WINTER CONDITION OF MALLARDS ON THE
SOUTHERN HIGH PLAINS OF TEXAS

BY

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ABSTRACT

Mallards arriving on the Southern High Plains of Texas in the fall are in poorer condition, with less lipid and protein and lower body weights, than birds during the winter. Adults gained lipids and some protein and were heaviest in early and mid-winter, but juveniles did not show the same degree of gain. Whereas lipid gains were substantial, protein remained stable after the initial increase. Adult hens showed relatively greater lipid gains, and wintered in better condition than other mallards. Cold fronts and thermal stress in November did not affect lipid and body weight gains of adults. During late winter, mallards, except for juvenile drakes, depleted lipids for thermogenesis and lost weight when thermal stress was greatest. Cold fronts in January and February added to this effect. Estimates of mallard survival potential decreased by 1 day with each 10 degree Celsius drop in ambient temperature. Mortality of mallards on the Southern High Plains of Texas related to condition-stress was considered to be a minor factor in overall winter mortality. Mallards departed in the spring with high lipid reserves and heavy body weights. Overall, mallards wintering in the region were in excellent condition between October and March, after the initial gains from their poor condition in the fall. Abundant waste-corn and intermittent cold fronts rather than prolonged cold spells allowed mallards to maintain this status. Condition indices were formulated for use in body condition assessment of mallards. Wet-skin weight was found to be the best predictor of mallard lipid reserves.

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CHAPTER I

WINTER CONDITION OF MALLARDS ON THE
SOUTHERN HIGH PLAINS OF TEXAS

Abstract

Body composition and condition of mallards (Anas platyrhynchos) wintering on the Southern High Plains of Texas was studied for 3 consecutive field seasons. A total of 634 mallards, including 347 drakes, 262 adults and 85 juveniles and 287 yens, 161 adults and 126 juveniles, was collected. Mallards in the fall were in poorer condition, with lower body weights and less lipid and protein, than birds during the winter. Juveniles did not show the same body weight and lipid gains as adults. Adult hens wintered in the best condition and juvenile hens in the poorest. Condition trends for juvenile drakes were dissimilar from other age-sex classes. Use of a high-energy and abundant waste-corn resource and less winter severity than in more northerly regions, allowed mallards on the Texas High Plains to maintain better body condition than birds wintering elsewhere. Prior to their spring departure, mallards gained lipids and body weight. Compared with lipid levels of breeding mallards, 50% of adult drakes and 40% and 37% of adult and juvenile hens, respectively, possessed high reserves before departing the Southern High Plains of Texas.

Introduction

Anderson and Batt (1983) summarized the need for research on wintering waterfowl populations. Winter stress has been shown to influence many waterfowl species (Alford and Bolen 1977, Bennett and Bolen 1978). Also, body weight and composition are not stable for

wintering waterfowl, with peaks and declines at different times of the nonbreeding season (Peteraon and Ellarson 1979, Reinecke et al. 1982). Body condition fluctuates since body weight changes are directly related to lipid and protein variability (Reneicke et al. 1982). "Condition" has been defined by Owen and Cook (1977) as an individual's fitness to withstand present and future needs. Essentially, condition implies the relationship between the individual's endogenous energy stores and demands for energy related to activity.

Mallards have an extensive wintering range, often staying in regions of harsh winters (Bellrose 1976). Heitmeyer and Fredrickson (1981) illustrated the importance of critical winter habitat to mallards, and several studies have assessed body condition of different wintering populations (Jorde 1981, Gordon 1981, White 1982).

Mallards wintering on the Southern High Plains of Texas are greater in number than the Gulf Coast flocks in the Central Flyway (Bellrose 1976). The Southern High Plains is primarily an agricultural region where wintering waterfowl have adopted a field-feeding strategy utilizing waste corn (Baldassarre and Bolen, in press). Mallards join pintails (A. acuta), wigeons (A. americana) and green-winged teal (A. crecca) in morning and evening flights seeking waste corn. Obenberger (1982) found that corn was a positive influence on waterfowl use of the High Plains. Corn is the primary food item for these species, and is high in energy but low in protein compared with seeds of native plants of the playa lakes (Baldassarre et al. 1983).

Such a high level of dietary energy influences body condition, mainly through the conversion of carbohydrates to endogenous lipids for storage in the body (Hazelwood 1976). Lipids are the major energy

store of the body required for metabolic energy for thermogenesis during periods of winter stress (Blem 1976). Mallards wintering on the Southern High Plains of Texas exist on a high energy plane, but face potential thermal stress during certain times of the winter. The objective of this study was to assess body condition of mallards wintering on the Southern High Plains of Texas.

Study Area

Mallards were collected in Castro County, situated on the Southern High Plains of Texas between 34°20'N and 34°60'N latitude and 102°00'W and 102°30'W longitude. Much of the region is planted in corn, wheat, sorghum and cotton and is characterized by thousands of playa lakes that provide ideal wintering waterfowl habitat (Bolen and Guthery 1982). Although extensive modification of playas has occurred, intensive crop irrigation ensures substantial surface water for waterfowl use. Waterfowl utilize tailwater pits and large open-water playas with bare shorelines or those dominated by emergent vegetation (Obenberger 1982).

The High Plains of Texas is second only to the Texas Gulf Coast in importance as waterfowl habitat in the Central Flyway (Buller 1964). As many as 300,000 mallards winter there annually (Bellrose 1976). This population is managed as the High Plains Mallard Management Unit where greater bag limits and longer seasons govern this lightly harvested population (Funk et al. 1971).

Methods

A total of 634 mallards (262 adult drakes, 85 juvenile drakes, 161 adult hens, and 126 juvenile hens) were collected by shooting between 1 October and 15 March 1979-80, 1980-81 and 1981-82. These

birds were aged using standard techniques (Hochbaum 1942, Carney and Geis 1960, Krapu et al. 1979). The wing of each bird was measured from the alula to the tip of the 10th primary. All ducks were weighed and plucked before freezing.

Frozen birds later were thawed and skinned. The skin and attached subcutaneous fat were ground twice in a commercial meat grinder. Sternum and clumen lengths were measured, and esophageal and gizzard contents were removed and weighed. The bill and feet were discarded and the non-eviscerated carcass was ground twice in a grinder. The lipid content of the skin and carcass homogenate was determined by Soxhlet ether extraction and moisture content by dissication. The Kjeldahl nitrogen technique was used to analyze a carcass homogenate for protein content (A.O.A.C. 1970).

The term, body weight, refers to unplucked body weight minus stomach contents. Lean weight refers to lipid-free dry weight. A Lipid Index ($LI = \text{Total Body Lipid} / \text{Wing Length}$) was calculated to classify each sample according to energy stores, as measured by lipids (Blem 1976), using wing length to account for differences in structural size of individual birds (Owen and Cook, 1977). Wing length was considered to be an excellent indicator of structural size (Wishart 1979). Further, wing length correlated poorly ($r=0.19, P<0.0001$) with total body lipid (Whyte, unpubl. data). Changes in both parameters were considered to be independent.

The nonbreeding season was divided into 5 collection periods, each of 33 days:

Fall	1 October - 2 November
Early Winter	3 November - 5 December

Midwinter	6 December - 7 January
Late Winter	8 January - 9 February
Early Spring	10 February - 15 March

Statistical analyses followed Snedecor and Cochran (1967). Differences in body weight and composition components among collection periods, age-sex classes and years were tested using a split-plot model for an analysis of variance. A Duncan's Multiple Range Test was used to separate means. Regressions were used to relate body weight to lipid, protein and moisture. Differences in regression slopes for age-sex classes were tested with an analysis covariance, using the Body Weight .. X Age-Sex Class interaction term to test slopes.

Results

Variation in Body Composition Between Collection Periods

Adult Drakes

Mean fall lipid levels were lower ($P < 0.01$) than lipid levels from all other collection periods (Table 1). Elevated values occurred in midwinter and early spring. Carcass protein levels were stable between early winter and early spring; however, fall levels were less ($P < 0.01$) than at other times except early spring. Fall body weights of adult drakes were less ($P < 0.01$) than for other collection periods, except for late winter. Heaviest body weights occurred in early winter and early spring. Lean weight increased ($P < 0.01$) from fall to early winter, but remained stable thereafter.

Adult Hens

Fall lipid levels were lower ($P < 0.01$) than for birds from other

Table 1. Mean body weights and composition components (g) of adult mallards collected in Castro County, Texas, between fall and early spring 1979-80, 1980-81, and 1981-82.

Age-Sex Class Collection Period	N	Body Weight and Composition Components (s)				
		Body Lipid	Carcass Protein	Body Moisture	Body Weight	Lean ^a Weight
Adult Drakes						
Fall	29	129 B ^b	191 B	672 AB	1193 B	265 B
Early Winter	48	180 A	202 A	682 A	1266 A	283 A
Midwinter	43	192 A	205 A	670 AB	1254 A	274 AB
Late Winter	87	174 A	206 A	657 B	1237 AB	275 AB
Early Spring	55	199 A**	199 AB**	660 AB**	1264 A**	288 A**
Adult Hens						
Fall	22	124 B	175 B	610 A	1084	243
Early Winter	25	167 A	184 A	602 AB	1130	255
Midwinter	27	201 A	178 AB	582 AB	1115	236
Late Winter	42	171 A	174 B	576 B	1088	240
Early Spring	45	180 A**	176 B*	584 AB**	1114 NS	248 NS

^aLean weight refers to lipid-free dry weight.

^bMeans with different letters within a column indicate differences within age-sex classes between collection periods (** $P < 0.01$; * $P < 0.05$; NS = Not Significant, $P > 0.05$).

collection periods (Table 1). Highest levels were recorded in mid-winter and early spring. Carcass protein increased ($\underline{P}<0.05$) between fall and early winter, and decreased slightly thereafter. No differences ($\underline{P}>0.05$) in body weight were found between collection periods. Also, lean weights were not different ($\underline{P}>0.05$) between collection periods.

Juvenile Drakes

Lipid levels were lowest in the fall and steadily increased to peak in late winter (Table 2). Fall and late winter levels were different ($\underline{P}<0.05$) from each other. Carcass protein levels were stable and not different ($\underline{P}>0.05$) between collection periods. Body weights were not different ($\underline{P}>0.05$) between collection periods. Juvenile drakes showed no differences ($\underline{P}>0.05$) between collection periods for lean weight.

Juvenile Hens

Lipid levels were not different ($\underline{P}>0.05$) between collection periods (Table 2). Carcass protein was highest in the fall, and only late winter was different ($\underline{P}<0.05$) from the fall. Body weights and lean weights were not different ($\underline{P}>0.05$) between collection periods.

Variation in Body Composition Between Age-Sex Classes

No significant ($\underline{P}>0.05$) differences in body lipids were found between age-sex classes in fall or early spring. Adult drakes had greater ($\underline{P}<0.05$) lipid levels than juveniles, but not greater than adult hens in early winter. Adults had more ($\underline{P}<0.01$) lipids than juveniles in midwinter, but in late winter only juvenile hens had less ($\underline{P}<0.05$) lipids than the others.

Table 2. Mean body weights and composition components (g) of juvenile mallards collected in Castro County, Texas, between fall and early spring 1979-80, 1980-81, and 1981-82.

Age-Sex Class Collection Period	Body Weight and Composition Components (s)					
	N	Body Lipid	Carcass Protein	Body Moisture	Body Weight	Lean ^a Weight
Juvenile Drakes						
Fall	24	117 B ^b	191	662	1173	264
Early Winter	19	133 AB	193	663	1177	267
Midwinter	12	142 AB	184	624	1138	265
Late Winter	19	171 A	194	653	1214	245
Early Spring	12	149 AB*	192 NS	637 NS	1160 NS	274 NS
Juvenile Hens						
Fall	26	110	171 A	590 A	1037	238
Early Winter	29	144	166 AB	571 AB	1036	231
Midwinter	27	143	168 AB	577 AB	1036	233
Late Winter	20	128	162 B	551 B	996	230
Early Spring	24	160 NS	169 AB*	594 A**	1090 NS	248 NS

^aLean weight refers to lipid-free dry weight.

^bMeans with different letters within a column indicate differences within age-sex classes between collection periods (** $P < 0.01$; * $P < 0.05$; NS = Not Significant, $P > 0.05$).

Drakes had more carcass protein than hens, and adults had greater levels than juveniles. A difference ($\underline{P}<0.01$) between drakes and hens in fall, late winter, and early spring was recorded. Juvenile hens had the lowest protein levels and lean weights at all times.

Drakes had greater body weights than hens at all times, with adults being heavier than juveniles for each sex. Adult drakes were heaviest and juvenile hens the lightest. Drakes were heavier ($\underline{P}<0.01$) than hens in the fall, but only adult drakes were heavier ($\underline{P}<0.01$) than the others in early spring.

Regression of Body Weight on Lipid, Protein and Moisture

Regressions of body weight on total body lipid, carcass protein and body moisture were highly significant ($\underline{P}<0.0001$) for all age-sex classes (Figure 1). No differences were found between slopes of regression lines for age-sex classes for lipid ($\underline{P}>0.46$), protein ($\underline{P}>0.69$) or moisture ($\underline{P}>0.20$).

Variation in Lipid Index Categories

The Lipid Index=Total Body Lipid/Wing Length, separated mallards into 4 Lipid Index Categories (Table 3). Little overlap in total body lipids occurred between the upper level of one category and the lower level of the next highest category. The most extensive overlap was 24g between the upper level of Poor/Fair and the lower level of Good for adult hens. Other overlaps amounted to less than 10g, and 91.2% of the birds were categorized correctly when a discriminant function process was used as a test.

Protein levels were not different ($\underline{P}>0.05$) between categories for juvenile hens, but differences ($\underline{P}<0.01$) occurred between levels

Figure 1. Regression equations of total body lipid, carcass protein and body moisture on body weight of mallards, by age-sex class, during the winter. Regressions are significant ($P < 0.0001$). Adult drakes = AHYM, adult hens = AHYF, juvenile drakes = HYM, and juvenile hens = HYF.

Table 3. Lipid Index values and lipid and protein levels, and lean and body weights of mallards, by age-sex class, assigned to Lipid Index Categories.

Age-Sex Class Parameter	Lipid Index Categories			
	Poor/Fair	Good	Excellent	Exceptional
Adult Drakes				
Lipid Index	2.42D ^a (78) ^b (0.42-3.46)	5.50C(129) (3.54-6.99)	8.29B(86) (7.00-10.32)	11.46A(6) ** (10.72-12.89)
Lipid (g)	71D (13-103)	161C (104-214)	242B (201-302)	343A ** (311-382)
Protein (g)	188C (150-213)	203BC (162-275)	206B (169-258)	225A ** (178-273)
Lean Weight ^d (g)	276 (217-381)	279 (212-437)	279 (218-372)	289 ** (252-315)
Body Weight (g)	1104D (946-1263)	1231C (1010-1420)	1316B (1146-1474)	1490A ** (1384-1597)
Adult Hens				
Lipid Index	2.23D(17) (0.57-3.43)	5.46C(80) (3.52-6.95)	8.28B(55) (7.04-10.28)	11.20A(6) ** (10.54-12.30)
Lipid (g)	60D (16-94)	149C (70-197)	228B (191-279)	305A ** (283-331)
Protein (g)	162B (119-185)	176A (149-212)	181A (150-226)	188A ** (183-199)
Lean Weight (g)	234 (196-294)	246 (192-374)	247 (191-329)	237 NS (203-276)
Body Weight (g)	960C (747-1104)	1081B (901-1223)	1173A (1000-1369)	1233A ** (1146-1326)

Table 3. Continued.

Juvenile Drakes				
Lipid Index	1.95C(26) (0.13-3.50)	5.27B(38) (3.77-6.97)	7.91A(21) ** (7.09-9.82)	e
Lipid (g)	56C (4-101)	150B (107-199)	227A ** (200-268)	
Protein (g)	178C (149-223)	192B (156-232)	206A ** (180-235)	
Lean Weight (g)	253 (194-327)	280 (218-358)	276 NS (183-331)	
Body Weight (g)	1066 (847-1284)	1188 (986-1385)	1290 NS (1087-1404)	
Juvenile Hens				
Lipid Index	2.45D(40) (0.53-3.44)	5.33C(56) (3.59-6.94)	8.40B(25) (7.06-10.33)	10.70A(2) ** (10.58-10.82)
Lipid (g)	66D (13-94)	144C (93-194)	226B ** (189-289)	281A ** (276-287)
Protein (g)	161 (130-198)	169 (141-205)	173 NS (158-194)	176 NS (174-177)
Lean Weight (g)	233 (179-301)	239 (190-325)	235 NS (165-355)	266 NS (237-295)
Body Weight (g)	946C (743-1122)	1061B (919-1208)	1130AB ** (1024-1266)	1219A ** (1157-1281)

^aMeans in same row with different letters indicate differences in characters between Lipid Index

^bCategories (** P<0.01; * P<0.05; NS = Not Significant, P>0.05).

^cSample size in parentheses.

^dRanges below means.

^eLean weight refers to lipid-free dry weight.

^fNo juvenile drakes in Exceptional Condition.

for other age-sex classes. Lean weight was not different ($\underline{P} > 0.05$) between categories for adult drakes and adult and juvenile hens. Differences ($\underline{P} < 0.01$) occurred for body weights among categories in each age-sex class. Considerable overlap existed between upper and lower levels of adjacent categories for protein, lean and body weights.

Mallards shifted between Lipid Index categories from fall to early spring (Figure 2). Generally, upward shifts happened in early and midwinter and early spring, and downward shifts in late winter. In fall, adult drakes (82%) were equally divided between Poor/Fair and Good condition, but between 51-60% were in the latter between early and late winter. The early spring population contained 33% and 44% of adult drakes in Good and Excellent condition, respectively. The majority of adult hens (70%) were in Good condition in fall, but 48% were classified in Excellent condition in midwinter. A reversal in late winter resulted in 49% of adult hens in Good condition. This category contained 56% of adult hens in early spring, with a further 36% rated Excellent.

Fifty percent of juvenile drakes were in Poor/Fair condition in the fall, and 53% and 58% were in Good condition in early and midwinter, respectively. During late winter 50% of juvenile drakes were in Excellent condition, but by early spring 67% were ranked in Good condition. Between 37-54% of juvenile hens were classified in Good condition from fall through early spring. The second greatest number of juvenile hens (27-46%) were in Poor/Fair condition from fall to late winter, but the early spring population has 33% of the birds in Excellent condition.

Figure 2. Percentages of mallards, by age-sex class, classified by Lipid Index Categories between fall and early spring from Castro County, Texas.

Discussion

Body Composition and Condition Trend

Mallards arriving on the Texas High Plains in the fall were, on the average, in poorer condition than birds collected during the winter. Fall-collected mallards were lighter in body and lean weights, and had less protein and lipid reserves than winter-collected birds. Mallards fed heavily on waste corn until they departed in the spring (Baldassarre and Bolen, in press).

During early and midwinter, mallards gained weight and increased lipid and protein reserves over fall levels. Protein tended to stabilize after the initial increase, but lean weight varied inconsistently between collection periods and years. Corn provided a high energy but low protein diet (Baldassarre et al, 1983), and, since mallards suffered no protein drain in winter, it is possible they obtained protein from natural foods in playa lakes as Quinlan (1982) suggested for green-winged teal. Elsewhere, similar reports exist for body weight and lipid gains of oldsquaws (Clangula hyemalis) (Peterson and Ellarson 1979), cackling geese (Branta canadensis minima) (Raveling 1979) and black ducks (Anas rubripes) (Reinecke et al. 1982) for the same time of the year. Folk et al. (1966) and Owen and Cook (1977) found the same schedule of body weight gains for mallards wintering in Czechoslovakia and Britain, respectively. Lipids represent the major energy store of the body (Blem 1976), and it generally is accepted that lipid accumulation in early winter by waterfowl is advantageous for future use (Peterson and Ellarson 1979, Reinecke et al. 1982). Stored lipids provide an endogenous store that offset potential negative energy balance in winter stress

periods.

Mallards on the High Plains secured lipid stores and gained weight when, according to Baldassarre and Bolen (in press), optimal feeding conditions existed. The combination of natural lipid and body weight gain, a high energy diet, and optimal waste-corn conditions in November allowed mallards to attain excellent body condition. Obenberger (1982) concluded cornfields remained constantly available for field-feeding ducks throughout the winter, and Baldassarre and Bolen (in press) found waterfowl selected fields with the greatest amount of available corn-wastage throughout the winter. Hence, for the purpose of this study, it was assumed food was not a limiting factor for wintering mallards. Consequently, mallards on the High Plains often were heavier and possessed greater lipid reserves than mallards wintering in different habitats. In midwinter, adult hens collected on the High Plains were heavier and had more lipids than adult hens occupying lowland hardwood wetlands in Missouri (White 1982). Juvenile hens had comparable body weights, but those from the High Plains had slightly more lipids. Overall, mallards on the High Plains were in excellent body condition in early and midwinter compared with individuals collected at other times during the winter and, in the case of hens, with mallards wintering elsewhere.

Mallards, except for juvenile drakes, declined in body weight and depleted lipid reserves in late winter similar to other waterfowl in January (Folk et al. 1966, Owen and Cook 1977, Raveling 1979, Peterson and Ellarson 1979, Reinecke et al. 1983). Decreasing ambient temperatures stimulate higher metabolic rates of mallards (Smith and Prince 1973), and they then mobilize endogenous lipids for

thermogenesis during the coldest winter weather. However, despite lipid mobilization, the low body weights and lipid levels of mallards in late winter were higher than levels of fall-collected birds. Although affected by thermal stress, mallard body condition was superior in late winter compared to fall. Further, in terms of lipids, mallards on the High Plains were in better condition than mallards in Nebraska (Jorde 1981) or hens in Missouri (White 1982) at the coldest time of the year. Mallards wintering on the High Plains existed on a high energy plane, and experienced less winter stress than mallards in Nebraska and Missouri.

Except for juvenile drakes, body condition improved in early spring with corresponding increases in endogenous lipid and body weights. Most waterfowl exhibit similar increases (Folk et al. 1966, Owen and Cook 1977, Peterson and Ellarson 1979, Raveling 1979). Mallards on the High Plains (except for juvenile drakes) had similar body weights but more endogenous lipids than mallards in Nebraska in the winter and spring (Jorde 1981). Further, hens in the early spring were in superior condition compared to hens collected in March in Missouri (White 1982).

These trends for different age-sex classes from fall to early spring were repeated during the 3 years of this study. However, consistency of body composition and condition changes was relatively low for each age-sex class between collection periods and years. The most consistent trend for any group among years was for adults. Parallel changes for adult drakes and hens were strongest in early and midwinter and early spring when body weight and lipids increased. Shifts in lipid levels for adults largely were similar for collection

periods among years, but protein and lean weight showed inconsistency among collection periods and years.

Colder than normal temperatures, implying greater stress, can influence body composition and condition for birds at any time of the winter during that year. For example, late winter in 1981-82 was slightly colder than the other years (Appendix R) and mallard condition was depressed as a result. Body weights, lipid and protein levels of drakes were less than for other years.

The relationship between changes in body composition of waterfowl and possible regulatory mechanisms is unresolved. King (1972) considered diversity in regulatory mechanisms more prominent than uniform trends for birds. Reinecke et al. (1982) concluded winter declines in lean weights of female black ducks developed from an adaptation instead of from stress, and suggested this was evidence for an endogenous body-composition cycle. However, late winter trends in lean weight showed slight increases or no changes in mallards during the course of this study.

Other evidence from this study for an endogenous body cycle for mallards is inconclusive. Mallards on the High Plains apparently suffered no food shortages, but still mobilized lipids for energy in late winter. Since lipid levels did not decline significantly, this could be interpreted as "programmed mobilization" for partial use of an energy reserve. During late winter, there may be more disadvantages in maintaining a high lipid reserve than advantages from its caloric content (Reinecke et al. 1982). This reasoning suggests mallards were not stressed but were adapting internally to the coldest winter weather.

However, despite their high condition status in late winter, mallards did respond to cold temperatures as if stressed. They consumed more waste corn in late winter than at other times as indicated by greater esophageal contents of birds collected returning from morning flights (Appendix Q). These mallards must have been foraging at a greater rate since the duration of the morning flight was not increased in January and February (Baldassarre and Bolen, in press). This strategy is similar to the responses of other waterfowl faced with decreasing temperatures (Longcore and Cornwell 1964, Owen 1970). Extra consumption of a high energy food allowed mallards to deplete less lipids to obtain energy when stressed.

Differences Between Age-Sex Classes

Drakes were structurally larger (Appendix I), heavier and had greater lean weights, body moisture and protein levels than hens. Jorde (1981) described similar sex differences in body composition. Adults had greater lipid stores than juveniles (Gordon 1981), but Jorde (1981) found females and juveniles possessed lipid stores nearly equal to or higher than male or adult counterparts.

Because there were no differences in the slopes of regression lines for body weight on lipid, protein or moisture, it is assumed changes in these components were similar for all age-sex classes. Therefore, no one group had a physiological advantage in accumulating or depleting lipids.

Overall, adult hens were in better condition throughout the winter than other mallards. They possessed lipid reserves comparable to drakes, a relationship reported in Nebraska (Jorde 1981) and Oklahoma (Gordon 1981). Peak lipid accumulation occurred in midwinter

for adults, and hens increased their lipid reserves 62% between fall and midwinter. Adult drakes showed a 49% increase. The corresponding increase for juvenile hens was only 30%, but juvenile drakes accumulated 46% more lipids by late winter over their fall reserves. Despite having the same physiological capabilities, adults showed greater endogenous energy accumulations in the form of lipids than juveniles.

Because all age-sex classes consumed similar amounts of corn in early and midwinter (Appendix Q), all mallards were on a similar level of dietary energy. Therefore, since juveniles failed to store as much lipid as adults, it is postulated they may have used energy in activities not undertaken by adults. Juveniles move widely during their first winter (Martinson and Hawkins 1968, Jorde 1981), and flight is energetically costly (Prince 1979). Also, age-specific habitat selection, favoring adults, may be adversely affecting the energy usage of juveniles, similar to the situation described by Jorde (1981) for mallards in Nebraska. Further research is needed to clarify these relationships.

When mallards were ranked into lipid Index Categories, 48% of the adult hens in midwinter were in Excellent condition, with a further 11% in Exceptional condition. Corresponding percentages for adult drakes were 40% and 2%, respectively. By midwinter, 54% of juvenile hens were in Good condition, but only 19% were in Excellent condition and none in Exceptional condition.

Further, severe winter weather, as occurs in late winter, is known to influence local movements of hens. Dispersal flights by hens away from cold fronts (Alford and Bolen 1977, Bennett and Bolen

1978), and the preponderance of drakes in northerly flocks (Anderson and Timken 1972, Bellrose et al. 1961) illustrate the advantages drakes have over hens in coping with low temperature extremes (Smith and Prince 1973).

Adult hens mobilized 15% of their midwinter lipid reserves during the thermal stress associated with late winter. Lipid mobilization by adult drakes was only 9% of their midwinter reserves. A large-bodied bird loses less heat than a smaller-bodied bird (Calder 1974); therefore, drakes have greater powers of heat conservation than hens, and would need to mobilize less lipid than hens to thermoregulate at the same ambient temperature. The greater buildup of lipids by hens prior to late winter indicates some compensation for this disadvantage. Both adult drakes and hens consumed equal amounts of waste corn on morning flights in late winter (Appendix Q), and despite hens losing proportionally more lipids than drakes, greater numbers of hens maintained better condition than drakes. Hens, paired or unpaired, have lower winter energy budgets than drakes (Jorde 1981), which would offset their disadvantage in heat loss related to body size. Therefore, the same amount of corn is relatively more important to hens than drakes. The combination of a low energy budget, high corn consumption and high lipid reserves allowed adult hens to maintain better late winter condition than drakes. Thirty nine percent of adult hens were in Excellent condition in late winter compared to 29% of adult drakes. Juvenile hens mobilized 10% of their midwinter lipids, but consumed more waste corn than other mallards in late winter (Appendix Q). Juvenile hens also offset relatively low endogenous energy reserves by consuming extra waste

corn during field feeding flights.

Juvenile drakes gained weight, protein and lipids in late winter, contrary to trends in body composition of other mallards. Jorde (1981) also reported heavy weights and high lipid reserves of juvenile drakes in Nebraska during January-February. The reasons for these increases are unclear; however, it is postulated age-specific variation in daily energy expenditures may be a factor. For example, juvenile drakes perhaps are using less energy in courtship activities than adult drakes, which are most likely paired at this stage of the winter (Johnsgard 1960). Jorde (1981) reported unpaired mallard drakes spent half as much time involved in courtship activities as paired drakes. Testis weights of juvenile drakes (Appendix O) were less than for adults (Appendix N) in late winter, indicating lower testosterone production and reduced spermatogenesis (Johnson 1961). Therefore, because juvenile drakes consumed large quantities of corn in late winter (Appendix Q), and devoted less energy to some activities such as courtship, they accumulated lipids and gained weight while other mallards experienced losses. Additional research, similar to Jorde's (1981) study of mallard time budgets, is needed to clarify this relationship.

The greatest lipid gain in early spring was by juvenile hens (25%), whereas adult drakes (14%) and hens (5%) put on considerably less. Significantly, adult hens survived the late winter in better condition than other mallards and therefore did not accumulate excessive amounts of lipid in early spring. However, juvenile hens were in the poorest condition in late winter and had to compensate with greater lipid gains prior to migration and breeding. Four

percent of adult hens were in Exceptional condition, with another 36% and 56% in Excellent and Good condition, respectively. Similar numbers of juvenile hens were in Exceptional (4%) and Excellent (33%) condition. However, 25% of juvenile hens remained in Poor/Fair condition in early spring.

The contribution of lipid reserves to mallard reproductive activities is substantial (Krapu 1981); lipid level of prelaying mallard hens was 109.6g. Adult and juvenile hens from the High Plains in Excellent condition possessed at least 191g and 189g lipids, respectively. Therefore, the 40% of adult hens in Excellent or Exceptional condition finish the winter on the High Plains with adequate energy reserves preparatory to migration and breeding. Thirty-seven percent of juvenile hens had the same capacity. Further, 44% of adult drakes in Excellent condition in early spring possessed at least 201g lipid, and 8% in Exceptional condition had a minimum of 311g lipid. Therefore, 52% of adult drakes departing from the High Plains in the spring had ample lipid stores.

Conclusions

Mallards wintering on the High Plains of Texas were in poorer condition, with lowest body and lean weights, protein and lipid reserves in fall, than in any time of the winter.

Mallards on the High Plains showed fluctuations in body composition typical of other waterfowl during the nonbreeding season. However, because they existed on a high energy diet and apparently suffered no food shortages, mallards on the High Plains maintained better body condition than those wintering elsewhere.

Adult hens mobilized and depleted proportionally more lipids than other ages or sexes during the winter, but still remained in better condition overall, especially in late winter when thermal stress was greatest.

Juveniles did not show the same level of body weight and lipid gains as adults in early and midwinter. Juvenile hens were in the poorest condition throughout the winter, but improved in the spring. Juvenile drakes, unlike other mallards, reached peak weight in late winter and experienced a decrease in early spring.

By early spring, adult (40%) and juvenile (37%) hens possessed high lipid reserves in preparation for migration and nesting. More than 50% of adult drakes were in prime condition at this time, relative to lipid levels reported for breeding ground drakes.

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CHAPTER II

IMPACT OF WINTER STRESS ON MALLARDS

Introduction

Winter stress, manifested by cold temperatures, high wind speeds and snowfall, affects regional sex ratios of waterfowl flocks (Anderson and Timken 1972), habitat selection (Jorde 1981) and localized movements of hens (Alford and Bolen 1977, Bennett and Bolen 1978). Low ambient temperatures also increase food consumption (Longcore and Cornwell 1964, Owen 1970), metabolic rates (Smith and Prince 1973) and cause waterfowl to starve to death more rapidly (Jordan 1953). Body composition and condition varies in winter, with important changes occurring during periods of severe weather (Peterson and Ellarson 1979, Reinecke et al. 1982). The objective of this study was to relate body composition and condition of mallards (Anas platyrhynchos) to winter stress, and to estimate the survival potential of mallards wintering on the Southern High Plains of Texas. Condition in this study refers to the lipid component of the body, and its influence on body weight and importance as an energy reserve (Blem 1976).

Study Area and Methods

A total of 634 mallards (262 adult drakes, 85 juvenile drakes, 161 adult hens, and 126 juvenile hens) were collected between October and March 1979-80, 1980-81 and 1981-82. All were collected in Castro County, Texas (see Bolen and Guthery [1982] for regional description). Specimens were aged following Krapu et al. (1979). Body weights were recorded after the gizzard and esophageal contents

were removed. Plucked birds were ground twice in a meat grinder. Homogenates were analyzed for lipid and protein contents using the Soxhlet ether extraction and Kjeldahl nitrogen processes, respectively (A.O.A.C. 1970). Body moisture also was determined, and lean weight was reported here as lipid-free dry weight.

Daily maximum and minimum ambient temperatures were obtained for Dimmitt (Castro County), Tulia (Swisher County) and Olton (Lamb County) from the National Oceanic and Atmospheric Administration, and averaged to calculate temperatures for the immediate area. Snowfall data also were recorded. Three periods of winter stress were identified by consecutive days of low temperatures and the occurrence of substantial snowfall. A 2-week interval was selected before and after each stress period for comparisons; mallard data were grouped relative to these time intervals. A t-test was used to detect significant differences in body and lean weights, lipid and protein levels for mallards before and after each stress period (Snedecor and Cochran 1967). Because samples of juveniles were low in relation to stress intervals, only adults were used. However, survival potentials were estimated for all age-sex classes.

Survival potential of mallards was estimated using body weights, lipid and protein levels of birds collected in late winter (8 January - 9 February). Death results from a 49% body weight loss (Jordan 1953). Lipid and protein losses associated with a 49% weight loss were determined from the regression of lipid and protein on body weight. Energy losses consequent to these depletions were based on the conversion of 1g lipid and 1g protein to 9 and 5.5 kcal energy, respectively (Ricklefs 1974). The daily Existence Energy Requirement (EER) was

calculated from metabolism equations for black ducks (Anas rubripes) acclimated to 5 C (Woolley and Owen 1977). Because black ducks and mallards are of similar size (Bellrose 1976), the use of these data was considered appropriate. Survival potential was calculated as the number of days a mallard could survive at 0 C, -10 C and -20 C, respectively, by dividing the total energy loss (lipid + protein) before death by daily EER.

Results and Discussion

Short-term cold fronts represent winter stress for waterfowl on the Southern High Plains of Texas, rather than many weeks of continually depressed temperatures and extended snow-cover. Hence, the effect on body condition of mallards coincides with the time of year at which stressful weather occurs.

Despite snowfall and low ambient temperatures during 16 - 30 November 1980, mallards collected after this period were in better condition, with heavier body weights and greater lipid reserves, than those collected before (Fig. 3A). Lipid increases were 62g and 94g for drakes and hens, respectively. The difference was significant for lipids of both drakes ($P < 0.10$) and hens ($P < 0.05$). Lean weights increased slightly in drakes but decreased in hens, and protein essentially was unchanged for both. Mallards typically gain weight at this time of year (Folk et al. 1966, Owen and Cook 1977), and this trend was not influenced by this sudden November cold front. One factor ensuring mallards improved condition in early winter, regardless of stress, is the availability of waste corn in November. Presumably, mallards on the High Plains are unaffected by winter stress in November because of optimal feeding conditions involving a

Body Condition of Adult Mallards in Relation to Winter Stress

Figure 3. Variation in body and lean weight, lipid and protein reserves of adult mallards in relation to 3 periods of severe winter weather on the Southern High Plains of Texas. Sample size in parentheses.

readily available high-energy food resource (Baldassarre et al. 1983, Baldassarre and Bolen, in press).

Waste corn is considered an abundant food resource throughout the winter on the Texas Plains (Obenberger 1982, Baldassarre et al. 1983). However, mallards are affected by winter stress from mid-December to mid-February, after experiencing progressively colder weather (Appendix R). Cold weather from 19-26 December, 1980, caused mallards to mobilize and deplete lipids for energy, and lose weight (Fig. 3B). The lipid decline was 3 times greater for drakes (79g) than hens (24g) but, because hens consumed more waste corn than drakes at this time of year (Appendix Q), they acquired greater dietary energy to offset energy losses in cold weather. Body weight ($P < 0.05$) and lipid ($P < 0.10$) losses were significant only for drakes. Similarly, snowfall and extended cold temperatures from 8-19 February 1980 also resulted in lipid and body weight losses (Fig. 3C). Drakes collected between 20 February - 4 March, 1980, had 27g less lipids than those collected between 27 January - 7 February, 1980, because of mobilization during the intervening 12 days of snow and cold. Hens mobilized 28g lipid during the same period. In both cases, protein was stable or decreased slightly, and lean weight varied inconsistently for both sexes relative to the days of stressful weather.

Smith and Prince (1973) found metabolic rates increase with decreasing temperatures, and cold-stressed mallards mobilize lipids for thermogenesis as a result. However, extra energy was required in December to mid-February, and mallards increased the length of their evening field-feeding flights (Baldassarre and Bolen, in press).

Further, birds collected after the morning flights in late winter had more corn in their esophagus than birds collected at other times (Appendix Q). Therefore, extra corn was consumed for energy, apparently at a faster foraging rate, since the duration of the morning flight did not increase at this time (Baldassarre and Bolen, in press). Increased food consumption is typical of waterfowl faced with decreasing temperatures below a certain point (Longcore and Cornwell 1964, Owen 1970). Because Obenberger (1982) found no significant difference in sex ratios of mallards on the High Plains between October and March, it is assumed dispersal flights away from cold fronts were not a major event as reported for female pintails (A. Acuta) (Alford and Bolen 1977) and green-winged teals (A. crecca) (Bennett and Bolen 1978).

The survival potential of mallards deprived of food at 0°C was 7 days for drakes, and 6 and 5 days for adult and juvenile hens, respectively (Table 4). However, at -10°C and -20°C all mallards had similar survival potentials except for juvenile hens which had 1 day less at both temperatures. Smaller hens, especially juveniles, have lower survival potentials because of reduced heat conservation capabilities relative to a small body size (Calder 1974). These survival potentials probably are underestimated, because mallards seek sheltered habitats and behaviorally adjust to survive severe cold (Jorde 1981). However, they are realistic when compared with Smith and Prince's (1979) data for weight losses of mallards fasted for 18 hours.

Conditions realizing the combination of food deprivation and 0°C, -10°C and -20°C for an extended number of days seldom occur on

Table 4. Survival potential of mallards in late winter deprived of food resources at 0 C, -10 C and -20 C respectively, based on daily existence energy requirements, and body weight, and lipid and protein losses.

Age-Sex Class	Weight ^a after 49% Loss			Loss of ^b		Loss of ^b		Daily ^c EER at OC		Daily ^c EER at -10 C		Daily ^c EER at -20 C		Survival at -20 C days at -20 C
	Body Weight (g)	Body Lipid (g)	Body Protein (g)	Weight after 49% Loss (g)	Lipid/ Energy to Death (g/kcal)	Protein/ Energy to Death (g/kcal)	Loss of ^b	Daily ^c EER at OC (kcal)	Survival days at OC	Daily ^c EER at -10 C (kcal)	Survival days at -10 C	Daily ^c EER at -20 C (kcal)	Survival days at -20 C	
Adult Drakes	1237	174	206	631	174/1566	75/412	276	276	7	359	5	441	4	
Adult Hens	1088	171	174	555	171/1539	62/341	306	306	6	386	5	465	4	
Juvenile Drakes	1214	171	194	619	171/1539	74/407	276	276	7	359	5	441	4	
Juvenile Hens	996	128	162	508	128/1152	51/280	306	306	5	386	4	465	3	

^aCalculated from weight loss to death of 4 adult drake mallards dying during 22-29 days in winter (Jordan 1953).

^bBased on regressions of lipid and protein on body weight and lg lipid=9kcal energy; lg protein=5.5 kcal energy (Ricklefs 1974).

^cDaily existence energy requirement (EER) based on metabolism equations for black ducks acclimated at 5 C (Woolley and Owen 1977).

the Texas High Plains. Maximum ambient temperatures briefly stay below 0 C for several continuing days, and enough snow to cover the waste corn resource is also rare. Therefore, non-hunting mortality among mallards wintering on the High Plains seems more related to disease (Moore and Simpson 1980) than to conditions associated with winter stress.

Conclusions

Mallards were not adversely affected by winter stress associated with cold fronts in November, when optimal field-feeding conditions exist for exploiting a high-energy corn resource. Later in the winter, however, body weights and lipid reserves decreased with cold stress, as mallards strived to maintain homeostasis, despite consuming more corn. The estimated time mallards can survive without food is about 1 week at 0 C and less than 5 days at lower temperatures. Juvenile hens have lower survival potentials at all temperatures than other age-sex classes. Because winter stress occur during short-term cold fronts rather than prolonged periods of cold weather, stress-related mortality for mallards on the High Plains seems minimal.

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CHAPTER III

FAT DEPOT CHARACTERS AND CONDITION

INDICES OF MALLARDS

Introduction

The relationships between endogenous fat reserves, body weight and condition of ducks are of interest to waterfowl biologists. Fat represents the major energy store of the body (Blem 1976). Its accumulation and depletion is a major influence on body weight changes in waterfowl (Raveling 1979, Reinecke et al. 1982). Owen and Cook (1977) defined "condition" as the individual's fitness to withstand present and future energy needs relative to its ecological activity. Early waterfowl studies considered body weight indicative of condition, with heavier ducks being considered in better condition than lighter ones (Bellrose and Hawkins 1947, Folk et al. 1966).

Continuing interest in waterfowl condition led to the formulation of condition indices, with body weight being adjusted for structural size (Owen and Cook 1977, Bailey 1979, Wishart 1979). These indices proved useful for assessing condition of live-trapped ducks (Owen and Cook 1977, Gordon 1981). Measurements of discrete fat depots, such as omental fat (Woodall 1978) or abdominal fat (Wishart 1979, Bailey 1979) and skin fat (Wishart 1979, Bailey 1979) were used to assess the condition of hunter-killed birds. These methods avoid the expensive Soxhlet ether extraction process for carcass lipid determination used in other studies (Peterson and Ellarson 1979, Krapu 1981). Despite the prominence of the mallard (Anas platyrhynchos), only scant condition data exist for the species (Owen and Cook 1977, Gordon 1981). The objective of this research was to describe relationships between discrete

fat depots and to test the reliability of these depots and condition indices when assessing the condition of mallards. Since fat is metabolized selectively for energy before protein (Whittow 1976), condition in this study refers to the energy reserves related only to fat.

Study Area and Methods

A total of 634 mallards (262 adult drakes, 85 juvenile drakes, 161 adult hens and 126 juvenile hens) was collected between October and March 1979-80, 1980-81 and 1981-82 in Castro County, Texas on the Southern High Plains (See Bolen and Guthery [1982] for regional description). Specimens were aged following Krapu et al. (1979).

Wing length was measured from the alula to the tip of the 10th primary. Body weight was recorded following removal of esophageal and gizzard contents. Fat on the gizzard and in the lower omentum was removed and termed "omental fat" (Woodall 1978), and fat stripped from the intestines was labelled "visceral fat". After plucking, the skin plus attached fat was removed, weighed and used in the Soxhlet ether extraction process to determine "subcutaneous fat" (A.O.A.C. 1970). Wet skin weight was used for condition indices and subcutaneous fat assessed lipid depots. Omental and visceral fat were returned to the skinned carcass, which then was ground twice in a grinder for an homogenate determining "carcass fat" by the Soxhlet process. Subcutaneous and carcass fat were added to calculate "total body fat".

Mallards were separated by age-sex class to determine fat-depot relationships throughout the winter, and birds were grouped for predictions of condition following Woodall (1978), Wishart (1979), and Bailey (1979). The relationships between lipid depots were deter-

mined using Spearman's correlation coefficient, and a Fisher's Z-test for differences between correlation coefficients (Downie and Heath 1959). An analysis of variance and a Duncan's Multiple Range test tested and separated differences between lipid depots for collection periods (Snedecor and Cochran 1967). The regression of total body fat on independent lipid variables and condition indices followed Snedecor and Cochran (1967).

Results and Discussion

Changes in subcutaneous, omental and visceral fat depots were identical and reflected total body fat fluctuations of mallards throughout the winter (Table 5). Lipid accumulations between fall and early winter were highly significant ($P < 0.01$) for adults, but later changes were not significant. Juveniles had significant ($P < 0.05$) changes in omental fat plus "other carcass fat" in winter but not in subcutaneous or visceral fat. Generally, total fat and all depots increased from fall to midwinter, declined in late winter and then increased again in early spring. Juvenile drakes, however, did not show late winter declines or early spring increases.

Subcutaneous, omental and visceral fat depots represented 69-79% of total body fat in all age-sex classes. Further, subcutaneous fat made up 59-67% of total body fat throughout the winter. Omental and visceral fat comprised 5-9% and 3-6% of total body fat at all times, respectively.

All correlation coefficients between fat depots were highly significant ($P < 0.0001$), indicating mallards accumulated and depleted depots concurrently (Table 6). The highest correlation occurred

Table 5. Mean weights of discrete fat depots and total body fat for mallards, by age-sex class, between fall and early spring.

Age-Sex Class	Collection Period	N	Fat Depots (g)				Total
			Subcutaneous	Omental	Visceral	Other	
Adult _b Drakes ^a							
Fall		22	74 B ^C	6 B	4 B	36 B	120 B
Early Winter		37	112 A	13 A	8 A	42 AB	175 A
Midwinter		26	118 A	16 A	9 A	45 AB	188 A
Late Winter		42	103 AB	13 A	7 A	50 A	173 A
Early Spring		37	130 A**	17 A**	10 A**	51 A**	208 A**
Adult Hens							
Fall		22	79 B	8 B	4 C	33 B	124 B
Early Winter		25	107 A	13 AB	7 BC	38 AB	167 A
Midwinter		27	123 A	18 A	12 A	48 A	201 A
Late Winter		42	110 A	14 A	8 A	39 AB	171 A
Early Spring		45	118 A**	14 A**	7 BC**	41 AB**	180 A**
Juvenile Drakes ^a							
Fall		15	73	8 B	5	27 B	113
Early Winter		15	105	12 AB	7	32 AB	156
Midwinter		11	91	11 AB	6	40 A	148
Late Winter		15	99	13 A	7	38 A	159
Early Spring		10	83 NS	9 AB*	6 NS	42 A*	140 NS
Juvenile Hens							
Fall		26	71	7 B	5	27 B	110
Early Winter		29	92	12 A	7	33 AB	144
Midwinter		27	87	12 A	7	37 A	143
Late Winter		20	80	10 AB	6	32 AB	128
Early Spring		24	100 NS	13 A*	8 NS	39 A*	160 NS

Table 5. Continued

- ^aMeans for adult and juvenile drakes calculated only for 1980-81 and 1981-82.
- ^bCollection periods referring to the following time intervals: Fall = 1 October - 2 November; Early Winter = 3 November - 5 December; Midwinter = 6 December - 7 January; Late Winter = 8 January - 9 February; Early Spring = 10 February - 15 March.
- ^cMeans with different letters within a column indicate differences within age-sex classes between periods (** $P < 0.01$; * $P < 0.05$; NS = Not Significant, $P > 0.05$).

Table 6. Spearman correlation coefficients between subcutaneous, omental and visceral fat depots for mallards (combined age-sex classes and collection periods).

Fat Depots	Correlation Coefficients (r)	
	Age-Sex ^a	Range Within ^a Fall - Early Spring
Omental Vs Visceral	0.91	0.82-0.96
Omental Vs Subcutaneous	0.88	0.78-0.97
Visceral Vs Subcutaneous	0.82	0.74-0.96

^aAll coefficients significant at $P < 0.0001$.

between the two internal depots, omental and visceral, whereas subcutaneous and visceral were the least correlated. These relationships prevailed for all age-sex classes between October and March. Therefore, depots were changing concurrently regardless of age-sex class and time of year. There were no differences ($P > 0.05$) between correlation coefficients of fat depots for age-sex classes during fall and late winter. However, differences ($P < 0.05$) occurred in some periods involving fat accumulation. Subcutaneous and omental fat differed ($Z = 3.3$, $P < 0.05$) during early winter for drakes. During midwinter differences ($Z = 2.4$, $P < 0.05$) in omental and visceral fat occurred for adults. Differences ($Z = 2.1$, $P < 0.05$) in subcutaneous and visceral fat occurred between adults and juvenile drakes during early spring. Whereas high correlations always existed regardless of age-sex or month, differences between fat depots for age-sex classes were detectable when fat was accumulating. Since this process involves conversion of carbohydrate to fat stores (Hazelwood 1976), this suggests any differences in fat accumulation may be related to age-sex class variations in daily energy expenditures, as described by Jorde (1981).

Some vertebrates, notably white-tailed deer (Odocoileus virginianus) exhibit differential use of fat depots (Ransom 1976); however, waterfowl do not show similar physiological adaptations. Mallards in this study experienced fat-depot changes similar to red-billed teal (Anas erythrorhynchos) (Woodall 1978) and cackling geese (Branta canadensis minima) (Raveling 1979). Subcutaneous fat is the largest depot of the mallard body, providing insulation during thermal stress. It also is the last to be depleted when fat

is mobilized for energy. However, this reflects the large amount of subcutaneous fat compared to other depots and not selective retention of this insulative layer.

Wet skin weight, and omental and visceral fat were better predictors of total body fat than was body weight (Table 7). Whereas body weight only explained 49% of the variation in total body fat, wet skin weight accounted for 90%. Omental and visceral fat predicted 81% and 72%, respectively.

Condition indices (CI) were calculated using body weight (BWT), omental fat (OFAT) and wet skin weight (WSW). Wing length (WING) was adopted as an indicator of structural size (Wishart 1979). Several CIs using combinations of sternum and culmen length with the fat predictors were computed but proved poorer predictors than those using wing length. The CI-BWT/WING yielded only 4% more predictability of total body fat than body weight and was not different ($Z=0.3, \underline{P}<0.05$). Woodall (1978) and Gordon (1981) found better predictability with CI=BWT/WING than with body weight alone, but their sample sizes were smaller and they used birds collected during shorter intervals than in this study. There was no increase in predictability of total body fat when CI=WSW/WING and CI=OFAT/WING were compared with wet skin weight and omental fat.

Conclusions

Fat depots depleted and accumulated concurrently, although some age-sex differences were observed at times of accumulation. Assuming these data apply to live mallards, CI=BWT/WING can be used to assess the condition of live-trapped birds. However, no additional predictive power is gained between CI=BWT/WING and body weight alone, but

Table 7. Regression of total body fat (Y) on body weight, independent fat depots and selected Condition Indices for mallards collected on the Southern High Plains of Texas.

Independent Variable	N	Mean	Range	r^a	r^2	CV	Equation
Body Weight (BWT)	634	1160	743-1597	0.70	0.49	29.97	$\hat{Y} = 249.6 + 0.36(\text{BWT})$
Wet Skin Weight (WSW)	634	163	29-343	0.95	0.90	13.22	$\hat{Y} = 43.7 + 1.27(\text{WSW})$
Omental Fat (OFAT)	634	13	0-40	0.90	0.81	18.05	$\hat{Y} = 60.2 + 8.06(\text{OFAT})$
Visceral Fat (VISFAT)	517	.7	0-26	0.85	0.72	21.47	$\hat{Y} = 75.9 + 11.35(\text{VISFAT})$
CI = BWT/WING	626	41.1	6.8-27.2	0.73	0.53	28.67	$\hat{Y} = 351.5 + 12.52(\text{BWT/WING})$
CI = WSW/Wing	626	5.8	1.1-11.6	0.94	0.88	14.50	$\hat{Y} = 45.3 + 36.1(\text{WSW/WING})$
CI = OFAT/WING	626	0.4	0.0-1.4	0.89	0.80	18.93	$\hat{Y} = 61.1 + 225.5(\text{OFAT/WING})$

^aAll regressions significant ($P < 0.0001$).

CI reduces variation somewhat when structural size is considered. Overall, both have low correlations with total body fat, and an improved technique, such as the application of an ultrasonic flaw detector, is needed for live mallards (Baldassarre et al. 1980). Omental fat is ideal to evaluate condition of mallards in the hunters' bag in a check point situation. Removal of omental fat is not difficult and does not involve destruction of the carcass (Woodall 1978). Research requiring body-condition evaluations could utilize body weight, $CI=BWT/WING$, or omental fat. However, if mallards are sacrificed, their condition is best assessed by recording plucked wet skin weight. This depot represents the largest reserve of body fat in mallards and proved the best predictor of total body fat.

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APPENDICES

APPENDIX A

Table 8. Mean lipid, protein and moisture levels, and body and lean weights of adult drake mallards collected in Castro County, Texas, between fall and early spring, in 1979-80, 1980-81, and 1981-82.

Body Weight and Composition Components (g) Year	Collection Periods			
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring
Lipid				
1979-80	155 (7) ^a	196 (11)	200 (17)	174 (45) 180 (18)
1980-81	136 (11)	165 (18)	188 (14)	177 (18) 232 (20)
1981-82	104 (11)	185 (19)	187 (12)	171 (24) 180 (17)
Protein				
1979-80	184	220	212	217 201
1980-81	192	195	203	200 200
1981-82	195	199	198	190 194
Moisture				
1979-80	613	687	672	664 649
1980-81	721	694	671	659 677
1981-82	660	667	665	643 652
Body Weight				
1979-80	1163	1311	1265	1258 1226
1980-81	1238	1236	1247	1220 1300
1981-82	1166	1268	1246	1212 1261
Lean Weight				
1979-80	238	278	263	266 255
1980-81	257	262	267	280 281
1981-82	291	307	288	294 330

^a Sample size in parentheses.

APPENDIX B

Table 9. Mean lipid, protein and moisture levels, and body and lean weights of adult hen mallards collected in Castro County, Texas, between fall and early spring, in 1979-80, 1980-81, and 1981-82.

Body Weight and Composition Components (g) Year	Collection Periods			
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring
Lipid				
1979-80	149	173 (9)	195 (11)	163 (19)
1980-81	134 (11)	166 (9)	238 (11)	184 (15)
1981-82	73 (5)	159 (7)	130 (5)	168 (8)
Protein				
1979-80	187	194	184	182
1980-81	170	178	179	172
1981-82	172	180	162	159
Moisture				
1979-80	610	612	567	585
1980-81	612	596	614	584
1981-82	604	598	547	541
Body Weight				
1979-80	1119	1166	1096	1098
1980-81	1089	1098	1184	1099
1981-82	1031	1125	1004	1046
Lean Weight				
1979-80	232	254	228	230
1980-81	242	241	244	243
1981-82	258	275	238	257

^a Sample size in parentheses.

APPENDIX C

Table 10. Mean lipid, protein and moisture levels, and body and lean weights of juvenile drake mallards collected in Castro County, Texas, between fall and early spring, in 1979-80, 1980-81, and 1981-82.

Body Weight and Composition Components (g) Year	Collection Periods			
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring
Lipid				
1979-80	122 (9) ^a	47 (4)	79 (1)	233 (3) 194 (2)
1980-81	101 (9)	146 (6)	119 (5)	203 (6) 130 (4)
1981-82	132 (6)	164 (9)	172 (6)	130 (9) 147 (6)
Protein				
1979-80	184	183	149	219 202
1980-81	186	193	182	191 183
1981-82	210	198	192	188 194
Moisture				
1979-80	620	630	467	709 562
1980-81	683	675	640	653 625
1981-82	692	670	637	634 670
Body Weight				
1979-80	1142	1038	847	1365 1128
1980-81	1148	1202	1124	1232 1105
1981-82	1258	1222	1199	1151 1208
Lean Weight				
1979-80	243	236	195	276 222
1980-81	245	261	256	273 260
1981-82	323	286	285	294 299

^a Sample size in parentheses.

APPENDIX D

Table 11. Mean lipid, protein and moisture levels, and body and lean weights of juvenile hen mallards collected in Castro County, Texas, between fall and early spring, in 1979-80, 1980-81, and 1981-82.

Body Weight and Composition Components (g) Year	Collection Periods			
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring
Lipid				
1979-80	108 (8) ^a	107 (9)	137 (5)	108 (4) 136 (1)
1980-81	134 (9)	179 (9)	164 (12)	156 (8) 170 (11)
1981-82	89 (9)	146 (11)	120 (10)	110 (8) 152 (12)
Protein				
1979-80	173	170	181	155 149
1980-81	163	167	169	174 171
1981-82	178	163	161	153 168
Moisture				
1979-80	575	567	589	536 500
1980-81	583	567	586	595 606
1981-82	610	578	559	514 590
Body Weight				
1979-80	1030	1004	1042	978 945
1980-81	1022	1051	1067	1062 1098
1981-82	1058	1050	996	939 1100
Lean Weight				
1979-80	240	226	223	204 202
1980-81	214	226	234	234 230
1981-82	262	240	237	238 269

^aSample size in parentheses.

APPENDIX E

Table 12. Range of body weights and composition components and coefficients of variation (CV) for adult drake mallards collected in Castro County, Texas, between fall and early spring.

Body Weight and Composition Components (g)	Collection Periods			
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring
Body Lipid (CV)	46-253 45	53-281 31	78-382 34	13-343 38 47-355 37
Protein	150-219 9	169-253 8	177-259 8	162-275 12 169-273 9
Moisture	566-795 9	569-778 7	573-746 6	542-768 8 554-798 7
Body Weight	996-1437 8	1042-1474 7	1055-1533 8	946-1597 9 1020-1565 8
Lean Weight	217-318 11	212-438 13	222-367 10	218-372 11 221-399 15

APPENDIX F

Table 13. Range of body weights and composition components and coefficients of variation (CV) for adult hen mallards collected in Castro County, Texas, between fall and early spring.

Body Weight and Composition Components (g)	Collection Periods			
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring
Body lipid (CV)	17-252 50	16-287 42	44-331 32	24-276 32 74-318 31
Protein	150-199 9	155-226 10	131-203 8	119-213 10 155-196 6
Moisture	529-678 7	525-715 8	449-658 8	417-658 8 510-660 6
Body Weight	901-1258 10	973-1369 10	792-1305 9	747-1269 10 976-1326 7
Lean Weight	191-302 12	212-329 12	193-281 9	196-312 11 192-374 15

APPENDIX G

Table 14. Range of body weights and composition components and coefficients of variation (CV) for juvenile drake mallards collected in Castro County, Texas, between fall and early spring.

Body Weight and Composition Components (g)	Collection Periods			
	Fall	Early Winter	Mid-Winter	Late Winter Early Spring
Body lipid (CV)	6-232 60	4-262 53	39-237 41	9-249 39 11-268 45
Protein	151-232 11	159-218 8	149-226 11	156-253 9 172-224 8
Moisture	540-802 9	566-770 8	467-750 12	528-742 9 523-755 10
Body Weight	898-1334 10	928-1324 10	847-1385 13	1010-1404 10 978-1384 8
Lean Weight	204-358 16	194-310 11	195-320 13	218-349 12 183-324 13

APPENDIX H

Table 15. Range of body weights and composition components and coefficients of variation (CV) for juvenile hen mallards collected in Castro County, Texas, between fall and early spring.

Body Weight and Composition Components (g)	Collection Periods			
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring
Body lipid (CV)	41-206 42	13-289 52	56-253 38	15-242 56 51-276 42
Protein	148-205 10	133-190 8	144-186 7	130-194 13 149-183 6
Moisture	504-674 8	444-629 8	500-656 7	433-663 12 494-656 8
Body Weight	871-1208 8	791-1206 10	910-1147 7	743-1261 15 945-1281 9
Lean Weight	165-299 13	203-310 10	206-287 10	179-355 17 202-325 13

APPENDIX I

Table 16. Mean and range of wing, sternum and culmen lengths of mallards, by age-sex class, collected in Castro County, Texas, between fall and early spring.

Parameter (cm)	Collection Periods				
	Fall	Early Winter	Mid-Winter	Late Winter	Early Spring
Adult Drakes					
Wing	29.2 (29) ^a 27.7-30.9	29.2 (48) 27.1-31.6	29.2 (43) 27.5-31.5	29.2 (86) 26.5-31.7	29.2 (54) 27.2-31.3
Sternum	11.0 (29) 10.0-11.8	11.0 (48) 10.3-11.7	11.0 (43) 10.1-11.7	11.0 (85) 10.2-11.7	11.0 (54) 10.3-11.8
Culmen	5.4 (28) 4.8-5.8	5.5 (47) 4.8-5.9	5.4 (43) 5.0-5.9	5.4 (87) 4.8-6.2	5.3 (55) 4.7-5.9
Adult Hens					
Wing	26.5 (20) 13.3-28.4	27.6 (25) 26.2-28.7	27.3 (27) 26.3-28.8	27.3 (41) 25.8-28.4	27.4 (45) 25.6-28.7
Sternum	10.2 (22) 9.8-10.8	10.2 (25) 9.5-11.0	10.1 (27) 9.1-10.6	10.1 (41) 9.3-10.7	10.2 (45) 9.4-10.9
Culmen	5.2 4.7-5.6	5.2 5.0-5.6	5.0 4.1-5.7	5.0 4.8-5.4	5.1 4.5-5.6
Juvenile Drakes					
Wing	28.6 (24) 27.5-30.3	28.6 (19) 27.7-30.1	28.5 (12) 27.7-29.9	28.6 (18) 26.8-29.6	28.4 (12) 27.3-29.8

Table 16. Cont.

Sternum	10.7 (24) 9.5-11.2	11.0 (19) 10.4-11.4	10.9 (12) 10.2-11.7	11.0 (18) 9.7-11.7	10.9 (12) 10.2-11.5
Culmen	5.5 (24) 5.0-5.9	5.6 (19) 5.0-5.9	5.5 (12) 5.1-5.8	5.4 (18) 5.2-5.7	5.4 (12) 5.1-5.7
Juvenile Hens					
Wing	27.3 (26) 25.8-28.5	26.8 (29) 24.9-28.3	26.7 (26) 25.7-27.8	26.9 (18) 25.8-28.8	26.8 (24) 26.1-27.8
Sternum	10.3 (26) 9.6-11.2	10.1 (29) 9.4-10.7	10.1 (27) 9.5-10.6	10.1 (18) 9.3-10.9	10.2 (24) 9.6-10.7
Culmen	5.2 (26) 4.9-5.8	5.1 (29) 4.7-5.6	5.0 (27) 4.5-5.6	5.0 (20) 4.5-5.6	5.0 (24) 4.4-5.5

^aSample size in parentheses.

APPENDIX J

Table 17. Mean and range of body organ sizes of adult drake mallards collected in Castro County, Texas, between fall and early spring.

Organ Sizes	Collection Periods				
	Fall	Early Winter	Mid-Winter	Late Winter	Early Spring
Liver (g)	31.5 (29) ^a 19.1-49.6	31.8 (46) 16.4-59.6	33.3 (42) 19.1-57.3	30.3 (82) 14.0-55.2	33.2 (53) 17.3-54.3
Heart (g)	14.2 (29). 10.3-25.8	14.4 (48) 10.1-23.6	13.2 (43) 6.5-19.1	13.1 (87) 9.3-20.4	13.3 (55) 10.3-16.7
Pancreas (g)	3.1 (22) 2.1-4.3	2.8 (36) 1.4-4.2	2.9 (24) 1.9-4.3	2.6 (41) 1.0-4.3	2.6 (36) 1.6-3.8
Gall Bladder (g)	1.2 (19) 0.4-2.5	1.1 (30) 0.1-2.5	1.0 (23) 0.2-2.2	1.2 (50) 0.2-2.3	1.1 (36) 0.3-5.7
Gizzard (g)	43.5 (29) 31.0-58.3	43.9 (48) 32.2-62.0	39.9 (43) 32.9-48.0	38.4 (87) 20.7-52.8	38.0 (55) 28.4-54.0
Left Adrenal (g)	0.07 (27) 0.03-0.14	0.07 (47) 0.03-0.17	0.08 (40) 0.04-0.14	0.08 (81) 0.03-0.16	0.07 (52) 0.03-0.12
Right Adrenal (g)	0.07 (28) 0.02-0.16	0.07 (47) 0.02-0.20	0.08 (41) 0.04-0.14	0.08 (79) 0.04-0.16	0.07 (49) 0.03-0.12
Right Thyroid (g)	0.09 (11) 0.03-0.16	0.07 (19) 0.03-0.12	0.06 (11) 0.03-0.11	0.05 (22) 0.04-0.09	0.06 (14) 0.04-0.11

Table 17. Continued

Left Thyroid (g)	0.08 (11) 0.03-0.15	0.06 (17) 0.03-0.10	0.06 (11) 0.03-0.11	0.05 (16) 0.04-0.07	0.07 (13) 0.03-0.25
Intestine Length (cm)	147 (29) 117-176	152 (46) 128-177	151 (43) 124-196	147 (87) 94-176	148 (55) 120-191

^a Sample size in parentheses.

APPENDIX K

Table 18. Mean and range of body organ sizes of adult hen mallards collected in Castro County, Texas, between fall and early spring.

Organ Sizes	Collection Periods				
	Fall	Early Winter	Mid-Winter	Late Winter	Early Spring
Liver (g)	30.4 (22) ^a 10.7-46.0	30.4 (24) 18.4-50.9	32.0 (27) 13.6-44.8	27.8 (42) 15.6-49.4	31.0 (45) 18.0-54.0
Heart (g)	11.1 (22)• 7.8-13.6	12.6 (25) 9.1-23.8	12.0 (27) 9.2-18.8	11.5 (40) 9.3-17.7	11.8 (45) 10.1-14.7
Pancreas (g)	2.7 (16) 1.9-3.6	2.6 (16) 1.5-3.4	2.6 (16) 1.8-3.3	2.6 (23) 1.9-3.6	2.7 (26) 1.6-4.7
Gall Bladder (g)	0.9 (18) 0.3-1.5	1.1 (19) 0.3-2.8	1.0 (17) 0.4-1.8	0.8 (36) 0.2-1.6	1.1 (33) 0.4-2.3
Gizzard (g)	40.4 (22) 32.0-70.0	38.7 (25) 31.3-49.6	35.2 (27) 26.1-44.8	33.8 (42) 22.0-46.3	34.3 (45) 27.2-44.6
Left Adrenal (g)	0.07 (20) 0.03-0.14	0.07 (18) 0.04-0.12	0.06 (26) 0.02-0.10	0.06 (34) 0.04-0.09	0.07 (39) 0.03-0.11
Right Adrenal (g)	0.07 (22) 0.04-0.14	0.07 (18) 0.05-0.15	0.06 (25) 0.03-0.10	0.07 (41) 0.04-0.09	0.07 (42) 0.03-0.10
Right Thyroid (g)	0.07 (5) 0.05-0.09	0.07 (5) 0.05-0.12	0.04 (4) 0.02-0.06	0.06 (8) 0.03-0.11	0.05 (12) 0.03-0.08

Table 18. Continued.

Left Thyroid (g)	0.07 (5) 0.04-0.08	0.06 (5) 0.03-0.11	0.04 (4) 0.03-0.06	0.05 (8) 0.02-0.10	0.04 (12) 0.01-0.07
Intestine Length (cm)	142 (22) 123-163	143 (25) 121-170	149 (27) 117-181	141 (42) 115-176	142 (45) 118-166

^a Sample size in parentheses.

APPENDIX L

Table 19. Mean and range of body organ sizes of juvenile drake mallards collected in Castro County, Texas, between fall and early spring.

Organ Sizes	Fall	Collection Periods			
		Early Winter	Mid-Winter	Late Winter	Early Spring
Liver (g)	30.7 (24) ^a 15.3-50.1	29.4 (19) 19.0-53.7	28.2 (12) 18.2-47.0	32.8 (18) 17.2-47.5	35.6 (11) 23.2-59.4
Heart (g)	12.0 (24) 8.7-15.5	13.5 (19) 9.2-21.4	12.5 (12) 10.1-18.0	12.2 (18) 9.8-15.1	12.4 (11) 09.8-15.1
Pancreas (g)	3.3 (14) 1.3-5.2	3.2 (15) 1.9-4.7	2.8 (11) 1.7-4.3	2.9 (14) 2.0-4.0	2.8 (10) 1.7-5.0
Gall Bladder (g)	0.9 (17) 0.2-1.9	1.0 (14) 0.6-1.8	1.0 (8) 0.3-2.6	0.9 (14) 0.3-1.5	1.3 (8) 0.7-2.7
Gizzard (g)	44.2 (24) 32.1-63.1	43.0 (19) 27.5-60.1	36.8 (12) 25.1-51.0	39.3 (18) 32.0-48.3	36.8 (12) 27.0-42.3
Left Adrenal (g)	0.07 (22) 0.04-0.10	0.07 (19) 0.02-0.12	0.10 (12) 0.04-0.18	0.07 (18) 0.03-0.11	0.07 (12) 0.02-0.12
Right Adrenal (g)	0.07 (24) 0.03-0.11	0.07 (19) 0.01-0.12	0.10 (12) 0.04-0.18	0.08 (18) 0.05-0.12	0.08 (11) 0.05-0.14
Right Thyroid (g)	0.06 (6) 0.02-0.14	0.08 (9) 0.05-0.11	0.07 (6) 0.03-0.12	0.05 (6) 0.03-0.08	0.05 (6) 0.02-0.06

Table 19. Continued.

Left Thyroid	0.06 (6) 0.04-0.13	0.08 (9) 0.05-0.11	0.07 (6) 0.03-0.11	0.05 (8) 0.03-0.07	0.04 (5) 0.02-0.06
Intestine Length (cm)	157 (24) 127-203	151 (19) 120-195	149 (12) 120-170	153 (18) 125-196	148 (11) 131-182

^a Sample size in parentheses.

APPENDIX M

Table 20. Mean and range of body organ sizes of juvenile hen mallards collected in Castro County, Texas, between fall and early spring.

Organ Sizes	Collection Periods				
	Fall	Early Winter	Mid-Winter	Late Winter	Early Spring
Liver (g)	29.6 (25) ^a 17.1-46.0	28.1 (29) 14.7-44.6	33.1 (25) 17.2-52.7	27.4 (19) 16.1-41.4	31.6 (24) 17.5-46.5
Heart (g)	10.8 (26) 7.7-14.5	11.4 (29) 8.2-16.4	11.0 (27) 9.4-14.6	10.5 (20) 9.4-13.9	11.5 (24) 9.4-13.9
Pancreas (g)	2.7 (18) 1.9-4.1	3.0 (20) 2.3-4.0	2.8 (19) 1.8-4.1	2.7 (16) 1.4-4.0	2.8 (23) 2.1-4.2
Gall Bladder (g)	0.9 (17) 0.5-1.7	1.3 (24) 0.6-2.0	0.9 (18) 0.1-1.7	0.9 (14) 0.3-1.7	0.9 (21) 0.3-2.0
Gizzard (g)	37.6 (26) 24.4-67.1	36.0 (29) 27.4-46.3	35.0 (27) 27.0-50.6	32.3 (20) 25.2-44.2	36.1 (24) 26.6-52.3
Left Adrenal (g)	0.07 (26) 0.02-0.18	0.07 (29) 0.03-0.14	0.07 (26) 0.03-0.14	0.07 (19) 0.05-0.12	0.07 (19) 0.05-0.10
Right Adrenal (g)	0.07 (26) 0.04-0.18	0.07 (29) 0.03-0.14	0.07 (27) 0.04-0.14	0.07 (19) 0.04-0.12	0.07 (22) 0.04-0.10
Right Thyroid (g)	0.08 (9) 0.04-0.13	0.07 (9) 0.04-0.14	0.07 (9) 0.04-0.10	0.05 (7) 0.03-0.07	0.06 (8) 0.02-0.14

Table 20. Continued

Left Thyroid (g)	0.09 (9) 0.04-0.13	0.06 (9) 0.03-0.13	0.06 (9) 0.03-0.10	0.05 (7) 0.03-0.07	0.05 (7) 0.02-0.10
Intestine Length (cm)	151 (26) 117-175	150 (29) 123-180	146 (26) 119-183	145 (20) 114-173	141 (24) 114-168

^a Sample size in parentheses.

APPENDIX N

Table 21. Mean and range of testis weights, lengths and widths of adult drake mallards collected in Castro County, Texas, between fall and early spring.

Testis Measurement	Collection Periods			
	Fall	Early Winter	Mid-Winter	Late Winter Early Spring
Left Testis Weight (g)	0.14 (28) ^a 0.08-0.24	0.16 (47) 0.08-0.29	0.23 (42) 0.08-0.95	0.26 (86) 0.10-2.00 0.90 (53) 0.16-10.18
Left Testis Length (mm)	12.9 (28) 0.9-17.0	13.9 (47) 10.0-18.0	14.7 (43) 10.0-24.0	14.9 (86) 11.0-30.0 20.3 (53) 12.0-45.0
Left Testis Width (mm)	4.9 (28) 3.0-7.0	5.1 (47) 3.0-7.0	5.8 (43) 3.0-12.0	6.1 (86) 3.0-12.0 8.7 (53) 5.0-21.0
Right Testis Weight (g)	0.15 (28) 0.06-0.26	0.15 (48) 0.08-0.23	0.22 (43) 0.08-0.72	0.27 (86) 0.10-2.05 0.88 (53) 0.15-10.30
Right Testis Length (mm)	12.8 (28) 8.0-17.0	13.1 (48) 10.0-17.0	13.9 (43) 10.0-21.0	14.3 (86) 10.0-30.0 19.8 (53) 12.0-43.0
Right Testis Width (mm)	5.2 (28) 3.0-7.0	5.3 (48) 4.0-7.0	6.0 (43) 3.0-10.0	6.2 (86) 3.0-13.0 8.9 (53) 5.0-25.0

^a Sample size in parentheses.

APPENDIX 0

Table 22. Mean and range of testis weights, lengths and widths of juvenile drake mallards collected in Castro County, Texas, between fall and early spring.

Testis Measurement	Collection Periods			
	Fall	Early Winter	Mid-Winter	Late Winter Early Spring
Left Testis Weight (g)	0.05 (22) ^a 0.01-0.12	0.07 (19) 0.01-0.14	0.18 (12) 0.03-0.35	0.18 (18) 0.07-0.44 0.54 (12) 0.14-02.45
Left Testis Length (mm)	11.4 (22) 7.0-16.0	11.7 (19) 10.0-15.0	13.2 (12) 9.0-16.0	14.4 (18) 10.0-20.0 18.0 (12) 12.0-31.0
Left Testis Width (mm)	2.8 (22) 2.0-5.0	3.5 (19) 2.0-6.0	5.1 (12) 3.0-8.0	5.2 (18) 3.0-8.0 8.1 (12) 5.0-16.0
Right Testis Weight (g)	0.06 (24) 0.01-0.12	0.07 (19) 0.01-0.14	0.18 (12) 0.03-0.34	0.18 (18) 0.08-0.35 0.51 (12) 0.10-02.00
Right Testis Length (mm)	10.5 (24) 5.0-14.0	11.2 (18) 8.0-15.0	12.5 (12) 9.0-16.0	14.0 (17) 9.0-17.0 17.2 (12) 11.0-30.0
Right Testis Width (mm)	3.4 (24) 2.0-5.0	3.5 (18) 2.0-7.0	5.3 (12) 3.0-8.0	5.0 (17) 2.0-8.0 7.2 (12) 4.0-11.0

^a Sample size in parentheses.

APPENDIX P

Table 23. Mean and range of oviduct weights, size of the largest ovarian follicle and mean number of follicles > 3.0 mm of hen mallards collected in Castro County, Texas, between fall and early spring.

Age-Sex Class Ovarian Parameter	Collection Periods			
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring
Adult Hens				
Oviduct Weight	1.11 (14) ^a 0.81-1.71	0.91 (16) 0.48-1.36	0.81 (16) 0.21-1.67	0.95 (23) 0.33-1.63 1.25 (26) 0.25-1.92
Size of Largest Follicle (mm)	2.0 (22) 1.0-5.0	1.9 (25) 1.0-3.5	2.2 (27) 1.0-5.0	2.6 (42) 1.0-5.5 4.1 (45) 2.0-8.0
Number of Follicles Greater than 3.0 mm	0 (22) 0-4	1 (25) 0-16	1 (27) 0-7	1 (42) 0-7 4 (45) 0-11
Juvenile Hens				
Oviduct Weight (g)	0.26 (16) 0.10-0.77	0.24 (19) 0.09-0.81	0.38 (21) 0.06-0.98	0.44 (16) 0.06-1.05 1.23 (23) 0.59-3.78
Size of Largest Follicle (mm)	0.7 (26) 0.5-2.0	1.2 (29) 0.5-3.0	1.5 (27) 0.5-2.5	2.2 (20) 0.5-4.0 3.7 (24) 1.0-6.0
Number of Follicles Greater than 3.0 mm	0 (26)	0 (29) 0-1	0 (27)	1 (20) 0-4 4 (24) 0-15

^aSample size in parentheses.

APPENDIX Q

Table 24. Mean and range of esophageal contents (g) of mallards with food in their esophagus, by age-sex class, shot before 0930 hours, collected in Castro County, Texas, between fall and early spring.

Age-Sex Class	Collection Periods			
	Fall	Early Winter	Mid-Winter	Late Winter Early Spring
Adult Drakes	44 (6) ^a 16-69	40 (13) 16-77	39 (18) 5-92	52 (25) 1-108 40 (18) 2-116
Adult Hens	17 (4) 7-34	34 (6) 7-51	48 (8) 6-125	52 (10) 25-74 37 (20) 6-54
Juvenile Drakes	45 (3) 14-64	28 (1)	35 (3) 11-59	53 (5) 4-96 30 (5) 1-99
Juvenile Hens	25 (5) 4-54	32 (7) <1-52	41 (7) 2-96	64 (6) 24-97 30 (8) 5-63

^a Sample size in parentheses.

APPENDIX R

Table 25. Mean and range of daily maximum and minimum ambient temperatures (C) of the study area for the 3-year average, 1979-80, 1980-81, and 1981-82.

3-Year Average and Separate Years Temperature	Collection Periods				
	Fall	Early Winter	Mid- Winter	Late Winter Early Spring	
3-Year Average Maximum	22 A ^a (4 - 35)	14 BC (-2 - 30)	13 C (-5 - 24)	9 D (-12 - 23)	16 B (-6 - 27)
Minimum	6 A (-6 - 15)	-2 B (-14 - 6)	-4 C (-12 - 10)	-7 D (-18 - 4)	-3 BC (-18 - -7)
1979-80 Maximum	22 A (4 - 35)	14 B (1 - 22)	11 B (-5 - 22)	10 B (-6 - 23)	14 B (-4 - 26)
Minimum	5 A (-3 - 12)	-3 B (-11 - 6)	-5 B (-12 - 2)	-5 B (-12 - 4)	-4 B (-14 - 5)
1980-81 Maximum	23 A (7 - 31)	14 B (-2 - 30)	14 B (-3 - 21)	11 B (-1 - 24)	15 B (-1 - 27)
Minimum	5 A (-6 - 12)	-3 B (-14 - 6)	-3 B (-10 - 10)	-5 C (-12 - 1)	-1 B (-17 - 7)
1981-82 Maximum	20 A (9 - 30)	17 AB (8 - 27)	13 B (1 - 24)	8 C (-12 - 21)	17 AB (-3 - 26)
Minimum	7 A (-2 - 14)	1 B (-5 - 6)	4 C (-11 - 4)	8 D (-17 - 2)	2 C (-13 - 5)

^aMeans with different letters in the same row indicate differences in daily ambient temperatures between collection periods ($P < 0.01$).