# CONDITION, FEEDING ECOLOGY, AND BEHAVIOR OF MALLARDS WINTERING IN NORTHCENTRAL OKLAHOMA

By

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# CONDITION, FEEDING ECOLOGY, AND BEHAVIOR OF MALLARDS WINTERING IN NORTHCENTRAL OKLAHOMA

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# CHAPTER I

## INTRODUCTION

The emphasis of waterfowl research in North America has been placed upon understanding the breeding phase of the annual life cycle. Few studies have considered the nonbreeding period. The change from widely spaced breeding birds to gregarious molting, migrating, and wintering concentrations results in a change in factors regulating survival and fitness (Prince 1979). Acquiring an understanding of these regulating factors during the wintering season as is being done for the breeding season, is essential to develop a complete perspective by which our continental waterfowl populations can be maintained and properly managed.

Of our North American waterfowl, the greatest amount of biological information has been accumulated on the mallard (Bellrose 1976, Palmer 1976). As a result, much of current waterfowl management practices are based on the mallard. Waterfowl management is more intensive and extensive on stopover and wintering areas (Fredrickson and Drobney 1979), yet there exists an absence of biological data for this period.

Condition of waterfowl during the wintering period may influence their breeding condition and productivity (Jones 1971, Milne 1976, Owen and Cook 1977, Chabreck 1979). Information pertaining to metabolic reserves and morphology is necessary to evaluate condition. Baseline data on lipid and protein levels and body and organ weights can reveal effects of the winter period on survival and may provide insight into subsequent reproductive performance. Additionally, baseline data on lipid and protein levels may elucidate the effects of diet and environmental conditions on individuals within a given population.

An understanding of food requirements of any wildlife species is paramount to its management (Sugden 1973). To obtain a complete understanding of the feeding ecology of a species one must study not only the foods consumed, but also the habitat utilized in procuring food, the feeding behavior of the bird, and the abundance and distribution of food resources potentially available for consumption (Swanson and Meyer 1973). The majority of feeding studies of wintering waterfowl have looked at food habits alone without evaluating food consumption in relation to resource availability and distribution.

Knowledge of activity patterns of a species and associated environmental variables enables researchers to better understand the ecological relationships which can be used to manage the species (Raveling et al. 1972). Studies of behavioral time budgets provide insight into the apportionment of time and energy relative to environmental conditions. This information can be critical to the proper management of a species during the winter and pre-breeding periods.

Oklahoma offers opportunities for investigating several aspects of wintering waterfowl ecology to provide biological data for this period. Within the state, mallards are the most abundant wintering species, peaking at approximately 200,000 birds in January (Barclay 1976). Concentrations of thousands of mallards are supported on several state and federal refuges and lesser numbers winter on many smaller reservoirs throughout the state.

The objectives of this study were to determine the physiological condition and evaluate condition indices as predictors of lipid and protein reserves; describe the feeding ecology; describe time budgets of behavior and activity patterns; and, assess the relationship of these factors for mallards wintering on a reservoir in northcentral Oklahoma.

# CHAPTER II

# DESCRIPTION OF STUDY AREA

The major portion of this study was conducted on Lake Carl Blackwell, a 650 ha turbid reservoir, and the surrounding land area within an 11 km radius. The lake, located in northcentral Oklahoma in Payne County, is approximately 11 km west of Stillwater (Latitude $36^{o}07'$ N, Longitude $97^{o}05'$ W, Fig. 1). Lake Carl Blackwell and the immediate property are owned by Oklahoma State University. The ecological history and physical descriptions of the lake are presented in Leonard (1950), de Gruchy (1952), and Norton (1968).

## Climate

The prevailing climate is temperate with pronounced seasonal variation in both temperature and precipitation (Myers 1976). Spring and fall are the most changeable seasons of the year, the weather being influenced by a combination of Gulf, Continental, and Pacific pressure systems. The greatest number of severe local storms and tornados develop during the spring months of March, April and May. During these months 29% of the annual precipiation and 19.3% of the annual snowfall occur. The fall season of September, October, and November is characterized by clear, sunny days but infrequent storms may yield large amounts of steady rain. Approximately 25% of the annual precipitation occurs during fall and 17.11% of the annual snowfall is

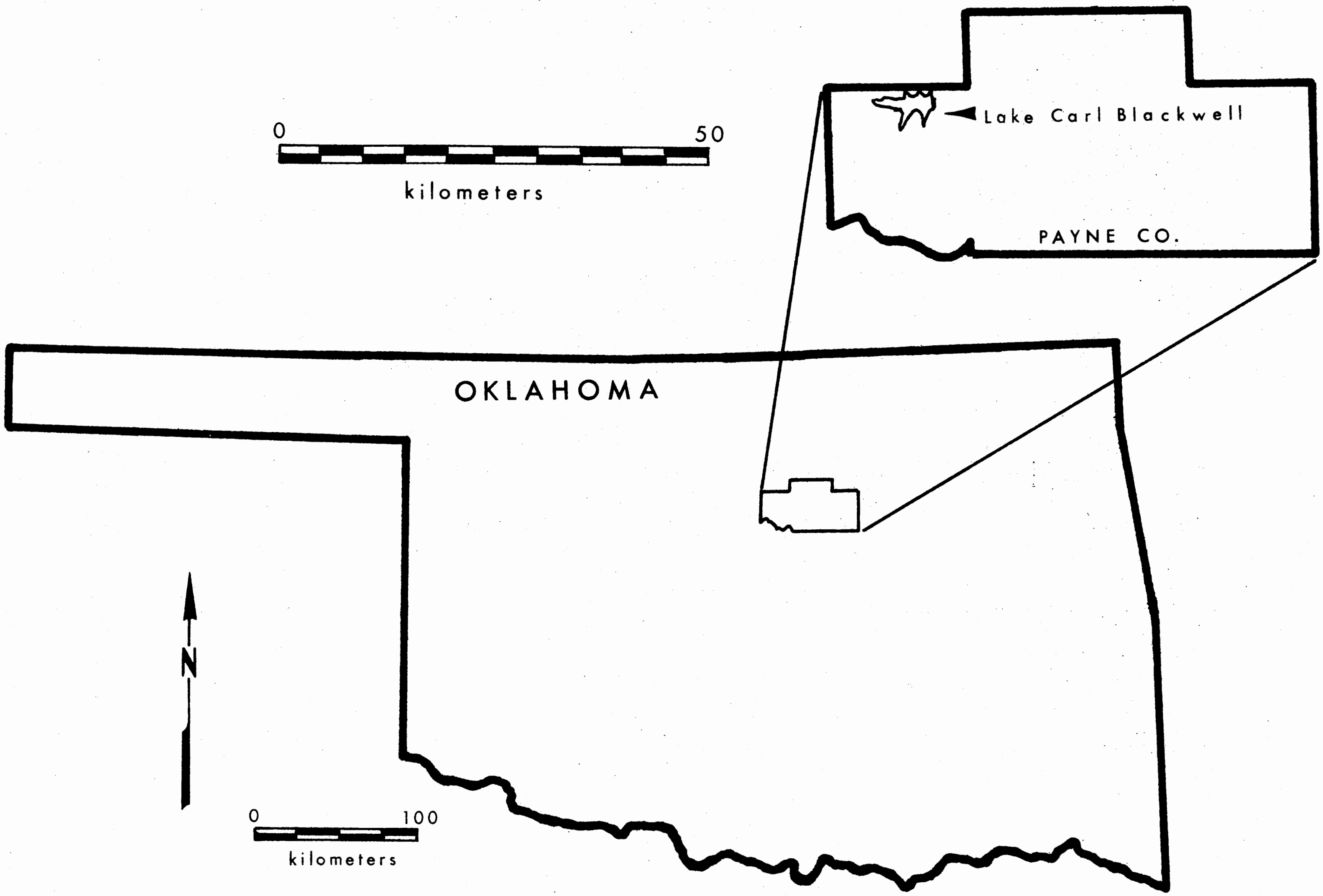


Fig. 1. Relative location of the study area.

recorded in October and November.

The winter months of December, January, and February are influenced by the continental air masses. Numerous and occasionally severe invasions of cold Canadian air cause extreme cold temperatures and on some occasions, when moist air from the Gulf meets the cold Canadian air, heavy precipitation of snow and/or sleet occurs. The mean maximum and minimum temperatures during the winter months are $10^{\circ}$ C and $-2.6^{\circ}$ C, respectively. Twelve percent of the annual precipitation and 63.59% of the annual snowfall is recorded during winter.

The summer months of June, July, and August are influenced predominately by the Gulf air stream. Localized showers and thunderstorms result in 34% of the annual precipitation being recorded during the summer. The mean maximum temperature is $33^{\circ}$ C and the mean minimum temperature is $20^{\circ}$ C. Low humidities and southerly winds prevail.

The mean annual precipitation is 82 cm and the mean annual snowfall is 26 cm. Measureable snowfall can be expected to occur on 4.6 days of the year. The mean number of freeze-free days is 192. Lake evaporation averages 145 cm annually, with approximately 70% occurring from May through October. The mean monthly temperatures range from $3^{\circ}$ C in January to $28^{\circ}$ C in July.

## Topography, Soils and Geology

The study area, situated in the Reddish Prairies, is characterized by smooth to rolling lands dominated by red sedimentary rocks of the Permian Red Beds formation (Gray and Galloway 1959). Major soil associations found in the Lake Carl Blackwell area include Renfrow --

Zaneis - Vernon, Darnell - Stephenville, and Yahola - Reinach (Brensing and Talley 1940, Payne County Soil Conservation Service 1973). Elevation above mean sea level ranges from 287 to 344 m (Brabander 1977).

## Vegetation

The Lake Carl Blackwell area is included in the Oak + Bluestem Parkland Ecoregion (Bailey 1976) and is located in the Cross Timbers/ Mixed Grass vegetational types (Gray and Galloway 1959).

The Cross Timbers vegetation type is typified by blackjack oak (*Quercus marilandica*), post oak (*Q. stellata*), hickory (*Carya* spp.), hackberry (*Celtis occidentalis*), elm (*Ulmus* spp.), and red bud (*Cercis canadensis*). Mixed grass areas are typified by little bluestem (*Andropogon scoparius*), big bluestem (*A. gerardii*), switch grass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*), Canadian wild rye (*Elymus canadensis*), buffalo grass (*Buchloe dactyloides*), and hairy grama (*Bouteloua curtipendula*). Overgrazing by cattle has resulted in the elimination of many characteristic grasses and encouraged growth of prairie threeawn (*Aristida oligantha*), silver bluestem (*A. saccharoides*), ragweed (*Ambrosia* spp.), and broomweed (*Gutierrezia* sp.).

Lake Carl Blackwell itself supports little vegetation. Constant turbidity due to wind action, surface runoff over colloidal soils, and fluctuating waterlevels severely limits the growth of emergent, floating leaved, and submergent vegetation. In extremely wet years, when the water level is high and remains fairly constant, scattered and sparse growths of cattail and floating leaved pondweeds (*Potamogeton* spp.) may be observed. However, this condition is rare. In normal years the water level declines from a high in the spring leaving exposed mud flats. Limited growth of moist-soil species, including wild millet (*Echinochloa crusgalli*), smartweed (*Polygonum* spp.), and sedges (*Cyperus* spp. and *Carex* spp.), occurs at certain locations on these mudflats.

## Land Use

The dominant land use of the study area is agricultural. Wheat, the main agricultural crop, is also used as winter forage for cattle. The rolling upland areas include a mixture of forest and native grassland used as pasture for cattle, and some dry land agriculture. Oil and gas production is also present.

# CHAPTER III

# METHODS AND MATERIALS

## Collection Methods

Mallards were live-trapped with a cannon net on Lake Carl Blackwell during January and February of 1979 and 1980. An attempt was made to capture birds once per week. Eight mallards, 2 adults and 2 immatures of each sex, were selected from each cannon net sample and killed by cervical luxation. These birds were later dissected and lipid and protein levels were determined. The sex and age of the remaining birds were determined using plumage characteristics (Carney 1964). The birds were then banded, weighed to the nearest 5 g, measured, fitted with colored urethane nasal saddles (Greenwood 1977) and released. External morphological measurements, including lengths of exposed culmen, tarsus, folded right wing, and the keel of the sternum, were made to the nearest millimeter.

During January and February 1980 additional wintering mallards were collected from 4 other Oklahoma reservoirs (Fig. 2) to acquire information on the condition of mallards around the state. Collections at Sequoyah NWR on Robert S. Kerr Reservoir were made with a 12 gauge shotgun. Mallards obtained at Ft. Cobb, Ft. Gibson, and Waurika reservoirs were captured with cannon and rocket nets by personnel of the Oklahoma Department of Wildlife Conservation. Additionally, body

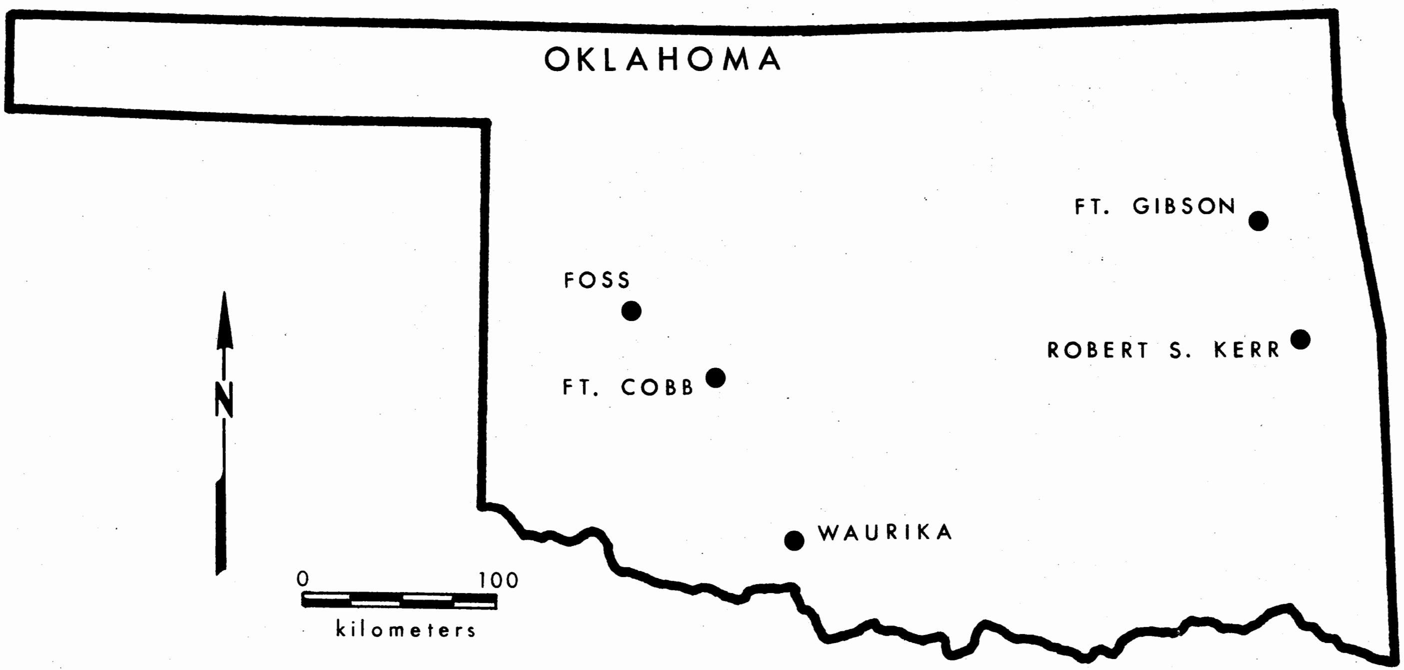


Fig. 2. Relative locations of reservoirs from which wintering mallards were sampled.

weights were obtained for a sample of mallards captured with cannon nets at Washita NWR on Foss Reservoir.

## Dissection Methods

External morphological measurements were taken on all mallards collected. Body weight was recorded to the nearest gram before and after all feathers were plucked. The right set of sternal muscles, including the pectoralis, supracoracoideus, and corabrachialis, and the right set of leg muscles, including all muscles having either their insertion or origin on the tibiotarsus and femur, were excised and weighed. The sternum was removed and the heart, liver, pancreas, and fat deposits within the abdominal cavity (excluding fat associated with the intestinal mesentary) were excised and weighed. Contents of the gastro-intestinal tract were removed, weighed, and subtracted from body weights. Wet weights of muscles and organs were recorded to the nearest 0.1 g. The ventriculus, excised sternal and leg muscle groups, and the remainder of the carcass were placed in separate plastic bags and frozen.

## Lipid and Protein Determinations

The excised sternal and leg muscle groups and the ventriculus from each bird were separately homogenized in a meat grinder. Aliquots were taken from each homogenate for lipid and protein determinations. The frozen carcass, including internal organs but minus the bill and feet, was then cut into pieces with a meat saw, combined with the muscle group and ventriculus homogenates and passed through a meat grinder. Aliquots were also taken from this total carcass homogenate for lipid and protein determinations.

Two 2 g aliquots from each homogenate, i.e. sternal muscle, leg muscle, ventriculus, and total carcass, were wrapped in filter paper, oven-dried for 24 hours at $100^{\circ}$ C, and re-weighed to determine dry weight and moisture content. Each aliquot was refluxed in 40 ml of anhydrous ethyl ether for 24 h using a Goldfisch extraction apparatus, oven-dried for another 24 h, and re-weighed to estimate the quantity of lipid extracted.

Two 1 g aliquots from each homogenate were analyzed for nitrogen content using Kjeldahl nitrogen procedures to estimate protein content.

## Feeding Ecology

Feeding areas utilized by mallards were located by following the birds as they made their daily feeding flights. Mallards were collected on feeding areas to determine foods consumed (Swanson and Bartonek 1970). A bird was observed to feed for a minimum of 10 minutes, collected and the esophageal contents immediately removed. Food abundance, availability and distribution were monitored throughout the winter at feeding sites. Agricultural fields were sampled with $\frac{1}{2}$ $m^2$ plots twice during the winter, once in early January and again at the end of February. Sample plot locations within each field were determined randomly. The top $\frac{1}{2}$ cm of soil from each sample plot was passed through a sieve (1 mm mesh size) and the remaining seeds were placed in a plastic bag. All seeds on stalks within the sample plot were also placed in the plastic bag. Dry weights of the seeds contained in each sample plot were determined.

## Behavior Observations

Diurnal activity patterns and time budgets of behavior were quantified using a focal animal sampling technique (Altman 1974). A focal individual was randomly selected from a flock by selecting the bird nearest the center of the visual field of a spotting scope and recording the amount of time spent in each behavioral activity for 10 consecutive minutes. Behavior categories included comfort movements, resting, actively swimming, walking, foraging, flying and courtship. The times of daily feeding flights were also recorded. Observations were made weekly on 2 consecutive days during the winter.

## Environmental Data Collection

Local weather and environmental variables were recorded daily at 1 hour intervals. Light intensity, snow depth, extent of ice cover, visibility, and cloud cover were estimated or measured on the study area. Ambient temperature, barometric pressure, precipitation, wind speed, wind direction, and solar radiation data were obtained from the Oklahoma State University Agronomy Research Station located approximately 11 km east of Lake Carl Blackwell.

## Statistical Analysis

Statistical analyses were performed using the procedures of SAS (Helwig and Council 1979) with an IBM/370-158 computer at Oklahoma State University. Chi-square, t-test, one-way analysis of variance, Duncan's multiple range test, and simple linear regression analysis were used.

# CHAPTER IV

# RESULTS

## Weather

The 2 winters during which the study was conducted differed in severity. The winter of 1979 (January and February) was the coldest in recorded history for Oklahoma. Mean daily temperatures recorded by the Oklahoma State University Agricultural Experiment Station were 5.5$^{o}$ C below the 1893-1975 83 year average of 4.0$^{o}$ C. The winter temperatures of 1980 were closer to normal, the mean daily temperature being 3.5$^{o}$ C. Mean daily temperatures averaged by week for 1979 and 1980 are compared with the 1893-1975 average in Figure 3. Above normal snowfall in the winter of 1979 resulted in measureable snow cover on the ground from the last week of December 1978 until late-February 1979. Measureable snow cover occurred only on 3 days during the winter of 1980.

The cold temperatures of 1979 resulted in Lake Carl Blackwell being essentially covered with ice from 6 January until 25 February. A small hole in the ice, approximately 30 m in diameter, was kept open by the activity of the waterfowl wintering on the lake. Ice cover was observed infrequently during winter 1980 and was restricted to protected, shallow bays and coves.

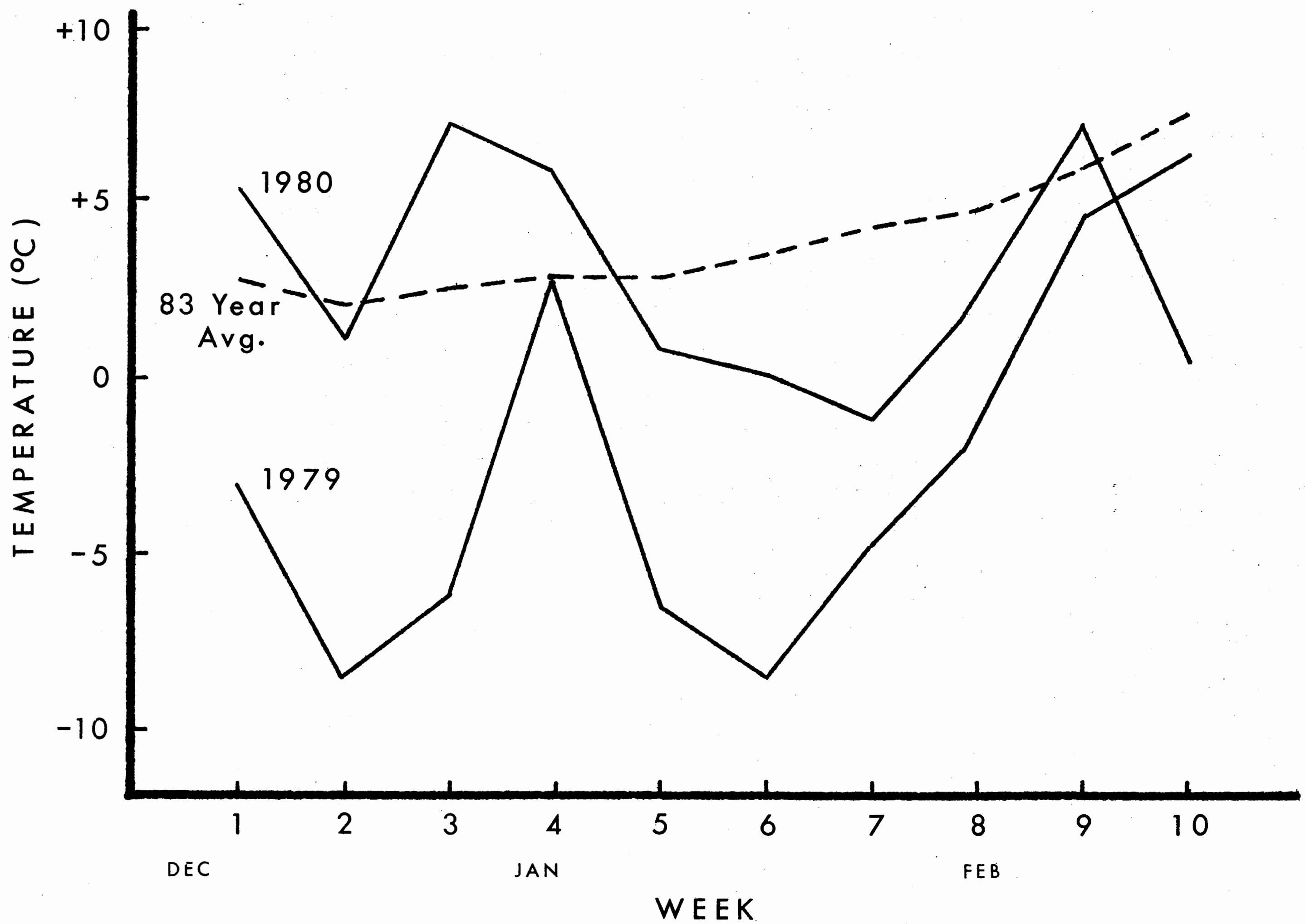


Fig. 3. Mean daily temperatures averaged by week for the winters of 1979 and 1980 and the 1893 - 1975 83 year average.

## Population Characteristics

Weekly ground counts provided estimates of 250 and 800 mallards wintering on Lake Carl Blackwell in 1979 and 1980, respectively. Males composed the greatest proportion of the population in both years (Table 1). A chi-square test indicated no significant difference ($\chi^2 = 0.1$, df = 1, $P > 0.10$) in the observed sex ratios between the 2 years. Age ratios changed between years with a significantly greater percentage of immature birds occurring in the winter of 1980 ($\chi^2 = 6.5$, df = 1, $P < 0.02$). The percentage of adult males was greater in 1979 ($\chi^2 = 7.3$, df = 1, $P < 0.01$). There was, however, no significant change ($\chi^2 = 04$, df = 1, $P > 0.10$) in the relative proportions of adult and immature females between years (Table 2).

## Morphology

### Structural Measurements

Structural size of mallards wintering on Lake Carl Blackwell was compared with t-tests using culmen, keel, tarsus and wing lengths (Table 3). Males had significantly greater culmen, keel, tarsus and wing lengths than females ($P < 0.0001$). There was no significant difference in culmen lengths between age classes ($P > 0.35$). Adults, however, possessed longer keel ($P < 0.0003$), tarsus ($P < 0.0001$), and wing ($P < 0.0001$) lengths. Between year comparisons of total individuals in the population revealed significantly greater culmen ($t = 2.81$, df = 381, $P < 0.005$), tarsus ($t = 5.14$, df = 381, $P < 0.0001$) and wing ($t = 2.31$, df = 381, $P < 0.02$) lengths for mallards in winter 1979. There was no difference in keel lengths between years ($t = 1.13$, df = 381, $P > 0.25$).

Table 1. Sex and age ratios from cannon net samples of mallards wintering on Lake Carl Blackwell.

| Year | N | Males:Females | % Immatures |
| --- | --- | --- | --- |
| 1979 | 143 | 54:46 | 52 |
| 1980 | 253 | 53:47 | 66 |

Table 2. Percent composition by sex and age classes from cannon net samples of mallards wintering on Lake Carl Blackwell.

| | | Males | | Females | |
|---|---|---|---|---|---|
| Year | N | Adult | Immature | Adult | Immature |
| 1979 | 143 | 0.29 | 0.25 | 0.18 | 0.27 |
| 1980 | 253 | 0.18 | 0.35 | 0.16 | 0.31 |

Table 3. Morphological measurements (mm) of mallards captured and released on Lake Carl Blackwell during January - February 1979 and 1980.

| | | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|---|
| Character | Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Culmen | Males | 78 | 55.1 | 2.44 | 115 | 54.7 | 2.17 |
| | Females | 60 | 51.8 | 2.05 | 130 | 51.2 | 1.95 |
| | Total | 138 | 53.6 | 2.79 | 245 | 52.8 | 2.69 |
| Keel | Males | 78 | 111.5 | 3.59 | 115 | 112.2 | 3.42 |
| | Females | 60 | 102.2 | 3.43 | 130 | 104.5 | 3.41 |
| | Total | 138 | 107.4 | 5.81 | 245 | 108.1 | 5.15 |
| Tarsus | Males | 78 | 47.2 | 1.64 | 115 | 46.2 | 1.71 |
| | Females | 60 | 44.7 | 1.73 | 130 | 45.0 | 1.56 |
| | Total | 138 | 46.1 | 2.10 | 245 | 45.0 | 2.00 |
| Wing | Males | 78 | 285.1 | 8.32 | 115 | 282.2 | 7.87 |
| | Females | 60 | 264.9 | 8.00 | 130 | 265.6 | 7.60 |
| | Total | 138 | 276.3 | 12.96 | 245 | 273.4 | 11.32 |

## Weight Measurements

Body weight comparisons (Table 4) within years using t-tests indicated males were heavier than females ($P < 0.0001$) and adults were heavier than immatures ($P < 0.0001$). Body weights of adults were heavier than immatures within each sex class ($P < 0.0001$). Comparisons between years revealed that adults ($t = 2.23$, df = 161, $P < 0.03$) and males ($t = 1.98$, df = 191, $P < 0.05$) were significantly heavier in 1979. The mean body weight of all individuals combined was heavier in 1979 ($t = 2.44$, df = 381, $P < 0.02$).

Comparisons of means with t-tests indicated sternal muscles (Table 5) were heavier for males than females within both years ($P < 0.01$). Adult birds had heavier sternal muscles than immatures ($P < 0.02$). Sternal muscle weights were heavier in adults than immatures within each sex class, but the difference was statistically significant for males only ($P < 0.02$). Between year comparisons using t-tests revealed no significant differences between age and sex classes ($P > 0.05$). The total individual sternal muscle weight difference, however, was statistically significant, 1979 birds being heavier ($t = 1.95$, df = 78, $P < 0.05$).

Comparisons of leg muscle weights (Table 6) using t-tests revealed males were heavier than females ($P < 0.01$) and adults had heavier leg muscle weights than immatures ($P < 0.02$). Within sex classes, adults had heavier leg muscle weights than immatures ($P < 0.05$). Leg muscle weights in nearly all sex and age classes were heavier in 1979 than 1980. The differences, however, were not statistically significant ($P > 0.05$).

Table 4. Body weights (g) of mallards captured and released on Lake Carl Blackwell during January - February 1979 and 1980.

| Class | 1979 N | 1979 $\bar{X}$ | 1979 SD | 1980 N | 1980 $\bar{X}$ | 1980 SD |
|---|---|---|---|---|---|---|
| Males | 78 | 1173 | 99.55 | 115 | 1147 | 89.31 |
| Adult | 43 | 1213 | 97.63 | 49 | 1178 | 76.42 |
| Immature | 35 | 1123 | 78.02 | 66 | 1124 | 91.79 |
| Females | 60 | 1008 | 87.63 | 130 | 1002 | 93.09 |
| Adult | 24 | 1052 | 77.45 | 47 | 1053 | 77.99 |
| Immature | 36 | 979 | 82.69 | 83 | 973 | 88.65 |
| Adults | 67 | 1155 | 119.31 | 96 | 1117 | 99.18 |
| Immatures | 71 | 1050 | 107.88 | 149 | 1040 | 117.27 |
| Total Individuals | 138 | 1101 | 124.84 | 245 | 1070 | 116.57 |

Table 5. Sternal muscle weights (g) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 123.5 | 10.68 | 16 | 118.5 | 12.22 |
| Adult | 12 | 128.4 | 12.48 | 8 | 123.8 | 9.76 |
| Immature | 12 | 118.6 | 5.50 | 8 | 113.3 | 12.71 |
| Females | 24 | 114.0 | 9.29 | 16 | 109.2 | 7.27 |
| Adult | 12 | 117.0 | 6.75 | 8 | 112.5 | 4.10 |
| Immature | 12 | 111.0 | 10.72 | 8 | 105.9 | 8.44 |
| Adults | 24 | 122.7 | 11.41 | 16 | 118.1 | 9.28 |
| Immatures | 24 | 114.8 | 9.21 | 16 | 109.6 | 11.10 |
| Total Individuals | 48 | 118.8 | 11.01 | 32 | 113.9 | 10.96 |

Table 6. Leg muscle weights (g) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 40.3 | 4.70 | 16 | 37.6 | 5.38 |
| Adult | 12 | 42.0 | 5.02 | 8 | 40.7 | 3.79 |
| Immature | 12 | 38.6 | 3.88 | 8 | 34.4 | 5.03 |
| Females | 24 | 34.1 | 2.47 | 16 | 32.7 | 2.26 |
| Adult | 12 | 35.1 | 2.87 | 8 | 33.8 | 1.97 |
| Immature | 12 | 33.2 | 1.63 | 8 | 31.6 | 2.11 |
| Adults | 24 | 38.5 | 5.32 | 16 | 37.2 | 4.61 |
| Immatures | 24 | 35.9 | 4.01 | 16 | 36.9 | 5.13 |
| Total Individuals | 48 | 37.2 | 4.85 | 32 | 35.1 | 4.75 |

Females had greater ventriculus muscle weights (Table 7) than males ($P < 0.02$) based on comparisons of means using t-tests. Other sex and age class comparisons within and between years revealed no statistically significant differences ($P > 0.10$), although mean weight values were higher in 1980.

Comparisons of heart weights (Table 8) using t-tests indicated males had heavier hearts than females ($P < 0.01$) and adult heart weights were greater than immatures ($P < 0.05$). No statistically significant differences ($P > 0.05$) were found between ages within each sex class. Between year comparisons revealed male ($t = 2.00$, $df = 36$, $P < 0.05$) and total individual ($t = 2.33$, $df = 78$, $P < 0.02$) heart weights were significantly heavier in 1979.

Liver weight means (Table 9), compared using t-tests, were heavier during the winter of 1979 than in 1980, but only male ($t = 2.25$, $df = 78$, $P < 0.03$) and total individual ($t = 2.28$, $df = 78$, $P < 0.03$) were significantly different. There were no statistically significant differences ($P > 0.05$) in liver weights between sex and age class comparisons within years, although male liver weights were heavier than females and adult livers were heavier than immatures.

Pancreas weights (Table 10) were heavier in 1979 than in 1980, but the only statistically significant difference occurred between the total individual means ($t = 2.45$, $df = 78$, $P < 0.01$). There were no statistically significant differences in pancreas weights between sex and age class comparisons using t-tests within each year ($P > 0.05$).

Weekly means of body, muscle and organ weights within each year were analyzed with one-way ANOVAs for seasonal differences. These were non-significant ($P > 0.10$), indicating no seasonal trends were

Table 7. Ventriculus muscle weights (g) of mallards collected on Lake Carl Blackwell during January-February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 36.7 | 5.28 | 16 | 38.7 | 5.07 |
| Adult | 12 | 37.8 | 5.49 | 8 | 40.5 | 3.62 |
| Immature | 12 | 35.5 | 5.03 | 8 | 37.0 | 5.92 |
| Females | 24 | 32.4 | 4.23 | 16 | 34.2 | 5.60 |
| Adult | 12 | 32.5 | 4.53 | 8 | 33.3 | 3.74 |
| Immature | 12 | 32.4 | 4.11 | 8 | 35.1 | 7.17 |
| Adults | 24 | 35.1 | 5.63 | 16 | 36.9 | 5.13 |
| Immatures | 24 | 33.9 | 4.78 | 16 | 36.1 | 6.42 |
| Total Individuals | 48 | 34.5 | 5.20 | 32 | 36.5 | 5.73 |

Table 8. Heart weights (g) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 15.7 | 2.11 | 16 | 14.5 | 1.72 |
| Adult | 12 | 16.7 | 2.12 | 8 | 15.0 | 1.50 |
| Immature | 12 | 14.8 | 1.66 | 8 | 14.1 | 1.90 |
| Females | 24 | 13.9 | 1.58 | 16 | 13.1 | 1.07 |
| Adult | 12 | 14.1 | 1.49 | 8 | 13.6 | 1.01 |
| Immature | 12 | 13.7 | 1.71 | 8 | 12.6 | 0.96 |
| Adults | 24 | 15.4 | 2.23 | 16 | 14.3 | 1.43 |
| Immatures | 24 | 14.2 | 1.74 | 16 | 13.4 | 1.63 |
| Total Individuals | 48 | 14.8 | 2.07 | 32 | 13.8 | 1.58 |

Table 9. Liver weights (g) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| Class | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 34.4 | 11.45 | 16 | 26.3 | 10.88 |
| Adult | 12 | 35.8 | 10.83 | 8 | 27.1 | 7.13 |
| Immature | 12 | 33.0 | 12.27 | 8 | 25.4 | 14.19 |
| Females | 24 | 28.4 | 7.93 | 16 | 25.4 | 12.29 |
| Adult | 12 | 30.3 | 8.51 | 8 | 26.6 | 13.26 |
| Immature | 12 | 26.4 | 7.11 | 8 | 24.2 | 12.02 |
| Adults | 24 | 33.1 | 9.99 | 16 | 26.9 | 10.29 |
| Immatures | 24 | 29.7 | 10.38 | 16 | 24.8 | 12.72 |
| Total Individuals | 48 | 31.4 | 10.22 | 32 | 25.8 | 11.43 |

Table 10. Pancreas weights (g) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| Class | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 2.8 | 0.63 | 16 | 2.4 | 0.72 |
| Adult | 12 | 2.8 | 0.60 | 8 | 2.7 | 0.70 |
| Immature | 12 | 2.8 | 0.67 | 8 | 2.2 | 0.69 |
| Females | 24 | 2.6 | 0.63 | 16 | 2.3 | 0.51 |
| Adult | 12 | 2.7 | 0.46 | 8 | 2.4 | 0.53 |
| Immature | 12 | 2.6 | 0.79 | 8 | 2.2 | 0.50 |
| Adults | 24 | 2.7 | 0.53 | 16 | 2.6 | 0.62 |
| Immatures | 24 | 2.7 | 0.72 | 16 | 2.2 | 0.58 |
| Total Individuals | 48 | 2.7 | 0.62 | 48 | 2.4 | 0.62 |

detectable.

## Lipid Reserves

Analysis of total body lipid levels (Table 11) using one-way ANOVAs revealed no statistically significant differences ($P > 0.05$) between sex and age classes either within or between years. However, adult lipid level means were consistantly higher than immatures.

Comparison of sternal muscle lipid levels (Table 12) between and within years using one-way ANOVAs revealed one statistically significant difference. Adults had higher sternal muscle lipid levels than immatures within both years. The difference, however, was significant only in 1979 ($F = 5.34$, df = 1,46, $P < 0.03$).

Leg muscle lipid levels (Table 13) were higher in 1979. Nevertheless, the only statistically significant between year differences were detected for females ($F = 5.01$, df = 1,38, $P < 0.03$) and total individuals ($F = 3.86$, df = 1,78, $P < 0.05$). Adults had higher leg muscle lipid levels than immatures during both years, but the difference was statistically significant only in 1979 ($F = 4.93$, df = 1,46, $P < 0.03$).

One-way ANOVAs indicated no statistically significant differences in ventriculus muscle lipid levels (Table 14) between sex and age classes within each year. Ventriculus muscle lipid levels were, however, significantly higher for males ($F = 4.82$, df = 1,38, $P < 0.03$), females ($F = 11.58$, df = 1,38, $P < 0.001$), adults ($F = 11.81$, df = 1,38, $P < 0.001$), immatures ($F = 5.33$, df = 1,38, $P < 0.02$), and total individuals ($F = 15.38$, df = 1,78, $P < 0.0002$) in 1979 than in 1980.

Comparisons of abdominal cavity fat deposits (Table 15) between

Table 11. Total body lipid levels (% dry weight) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 34.36 | 9.32 | 16 | 38.32 | 10.67 |
| Adult | 12 | 37.81 | 9.66 | 8 | 38.84 | 3.79 |
| Immature | 12 | 30.91 | 7.90 | 8 | 37.80 | 15.13 |
| Females | 24 | 38.46 | 9.73 | 16 | 35.47 | 9.13 |
| Adult | 12 | 39.44 | 8.27 | 8 | 39.51 | 9.46 |
| Immature | 12 | 37.49 | 11.29 | 8 | 31.45 | 7.19 |
| Adults | 24 | 38.62 | 8.83 | 16 | 39.17 | 6.97 |
| Immatures | 24 | 34.20 | 10.11 | 16 | 34.63 | 11.91 |
| Total Individuals | 48 | 36.41 | 8.65 | 32 | 36.90 | 9.87 |

Table 12. Sternal muscle lipid levels (% dry weight) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 8.05 | 2.33 | 16 | 7.37 | 2.15 |
| Adult | 12 | 8.80 | 2.53 | 8 | 7.48 | 1.64 |
| Immature | 12 | 7.30 | 1.94 | 8 | 7.26 | 2.68 |
| Females | 24 | 7.99 | 2.02 | 16 | 7.05 | 2.25 |
| Adult | 12 | 8.61 | 1.77 | 8 | 7.82 | 2.42 |
| Immature | 12 | 7.36 | 2.12 | 8 | 6.28 | 1.89 |
| Adults | 24 | 8.71 | 2.14 | 16 | 7.65 | 2.01 |
| Immatures | 24 | 7.33 | 1.99 | 16 | 6.76 | 2.30 |
| Total Individuals | 48 | 8.02 | 2.16 | 32 | 7.21 | 2.17 |

Table 13. Leg muscle lipid levels (% dry weight) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| Class | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 16.12 | 4.39 | 16 | 15.24 | 4.43 |
| Adult | 12 | 18.07 | 4.51 | 8 | 15.98 | 2.96 |
| Immature | 12 | 14.20 | 3.42 | 8 | 14.49 | 5.66 |
| Females | 24 | 17.10 | 4.03 | 16 | 14.23 | 3.77 |
| Adult | 12 | 17.71 | 4.05 | 8 | 15.69 | 3.60 |
| Immature | 12 | 16.43 | 4.09 | 8 | 12.78 | 3.56 |
| Adults | 24 | 17.89 | 4.19 | 16 | 15.83 | 3.19 |
| Immatures | 24 | 15.30 | 3.86 | 16 | 13.63 | 4.65 |
| Total Individuals | 48 | 16.59 | 4.20 | 32 | 14.73 | 4.08 |

Table 14. Ventriculus muscle lipid levels (% dry weight) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 5.24 | 2.93 | 16 | 3.55 | 1.07 |
| Adult | 12 | 5.95 | 2.78 | 8 | 3.57 | 1.24 |
| Immature | 12 | 4.53 | 3.03 | 8 | 3.53 | 0.96 |
| Females | 24 | 6.11 | 2.48 | 16 | 3.72 | 1.59 |
| Adult | 12 | 6.93 | 2.33 | 8 | 4.52 | 1.29 |
| Immature | 12 | 5.29 | 2.44 | 8 | 2.92 | 1.53 |
| Adults | 24 | 6.44 | 2.56 | 16 | 4.05 | 1.31 |
| Immatures | 24 | 4.91 | 2.72 | 16 | 3.23 | 1.27 |
| Total Individuals | 48 | 5.67 | 2.72 | 32 | 3.64 | 1.34 |

Table 15. Weights (g) of abdominal cavity fat deposits of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 10.5 | 7.54 | 16 | 12.2 | 6.62 |
| Adult | 12 | 13.1 | 8.92 | 8 | 11.0 | 3.95 |
| Immature | 12 | 7.8 | 4.92 | 8 | 13.4 | 8.67 |
| Females | 24 | 10.7 | 6.82 | 16 | 8.8 | 8.60 |
| Adult | 12 | 11.4 | 5.59 | 8 | 12.8 | 10.44 |
| Immature | 12 | 10.1 | 8.06 | 8 | 4.8 | 3.58 |
| Adults | 24 | 12.3 | 7.33 | 16 | 11.9 | 3.58 |
| Immatures | 24 | 8.9 | 6.63 | 16 | 9.1 | 7.77 |
| Total Individuals | 48 | 10.6 | 7.11 | 32 | 10.5 | 7.74 |

all sex and age classes within and between years using one-way ANOVAs revealed no statistically significant differences ($\underline{P} > 0.05$), although adult levels were somewhat higher than immatures within years.

The consistency with which adult lipid levels were higher than immature lipid levels indicated that smaller bodied individuals had lower lipid reserves since adults were heavier than immatures. This relationship is supported in Figure 4 where both equations are highly significant ($\underline{P} < 0.001$).

Weekly means of lipid levels within each year were analyzed with one-way ANOVAs for seasonal differences. These were non-significant ($\underline{P} > 0.10$) indicating no seasonal trends were detectable.

## Protein Reserves

Analysis of total body (Table 16), sternal muscle (Table 17), leg muscle (Table 18), and ventriculus muscle (Table 19) protein levels using one-way ANOVAs failed to reveal any statistically significant differences ($\underline{P} > 0.05$) between sex and age classes within or between years. A consistency which emerged was that 1979 birds had lower mean protein levels than 1980 birds and adults had lower levels than immatures. This pattern is inverse to that observed for lipid levels.

Weekly means of protein levels within each year were analyzed with one-way ANOVAs for seasonal differences. These were non-significant ($\underline{P} > 0.10$) indicating no seasonal trends were detectable.

## Evaluation of Condition Indices

Several condition indices were evaluated by regression analysis for their usefulness in prediction of lipid and protein reserves.

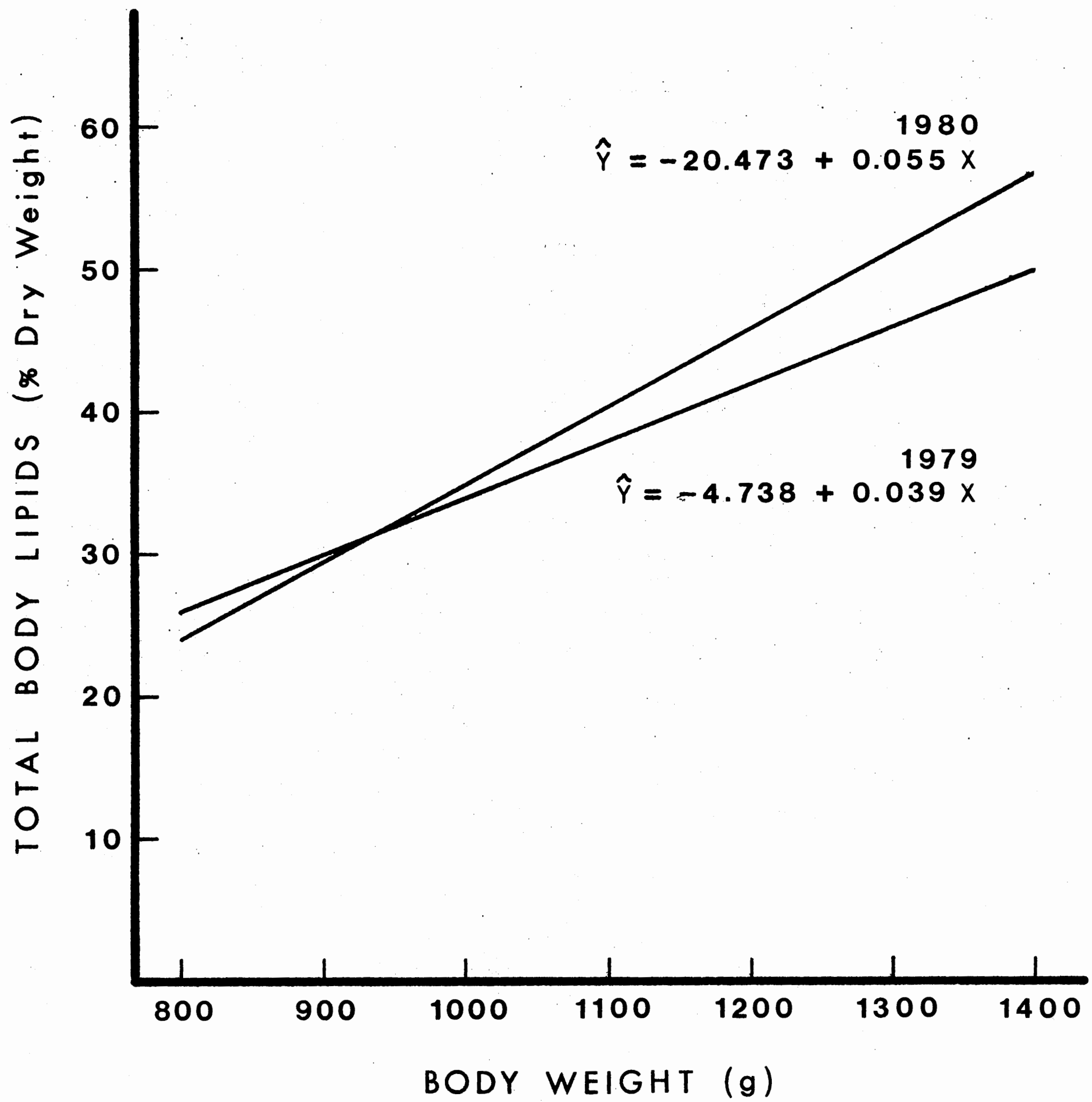


Fig. 4. Relationship of total body lipid levels (% dry weight) to body weight of mallards collected on Lake Carl Blackwell.

Table 16. Total body protein levels (% dry weight) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| Class | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 53.90 | 8.40 | 16 | 53.98 | 9.21 |
| Adult | 12 | 51.40 | 8.60 | 8 | 53.89 | 5.65 |
| Immature | 12 | 56.40 | 7.75 | 8 | 54.07 | 12.23 |
| Females | 24 | 52.06 | 8.92 | 16 | 56.18 | 8.47 |
| Adult | 12 | 50.34 | 7.73 | 8 | 52.25 | 9.06 |
| Immature | 12 | 53.79 | 10.01 | 8 | 60.11 | 6.02 |
| Adults | 24 | 50.86 | 8.05 | 16 | 53.07 | 7.35 |
| Immatures | 24 | 55.09 | 8.86 | 16 | 57.09 | 9.82 |
| Total Individuals | 48 | 52.98 | 8.63 | 32 | 55.08 | 8.77 |

Table 17. Sternal muscle protein levels (% dry weight) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| Class | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 86.30 | 3.36 | 16 | 88.51 | 2.74 |
| Adult | 12 | 84.59 | 3.69 | 8 | 88.18 | 1.44 |
| Immature | 12 | 88.00 | 1.91 | 8 | 88.83 | 3.71 |
| Females | 24 | 87.40 | 4.14 | 16 | 87.75 | 2.94 |
| Adult | 12 | 87.71 | 4.87 | 8 | 86.76 | 3.09 |
| Immature | 12 | 87.09 | 3.45 | 8 | 88.75 | 2.60 |
| Adults | 24 | 86.15 | 4.51 | 16 | 87.47 | 2.44 |
| Immatures | 24 | 87.55 | 2.77 | 16 | 88.79 | 3.09 |
| Total Individuals | 48 | 86.85 | 3.77 | 32 | 88.13 | 2.82 |

Table 18. Leg muscle protein levels (% dry weight) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 82.70 | 5.82 | 16 | 82.58 | 5.08 |
| Adult | 12 | 80.07 | 4.72 | 8 | 82.07 | 3.86 |
| Immature | 12 | 85.32 | 5.78 | 8 | 83.08 | 6.30 |
| Females | 24 | 81.04 | 5.36 | 16 | 83.57 | 5.17 |
| Adult | 12 | 81.17 | 4.27 | 8 | 80.77 | 4.18 |
| Immature | 12 | 80.90 | 6.47 | 8 | 86.37 | 4.68 |
| Adults | 24 | 80.62 | 4.44 | 16 | 81.42 | 3.94 |
| Immatures | 24 | 83.11 | 6.41 | 16 | 84.73 | 5.63 |
| Total Individuals | 48 | 81.87 | 5.60 | 32 | 83.07 | 5.07 |

Table 19. Ventriculus muscle protein levels (% dry weight) of mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 24 | 93.10 | 3.19 | 16 | 91.96 | 3.60 |
| Adult | 12 | 92.44 | 2.99 | 8 | 92.82 | 1.36 |
| Immature | 12 | 93.77 | 3.37 | 8 | 91.11 | 4.91 |
| Females | 24 | 90.93 | 3.76 | 16 | 92.93 | 2.61 |
| Adult | 12 | 90.38 | 3.90 | 8 | 92.17 | 3.41 |
| Immature | 12 | 91.48 | 3.70 | 8 | 93.14 | 1.70 |
| Adults | 24 | 91.41 | 3.56 | 16 | 92.77 | 2.51 |
| Immatures | 24 | 92.63 | 3.65 | 16 | 92.12 | 3.70 |
| Total Individuals | 48 | 92.02 | 3.62 | 32 | 92.45 | 1.16 |

These included body weight (BW), body weight/culmen x keel (BW/CK), and body weight/wing (BW/W).

Analysis of data from both winters resulted in abdominal cavity fat ($R^2$ = 0.79 in 1979 and 0.73 in 1980) being the best predictor of total body lipid reserves (Table 20). Comparison of condition indices derived from external morphological measurements indicated BW/W was a better predictor than BW/CK and BW.

The best predictor of total body protein reserves in both years of the study was BW/W (Table 21). BW/CK was a better predictor than BW. Sternal, leg, and ventriculus muscle weights were also evaluated but were poor predictors of total body protein reserves ($R^2 < 0.20$).

Total body lipid and protein levels were summed to create an estimate of total reserves. Regression of total body reserves on condition indices (Table 22) indicated BW/W explained the greatest amount of variation in total reserves for both 1979 and 1980.

$R^2$ values in the above analyses were consistantly lower in 1979 than 1980. However, within both years the same trend in $R^2$ values emerged. These results suggest BW/W provides the best estimate of body condition for live-trapped mallards.

Mean condition indices (BW/W) of mallards captured with cannon nets on Lake Carl Blackwell are presented in Table 23. Within year comparisons using t-tests indicated males had a significantly higher condition index value than females ($\underline{P} < 0.001$) and adults had higher condition indices than immatures ($\underline{P} < 0.0001$). Adults had significantly higher condition indices than immatures within each sex class ($\underline{P} < 0.01$). Between year comparisons revealed that both adults ($t = 2.01$, $df = 161$, $\underline{P} < 0.05$) and total individuals ($t = 1.97$,

Table 20. Regression of total body lipid reserves (Y) on lipid indices (X) for mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| Lipid Index | Year | $R^2$ | SE | Equation |
|---|---|---|---|---|
| Body Weight | 1979 | 0.21 | 0.01 | $\hat{Y} = -4.738 + 0.039X$ |
| | 1980 | 0.46 | 0.01 | $\hat{Y} = -20.472 + 0.055X$ |
| Body Weight/ Culmen x Keel | 1979 | 0.42 | 71.60 | $\hat{Y} = -39.476 + 218.859X$ |
| | 1980 | 0.53 | 78.07 | $\hat{Y} = -48.035 + 461.760X$ |
| Body Weight/Wing | 1979 | 0.43 | 3.57 | $\hat{Y} = -29.039 + 17.115X$ |
| | 1980 | 0.57 | 3.35 | $\hat{Y} = -43.987 + 21.248X$ |
| Abdominal Cavity Fat | 1979 | 0.79 | 0.09 | $\hat{Y} = 23.656 + 1.203X$ |
| | 1980 | 0.73 | 0.12 | $\hat{Y} = 25.383 + 1.096X$ |

Table 21. Regression of total body protein reserves (Y) on protein indices (X) for mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| Protein Index | Year | $R^2$ | SE | Equation |
|---|---|---|---|---|
| Body Weight | 1979 | 0.27 | 0.01 | $\hat{Y} = 94.634 - 0.039X$ |
| | 1980 | 0.42 | 0.01 | $\hat{Y} = 104.108 - 0.047X$ |
| Body Weight/ Culmen x Keel | 1979 | 0.42 | 63.82 | $\hat{Y} = 121.019 - 372.084X$ |
| | 1980 | 0.55 | 68.47 | $\hat{Y} = 131.391 - 414.855X$ |
| Body Weight/Wing | 1979 | 0.49 | 3.09 | $\hat{Y} = 114.982 - 16.214X$ |
| | 1980 | 0.56 | 3.02 | $\hat{Y} = 126.057 - 18.645X$ |

Table 22. Regression of total body reserves (Y) on condition indices (X) for mallards collected on Lake Carl Blackwell during January - February 1979 and 1980.

| Condition Index | Year | $R^2$ | SE | Equation |
|---|---|---|---|---|
| Body Weight | 1979 | 0.21 | 0.004 | $\hat{Y} = 18.173 + 0.015X$ |
| | 1980 | 0.44 | 0.004 | $\hat{Y} = 11.187 + 0.021X$ |
| Body Weight/ Culmen x Keel | 1979 | 0.42 | 27.692 | $\hat{Y} = 4.750 + 161.189X$ |
| | 1980 | 0.45 | 32.813 | $\hat{Y} = 2.688 + 165.315X$ |
| Body Weight/Wing | 1979 | 0.45 | 1.364 | $\hat{Y} = 8.110 + 6.829X$ |
| | 1980 | 0.53 | 1.355 | $\hat{Y} = 2.742 + 7.974X$ |

Table 23. Condition indices (Body Weight/Wing) of mallards captured and released on Lake Carl Blackwell during Janary - February 1979 and 1980.

| | 1979 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Class | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Males | 78 | 41.1 | 3.14 | 115 | 40.6 | 2.85 |
| Adult | 43 | 42.0 | 3.05 | 49 | 41.0 | 2.66 |
| Immature | 35 | 40.0 | 2.92 | 66 | 40.4 | 2.96 |
| Females | 60 | 38.1 | 2.92 | 130 | 37.7 | 3.09 |
| Adult | 24 | 39.2 | 2.57 | 47 | 39.0 | 2.60 |
| Immature | 36 | 37.3 | 2.94 | 83 | 37.0 | 3.11 |
| Adults | 67 | 41.0 | 3.18 | 96 | 40.0 | 2.80 |
| Immatures | 71 | 38.6 | 3.21 | 149 | 38.5 | 3.48 |
| Total Individuals | 138 | 39.8 | 3.40 | 245 | 39.1 | 3.32 |

df = 381, $P < 0.05$) had significantly higher condition indices in 1979.

Information on condition of mallards wintering at other locations in Oklahoma during 1980 was also obtained. A relatively large variation in lipid and protein reserves between locations was observed, but a one-way ANOVA and Duncan's multiple range test revealed few statistically significant differences (Table 24). Mallards from Ft. Cobb reservoir in western Oklahoma had the highest lipid and lowest protein levels while mallards from Ft. Gibson reservoir in eastern Oklahoma had the lowest lipid and highest protein levels. An examination of condition indices (Table 25) showed Ft. Cobb mallards had the highest value and Ft. Gibson birds had the lowest value which corresponded with relative lipid levels. However, condition index values of mallards from the other locations were ordered differently than lipid levels. These results must be interpreted cautiously as sample sizes were small.

## Feeding Ecology

Observations of feeding birds and crop contents of collected birds revealed mallards wintering on Lake Carl Blackwell during 1979 and 1980 relied mostly on corn (*Zea mays*) as a food source. When field work was initiated during the first week of January 1979 mallards were observed feeding in a sorghum (*Sorghum vulgare*) field (MF) just east of the Lake Carl Blackwell dam (Fig. 5). However, by the end of the week this field was abandoned by feeding birds even though food was still available (Table 26). Observations of daily feeding flights at this time revealed the birds had begun to feed at a small pond (PWC) about 11 km southeast of the lake. The owner of the pond maintained an ad

Table 24. Total body lipid and protein levels (% dry weight) of mallards collected from wintering areas throughout Oklahoma during January - February 1980.

| Location | N | % Lipid $\bar{X}$ | % Lipid SD | % Protein $\bar{X}$ | % Protein SD |
|---|---|---|---|---|---|
| Ft. Cobb Reservoir | 8 | 40.47[a] | 7.08 | 50.74[b] | 6.38 |
| Lake Carl Blackwell | 32 | 36.90[a] | 9.87 | 55.08[b] | 8.77 |
| Robert S. Kerr Reservoir | 16 | 36.44[a] | 5.32 | 53.07[b] | 5.09 |
| Waurika Reservoir | 8 | 31.26[a,b] | 8.22 | 58.06[a] | 6.22 |
| Ft. Gibson Reservoir | 8 | 26.43[b] | 9.05 | 62.95[a,b] | 9.11 |

[a,b] Means with the same letter within each column are not significantly different. Data analyzed with Duncan's multiple range test.

Table 25. Condition indices (Body Weight/Wing) of mallards from wintering areas throughout Oklahoma during January - February 1980.

| Location | N | $\bar{X}$ | SD |
|---|---|---|---|
| Ft. Cobb Reservoir | 8 | 41.8[a] | 3.35 |
| Robert S. Kerr Reservoir | 16 | 41.7[a] | 3.06 |
| Waurika Reservoir | 8 | 39.9[a,b] | 3.38 |
| Foss Reservoir | 86 | 39.7[a,b] | 3.65 |
| Lake Carl Blackwell | 245 | 39.1[b] | 3.32 |
| Ft. Gibson Reservoir | 48 | 38.8[b] | 2.36 |

[a,b] Means with the same letter are not significantly different. Data analyzed with Duncan's multiple range test.

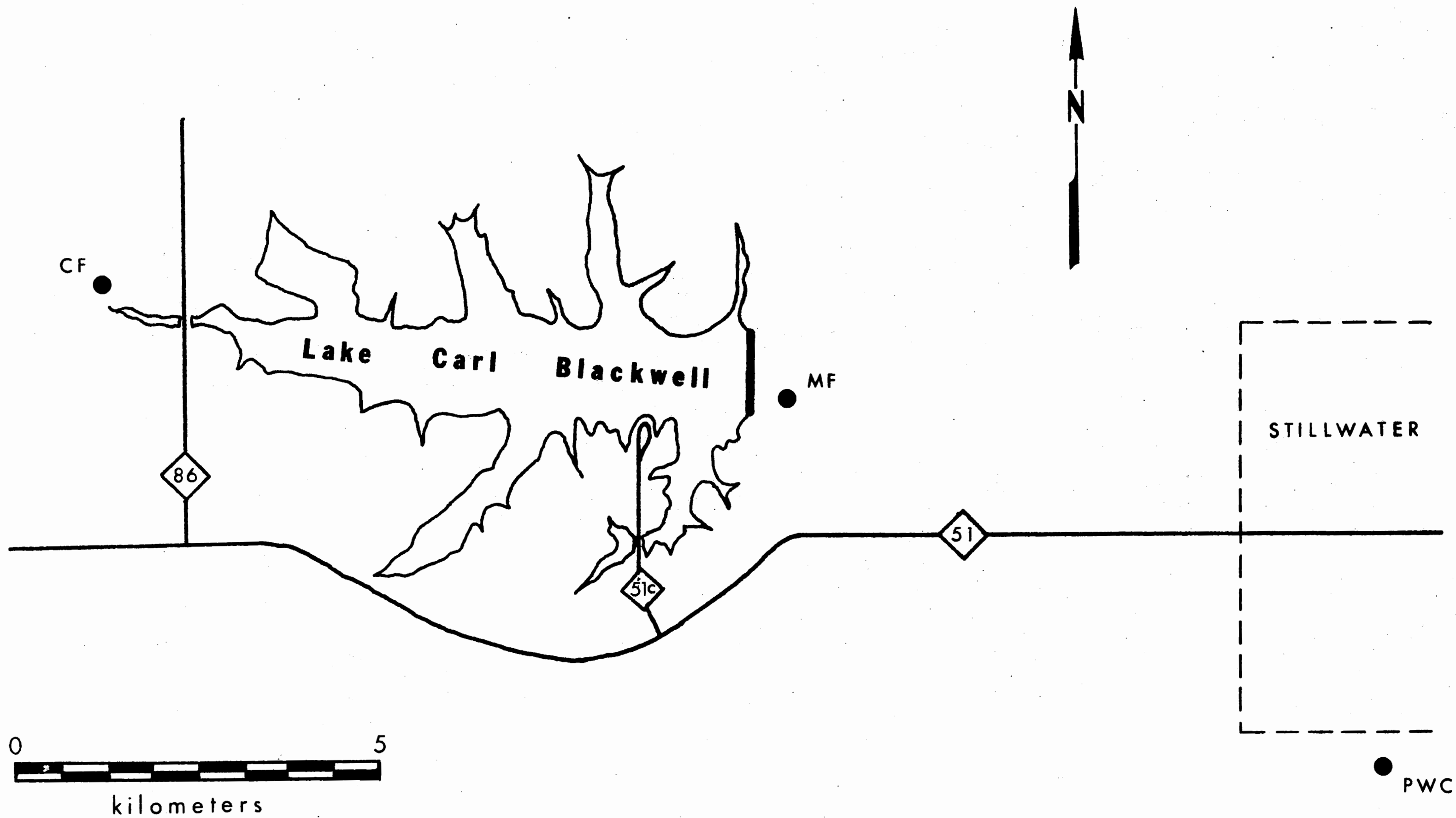


Fig. 5. Relative location of feeding sites used by mallards wintering on Lake Carl Blackwell.

Table 26. Estimates of food availability at feeding sites on the Lake Carl Blackwell Study Area during the winters of 1979 and 1980.

| Feeding Site | Area (ha) | Food Type | Sample[a] Time | g / m$^2$ 1979 $\bar{X}$ | 1979 SD | 1980 $\bar{x}$ | 1980 SD |
|---|---|---|---|---|---|---|---|
| MF | 1.6 | Sorghum | J | 176.35 | 97.79 | 325.36 | 226.86 |
| | | | F | No Sample | | No Sample | |
| CF | 2.0 | Corn | J | NA[b] | | 461.70 | 423.76 |
| | | | F | NA | | 0 | 0 |
| PWC | - | Corn | J | Ad libitum | | Ad libitum | |
| | | | F | Ad libitum | | Ad libitum | |

[a] Samples were taken during the first week of January (J) and the last week of February (F).

[b] Corn was on standing stalks and therefore not available to feeding mallards.

[c] No sample was taken as a change in food availability would not have been detectable due to the limited feeding which occurred after the January sample.

libitum supply of corn on the ice for a small flock of domestic ducks. This food source was used until the mallards wintering on Lake Carl Blackwell departed with the onset of spring migration at the end of February.

Mallards wintering on Lake Carl Blackwell in 1980 foraged in an unharvested corn field (CF) west of the lake (Fig. 5). This field was an experimental plot maintained by the Oklahoma State University Agronomy Department whose personnel had knocked down the standing stalks during the preceding fall. Corn was present in this same field during the winter of 1979, but it was unavailable as a mallard food source because the stalks were left standing. This feeding site (CF) was used by the entire Lake Carl Blackwell mallard population in 1980 until the third week of February. Near the end of this week some mallards were observed feeding in the sorghum field (MF) east of the dam but utilization was minimal because the majority of birds departed by the end of February when spring migration occurred. The shift in feeding sites apparently was related to the complete utilization of available corn at the CF site (Table 26). The PWC site was not visited during 1980 even though corn was again available ad libitum.

Stock ponds, which are sources of wild aquatic foods, were ice covered during the winter of 1979 and therefore unavailable as feeding sites. Ponds were essentially ice free in 1980, but foraging activities were never observed on them.

## Behavior

Behavior observations on Lake Carl Blackwell were difficult to obtain in both 1979 and 1980. Waterfowl wintering on the lake in 1979 congregated around a hole in the ice approximately 350 m from the nearest shoreline. This distance hindered observations via poor spotting scope resolution at high powers, visual interference by heat waves on sunny days, and observer eye fatique. Another problem was the presence of 400 Canada geese (Branta canadensis) that rested around the edge of the hole and frequently blocked mallards from view as they tended to stay within the periphery of geese. Problems in 1980 were quite different. The large size and configuration of Lake Carl Blackwell compounded with limited access make it very time-consuming to search the lake for birds or move from point to point. Inasmuch as Lake Carl Blackwell was essentially ice-free it often took several hours to locate mallards on the lake and move within observation distance. In addition, the birds often flew as the observer attempted to get in position because the shoreline of the lake is open, especially on the north side.

There was no statistically significant difference in the percent time spent feeding ($t = 1.05$, $df = 213$, $P > 0.25$), flying ($t = 0.01$, $df = 213$, $P > 0.99$), walking ($t = 0.52$, $df = 211$, $P > 0.60$), and in courtship ($t = 1.37$, $df = 213$, $P > 0.17$) between years (Table 27). Mallards spent significantly more time involved in comfort movements ($t = 3.33$, $df = 213$, $P < 0.001$) and swimming ($t = 1.97$, $df = 213$, $P < 0.05$) in 1980. A greater proportion of time was spent resting in 1979 ($t = 3.36$, $df = 213$, $P < 0.0009$).

Data from 1979 was used to examine diurnal activity patterns of mallards wintering on Lake Carl Blackwell (Fig. 6). Two peaks of activity were apparent, one occurred during the early morning around 0700 h and the other in the late afternoon around 1600-1800 h. The

Table 27. Percent of time spent in various activities by mallards wintering on Lake Carl Blackwell during 1979 and 1980.

| | Percent of Time Spent | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Feeding | Courtship | Comfort Movements | Swimming | Flying | Walking | Resting |
| 1979 | 4.7 | 3.0 | 15.8 | 14.7 | 1.1 | 2.8 | 57.9 |
| 1980 | 7.5 | 1.0 | 30.4 | 24.1 | 1.1 | 2.2 | 33.9 |

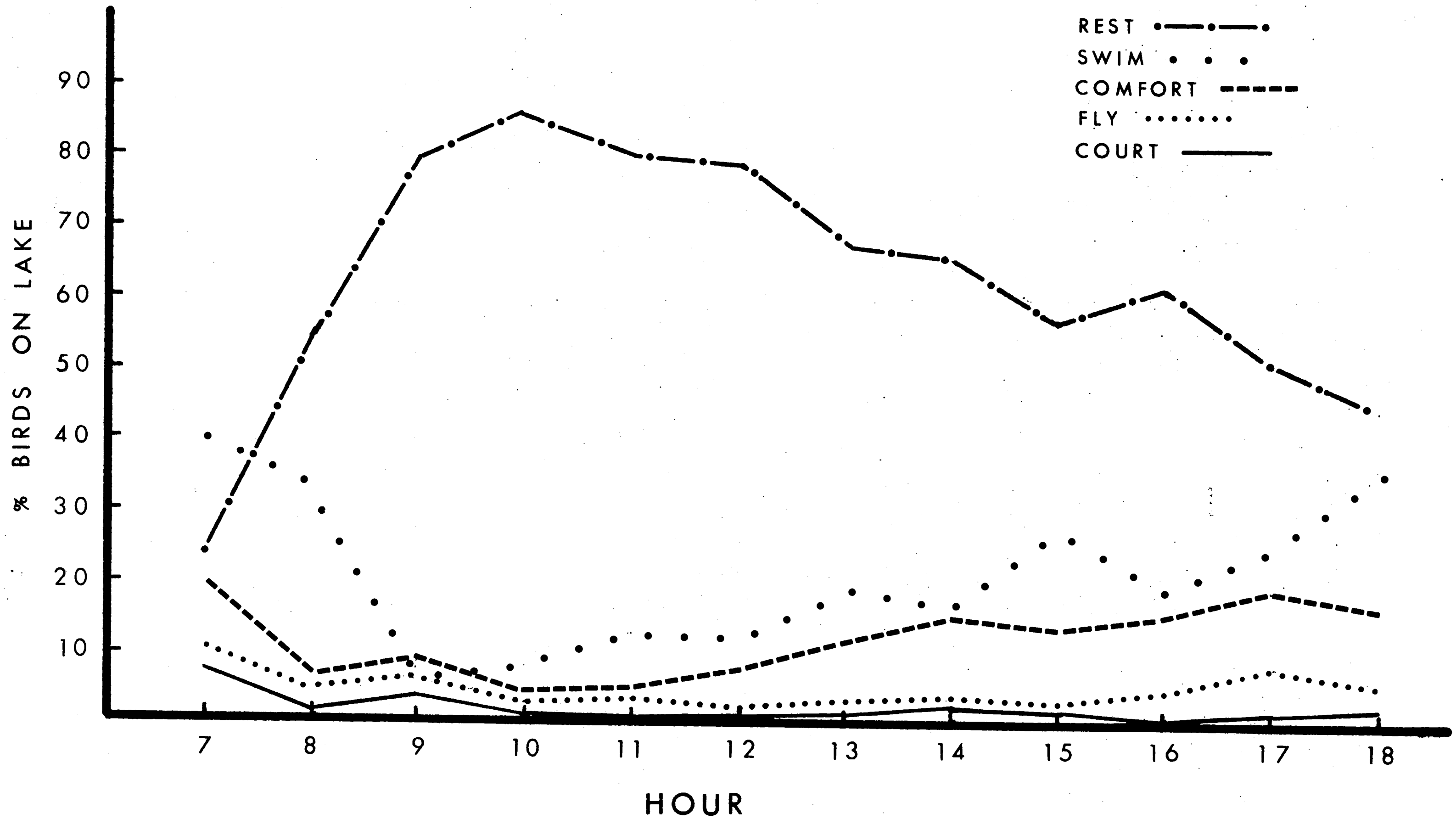


Fig. 6. Diurnal activity of mallards on Lake Carl Blackwell during the winter of 1979.

percentage of the population of the lake involved in swimming, courtship, flying, and comfort movements was highest at these times. Morning activity was confined to a shorter period of time than afternoon activity. Activity levels were low during mid-day but began to gradually increase throughout the afternoon to evening highs. These activity peaks correspond with times of feeding flights (Table 28). Mallards on Lake Carl Blackwell made 2 feeding flights daily during both years.

Effects of weather on behavior were analyzed for both 1979 and 1980. Simple correlation coefficients were calculated for the occurrence of various behaviors in 1979 with ambient temperature, barometric pressure, wind velocity, solar radiation (index to cloud cover and light intensity) and precipitation (Table 29). Feeding behavior exhibited small but significant positive correlations with barometric pressure and wind velocity and was negatively correlated with temperature. Nevertheless, the results of this analysis are inconclusive due to an inadequate number of behavior observations associated with all weather conditions.

Table 28. Departure and return times for feeding flights of mallards wintering on Lake Carl Blackwell (LCB) during 1979 and 1980.

| | 1979 | | | | | | 1980 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Morning[a] | | | Afternoon[b] | | | Morning | | | Afternoon | | |
| Flight | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD | N | $\bar{X}$ | SD |
| Departure from LCB | 6 | 0.60 | 0.64 | 17 | 1.68 | 0.81 | 8 | 0.27 | 0.62 | 25 | 1.68 | 0.53 |
| Return to LCB | 10 | 2.52 | 0.77 | 5 | 0.24 | 0.20 | 7 | 1.94 | 0.37 | 19 | 0.02 | 0.28 |

[a] Expressed as hours after sunrise. Sunrise varied from 7.63 - 7.10 h.

[b] Expressed as hours before sunset. Sunset varied from 17.48 - 18.03 h.

Table 29. Simple correlation coefficients for behavior categories with weather parameters.

| Parameter | Behavior | | | | | |
|---|---|---|---|---|---|---|
| | Feed | Courtship | Comfort | Swim | Fly | Rest |
| Temperature | -0.311[b] | 0.011 | 0.125 | 0.057 | 0.073 | 0.028 |
| Barometric Pressure | 0.174[a] | 0.094 | -0.063 | -0.102 | -0.122 | -0.122 |
| Wind Velocity | 0.161[a] | -0.095 | 0.001 | 0.160 | 0.014 | -0.084 |
| Solar Radiation | -0.053 | 0.056 | 0.070 | 0.056 | 0.020 | -0.002 |
| Precipitation | -0.064 | -0.062 | 0.144 | 0.006 | 0.220 | -0.065 |

[a] $\underline{P} < 0.05$

[b] $\underline{P} < 0.01$

CHAPTER V

# DISCUSSION AND CONCLUSIONS

Body weight flucuations often reflect critical events, e.g., weight loss in stressed individuals, and are of value in the assessment of physiological condition (Clark 1979). Significant differences in body weight were detectable in this study. However, there may exist considerable individual variation in body weight due to structural variations alone. Thus, heavier birds are not necessarily in the best condition and some correction for variation in structure size is required (Harris 1970, Wishart 1979).

A good index of condition must be objective, it should accurately reflect the animal's reserves, and it should be easily obtained (Smith 1970). BW/W used as a condition index in this study was easy to obtain and it explained a large amount of the variation in lipid and protein reserves of mallards. BW/W has been found to be a good predictor of lipid reserves in red-billed teal (Woodall 1978). Other investigators (Bailey 1979, Wishart 1979) have found body weight adjusted for structural variation to provide a good indication of lipid and protein reserves. Owen and Cook (1977) used BW/W as an index to condition of mallards in England during a 13 year study of body weight, wing length and condition.

Sample sizes used to determine condition index means in this study were considerably larger than those used for lipid and protein estimates, and significant differences in BW/W were detectable. A comparison of the condition of birds in this study with the condition of mallards in England (Owen and Cook 1977) during January and February showed Oklahoma mallards had lower mean BW/W values. Owen and Cook (1977) reported adult male and adult female BW/W values ranging between 42.0 - 45.0 and 40.0 - 42.0, respectively. Mean BW/W values for adult males from Lake Carl Blackwell were 41.1 (1979) and 40.6 (1980) and adult females were 38.1 (1979) and 37.7 (1980). Total population BW/W values were 39.8 and 39.1 in 1979 and 1980, well below total population values taken by inspection from Owen and Cook (1977). BW/W values of mallards from other locations in Oklahoma also seem to be lower than mallards in the English study. Explanation of these differences is difficult from the data as presented. Food availability and cold weather are the 2 most probable factors influencing mallard condition (Owen and Cook 1977) and if these data were comparable between the studies an explanation may exist therein.

Relative comparisons of BW/W values of mallards from various wintering locations throughout Oklahoma during 1980 indicated mallards from Lake Carl Blackwell and Ft. Gibson were in the poorest condition while Ft. Cobb and Robert S. Kerr mallards were in the best condition. Ft. Cobb reservoir, Robert S. Kerr reservoir (Sequoyah NWR), and Foss reservoir (Washita NWR) annually attract thousands of mallards during the winter apparently, in response to abundant supplies of grain foods. Waurika reservoir is a relatively new lake, still in the process of filling, and has only recently begun to receive wintering waterfowl use. Ft. Gibson reservoir has traditionally wintered large numbers of mallards, but the number has been steadily declining in recent years. Lake Carl Blackwell has wintered a small population of mallards for many years, however, food availability around the lake varies substantially from year to year. Although information on mallard abundance at various reservoirs in relation to food availability may allow speculation concerning the differences in condition observed among the areas, no real conclusions were possible. Large sample sizes of birds from each area acquired over a period of several years may elucidate this matter further. In addition, since condition estimates are influenced by age and sex, careful attention should be given to the age and sex composition of samples to avoid potential biases in condition index estimates for a given population. Small sample sizes and the age and sex composition of samples confounded the results of this study.

The extreme differences in the severity of the 2 winters during this study provided an opportunity to evaluate the hypothesis that larger body size confers an advantage of endurance that enables an individual to better withstand climatic stress (Calder 1974). While the adaptive significance of geographic gradient in weight is controversial (McNab 1971, Calder 1974, Clark 1979), evidence suggests larger body size may be advantageous under colder conditions due to proportionately greater lipid reserves (Blem 1973) and increased insulative effects of larger lipid stores (Blem 1974). Larger individuals are more efficient at utilizing stored energy reserves (lipids) during periods of reduced feeding which may accompany severe weather (Calder 1974, Ketterson and Nolan 1976). Mallards wintering at the northern edge of their range have been observed to reduce daily feeding flights to 1 per day and the duration of feeding flights decreased with the decline of the average 3-day temperature (Reed 1971). Weight-specific metabolic rates (cal/g x hr), i.e. energy expended for maintenance relative to weight, decreases with increasing body weight (Wolf and Hainsworth 1978). Also, large body size influences temperature regulation through a decrease in heat loss resulting from a relative decrease in body surface area (Calder 1974).

Data from this study appear to support the hypothesis that larger body size is advantageous in colder conditions. Structural measurements showed that mallards wintering on Lake Carl Blackwell in 1979 were larger than 1980 birds and mean body weights were significantly heavier in the colder winter of 1979. Muscle and organ weights supported this size difference to a lesser extent. A factor contributing to lighter mean body weights in 1980 was the age composition of the population. The presence of a greater proportion of immatures in 1980 resulted in an increase in the percentage of lighter individuals in the populations. However, adult mallards were significantly lighter in 1980. In addition, BW/W values indicated mallards wintering on Lake Carl Blackwell in 1979 were in better condition than 1980 birds. Since total body lipid reserves were lower in smaller individuals and mean body weights were lower in 1980 this result seems valid. Although protein reserves appeared to vary inversely to lipid reserves in relation to body size, this trend in the data is probably a response to the changes in the relative proportions of lipid reserves and that protein reserves were essentially constant.

It appears then that during colder winters larger individuals in better condition remain on Lake Carl Blackwell while smaller individuals move to less adverse conditions. Additionally, a change in total population numbers occurs, and fewer birds winter on the lake in colder years. Movements of lighter weight individuals away from adverse weather conditions have been observed to occur in several waterfowl species. Female green-winged teal (Anas crecca) and female pintails (Anas acuta) apparently move southward when adverse weather occurs on wintering areas in the Texas panhandle (Alford and Bolen 1977, Bennett and Bolen 1978). Adult male common goldeneyes (Bucephala clangula) predominate on the species northern wintering areas whereas adult females and immatures occur in larger proportions elsewhere (Nilsson 1970, Sayler and Afton 1980). Because many duck species are dimorphic, males being heavier than females and adults being heavier than immatures (Bellrose 1976), these studies suggest that a response of smaller bodied individuals is to move farther south during colder weather. Body size difference has been postulated as an explanation of disparate sex ratios (skewed towards males) observed in wintering flocks of several waterfowl species at the northern periphery of their range (Bellrose 1976) and the general geographical distribution pattern of wintering dabbling duck species (Prince 1979).

Dabbling duck species are best adapted for a climate with temperatures greater than $0^{\circ}$ C (Prince 1979). When these species winter in areas where temperatures fall below this point, energy requirements increase and behavioral and physiological changes occur to conserve energy. Behavioral time budget data indicated mallards wintering on Lake Carl Blackwell adjusted their activities in response to climatic stress. Mallards spent almost 60% of the day resting during the cold winter of 1979 as opposed to approximately 30% of the day resting during the warm winter of 1980. More energy expensive activities, such as comfort movements and swimming, were considerably reduced in 1979. Flying and walking were minimal in both years and these behaviors were primarily associated with foraging. Thus it appears activity was reduced during cold weather to conserve energy. Reed (1971) reported a similar behavioral response of mallards and black ducks wintering in southeastern Michigan.

Mallards wintering on Lake Carl Blackwell were dependent on agricultural grains as a food source. Nutritional value of foods is an important factor influencing which foods are consumed, especially during the breeding season. However, energy apparently is the main ecological factor influencing food consumption during the non-breeding period (Prince 1979). Agricultural grains are high energy foods (Watt and Merril 1963). A preference for corn was exhibited by Lake Carl Blackwell mallards in both years. The birds flew greater distances to consume corn rather than feed on the relatively closer sorghum which is often used by mallards almost exclusively at other wintering locations. The apparent selection of corn over sorghum and natural aquatic foods (1980) may be related to the energy content of the food. The metabolizable energy of corn is higher than sorghum grains (Scott et al. 1969) and agricultural grains generally have a higher energy content than the natural aquatic plant foods available (Spinner and Bishop 1950). Thus in terms of an energy cost-benefit analysis, Lake Carl Blackwell mallards may have benefited energetically by flying farther and feeding on a relatively higher energy food.

Foraging efficiency may have also influenced Lake Carl Blackwell mallards to select corn. During 1979, a mallard feeding at the pond where corn was available ad libitum could obtain a given volume of food in less time than a mallard feeding in the sorghum field. This also seemed to be true in 1980 as corn in the field used for feeding was lying on the ground and appeared to be more easily obtained than sorghum. Virtually all available sorghum was on standing stalks in both 1979 and 1980, therefore it would likely require more time and energy for a mallard to pull down sorghum stalks to obtain as much sorghum as corn. Handling time per unit of food may have also been important as an individual corn seed is considerably larger than a sorghum seed. Consequently, fewer corn seeds would have to handled to consume an equal food volume.

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