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IMPACT OF WINTER STRESS ON MALLARD BODY COMPOSITION

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ABSTRACT.—Adult Mallards wintering on the Southern High Plains of Texas lost weight and lipid reserves during and after periods of cold, stressful weather between December and February. Cold fronts and snowfall in November, when feeding conditions were best, did not affect gains in lipid and body weights. Protein levels were unaffected at all times. Survival potentials were estimated to be more or less equal among adult males and females and juvenile drakes at 0°C, −10°C, and −20°C. Juvenile hens had the lowest survival potentials at the three temperatures.

Cold, snowfall, and wind during winter affect regional sex ratios (Anderson and Timken 1972), habitat selection (Jorde 1981), and localized movements of females in flocks of waterfowl (Alford and Bolen 1977, Bennett and Bolen 1978). Low ambient temperatures are also associated with increased food consumption (Longcore and Cornwell 1964, Owen 1970), metabolic rates (Smith and Prince 1973), and starvation (Jordan 1953). Furthermore, important changes in body composition and condition occur in winter during periods of severe weather (Peterson and Ellarson 1979, Reinecke et al. 1982).

Because many Mallards (*Anas platyrhynchos*) overwinter in areas of harsh, cold weather (Bellrose 1976), we conducted a study on the Southern High Plains of Texas to relate their body composition and condition to winter stress associated with the region's periodic cold fronts and snowfall. Additionally, we estimated the survival potentials of these birds, based on their energy reserves at the coldest time of the winter. "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). "Winter stress" results from exposure to low ambient temperatures and snowfall; these weather conditions can potentially disturb a bird's thermoregulation and metabolism, thereby resulting in catabolism of lipid reserves and weight loss.

STUDY AREA AND METHODS

We collected 76 male adult and immature, and 57 female adult Mallards in order to determine the impact of winter stress on Mallard body condition. Collecting was done during three separate periods of harsh winter weather: January–March 1980, November–December 1980, and January 1981. We also used data on body condition from 87 adult and 19 immature males, and 42 adult and 20 immature females, collected between 8 January and 9 February 1980, 1981, and 1982, to estimate survival potential. All the ducks were shot on playa lakes or irrigation tailwater pits in Castro County, Texas (see Bolen and Guthery 1982 for regional description). Specimens were aged following Krapu et al. (1979). We removed the gizzard and esophageal contents before weighing the birds. 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). We determined the birds' body moisture by dessication in a drying oven (130°C for 3 hours); lean weight is reported here as lipid-free dry weight.

Daily maximum and minimum ambient temperature data, available from the National Oceanic and Atmospheric Administration, were averaged for Castro County (Dimmitt), Swisher County (Tulia), and Lamb County (Olton). These counties presumably encompass the local movements of Mallards, and temperatures there reflect the regime to which birds in our samples were exposed. We also recorded snowfall data. Three periods of potential winter stress were identified by at least seven consecutive days of low temperatures and snowfall. A two-week interval, with higher temperatures and without snowfall, before and after each stress period, was selected for comparisons; our data were grouped relative to these time intervals. A *t*-test was used to detect

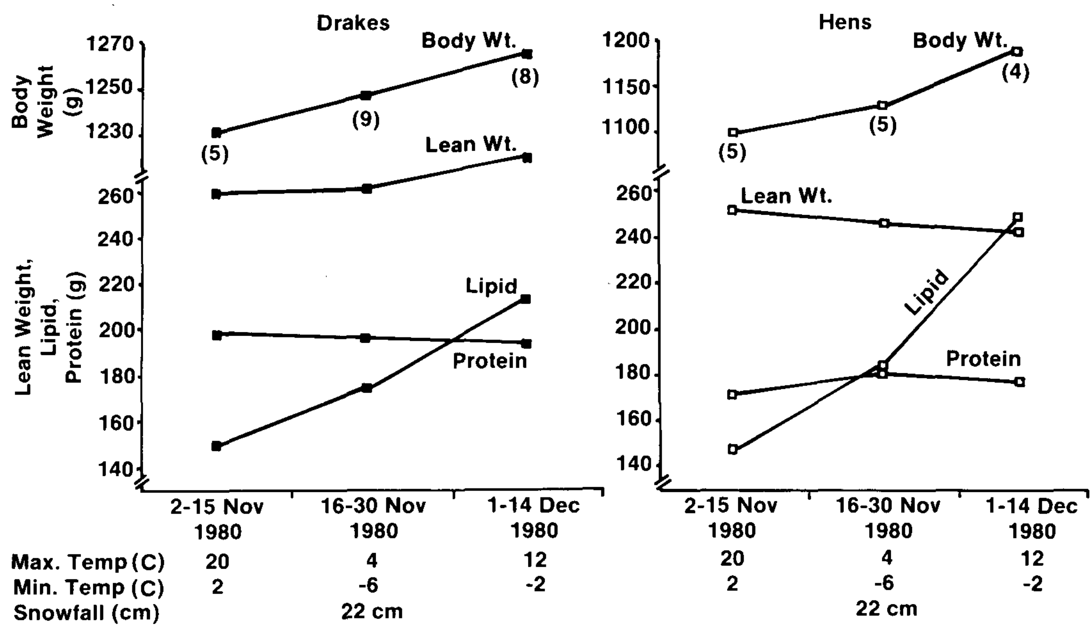

FIGURE 1. Variation in mean body and lean weights, and lipid and protein reserves for adult Mallards before (2–15 Nov.), during (16–30 Nov.), and after (1–14 Dec.) a period of snowfall and low ambient temperatures in 1980. Sample sizes in parentheses.

significant differences in the Mallards' body and lean weights, and lipid and protein levels before and after each potential stress period (Snedecor and Cochran 1967). Because few samples of immature birds were collected during periods of winter stress, we used only adult samples for our statistical analysis. We estimated survival potentials, however, for all age-sex classes.

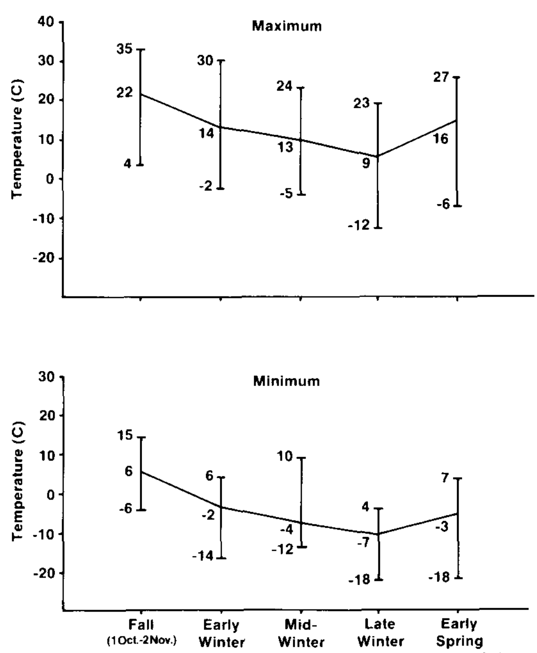

FIGURE 2. Mean and range of daily maximum and minimum ambient temperatures (°C) for five time periods during the winters of 1979–1980, 1980–1981, and 1981–1982 when Mallards were collected for estimates of winter stress.

For the purpose of this paper, we defined "survival potential" as the number of days a non-feeding Mallard can survive on its endogenous energy reserves, namely lipid and protein, at 0°C, −10°C, and −20°C. Survival potentials were estimated using body weights, and lipid and protein levels of birds collected in late winter (8 January–9 February), and were calculated by dividing the total energy loss (lipid + protein) before death by the daily Existence Energy Requirement (EER) of the bird. The most reliable estimate of Mallard body weight loss resulting in death is 49% (Jordan 1953); the lipid and protein losses associated with this value were determined from a regression of lipid and protein on body weight. We assumed the energy losses associated with the 49% body weight loss until death would come almost entirely from the endogenous lipid reserve and protein source from the muscle mass. Since body moisture is not an energy source for the birds, we did not consider dehydration in our determinations. Energy losses consequent to these lipid and protein depletions were based on the conversion of 1 g lipid and 1 g protein to 9.0 and 5.5 kcal energy, respectively (Ricklefs 1974). The EER was calculated from metabolism equations for American Black Ducks (*Anas rubripes*) acclimated to 5°C

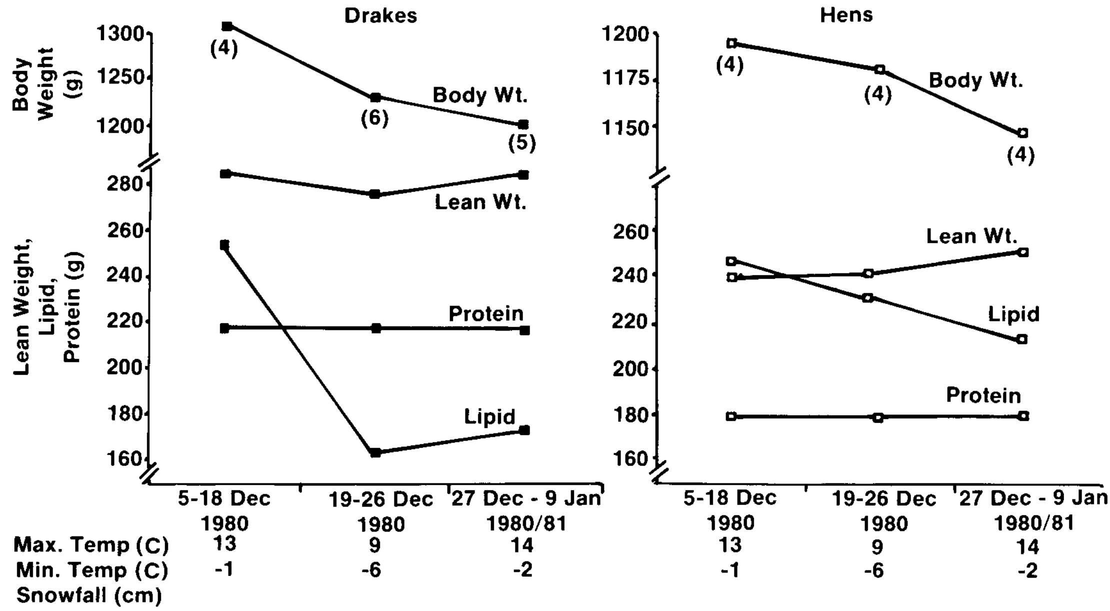

FIGURE 3. Variation in mean body and lean weights, and lipid protein reserves for adult Mallards before (5–18 Dec.), during (19–26 Dec.), and after (27 Dec.–9 Jan.) cold weather in the winter of 1980–1981. Sample sizes in parentheses.

(Woolley and Owen 1977). Because American Black Ducks and Mallards are of similar size (Bellrose 1976), our use of these data seemed appropriate.

RESULTS AND DISCUSSION

Short-term cold fronts cause potential winter stress for waterfowl on the Southern High Plains of Texas. Hence, the body condition of Mallards is subjected to stress at discrete but unpredictable intervals during the winter in that region. Despite snowfall and low ambient temperatures during 16–30 November 1980, Mallards collected after this period were heavier, in better condition, and had greater lipid reserves than those collected before (Fig. 1). Lipid changes were 62 g and 102 g for drakes

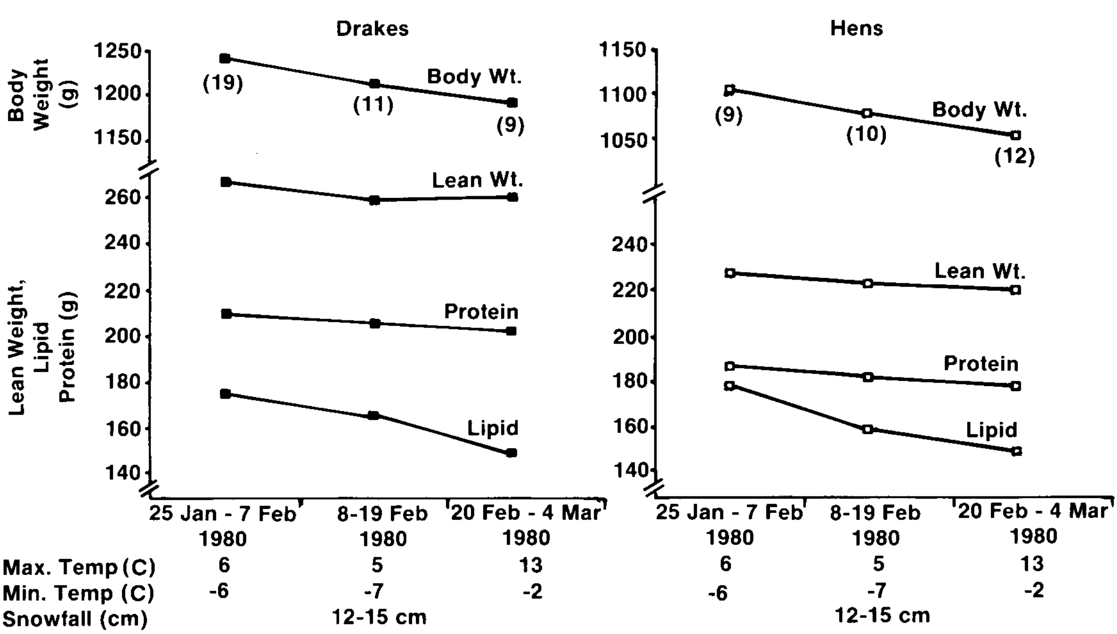

FIGURE 4. Variation in mean body and lean weights, and lipid and protein reserves for adult Mallards before (25 Jan.–7 Feb.), during (8–19 Feb.), and after (20 Feb.–4 Mar.) a period of snowfall and low ambient temperatures in 1980. Sample sizes in parentheses.

TABLE 1. Survival potential of mallards in late winter (8 Jan.–9 Feb. 1980–1981–1982) deprived of food supplies at 0°C, −10°C, and −20°C, respectively, based on daily existence energy requirements, body weight, and lipid and protein losses.

Age-sex class	Mean body weight (g)	Mean body lipid (g)	Mean body protein (g)	Weight[a] after 49% loss (g)	Loss of[b] lipid/energy to death (g/kcal)	Loss of[b] protein/energy to death (g/kcal)	Daily[c] EER at 0°C (kcal)	Survival days at 0°C	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 ($n = 87$)	1,237 ± 118	174 ± 66	206 ± 26	631	174/1,566	75/412	276	7	359	5	441	4
Hens ($n = 42$)	1,088 ± 105	171 ± 56	174 ± 18	555	171/1,539	62/341	306	6	386	5	465	4
Immatures												
Drakes ($n = 18$)	1,214 ± 121	171 ± 67	194 ± 18	619	171/1,539	74/407	276	7	359	5	441	4
Hens ($n = 20$)	996 ± 145	128 ± 72	162 ± 20	508	128/1,152	51/280	306	5	386	4	465	3

[a] Calculated from weight loss to death of four adult drake Mallards dying during 22–29 days in winter (Jordan 1953).
[b] Based on regressions of lipid and protein on body weight and 1 g lipid = 9 kcal energy; 1 g protein = 5.5 kcal energy (Ricklefs 1974). See text for assumptions.
[c] Daily existence energy requirement (EER) based on metabolism equations for American Black Ducks acclimated at 5°C (Woolley and Owen 1977).

and hens, respectively. The difference was significant for lipids of both drakes ($P < 0.10$) and hens ($P < 0.05$). Lean weights were slightly higher for drakes but lower for hens, and protein was essentially 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 the November cold front. One factor ensuring the birds' improved condition in early winter, regardless of harsh winter weather, is the availability of waste corn in November. Presumably, Mallards on the Texas High Plains are unaffected by harsh weather and associated winter stress in November because readily available supplies of high-energy food provide optimal feeding conditions (Baldassarre et al. 1983, Baldassarre and Bolen 1984).

Waste corn is an abundant food resource throughout the winter on the Southern High Plains of Texas (Obenberger 1982, Baldassarre et al. 1983). Mallards were, however, affected by winter stress from mid-December to mid-February, after experiencing progressively colder weather (Fig. 2). They mobilized and depleted lipids for energy, and lost weight during cold weather between 19–26 December 1980 (Fig. 3). Drakes collected after this cold spell had 77 g less lipids than those collected earlier. For hens, the loss was 32 g. The greater loss for drakes is difficult to explain, but despite having the metabolic advantage of a larger body size over the small-bodied hens (Calder 1974), drakes consumed less waste corn than hens at this time of the year (Whyte 1983). Losses of body weight ($P < 0.05$) and lipid ($P < 0.10$) were significant only for drakes. Similarly, snowfall and extended cold temperatures from 8–19 February 1980 also resulted in losses of lipid and body weight (Fig. 4). Drakes collected between 20 February–4 March 1980 had 27 g less lipids than those collected between 25 January–7 February 1980 because they mobilized and depleted lipids during the intervening 12 days of snow and cold. Hens mobilized 28 g 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 snow and cold temperatures.

Smith and Prince (1973) found metabolic rates to 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 spent more time on their evening field-feeding flights (Baldassarre and Bolen 1984). Birds collected after the morning flights in late winter also had more corn in their crops than birds collected at other times (Whyte 1983). Therefore, they ate extra corn, apparently at a faster foraging rate, because the duration of the morning flight did not increase at this time (Baldassarre and Bolen 1984). 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 Texas High Plains between October and March, we assume that sex-specific dispersal flights triggered by cold fronts were not a major event, as they were reported for female Northern Pintails (*A. acuta*; Alford and Bolen 1977) and Green-winged Teal (*A. crecca*; Bennett and Bolen 1978).

The survival potential of late-winter Mallards deprived of food at 0°C was seven days for drakes, and six and five days for adult and immature hens, respectively (Table 1). At −10°C and −20°C, however, all Mallards had similar survival potentials except for immature hens, which had one day less at both temperatures. Hens, especially immatures, have lower survival potentials than males because they are less able to conserve heat, owing to their small body size (Calder 1974). These survival potentials probably are underestimates because Mallards seek sheltered habitats and behaviorally adjust to survive severe cold (Jorde 1981). These survival potentials are, however, realistic when compared with Smith and Prince's (1973) data for weight losses of Mallards fasted for 18 hours.

The combined conditions of food deprivation and 0°C, −10°C, and −20°C temperatures for long periods seldom occur on the Texas High Plains. Maximum ambient temperatures stay below 0°C for only a few days at a time; also, it is rare for snow to cover the waste corn. Therefore, non-hunting mortality among Mallards wintering in this region seems related more to disease (Moore and Simpson 1980) than to conditions associated with harsh weather and winter stress.

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RECENT PUBLICATIONS

Sexual selection, lek and arena behavior, and sexual size dimorphism in birds.—Robert B. Payne. 1984. Ornithological Monographs No. 33, American Ornithologists' Union, Washington, D.C. 52 p. Paper cover. $8.00 ($6.50 to AOU members). Source: Frank R. Moore, Department of Biology, University of Southern Mississippi, Southern Station Box 5018, Hattiesburg, MS 39406; all orders must be prepaid and include a $0.50 handling charge. Sexual selection poses a number of theoretical questions about the behavior and morphology of animals that have different mating systems. Several of those issues are addressed here, by way of comparing birds that have lekking and arena behavior with birds that have territorial-polygynous mating systems, and with monogamous birds. Drawing on published and unpublished information, Payne examines the intensity of sexual selection and then male competition and female choice of mates. In the major part of his paper, he uses measurements of specimens to compare sexual size dimorphism with mating systems in the sixteen families of birds in which lekking or arena behavior is known in at least one species. This well-reasoned article will be important for those who are interested in the evolution of avian sexual behavior patterns. Graphs, references.

Geographical ecology/patterns in the distribution of species.—Robert H. MacArthur. 1984. Princeton University Press, Princeton, NJ. 269 p. Paper cover. Price not given. This is a reprint edition of a classic work in ecology, first published in 1972. "To do science," MacArthur wrote, "is to search for repeated patterns, not simply to accumulate facts, and to do the science of geographical ecology is to search for patterns of plant and animal life that can be put on a map. . . . The theme running through this book is that the structure of the environment, the morphology of the species, the economics of species behavior, and the dynamics of population changes are the four essential ingredients of all interesting biogeographic patterns." He developed challenging ideas with the aid of mathematics and expressed them lucidly. Illustrations, selected list of references, and index.

Avian ecology.—C. M. Perrins and T. R. Birkhead. 1983. Blackie & Son Limited. 221 p. Paper cover. No price given. Source: Chapman and Hall, 733 Third Avenue, New York, NY 10017. This new title in the Tertiary Biology Series joins others that may be of interest: *Mammal ecology, Tropical rain forest ecology, Saltmarsh ecology, The estuarine ecosystem, Population genetics,* and a number of cellular biology and physiology titles. The present book succeeds in giving an overview of behavioral ecology/evolution to the serious student of birds. It is perhaps best used as supplemental reading for an ornithology or ecology course as it does not provide enough for either subject alone. Good bibliography of palearctic and nearctic subjects. A few monochrome photos, many well-done figures.—J. Tate.