neighboring individuals could provide a means of testing the capacity for individual recognition. It should also be possible to induce changes in the strength of response to neighboring individuals by altering their plumage with dyes.

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Overnight Weight Loss in Dark-eyed Juncos (*Junco hyemalis*)

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Because most birds confine feeding to daylight hours, energy to fuel overnight expenditures must be stored in advance (King 1972). Obviously, if a bird is unable to store energy during the day or if its rate of fat utilization is so great that stores are depleted before it is able to feed again, death may follow. The risks of overnight fasting may be greatest during winter, when nights are long, food sometimes scarce or difficult to find, and rates of energy utilization high (Chaplin 1974, Ketterson and Nolan 1976). In this connection, Calder (1974, 1975) has suggested that individuals of greater body size have greater fasting endurance because stored energy increases with size at a greater rate than does utilized energy. Fasting endurance, the ratio of stored energy to utilized energy, should therefore be greater in bigger birds. In many species, males tend to be larger than females. Ketterson and King (1977) have shown sexual differences in fasting ability among captive White-crowned Sparrows (*Zonotrichia leucophrys gambelii*) when males were heavier than females, as they typically are in the field (King and Farner 1966).

From a population of freshly-captured Dark-eyed Juncos (*Junco hyemalis*) we gathered data on body size and rate of overnight weight loss under controlled conditions. Here we relate variability in weight loss to size and sex. Among juncos, males have longer wings than females and have greater wet weight and lean body mass (Helms et al. 1967). Wet weight reflects mass but also includes contents of the gut, water content of tissues, and level of fat stores, all of which may vary with time of day and temperature (Kontogiannis 1967, Kendeigh et al. 1969, King 1974). Wing length is correlated with wet and dry fat-free weight in juncos, but in at least one population the relationship was linear only in females (Helms et al. 1967), and obviously factors other than mass may influence wing length (e.g. feather wear). Despite these deficiencies, we used wet weight (nearest 0.1 g) and wing length (nearest mm) as measures of body size because more satisfactory alternative measures of intrasexual size variation in live birds were not available.

Following Calder's model, we expected that males should be larger than females and consequently should lose more weight overnight at a faster rate, but the proportion of total body weight lost should

TABLE 1. Sex, body size, and overnight weight loss among Dark-eyed Juncos wintering near Blooming-ton, Indiana[a].

	Males	Females	Sexes pooled
Wing length (mm)	80.7 ± 1.65[b] (54)	76.6 ± 1.25***[c] (33)	79.16 ± 2.51 (87)
W_c (g)	22.43 ± 1.39 (29)	21.00 ± 1.64** (13)	21.99 ± 1.60 (42)
W_i (g)	21.48 ± 1.49 (54)	20.47 ± 1.42** (33)	21.09 ± 1.52 (87)
$W_i - W_f$ (g)	1.46 ± 0.382 (54)	1.47 ± 0.385 (33)	1.46 ± 0.381 (87)
$(W_i - W_f)/t$ (g/h)	0.114 ± 0.029 (54)	0.113 ± 0.029 (33)	0.114 ± 0.029 (87)
$(W_i - W_f)/W_i$ (%)	6.78 ± 1.64 (54)	7.16 ± 1.72 (33)	6.92 ± 1.67 (87)

[a] Symbols defined in text
[b] Mean, standard deviation, sample size
[c] Sexes were compared by t-tests, ** = $P < .01$, *** = $P < .001$

be lower than in females. The same prediction should apply intrasexually: heavier individuals and those with longer wings should lose more absolute weight and at a faster rate, but a lesser amount relative to total body weight.

Dark-eyed Juncos (n = 87) were netted or trapped from 28 January to 1 March 1974 near Bloomington, Indiana. Dates indicate that they were winter residents and not migrants (Ketterson and Nolan 1976). Birds were caught in late afternoon ($\bar{x}$ = 1630, extremes 1430–1810), and most were weighed immediately in the field. All were transported to the laboratory, weighed again, measured (flattened wing), and sexed by plumage and wing length (Ketterson and Nolan 1976). They were then placed individually in paper bags in a 4°C darkened cold room. Mean elapsed time between the field and the laboratory weighings was 2.6 h; average time of entrance into the cold room was 1908 (extremes 1720–2010). Although gut evacuation probably continues up to 5 h after most recent feeding, the greatest weight loss due to this factor occurs during the first 2.5 h after food is withheld. Thus in the current experiment, weight loss in the cold room should have been largely independent of initial level of gut contents (Kontogiannis 1967).The following morning the birds were reweighed (mean time 0757, extremes 0740–0840) and returned to the field. Mean duration of stay in the cold room was 12.75 h. Natural duration of darkness at Bloomington over the study period is 13 h 55 min (28 January) to 12 h 42 min (1 March) (Smithsonian Institution 1963).

Taking W_c as weight at capture, W_i as weight at initiation of stay in cold room, W_f as final weight, and t as hours in cold room, the following variables were noted for each individual: $(W_i - W_f)$, weight loss in cold room; $[(W_i - W_f)/W_i] \cdot 100$, percent loss in cold room; and $(W_i - W_f)/t$, rate of weight loss in cold room. Data were summarized statistically using the procedures of Sokal and Rohlf (1969).

As expected, males were significantly heavier and had longer wings than females (Table 1). The sexes were virtually indistinguishable in rate and amount of weight loss. Because females were lighter upon entering the cold room they tended to lose slightly more proportionally, but not significantly so (Table 1).

When wet weight was used as a size indicator intrasexually, larger birds lost weight at a faster rate, and thus lost more absolute weight (Table 2). Proportional weight loss was independent of size. Wing length was not related to any of the weight-loss variables. Among males, however, wing length was positively correlated with wet weight, and thus indirectly to weight loss.

Multiple regression analysis of rate of weight loss on weight upon entrance to cold room and wing length in males gave the following results: rate of weight loss = 0.182 + 0.008(W_i) − 0.003(wing length). The regression was significant (F = 4.46, df = 2,51, $P < 0.01$), and W_i proved a predictor of rate of weight loss independently of variation in wing length (s_b = 0.0027, $P < 0.01$). Wing length did not predict rate of loss independently of wet weight (s_b = 0.0024, n.s.) and must be considered a less reliable indicator of body size in this context. Similar results were obtained when the same analyses were run with females.

Notably, none of the birds died overnight, nor was any released in an apparently weakened state. The

TABLE 2. Correlations between estimates of body size and weight loss variables[a].

	Male	Female
Wet weight vs.		
Rate of weight loss	.360 (54) <.01	.371 (33) <.05
Amount lost	.380 (54) <.01	.368 (33) <.05
% loss	.129 (54) n.s.	.111 (33) n.s.
Wing length vs.		
Rate of weight loss	.046 (54) n.s.	.007 (33) n.s.
Amount lost	−.019 (54) n.s.	−.035 (33) n.s.
% loss	−.126 (54) n.s.	−.102 (33) n.s.
Wing length vs.		
Wet weight	.355 (54) <.01	.241 (33) n.s.
Sexes pooled	.263 (87) <.05	

[a] Given are product-moment correlation coefficient, sample size, and level of significance

lowest morning weight observed was 15.2 g; our unpublished observations indicate that this is danger-ously close to the lower weight limit in this species. The next lowest weight observed was 16.0 g; the mean morning weight (sexes pooled) was 19.64 g (s = 1.454, n = 87), indicating a wide margin of safety.

Because juncos exhibit geographic variation in their wintering sex ratio (Ketterson and Nolan 1976), sexual comparisons of response to fasting are of interest. Males winter farther north than females in regions where nights are longer, storms more frequent, and snow cover more prolonged, all of these being circumstances potentially requiring longer fasting. Nevertheless our results do not indicate that males are significantly better adapted to overnight fasting than are females. However, if fasting were prolonged beyond the 12.75 h used in this study, males might prove better adapted since they were initially heavier, yet lost weight at an equivalent rate.

How long do the data indicate fasting is possible? Published reports suggest that several species can tolerate losses of up to 30% wet weight and still recover (Kendeigh 1945, Helms and Drury 1960, Ivacic and Labisky 1973, Ketterson and King 1977 and references cited therein). Employing the mean observed weight at capture (W_c) for each sex and assuming a 30% loss at the rate observed, males should be able to fast 59.0 h and females 55.8 h. These estimates are greater than those of Ketterson and Nolan (1976), who used different assumptions to predict that juncos weighing 22.5 g and 21 g should be able to fast 41.4 and 39.8 h, respectively.

One of us (Ketterson) has measured fasting endurance in a small number of juncos captured during mid-winter in northwestern Ohio, and these data support the fasting estimates reported here. The most enduring junco successfully fasted 81 h at 4°C and suffered a loss of 39% body weight; the average junco fasted 63.5 h (n = 6). Because the Ohio birds were heavier than those that we report on here $(\bar{x}W_c = 24.9$ g), the agreement between our current estimate of fasting endurance and that observed in Ohio is quite good.

In sum, our results do not indicate important sex- or size-related differences in short-term fasting ability, but they do seem to imply that such differences might be important over longer time periods. Further, when rate of weight loss was used to estimate long-term fasting endurance, the estimate con-curred with data obtained directly. Finally, juncos wintering in Indiana are rarely strained by overnight fasting and are typically prepared to go an entire day without food, if necessary.

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Intersong Interval and Song Pattern Variability of the Five-striped Sparrow

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Hartshorne (1973) has recognized two major types of singing patterns in birds, one in which the same song is repeated with relatively long time intervals between each song, and one in which successive songs are different with relatively short time intervals between each song. He has postulated that these patterns result from a tendency to avoid monotony when singing. Individuals within a species may all sing with the same pattern, or in some species individuals may sing both patterns. Verner (1975) has described the latter situation for the Long-billed Marsh Wren (*Cistothorus palustris*) where the intersong interval between two successive songs was longer when the songs were the same.

The songs of the Five-striped Sparrow (*Aimophila quinquestriata*) are well suited to study this aspect of bird song. A typical song consists of an introductory note and 1–6, usually 2, note complexes (a manuscript describing the songs is in preparation). Songs are delivered in a variety of sequencing behaviors at an average rate of 15–16 songs per min. On occasion, singing patterns with recurrence numbers of 0, 1, and 2 occur. A singing pattern with a recurrence number of 0 consists of identical transitions (AAAAAA...), a recurrence number of 1 denotes alternating transitions (ABABAB...), while a recurrence number of 2 designates songs occurring in a triplet fashion (ABCABC...). The anti-monotony hypothesis suggests that the intersong interval should decrease with the increase in the number of different songs comprising a singing pattern. Thus, the intersong intervals of identical transitions should be greater than the intersong intervals of alternating songs, which in turn should be greater than the intersong intervals of songs occurring in a triplet fashion.