

SHORT COMMUNICATIONS

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A COMPARISON OF WING SHAPE BETWEEN MIGRATORY AND SEDENTARY DARK-EYED JUNCOS (*JUNCO HYEMALIS*)¹

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One of the common generalizations concerning avian ecomorphology is that migrant birds have longer, more pointed wings than closely related nonmigrants (Chapman 1940, Kipp 1942, Dorst 1962, Stegmann 1962, Gaston 1974). Pointed wings have relatively longer distal (outer) primaries, relatively shorter proximal (inner) primaries, and a wingtip closer to the leading edge of the wing (Chapman 1940:425, Dorst 1962:380-381, Stegmann 1962:52). Pointed wings presumably are favored in migrants because they enable faster, more energy-efficient flight. However, the relationship between wing shape and distance migrated is sometimes ambiguous. Distance migrated is not always positively correlated with wing pointedness (e.g., Keast 1980) and, even when it is, other factors may contribute to the relationship (e.g., Chapman 1940, Gaston 1974, Aldrich 1984).

In previous studies of wing shape of age/sex classes of Dark-eyed Juncos (*Junco hyemalis*), we (Chandler and Mulvihill 1990, Mulvihill and Chandler 1990) described significant variation that did not appear to be related to differential migratory effort among these classes. However, the gradient in distance migrated by age/sex classes of juncos (with females and adults migrating, on average, farther than males and immatures; Ketterson and Nolan 1976, 1979, 1983) may be insufficient to select for distinct, migration-related differences in wing shape among the age/sex classes (Mulvihill and Chandler 1990). To explore this possibility, we evaluated a steeper gradient of migratory effort by comparing the wing shape of adult male juncos from migratory populations (*J. h. hyemalis*) with that of adult male juncos from largely sedentary Appalachian populations (*J. h. carolinensis*). The specific objectives of this comparison were to determine whether migratory

and sedentary juncos differ in wing shape and, if so, whether these differences support the generalization that migrants have longer, more pointed wings.

METHODS

Adult male juncos from migratory populations (*J. h. hyemalis*) were captured as migrants and as winter residents at Powdermill Nature Reserve, Westmoreland County, Pennsylvania (40°10'N, 79°16'W) between October 1983 and December 1986 (Chandler and Mulvihill 1990, Mulvihill and Chandler 1990). Adult male juncos from largely sedentary populations (distinguishable as *J. h. carolinensis* based on bill color, size, and plumage; Miller 1941, R. S. Mulvihill, unpubl. data) were captured at Powdermill between January 1984 and April 1989, and at Mountain Lake Biological Station, Giles County, Virginia (37°22'N, 80°32'W) in January 1989. Sedentary juncos were captured on (Mountain Lake) or within a few kilometers of (Powdermill) the breeding grounds.

Details of methods used in measuring, aging, and sexing juncos are given by Chandler and Mulvihill (1988, 1990) and Mulvihill and Chandler (1990); a brief summary is provided here. For each individual we measured wing length and the distances (along the wing chord) between the wingtip and the tip of each of the nine primaries (Fig. 1 in Chandler and Mulvihill 1988). For primary 1 we termed this distance P1; for primary 2, P2, and so on for each primary (P1-P9). All measurements were to the nearest 0.5 mm. Juncos were sexed based on size and plumage characters (summarized by Ketterson and Nolan 1976). Age was determined by the degree of skull pneumatization and the presence or absence of retained juvenal wing feathers (Yunick 1981; R. S. Mulvihill, unpubl. data). Juncos were categorized as immature (less than one year of age) or adult (greater than one year of age). All birds were weighed to the nearest 0.1 g, and fat levels were scored (by the same person) on a scale of 0-3. Fat-free body mass was estimated by regressing the natural logarithm of body mass on fat scores and using residual body mass in subsequent analyses.

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Differences in wing length, P1–P5, P8, and P9 between the two populations were assessed using analysis of variance (ANOVA). Primaries 6 and/or 7 usually form the wingtip in juncos (i.e., are the longest primaries and, therefore, their distance from the wingtip is zero). We quantified the frequency of four observed wingtip placements (primary 6, 6 & 7, 7, or 7 & 8) between populations using a χ^2 -test. We evaluated overall differences in wing shape between *hyemalis* and *carolinensis* using multivariate analysis of variance (MANOVA). Canonical discriminant analysis was used to describe the linear combination of wing-shape variables that discriminated maximally between populations. Finally, analysis of covariance (ANCOVA) was used to determine whether the canonical axis provided significant discrimination between populations after accounting for the effects of a confounding variable (residual body mass). All statistical analyses were performed using SAS (SAS Institute, Inc. 1988).

RESULTS

Adult male juncos from sedentary populations had significantly longer wings than their migratory counterparts (Table 1). Sedentary juncos also had significantly smaller P5 (primary 5 falls closer to the wingtip) and significantly larger P8 and P9 (primaries 8 and 9 fall farther from the wingtip) than did migratory individuals (Table 1). There was no significant difference in the frequency of alternative wingtip placements between the two populations ($\chi^2 = 5.03$, $df = 3$, $P = 0.169$).

When the seven wing-shape variables (wing length, P1–P5, P8, and P9) were considered simultaneously, there were significant differences in wing shape between the two populations (MANOVA, Wilks' lambda = 0.758, $P < 0.001$). The dimension of wing shape primarily responsible for this difference (as described by canonical discriminant analysis; Table 2) was an axis representing positive covariation between wing length and distal primary distances (particularly P9). Sedentary and migratory juncos differed significantly along this canonical axis (Table 1). Sedentary juncos had long

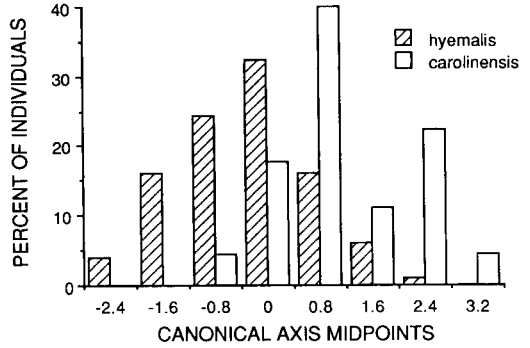


FIGURE 1. Canonical scores of adult male Dark-eyed Juncos from migratory (*hyemalis*) and sedentary (*carolinensis*) populations. The canonical axis describes a gradient of increasing wing length and increasing distal primary distances (particularly P9).

wings and large P9 (high canonical axis scores; Fig. 1), while migratory juncos had shorter wings and smaller P9 (low scores on the canonical axis; Fig. 1).

Mean residual body mass differed significantly between migratory and sedentary juncos (Table 1). Furthermore, there was a significant correlation between canonical scores and residual body mass ($r = 0.394$, $P < 0.001$). This raised the possibility that wing-shape differences between populations might be due solely to size differences between *hyemalis* and *carolinensis*. When canonical axis scores were regressed on residual body mass, there was no significant difference between the slopes for the two populations (heterogeneity of slopes model, $F = 0.33$, $P = 0.564$). This lack of a significant difference in slopes permitted a comparison of the elevation of the two regression lines (common slopes model). Based on this analysis, the canonical axis provided significant discrimination between *hyemalis* and *carolinensis* even after accounting for dif-

TABLE 1. Wing-shape comparison ($\bar{x} \pm SE$) between adult male Dark-eyed Juncos from migratory (*J. h. hyemalis*) and sedentary (*J. h. carolinensis*) populations.

Variable	Population		ANOVA	
	<i>hyemalis</i> (n = 198)	<i>carolinensis</i> (n = 48)	F	P ^a
Wing length (mm)	78.38 (0.108)	80.29 (0.232)	56.19	***
Primary distances ^b (mm)				
P1	16.60 (0.074)	16.76 (0.157)	0.79	ns
P2	14.67 (0.068)	14.77 (0.160)	0.33	ns
P3	12.27 (0.066)	12.20 (0.160)	0.27	ns
P4	7.84 (0.068)	7.69 (0.137)	1.08	ns
P5	2.32 (0.045)	2.07 (0.083)	6.30	*
P8	1.22 (0.037)	1.46 (0.079)	8.00	**
P9	7.21 (0.066)	7.82 (0.178)	14.61	***
Canonical axis	-0.268 (0.071)	1.189 (0.145)	77.56	***
Residual body mass	-0.024 (0.004)	0.106 (0.011)	156.19	***

^a ns = $P > 0.05$, * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$.

^b Distance from the tip of the longest primary to the tip of primary 1 (P1), primary 2 (P2), etc.

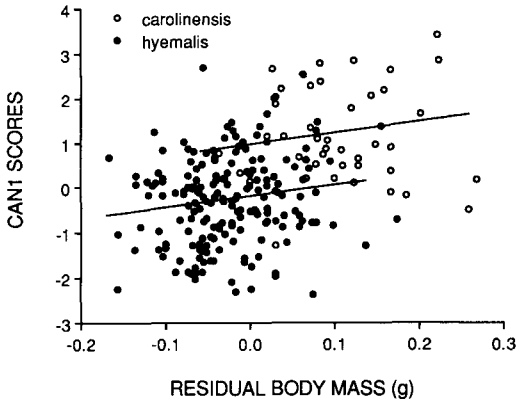


FIGURE 2. Relationship between canonical axis scores and residual body mass in migratory (*hyemalis*) and sedentary (*carolinensis*) Dark-eyed Juncos. Regression lines represent the "common slope" regressions for adult males from each population (ANCOVA).

ferences in residual body mass between the two populations (ANCOVA, $F = 26.62$, $P < 0.001$; Fig. 2).

DISCUSSION

Adult male Dark-eyed Juncos from largely sedentary populations (*carolinensis*) have significantly different wing shape than their migratory counterparts (*hyemalis*). Compared to *hyemalis*, male *carolinensis* have longer wings, primary 5 reaches closer to the wingtip (small P5), and primaries 8 and 9 fall farther from the wingtip (large P8 and P9; Table 1). These differences, as described by canonical discriminant analysis (Table 2), are sufficient to distinguish the two populations even after accounting for interpopulation differences in residual body mass (Fig. 2).

Based on previous comparisons within and among other species (e.g., Chapman 1940; Kipp 1942, 1958; Gaston 1974), juncos from a migrant population were expected to have more pointed wings than those from a largely sedentary population. The differences in primary distances between *carolinensis* and *hyemalis* are consistent with this generalization. The smaller P5, larger P8, and larger P9 observed in *carolinensis* all reflect a shift toward a slightly rounder wing relative to *hyemalis* (Dorst 1962:380–381, Stegmann 1962:52, Kokshaysky 1973). The rounder wings of *carolinensis* (and other resident populations) presumably reflect a shape that is free from selection for migratory performance and more adapted to other needs (such as foraging or avoidance of predators).

Despite their slightly more rounded wing, however, in *carolinensis* there was no shift in the wingtip away from the leading edge of the wing (another characteristic of rounded wings). Furthermore, the significantly longer wings of *carolinensis* are inconsistent with the typical pattern of relatively shorter wings in non-migratory populations (Chapman 1940, Gaston 1974, Keast 1980). Longer wings in *carolinensis* (as reflected

TABLE 2. Results of the canonical discriminant analysis of wing-shape differences between migratory (*J. h. hyemalis*) and sedentary (*J. h. carolinensis*) Dark-eyed Juncos.

	Total canonical structure
Wing length	0.877
P1	0.111
P2	0.072
P3	-0.066
P4	-0.132
P5	-0.319
P8	0.376
P9	0.484
Canonical correlation	0.492
Wilks' lambda	0.758
Probability	<0.001

in canonical axis scores) persist even after accounting for size differences between the populations (Fig. 2). If relatively long wings are advantageous for migratory individuals, other factors (such as allometric relationships or behavioral differences other than distance migrated) apparently operate to obscure a positive correlation between wing length and distance migrated in these populations (see also Mulvihill and Chandler 1990).

We undertook a comparison of wing shape between *carolinensis* and *hyemalis* because we had previously found in *hyemalis* that wing-shape variation among age/sex classes was not related to differential migratory effort among the age/sex classes (Mulvihill and Chandler 1990). The comparison of *carolinensis* and *hyemalis* involves a steeper gradient of migratory effort than that found among age/sex classes of *hyemalis* alone. Although some interpopulation differences in wing shape were consistent with the expected effects of differences in migratory effort, others were not. Furthermore, the magnitude of the wing-shape differences between *hyemalis* and *carolinensis* is small and no larger than the wing-shape differences observed among age/sex classes of *hyemalis* (Mulvihill and Chandler 1990). These results suggest that over the range of migratory effort displayed by these populations (from largely sedentary to medium-distance migrations), distance migrated does not have a pronounced effect on wing shape (Fig. 3c in Mulvihill and Chandler 1990).

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NOTEWORTHY BIRD RECORDS FROM SOUTHERNMOST CHILE¹

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Key words: Avifauna; distribution, Chile, Islas Diego Ramirez.

The following observations were made during trips to southern Chile 20–24 February 1986, and 22–23 February, and 5–12 March 1989. New distributional and breeding information was gathered for seven bird species I observed in the Chilean provinces of Ultima Esperanza, Magallanes, Tierra del Fuego, and Antartica. Common and scientific names follow those of Meyer de Schauensee (1982).

Eudyptes chrysolophus (Macaroni Penguin). One adult was seen with five Rockhopper Penguins (*E. chrysolophus*) on Isla Terhalten (55°26'S, 67°04'W), 3 March 1989. In Chile, the Macaroni Penguin is a confirmed breeder at Cabo Pilar, Isla Desolacion (52°44'S, 74°41'W), Islas Diego Ramirez (56°30'S, 68°43'W); a probable breeder on Isla Noir (54°30'S, 73°05'W) and Isla Deceit (55°53'S, 67°08'W) (Araya and Millie 1986).

Macaroni Penguins have been observed previously on Isla Terhalten in large numbers, but their occurrence has not been reported in the literature. This sighting is the first documented record for Isla Terhalten. The island should be monitored for evidence of breeding.

Netta peposaca (Rosy-billed Pochard). I observed one male approximately 9 km south of Porvenir (53°22'S, 70°22'W), 21 February 1986. Araya and Millie (1986) describe the range as including Magallanes province, but this is the first documented record for the species in Tierra del Fuego. Keith (1970) recorded pochards slightly farther south in Argentine Tierra del Fuego and Scott (1954, as cited by Humphrey et al. 1970) described the pochard as "reported" from Tierra del Fuego. The Rosy-billed Pochard may have a wider distribution than previously believed.

Phalacrocorax australis (Striated Caracara). I observed 15 Striated Caracaras, apparently mostly second and third year birds (Brown and Amadon 1968), on Isla Gonzalo, Islas Diego Ramirez, 23 February 1989. The birds were tame and tolerated approach to within a few meters. This species is known to scavenge in

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