

VARIATION IN MASS, WING, AND CULMEN WITH AGE, SEX, AND SEASON IN THE MEXICAN JAY

JERRAM L. BROWN AND NIRMAL BHAGABATI

*Department of Biological Sciences
State University of New York
Albany, New York 12222 USA*

Abstract.—We analyzed variation in body mass, wing chord, and culmen in the Mexican Jay (*Aphelocoma ultramarina*) in relation to age, sex, month, and year using linear regression. All measurements were taken from color-banded individuals of known sex and age as part of a long-term study in the Chiricahua Mountains of Arizona. There was no significant variation among observers for mass, but there was for wing chord and culmen. Therefore, analyses of the latter measures were restricted to data of one observer. Males were heavier than females. Mean body mass declined from winter to summer. Mass increased over the first two years in each sex but not in older birds. Males had longer wings than females. Mean wing chord increased considerably from age 1 to 2 and increased significantly even after age 2. Males had significantly longer culmens than females in summer but not winter. A discriminant function separated yearling males from females in winter. The sexes in older birds could be discriminated in summer but not winter.

VARIACIÓN EN MASA, LARGO DE ALA Y DEL CULMEN CON LA EDAD, EL SEXO Y LA TEMPORADA EN *APHELOCOMA ULTRAMARINA*

Sinopsis.—Analizamos la variación en masa corporal, largode ala, y del culmen en *Aphelocoma ultramarina* con relación a la edad, sexo, mes y año usando regresiones lineares. Todas las medidas fueron tomadas de individuos de sexo y edad conocidos marcados con colores como parte de un estudio a largo plazo en las montañas Chiricahua de Arizona. No se halló variación significativa entre observadores para la masa, pero si para largo de ala y culmen. Por lo tanto, analisis de las últimas medidas se restringieron a datos de un observador. Los machos pesaron más que las hembras. El promedio de masa corporal bajó de invierno a verano. La masa aumentó a traves de los primeros dos años para cada sexo pero no en aves de mayor edad. Los machos tenían alas más grandes que las hembras. El promedio del largo de ala aumentó considerablemente de edad 1 a 2 y aumentó significativamente aún después de edad 2. Los machos tuvieron culmenes significativamente más grandes que las hembras en verano pero no en invierno. Una función discriminante separó los machos de las hembras de primer año en invierno. Se podía distinguir entre los sexos en aves más viejas en verano pero no en invierno.

The Mexican Jay (*Aphelocoma ultramarina*) is a sexually monomorphic corvid with no reliable method of sexing based on external morphology. Although much information is available about variation in measurements of museum specimens (Pitelka 1951), such data are subject to limitations. The age of a bird at the time of collection was typically unknown after the first two years of age. Furthermore, sample sizes in any one population were usually not large and not distributed over many months or seasons. Preserved skins may also shrink by as much as 2–3% (Department of Interior and Department of Fisheries and Environment 1991), and this will confound fine-scale analyses of variation. We have overcome these limitations by using a large data set based on live, color-banded birds of known sex and age, measured over a range of months and years at a single study site. By quantifying body mass, wing chord, and culmen we

examined whether differences between the sexes are more useful for identification of sex than previously thought, at what ages differences based on age disappear, and whether variation is correlated with the month of measurement.

METHODS

Measurements were obtained from a population of Mexican Jays (subspecies *arizonae*) at the Southwestern Research Station of the American Museum of Natural History, Portal, Arizona (31°53'N, 109°12'W). Further details on this population are available elsewhere (Brown and Brown 1990; Brown 1994). The data included in these analyses were collected between January and July, 1969–1994.

Jays were sexed behaviorally. Only females incubate. Their mates were assumed to be males. Unsexed individuals were not used in this paper.

Most birds were banded initially as nestlings or at a stage (0–2 years) when age could be determined reliably. Older birds were captured using traps or nets. All birds were banded with both aluminum and color bands and released. Jays in their first year of age were recognized by retained feathers from juvenal plumage (Pitelka 1945). Some 2-yr-olds could be recognized by retention of juvenile bill coloration at the fleshy corners of the mouth. A few birds were 3-yr old or more when initially banded (5–16% in different years). Some of these birds are likely to be older than the stated age. Birds less than 6-mo old were excluded from our analysis. Individuals were all considered to be hatched on 1 May and were assigned ages they would have had on 1 May of the calendar year of measurement.

Mass was measured using a 300-g Pesola spring scale with the jay in an opaque cloth bag. Wing chord was measured in mm as the chord without flattening the feathers, using a wing rule. Culmen was measured from the tip of the bill to the base of the skull using dial calipers to 0.1 mm.

Variation in mass, wing chord, and culmen was analyzed by multiple linear regression and analysis of residuals from regression equations, following the method of Gosler et al. (1995). All analyses were carried out using SPSS (SPSS Inc. 1993). Age classes and ranges of months were chosen as dictated by sample size. Multiple measurements of a single bird in the same month and the same age class were averaged, so that each bird was represented only once at any stage in its lifetime. Although Mexican Jays have been known to reach nearly 20 years of age (Brown 1994: 11), sample sizes were low for older birds. Hence, older birds were lumped into one age class. Means of measurements by season, sex, month and age are given in Table 1.

A linear equation was obtained for each dependent variable using the independent variables MONTH, SEX (coded as 0 for females and 1 for males) and AGE, and the interaction terms MONTH \times SEX, SEX \times AGE and MONTH \times AGE. Non-significant terms were eliminated using backward regression, thus retaining the maximum number of terms simultaneously contributing to variance in a significant manner. The critical *P*-value for retaining a term in the backward regression algorithm was 0.1,

TABLE 1. Measurements (mean \pm SD, *n*) of Mexican Jays by age and sex.

Age	Mass (g)		Wing chord (mm)		Culmen (mm)	
	Males	Females	Males	Females	Males	Females
Winter: January to March						
1 yr	126.60 \pm 7.73 50	122.07 \pm 6.26 46	158.67 \pm 3.01 6	154.50 \pm 3.87 4	36.80 \pm 1.50 5	33.43 \pm 4.39 4
2 yr	129.32 \pm 6.61 28	124.60 \pm 7.39 25	165.71 \pm 2.69 7	159.00 \pm 2.00 5	37.12 \pm 1.63 7	35.63 \pm 0.60 6
≥ 3 yr	130.97 \pm 5.71 59	127.93 \pm 8.71 61	165.13 \pm 2.59 8	163.44 \pm 3.61 9	36.92 \pm 1.11 13	36.56 \pm 1.58 14
Summer: April to June ^a						
1 yr	120 \pm 6.47 22	117.97 \pm 6.11 32	156.31 \pm 2.91 16	155.52 \pm 3.94 17	36.44 \pm 1.65 17	36.01 \pm 1.27 29
2 yr	128.36 \pm 6.33 11	120.81 \pm 4.50 8	163.00 \pm 2.83 2	160.50 \pm 2.50 5	36.13 \pm 1.01 3	36.43 \pm 1.29 8
≥ 3 yr	128.45 \pm 5.88 70	125.14 \pm 5.94 42	165.71 \pm 2.72 21	162.15 \pm 2.76 13	37.24 \pm 1.38 24	36.44 \pm 1.45 16

^a For mass, summer measurements reported were taken between April and July.

TABLE 2. Final backward regression equation for mass ($n = 454$, $R^2 = 0.194$, $F_{4,449} = 27.07$, $P < 0.001$).

Term	Coefficient	<i>P</i>
Month	-0.852	<0.001
Sex	5.312	<0.001
Age	1.183	<0.001
Sex × age	-0.497	0.047
Constant	122.90	<0.001

to increase the probability of retaining marginally significant effects. The critical *P*-value for all other statistical procedures was 0.05. Visual inspection of histograms of standardized residuals, and of plots of standardized residuals over predicted values, confirmed that assumptions of the linear model were satisfied (Stevens 1992:92–96).

The unstandardized residuals from each of the resulting equations describe variance in the dependent morphometric variable, after controlling for variance accounted for by the independent variables in the equation. These residuals were tested graphically and by ANOVA for differences among observers and years when measurements were taken. Significant differences among some observers were detected for both wing chord and culmen. Hence, to minimize effects of observer error, only the senior author's observations were used for these two variables. There was no effect of year of measurement, hence data from all years were combined for each dependent variable. Further analyses were conducted by entering all independent variables (except the one of interest in that particular analysis) in a linear regression, and examining the residuals from this equation for variation over the independent variable of interest (i.e., the one that was excluded from the regression model in that run). All tests were two-tailed.

RESULTS

Variation in Mass

Age classes were defined as 1 to 9, with 1 to 8 representing ages 1–8-yr old respectively, and 9 representing all birds of 9-yr old or older. The end terms from the backward regression on mass are shown in Table 2.

Seasonal differences in mass.—Both sexes were pooled due to the absence of a MONTH × SEX interaction, yielding the equation in Table 2. Based on this equation, equation (1), shown below, was obtained by leaving out the MONTH term and retaining all the other terms that showed up as significant in the full backward regression equation in Table 2.

$$\text{mass} = 5.626 \text{ SEX} + 1.118 \text{ AGE} - 0.570 \text{ SEX} \times \text{AGE} + 120.370$$

$$(n = 454, R^2 = 0.154) \quad (1)$$

The residuals of this equation are a measure of mass after controlling for the effects of SEX, AGE, and their interaction.

Residual mass (from regression equation 1) declined from winter (Jan-

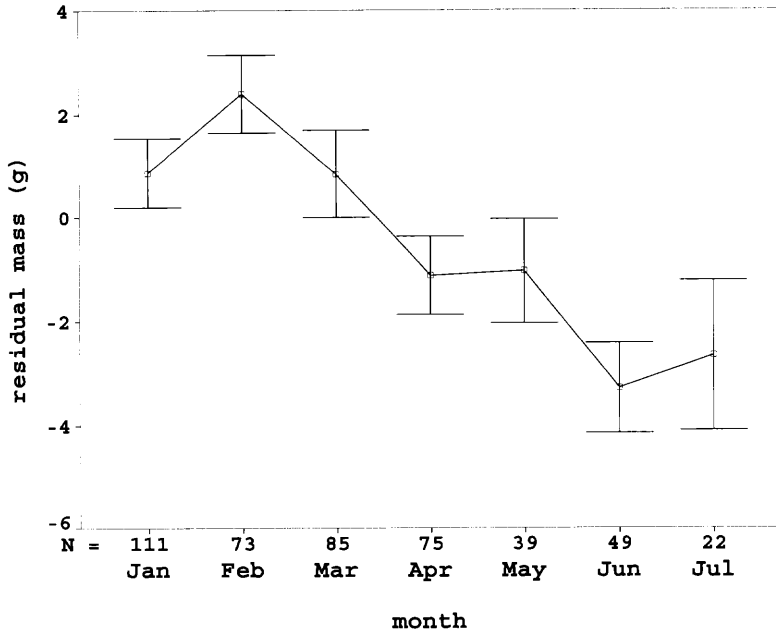


FIGURE 1. Mean (± 1 SE) residual mass variation in Mexican Jays (both sexes combined) from January to July. Residual mass was calculated from the regression equation (1), which controls for variation due to sex and age. Sample sizes are indicated above each month. The y-axis shows the number of grams away from the value predicted by equation (1), which controls for sex and age.

uary, February) to summer (June, July; Fig. 1) and varied among months (ANOVA, $F_{6,447} = 4.93$, $P < 0.001$, Tukey HSD). Residual mass in January, February and March was significantly higher than in June. Residual mass in February was higher than in April and July. The regression of residual mass over month was also significant (residual mass = -0.821 MONTH + 2.632; P -value of regression coefficient < 0.001 , $n = 454$, $R^2 = 0.05$).

Age differences in mass.—Equation (2) was used to control for the effects of MONTH (using logic analogous to that used in deriving equation (1)), and the residuals were analyzed for age-related variation:

$$\text{mass} = -0.648 \text{ MONTH} + 128.183 \quad (n = 454, R^2 = 0.024) \quad (2)$$

Note that in equation (2), the SEX term is not included. Thus, the residuals from this equation are not controlled for the effect of sex. Instead, residual mass was examined for age effects separately for each sex. This was done because of the significant AGE \times SEX interaction in the original backward regression (Table 2).

Mass varied significantly as a function of age (ANOVA of residuals from equation (2) showed a significant overall effect for both sexes; males: $n = 240$, $F_{8,231} = 5.21$, $P < 0.001$; females: $n = 214$, $F_{8,205} = 6.31$, $P < 0.001$;

TABLE 3. Sex differences in mass at each age: *t*-tests on residual mass (from equation (2)) over sex for each age class.

Age in years	<i>n</i>		<i>t</i> -value	<i>P</i>
	Females	Males		
1	78	72	3.52	0.001
2	33	39	3.36	0.001
3	35	27	2.27	0.027
4	13	24	2.69	0.011
5	9	16	0.29	0.772
6	9	17	1.69	0.104
7	16	9	1.59	0.126
8	10	15	1.48	0.154
>8	11	21	0.75	0.458

Fig. 2). Therefore, post-hoc pairwise comparisons using pooled variance estimates were conducted between consecutive age classes, thus enabling larger degrees of freedom. Yearling males had a significantly lower mean residual mass than 2-yr-old males ($t = 3.54$, $df = 231$, $P < 0.001$). This statistical effect of age was also observed in females but would not be significant if all pairwise comparisons between consecutive age classes were done ($t = 2.23$, $df = 205$, $P = 0.027$; Bonferroni-corrected critical *P*-value for eight pairwise comparisons between consecutive age classes was 0.006). No other significant differences between consecutive age classes were found in either sex. A further comparison between yearling and 3-yr-old females revealed significant residual mass differences between these two age classes (pooled variance estimates, $t = -3.941$, $df = 205$, $P < 0.001$; this is significant even with a Bonferroni-corrected critical *P*-value of 0.006 for nine pairwise comparisons). These results suggest an overall increase in mass in females in the first three years of life, but at a slower rate than in males.

When yearling birds were excluded from the analysis, the regression of residual mass over age was non-significant for both sexes. All of the above results suggest that mass increase, at least in males, is most pronounced in the first two years of life.

Sex differences in mass.—Residual masses from equation (2) were also analyzed for sex differences in each age class. Males had significantly higher mean residual mass than females in the first four years of life (Table 3). However, in the older age classes, sex differences in residual mass were not significant, although means for males were higher in all age classes except 5 and 9+ (Fig. 2). The latter must be due to sampling error or measurement error as there is no plausible reason for females to weigh more than males just in two distinct age classes. The trend suggests that males generally weigh slightly more than females, but this effect is less pronounced in older birds.

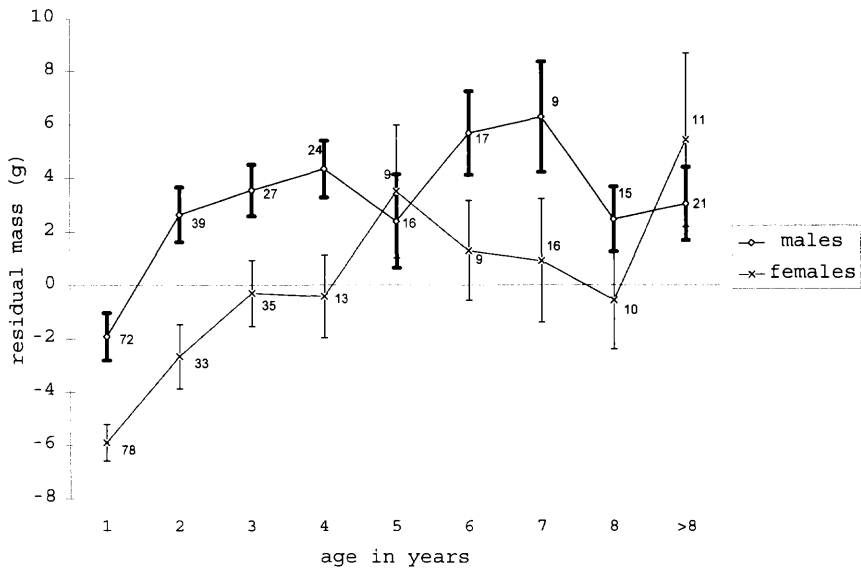


FIGURE 2. Mean (± 1 SE) residual mass variation in Mexican Jays with age. Residual mass was calculated from the regression equation (2), which controls for monthly variation. Sample sizes are indicated next to each data point. The y-axis shows the number of grams away from the value predicted by equation (2), which controls for month.

Variation in Wing Chord

For this analysis age classes were defined as 1–5, with 1, 2 and 3 representing 1-, 2- and 3-yr-old birds respectively, 4 representing 4- and 5-yr-old birds, and 5 meaning birds older than 5 yr. Variation between January and June was considered. The backward regression equation for wing chord (Table 4) shows significant effects of SEX, AGE, and the MONTH \times SEX interaction.

Age differences in wing chord.—Residuals from equation (3) (which controls for SEX and the MONTH \times SEX interaction) showed significant differences over age (ANOVA, $F_{4,112} = 42.501$, $P < 0.001$).

$$\text{wing chord} = 4.844 \text{ SEX} - 0.391 \text{ MONTH} \times \text{SEX} + 158.956 \quad (3)$$

$(n = 117, R^2 = 0.119)$

TABLE 4. Final backward regression equation for wing chord ($n = 117$, $R^2 = 0.583$, $F_{3,113} = 52.71$, $P < 0.001$).

Term	Coefficient	P
Sex	5.556	<0.001
Age	2.145	<0.001
Month \times sex	-0.787	0.002
Constant	153.726	<0.001

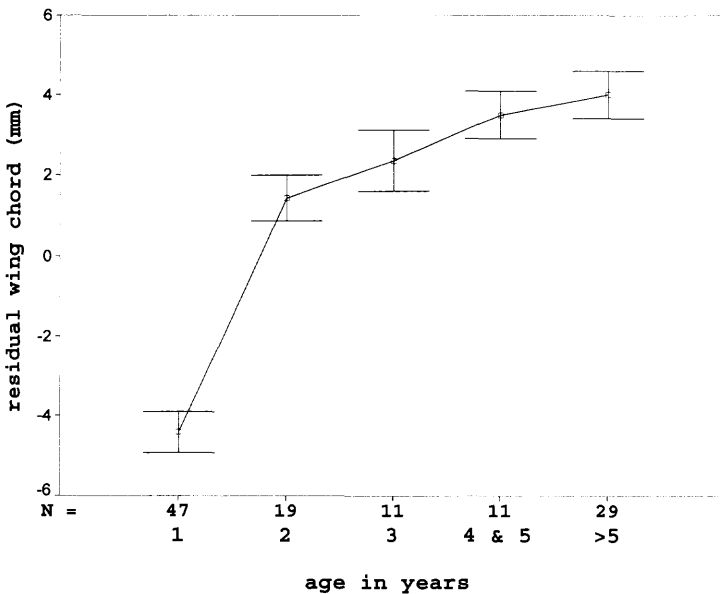


FIGURE 3. Mean (± 1 SE) residual wing chord variation in Mexican Jays (both sexes combined) with age. Residual mass was calculated from the regression equation (3), which controls for sex and the month \times sex interaction. Sample sizes are indicated above each age class. The y-axis shows the number of mm away from the value predicted by equation (3), which controls for sex and month.

Yearlings had significantly shorter residual wing chords than any of the other age classes, and 2-yr-olds also had significantly shorter residual wing chords than age class 5 (Fig. 3). When yearlings were excluded, the regression of residual wing chord on age was still significant (residual wing chord = $0.863 \text{ AGE} - 0.238$; P -value of regression coefficient = 0.0013, $n = 69$, $r^2 = 0.142$, Tukey HSD). This suggests that mean wing chord increases with age after the first year of life as well.

Sex differences in wing chord.—Due to the MONTH \times SEX interaction, the residuals from equation (4) (which controls for AGE) were examined for sex differences in two seasons: winter (defined as January–March) and summer (April–June):

$$\text{wing chord} = 2.144 \text{ AGE} + 155.061 \quad (n = 117, R^2 = 0.48) \quad (4)$$

Mean residual wing chords were significantly higher for males than for females in winter (14 males, 9 females, $t = 4.14$, $df = 21$, $P < 0.001$; difference between means = 6.154) as well as in summer (46 males, 48 females, $t = 2.4$, $df = 92$, $P = 0.019$, difference between means = 1.59). The MONTH \times SEX interaction does not appear to have any biological significance.

Variation in Culmen.—Age classes were defined as 1–4, with 1, 2, and 3

TABLE 5. Final backward regression equation for culmen ($n = 146$, $R^2 = 0.158$, $F_{5,140} = 5.14$, $P < 0.001$).

Term	Coefficient	<i>P</i>
Month	6.091	0.003
Sex	17.786	0.006
Age	8.611	0.006
Month \times sex	-2.629	0.099
Month \times age	-1.449	0.047
Constant	330.311	<0.001

representing the corresponding ages, and 4 representing all older birds. Measurements taken between January and June have been included. Table 5 shows the significant terms from the backward regression on culmen. The variables MONTH, SEX, AGE and their interactions accounted for 15.5% of the variation in culmen length.

Although MONTH and AGE both show up as significant in both main effects and interaction terms for culmen, analysis of residuals did not reveal any consistent patterns. Mean residual culmen lengths were not examined statistically over month because of low sample sizes (≤ 5) in some cells.

Sex differences in culmen length.—The residuals from equation (5) were analyzed for sex differences:

$$\text{culmen} = 1.195 \text{ AGE} + 0.234 \text{ MONTH} \times \text{AGE} + 360.78 \quad (5)$$

$(n = 146, R^2 = 0.052)$

The analysis was conducted separately for summer and winter because of the MONTH \times SEX interaction. The residual culmen lengths were not significantly different between the sexes in winter (January–March, $t = 1.78$, $df = 29$, $P = 0.086$), but males have significantly longer culmens than females in summer (April–June, $t = 2.11$, $df = 113$, $P = 0.037$).

Discriminant analysis.—Discriminant functions for sex were constructed using the variables mass, culmen, and wing-chord. This was done to see if the sexually dimorphic morphometric variables might prove useful for future identification of sex. Separate discriminant functions were derived for yearlings and older (age 3 yr and above) birds. Only birds of known sex, measured by one observer (J. L. Brown), were included. To control for seasonal effects, two discriminant functions were derived for each age category: one for winter (January–March), and the other for summer (April–June).

For yearling birds in winter, the following discriminant function was derived:

$$F = -0.032 \text{ Mass} + 0.459 \text{ Wing chord} + 0.033 \text{ Culmen} - 80.036$$

\times (Wilks' Lambda = 0.211, chi-square approximation = 8.545,
 $df = 3$, $P = 0.036$).

A yearling jay would be classified as male if $F \geq -0.190$, and as a female otherwise. In a jackknifing procedure applied to this sample, each individual was left out in turn and a discriminant function based on the remaining subsample was applied to the one individual left out; all five males and three of four females were classified correctly. However, for summer yearling birds, the Wilks' Lambda associated with the discriminant function was non-significant. Older birds in winter also did not yield a statistically significant discriminant function, but birds in summer could be well discriminated using the following function:

$$F = -0.085 \text{ Mass} + 0.384 \text{ Wing chord} + 0.056 \text{ Culmen} - 72.68$$

$$\times (\text{Wilks' Lambda} = 0.443, \text{ chi-square approximation} = 20.75,$$

$$\text{df} = 3, P < 0.001).$$

By this function, a jay is classified as a male if $F \geq -0.189$, and as a female otherwise. After jackknifing we found that 15 out of 17 (88.2%) males and 11 out of 12 (91.7%) females were correctly classified.

DISCUSSION

Seasonal variation.—Higher body mass of birds in winter has been reported by various authors (e.g., Haftorn 1989; also see summary in Baldwin and Kendeigh 1938). Storage of fat during times of food scarcity is presumed to account for this trend.

Our results suggest that culmen length may increase significantly from winter to summer. Seasonal variation in bill length, correlated with changes in food composition, has been reported in several species of birds (Davis 1954, Morton and Morton 1987). Mexican Jays feed mainly on acorns and pinyon nuts in the winter and on arthropods and lizards in summer (Brown 1994). The higher mechanical abrasion caused by the winter diet and digging to recover stored food may cause wearing down and consequent shortening of the bill tip in winter, which is offset by growth during summer. However, no such trend was observed on closer analysis of residuals. Higher sample sizes might yield a clearer trend. Mean culmen length was not significantly different between the sexes in winter, but it was in summer. This suggests different rates of seasonal bill growth in the two sexes.

Age effects.—For both mass and wing chord, age effects are most pronounced in the first two years of life. The correlation in age-related patterns between these two variables suggests a higher overall growth rate over the first two years. Significant sex differences in residual mass disappeared after the first 4 years. No plausible explanation exists for this trend.

Alatalo et al. (1984) proposed that short wings in early life increase maneuverability, which aids in predator avoidance and increases efficiency of prey capture at this vulnerable stage in the life cycle. Predation of jays by raptors and mammals is common in our population. Shorter wings in juveniles are not likely to be an adaptation for prey capture. The diet of

Mexican Jays consists principally of acorns, pinyon nuts, arthropods and lizards (Brown 1994), which do not require much agility of flight to gather. Aerial flycatching is rare. Wear on the tips of primaries of nestlings due to abrasion with the nest wall may also be responsible for shorter wing chords in yearlings, since Mexican Jays retain their remiges through the first prebasic molt (Pitelka 1945). Hence yearlings at the time of observation have the same primaries that they do as nestlings.

Sex differences.—There was significant sexual dimorphism in all three characters examined, with males having larger values. The discriminant functions for yearlings in winter and adults in summer, although based on small sample sizes, correctly classified all but four of the 38 birds. This suggests that, with additional data, it will be possible to sex these plumage-monomorphic birds morphometrically with confidence.

The independent variables in the complete regression equations for mass and culmen account for only 19.4% and 15.8% respectively of the total variance in these measurements, whereas they explain as much as 58.3% of the total variance in wing chord length. It is possible that more variance could be explained by substituting the MONTH variable with factors that mirror environmental changes more precisely, like ambient temperature or food availability. It is noteworthy that the effect of MONTH is not significant for wing chord, for which the highest amount of variance is explained.

General discussion.—Although observer effects have been minimized where necessary by taking only one observer into account, within-observer measurement error may account for some variance. However, this can be expected to be randomly distributed over all ages, sexes and seasons, and hence should not confound the analysis.

Body mass of birds is known to increase significantly over the course of the day (e.g., Haftorn 1989, Kontogiannis 1967), and this is also true for the Mexican Jay (G. Keys and J. Brown, unpubl. data). Unfortunately, because time of day was not included in our data set, this variable could not be considered; however, most banding operations were conducted in the morning.

It is also obvious that some of the relationships are not linear. Specifically, age effects are more pronounced in the first two years of life, and level off subsequently. Curvilinear models would have yielded higher R^2 values, but were not developed, as the objective of this study was description of patterns of variation, rather than development of a predictive model.

We now compare our results based on live birds with those reported by Pitelka (1951) for study skins of *A.u. arizonae*. Pitelka observed that females were usually smaller than males in all measurements by 4–5%. This result is in agreement with our conclusions. In his study, wing measurements were shorter for first-year males compared to adults of either sex. He did not address sexual dimorphism in wing length per se. In our study, first year birds of both sexes were found to have shorter wing chords than adults. Mean wing chord increases in length through subsequent

years at a slower rate. The birds are also sex dimorphic with respect to wing chord. Pitelka concluded that there was no significant age-related variation in mass in either sex in this genus. He also did not feel that seasonal variation would be significant in this non-migratory species. His sample sizes for mass data in populations of *A.u. arizonae* were small and did not permit any statistical inferences. In contrast, our study has shown clear trends in mass that are related to age, sex and season. Lastly, he did not look at variation in culmen length within populations, whereas we found such variation between the sexes, with the possibility of seasonal and age effects as well.

ACKNOWLEDGMENTS

We thank the Southwestern Research Station of the American Museum of Natural History and landowners Barrett, Cazier, and Mendez for permission to work on their property. We are grateful for long-term financial support from the U.S. National Science Foundation and the U.S. National Institutes of Mental Health. Above all we thank the many field assistants who have worked on this project over its 28 year history. For comments and advice on statistics we thank G. Robinson, T. Caraco, D. Lemmon, E. R. Brown, J. Jaccard, G. Alliger, J. D. Rising, and S. H. Li.

LITERATURE CITED

- ALATALO, R. V., L. GUSTAFFSON, AND A. LUNDBERG. 1984. Why do young passerine birds have shorter wings than older birds? *Ibis* 126:410-415.
- BALDWIN, S. P., AND S. C. KENDEIGH. 1938. Variations in the weight of birds. *Auk* 55:416-467.
- BROWN, J. L. 1994. Mexican Jay. Pp. 1-16, in A. Poole and F. Gill, eds. *The Birds of North America*, No. 118. Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, DC.
- AND E. R. BROWN. 1990. Mexican Jays: uncooperative breeding. Pp. 268-288, in P. B. Stacey and W. D. Koenig, eds. *Cooperative breeding in birds: long-term studies of ecology and behavior*. Cambridge University Press, Cambridge, United Kingdom.
- DAVIS, J. 1954. Seasonal changes in bill length of certain passerine birds. *Condor* 56:142-149.
- DEPARTMENT OF INTERIOR, USFWS, AND CWS DEPARTMENT OF FISHERIES AND ENVIRONMENT. 1991. *North American Bird Banding Manual*, Vol. II. U.S. Government Printing Office, Washington, DC.
- GOSLER, A. G., J. J. D. GREENWOOD, AND C. PERRINS. 1995. Predation risk and the cost of being fat. *Nature* 377:621-623.
- HAFORN, S. 1989. Seasonal and diurnal body weight variations in titmice, based on analyses of individual birds. *Wilson Bulletin* 101:217-235.
- KONTOGIANNIS, J. E. 1967. Day and night changes in body weight of the White-throated Sparrow, *Zonotrichia albicollis*. *Auk* 84:390-395.
- MORTON, M. L., AND G. A. MORTON. 1987. Seasonal changes in bill length in summering Mountain White-crowned Sparrows. *Condor* 89:197-200.
- PITELKA, F. A. 1945. Pterylography, molt, and age determination of American jays of the genus *Aphelocoma*. *Condor* 47:229-260.
- . 1951. Speciation and ecologic distribution in American jays of the genus *Aphelocoma*. *University of California Publications in Zoology* 50:195-464.
- SPSS INC. 1993. *SPSS for Windows*, Release 6.0., 6.0 ed. SPSS, San Francisco.
- STEVENS, J. 1992. *Applied Multivariate Statistics for the Social Sciences*, 2nd ed. Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Received 9 Sep. 1996; accepted 12 Feb. 1997.