.6	
Hordeum vulgare L.		148.9		12.0
Triticum aestivum L.		65.7		9.6
Echinochloa crusgalli (L.) Beauv.		38.1		2.9
Beckmannia syzigachne (Steud.) Fern.		0.1		tr
Scolochloa festucacea (Wild.) Link		0.1		tr
Agropyron repens (L.) Beauv.		tr		tr
Setaria viridus (L.) Beauv.		tr		tr
Cyperaceae	1.2		0.5	
Carex sp.		1.2		0.5
Scirpus sp.		tr		tr
Eleocharis sp.		tr		tr
Lemnaceae	tr		tr	
Lemna sp.				
Polygonaceae	0.7		0.1	
Polygonum lapathifolium L.		0.5		0.1
Convolvulus L.		0.1		tr
Hydropiper L.		tr		tr
Rumex persicarioides L.		0.1		tr
maritimus L.		tr		tr
Chenopodiaceae	76.4		20.0	
Chenopodium album L.		76.4		20.0
Ceratophyllaceae	0.1		tr	
Ceratophyllum demersum L.		0.1		tr
Rosaceae	0.1		0.2	
Rosa blanda Ait.		0.1		0.2
Leguminosae	tr		tr	
Melilotus alba Desr.				
Halorgaceae	0.1		0.1	
Myriophyllum exalbescens Fern.		0.1		0.1
Compositae	tr		tr	
Sonchus arvensis L.		tr		tr
oleraceus L.		tr		tr
TOTAL PLANTS	331.5		45.7	

Appendix 6. Volume and mean proportion of animal foods found in the gullets of 96 adult mallards collected in 1957, 1958 and 1959

Animal	Volume of food (milliliters)		Mean proportion of food (per cent)	
ANNELIDA	5.0		0.7	
Hirudinea		5.0		0.7
ARTHROPODA				
Crustacea	0.9		1.0	
Amphiopoda		0.9		1.0
Arachnoidea	tr		tr	
Hydracarina		tr		tr
Insecta				
Ephemeroptera	0.1		tr	tr
Odonata	15.3		5.5	
Anisoptera		7.0		1.7
Zygoptera		8.3		3.8
Hemiptera	0.9		0.2	
Notonectidae		0.1		tr
Corixidae		0.8		0.2
Trichoptera	80.0		17.8	
Coleoptera	10.1		3.3	
Haliplidae		3.0		0.8
Dytiscidae		6.1		2.0
Gyrinidae		0.1		0.3
Hydrophilidae		0.5		0.1
Hydraenidae		tr		tr
Chrysomelidae		0.1		tr
Staphylinidae		0.1		tr
Unidentified		0.2		0.1
Diptera	73.1		24.6	
Tipulidae		4.5		2.3
Culicidae		1.5		0.2
Tendipedidae		63.2		19.8
Ceratopogonidae		tr		tr
Stratiomyiidae		3.6		2.1
Anthomyiidae		0.3		0.1
Hymenoptera	tr		tr	tr
MOLLUSCA				
Gastropoda	1.7		1.2	
Lymnaeidae		0.4		0.2
Planorbidae		0.9		0.3
Physidae		0.1		0.3
Unidentified		0.3		0.4
TOTAL ANIMALS	187.1		54.3	

Appendix 7. Volume and mean proportion of plant foods found in the gullets of 62 juvenile mallards collected in 1957, 1958 and 1959

Plant	Volume of food (milliliters)		Mean proportion of food (per cent)	
Unidentified plants	0.5		0.4	
Sparganiaceae	tr		tr	
Sparganium sp.				
Zosteraceae	0.3		0.9	
Potamogeton pusillus L.		0.2		0.8
pectinatus L.		0.1		0.1
Gramineae	15.8		2.7	
Hordeum vulgare L.		11.5		1.6
Scolochloa festucacea (Wild.) Link		4.3		1.1
Cyperaceae	12.4		4.7	
Scirpus sp.		0.2		0.9
Carex sp.		5.0		1.9
atherodes Spreng.		6.8		1.8
Eleocharis palustris (L.) R. & S.		0.4		0.1
Lemnaceae	0.5		0.1	
Lemna sp.		0.5		0.1
Polygonaceae	0.1		tr	
Polygonum convolvulus L.		0.1		tr
Rumex persicarioides L.		tr		tr
Chenopodiaceae	0.1			
Chenopodium album L.		0.1		tr
Leguminoseae	tr		tr	
Melilotus alba Desr.				
Haloragaceae	0.2		0.1	
Myriophyllum exalbescens Fern.		0.2		0.1
Labiatae	0.1		tr	
Teucrium occidentale Gray		0.1		tr
TOTAL PLANTS	30.0		9.0	

Appendix 8. Volume and mean proportion of animal foods found in the gullets of 62 juvenile mallards collected in 1957, 1958 and 1959

Animal	Volume of food (milliliters)		Mean proportion (per cent)	
BRYOZOA				
Plumatellidae (Plumatella repens L.)	51.2		3.7	
ANNELIDA				
Hirudinea	4.9		1.2	
ARTHROPODA				
Crustacea				
Amphiopoda	6.2		2.8	
Arachnoidea				
Hydracarina	0.1		tr	
Insecta				
Unidentified insects	5.1		3.3	
Ephemeroptera	0.1		tr	
Odonata	8.3		6.0	
Anisoptera		4.0		1.5
Zygoptera		4.3		4.5
Hemiptera	2.7		2.6	
Notonectidae		0.6		0.3
Corixidae		2.0		2.2
Gerridae		tr		tr
Saldidae		0.1		0.1
Trichoptera	46.2		22.6	
Coleoptera	2.6		5.4	
Unidentified coleoptera		0.4		1.7
Haliplidae		0.4		1.3
Dytiscidae		1.2		0.8
Hydrophilidae		0.4		0.8
Curculionidae		0.2		0.8
Diptera	56.6		31.4	
Unidentified diptera		0.5		1.8
Tendipedidae		50.7		26.4
Ceratopogonidae		0.2		0.8
Stratiomyiidae		0.8		1.0
Tabanidae		4.3		1.3
Syrphidae		0.1		tr
Anthomyiidae		tr		tr
Hymenoptera	0.1		0.3	
MOLLUSCA				
Gastropoda	36.0		11.2	
Lymnaeidae		34.7		8.5
Planorbidae		0.7		0.5
Physidae		0.6		2.2
CHORDATA				
Pisces	1.7		0.5	
TOTAL ANIMALS	221.8		91.0	

Appendix 9. Plants found in the gizzards of 211 adult (A) and 135 juvenile (J) mallards collected in 1957, 1958 and 1959

Sparganiacea		
Sparganium sp.	A	J
Zosteraceae		
Potamogeton sp.		J
pectinatus L.	A	J
pusillus L.	A	J
Gramineae		
Beckmannia syzigachne (Steud.) Fern.	A	
Echinochloa crusgalli (L.) Beauv.	A	J
Hordeum jubatum L.		J
vulgare L.	A	J
Phleum pratense L.	A	
Scolochloa festucacea (Wild.) Link	A	J
Setaria viridis (L.) Beauv.	A	J
Triticum aestivum L.	A	
Puccinellia Nuttalliana (Schultes) Hitchc.	A	
Cyperaceae		
Carex sp.	A	J
atherodes Spreng.		J
aqualilis Wahlenb.	A	
sychnocephala Carey	A	
Eleocharis sp.	A	J
palustris (L.) R. & S.	A	J
Scirpus sp.	A	J
acutus Muhl.	A	J
americanus Pers.	A	
heterochaetus Chase		J
paludosus Nels.	A	J
Validus Vahl.	A	J
Lemnaceae		
Lemna minor L.	A	J
trisulca L.	A	J
Polygonaceae		
Polygonum sp.	A	J
aviculare L.	A	J
Convolvulus L.	A	J
Hydropiper L.	A	
lapathifolium L.	A	
Persicaria L.	A	
Rumex sp.	A	J
maritimus L.	A	
mexicanus Meisn.		J
persicarioides L.		J

Appendix 9. Plants found in the gizzards of 211 adult (A) and 135 juvenile (J) mallards collected in 1957, 1958 and 1959

Chenopodiaceae	
Chenopodium album L.	A J
Cruciferae	
Brassica sp.	J
Rorippa islandica (Oeder) Borbas	A
Saxifragaceae	
Saxifraga cespitosa L.	A
Caryophyllaceae	
Silene noctiflora L.	A
Ceratophyllaceae	
Ceratophyllum demersum L.	A J
Rosaceae	
Geum triflorum Pursh	A
Potentilla sp.	J
Rosa blanda Ait	A
Rubus sp.	J
Leguminosae	
Astragalus tenellus Pursh	A
Melilotus alba Desr.	A J
Onagraceae	
Gaura coccinea Pursh	A
Haloragaceae	
Myriophyllum exalbescens Fern.	A J
Hippuridaceae	
Hippuris vulgaris L.	A
Umbelliferae	A J
Cornaceae	
Cornus sp.	A
Polemoniaceae	
Collomia linearis Nutt.	A
Verbenaceae	
Verbena sp.	A

Appendix 9. Plants found in the gizzards of 211 adult (A) and 135 juvenile (J) mallards collected in 1957, 1958 and 1959

Labiatae		
Unidentified	A	J
Teucrium occidentale Gray		J
Plantaginaceae		
Plantago sp.	A	
eriopoda Torr.	A	
Rugelii Dcne.	A	
Caprifoliaceae		
Symphoricarpos occidentalis Hook.	A	
Compositae		
Agoseris glauca (Pursh) Raf.	A	
Antennaria aprica Greene	A	
Sonchus arvensis L.		J

Appendix 10. Animals found in the gizzards of 211 adult (A) and 135 juvenile (J) mallards collected in 1957, 1958 and 1959

BRYOZOA	
Plumatellidae (Plumatella repens L.)	J
ANNELIDA	
Hirudinea	A J
ARTHROPODA	
Crustacea	
Amphiopoda	A J
Arachnoidea	A J
Hydracarina	A J
Insecta	
Unidentified insects	A J
Ephemeroptera	A
Odonata	
Anisoptera	A J
Zygoptera	A J
Hemiptera	
Corixidae	A J
Gerridae	J
Saldidae	J
Trichoptera	A J
Coleoptera	
Unidentified coleoptera	A J
Haliplidae	A J
Dytiscidae	A J
Hydrophilidae	A J
Chrysomelidae	A
Curculionidae	J
Diptera	
Unidentified diptera	J
Tipulidae	A J
Culicidae	A
Tendipedidae	A J
Ceratopogonidae	A J
Stratiomyiidae	A J
Tabanidae	J
Anthomyiidae	A J
Hymenoptera	J
MOLLUSCA	
Gastropoda	
Unidentified gastropoda	A
Lymnaeidae	A J
Planorbidae	A J
Physidae	A J

Appendix 11. Mean proportion of plant and animal foods consumed by adult and young mallards during the summers of 1957, 1958 and 1959

Bi-weekly period		Mean proportion		Confidence limits 0.05 level	Sample size	
		Plant	Animal		Adult	Young
April	16-30	67.4	32.6	15.2	35	
May	1-15	53.5	46.5	26.6	14	
	16-31	24.9	75.1	23.7	13	2
June	1-15	27.6	72.4	16.2	27	2
	16-30	14.3	85.7	33.8	2	5
July	1-15	8.5	91.5	14.3	2	13
	16-31	3.8	96.2	3.3	2	24
Aug.	1-15	19.5	80.5	16.7	1	16