Wilson Bull., 105(4), 1993, pp. 597–603

RELATIONSHIP OF AGE AND SEX TO SIZE AND COLOR OF EASTERN PHOEBES

Kelvin F. Conrad[1,2] and Raleigh J. Robertson[1]

Abstract.—We recorded variation in body size and ventral plumage coloration in a population of individually marked Eastern Phoebes (*Sayornis phoebe*). The venter of Eastern Phoebes is mostly gray with gray mottling on the breast. Most birds have a white bib which, although usually small, may cover much of the breast and abdomen. We found no significant difference in percentage gray area between males and females, but after-second-year (ASY) birds had significantly less gray on their breasts than second-year (SY) birds. Males had significantly longer mean wing lengths, tarsal lengths, and vent–tail lengths than females. There was considerable overlap of wing, tarsal, and vent–tail lengths between the sexes, but the size differences held both overall and separately in SY and ASY birds. We generated a discriminant function which correctly classified 79% (39/49) of females and 95% (22/23) of males. Despite their similar appearance, male Eastern Phoebes are larger than females, at least in the parameters we measured. *Received 2 Nov. 1992, accepted 6 April 1993.*

The plumage of male and female Eastern Phoebes (*Sayornis phoebe*) appears similar, making sex identification difficult at a distance. Phoebes also have no distinct second year (SY) plumage which makes age classes difficult to distinguish. Phoebes may be aged in the hand by feather wear (Pyle et al. 1987) and may be sexed during the breeding season by the presence of a cloacal protuberance or brood patch. Voice and behavior are unreliable for sexing because females are often aggressive to conspecifics and can sing "male" territorial song (Smith 1969, pers. obs.), although only the female incubates. Phoebes cannot be sexed by external examination outside the breeding season.

There have been only two published studies of Eastern Phoebes that used individually marked birds (Middleton and Johnson 1956, Klaas 1975) and little is known about individual variation in color and size and how it relates to age and sex. As a precursor to understanding social interactions among age classes of Phoebes, we wanted to document differences in plumage color between age classes. We recorded variation in body size and ventral coloration in a population of individually marked Eastern Phoebes. We sought patterns of size or coloration that we could later relate to behavioral patterns, such as mate choice, and that could also serve as a means of aging and sexing Eastern Phoebes in the field. We here report the results of our study.

[1] Dept. of Biology, Queen's Univ., Kingston, Ontario, Canada K7L 3N6.
[2] Dept. of Biology, Acadia Univ., Wolfville, Nova Scotia, Canada B0P 1X0.

METHODS

We studied Eastern Phoebes from 1988 to 1990 near the Queen's Biological Station, Chaffeys Locks, Ontario, Canada (44°34'N, 76°19'W). We captured phoebes in mist nets during the breeding season and banded them with Canadian Wildlife Service leg bands. We banded 109 birds and captured 19 females and one male twice within a season. Birds were banded from the beginning of May to the middle of July, and only breeding birds were captured. We aged Eastern Phoebes as second year (SY) or after second year (ASY) according to the wing-wear criteria of Pyle et al. (1987). Birds we could not age with certainty were considered after hatch year (AHY). The AHY class, therefore, contained both SY and ASY birds. 24 AHY, 43 SY, and 11 ASY females and 10 AHY, 10 SY, and 11 ASY males were banded.

In 1989, sketches of captured Eastern Phoebes were made to record variation in ventral coloration. We held birds in direct sunlight in a standard position while an assistant sketched the pattern of breast and abdomen coloration on a egg-shaped template. Eastern Phoebes are mostly gray with lighter, gray-mottled breasts. Most birds have a white bib which, although usually small, may cover much of the breast and abdomen. The lower part of the abdomen is often tinted yellow. Our assistant was asked to delineate, with single, solid lines, the areas of gray (including gray-mottled), white and pale yellow. In order to reduce possible bias, we did not tell our assistant the reason for making the sketch. We used a graphics tablet and digitizing software to find the percentage of the total area of the template designated gray, white and pale yellow for each bird. We estimated percentage gray for 45 individuals. Seventeen of these birds had to be assigned to the AHY class and were excluded from further color analyses. After arcsine-transforming to normalize the percentage values (Sokal and Rohlf 1981), we performed a two-way analysis of variance (ANOVA) of percentage gray with sex and age class as grouping factors to see if the area of gray differed among age and sex groups.

We measured wing, tarsal, and vent–tail length with a metal ruler which had an upright stop affixed at 0 mm. Tarsal lengths were not recorded in 1988. We measured wing length by holding the wing in a natural position with its bend against the ruler stop and its length flattened along the ruler. We measured tarsal length by bending the foot at the intertarsal joint and the leg at the tibiotarsal joint, placing the ruler stop firmly against the tibia and reading the length to the bend in the foot (Alatalo et al. 1984). We measured vent–tail length as the distance from the center of the vent to the ends of the longest (outer) rectrices. This is not the "standard" measure of tail length, which includes only the length of the feathers, but was used because it was convenient to make in the field with minimal handling of the bird. Where two measurements of body-size parameters were obtained for a single female within a season, mean differences (±SE) between successive measurements of wing length ($N = 19$), tarsal length ($N = 17$), and vent–tail length ($N = 18$) were 0.37 ± 0.46 mm, 0.01 ± 0.22 mm and 0.21 ± 1.2 mm, respectively. We used only the first measurements obtained for each bird in our analyses. After testing each morphological character using ANOVA, we applied Fisher's linear discriminant function analysis (DFA) to all the characters to provide a method of identifying the sex of an individual. All statistical analyses were performed using the SYSTAT® statistical package in accordance with Wilkinson (1990).

RESULTS

The largest portion of an Eastern Phoebe's venter is gray, and, therefore, gray is easiest to measure. We chose to use percentage gray for our analysis of coloration. The area of gray is inversely proportional to the area of

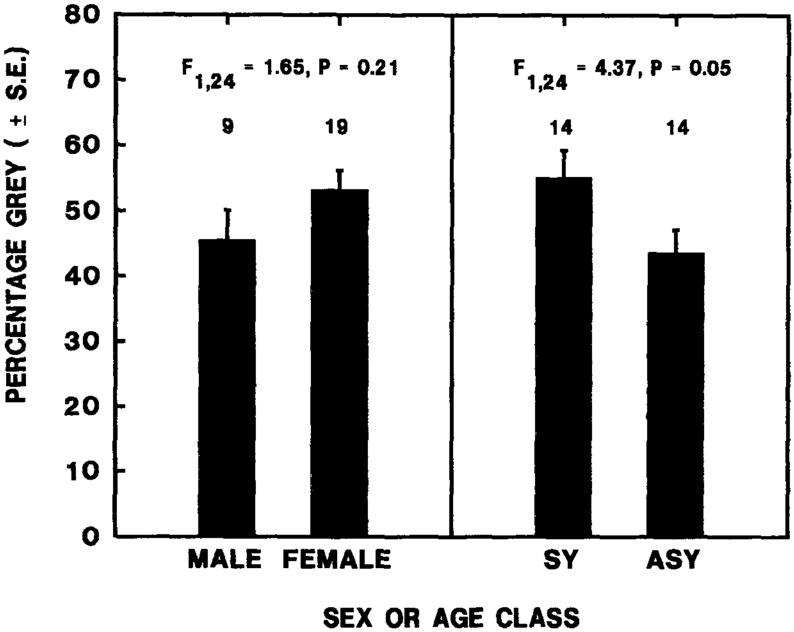

FIG. 1. Results of a two-way ANOVA of the effect of age (SY and ASY only) and sex on percentage of chest area that is gray. Percentage gray is significantly different between SY and ASY birds (arcsine-transformed data) but not between the sexes. The interaction of sex and age is also not significant ($F = 2.64$, df $= 1, 24$, $P = 0.12$). Inverse-transformation means and standard errors are plotted. Sample sizes for the comparisons appear above the bars.

white (Pearsons $r = -0.68$, df $= 43$, $P < 0.001$). We found no significant difference in percentage gray between males and females, but ASY birds had significantly less gray on their breasts than SY birds (Fig. 1).

We used two-way ANOVAs of SY and ASY birds to examine the relationship between age class, sex, and each of the three size parameters measured. There were no differences between age classes, but males were significantly larger in all three parameters (Table 1). Males also had significantly longer mean (±SE, N) wing lengths (86.8 ± 0.4, 31 vs 82.1 ± 0.3 mm, 76), tarsal lengths (20.0 ± 0.2 vs 19.2 ± 0.1 mm) and vent-tail lengths (75.6 ± 0.7 vs 72.7 ± 0.4 mm) than females when age classes were combined (Fig. 2). Although the means were significantly different, there was a great deal of overlap between the sexes in distributions of the three parameters (Fig. 2).

We first applied DFA to a model using wing, tarsal, and vent–tail lengths. This model fitted significantly (Wilk's Lambda 0.495, $F = 22.2$,

TABLE 1

COMPARISON (LEAST-SQUARES MEAN ± SE, N) USING TWO-WAY ANALYSES OF VARIANCE OF WING, TARSAL AND VENT–TAIL LENGTHS BETWEEN SY (SECOND YEAR) AND ASY (AFTER SECOND YEAR) MALE AND FEMALE EASTERN PHOEBES

	Female		Male		ANOVA[a]	Age × Sex		Age		Sex	
	SY	ASY	SY	ASY	df	F	*P*	F	*P*	F	*P*
Wing	81.6 ± 0.4, 43	83.0 ± 0.7, 11	87.5 ± 0.8, 10	86.8 ± 0.7, 11	1,71	2.74	0.10	0.31	0.58	53.0	0.00
Tarsus	19.3 ± 0.2, 27	19.6 ± 0.3, 8	20.4 ± 0.3, 7	20.0 ± 0.3, 10	1,48	1.42	0.15	0.06	0.78	5.28	0.01
Vent–tail	73.1 ± 0.6, 42	74.1 ± 1.0, 10	76.6 ± 1.0, 10	76.6 ± 1.2, 9	1,67	0.24	0.63	0.20	0.66	8.06	0.01

[a] Degrees of freedom for age, sex and the interaction in a two-way ANOVA using age and sex as grouping factors.
[b] Interaction term of two-way ANOVA.

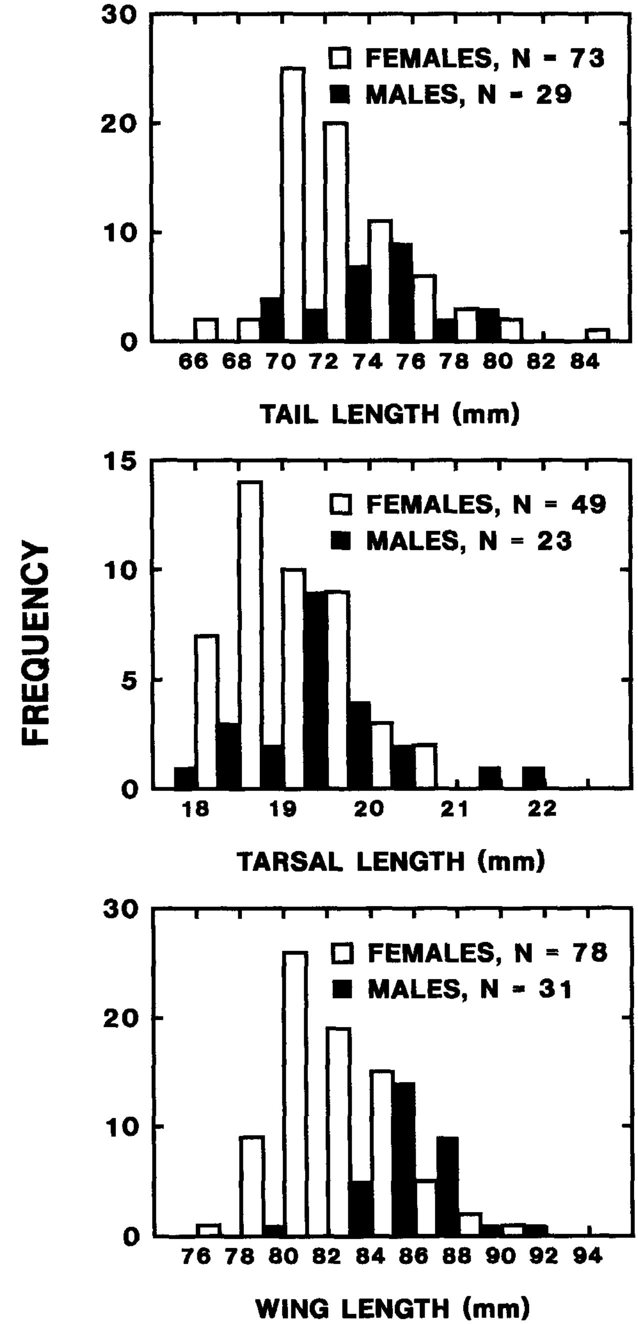

FIG. 2. Frequency distributions of male and female wing, tarsal, and vent–tail measurements. Males had significantly longer wings (t = 8.64, df = 107, $P < 0.001$), tarsi (t = 3.82, df = 70, $P < 0.001$), and vent–tail lengths (t = 3.88, df = 100, $P < 0.001$).

df = 3, 65, $P < 0.001$). However, vent–tail length had little influence (standardized canonical correlation = 0.004) and was difficult to measure in the field. A simpler model, using only wing and tarsal lengths also provided a significant fit (Wilk's Lambda 0.49, $F = 35.3$, df = 2, 69, $P < 0.001$) and resulted in the discriminant function: G = 0.872 (wing length) + 0.615 (tarsal length) − 77.97.

A value of G > 0, indicated the individual was male and a value of G ≤ 0, indicated the individual was female. This function correctly classified 79% (39/49) of females and 95% (22/23) of males, only one female less than the DFA model that included vent-tail length.

DISCUSSION

The amount of gray on an Eastern Phoebe's venter decreases with age, at least between second and later years. Much of the gray is replaced by white, particularly on the upper portion of the breast. Presumably this color change occurs during the second prebasic molt. This molt takes place during July and August, and all body and flight feathers are replaced (Pyle et al. 1987). All but one of the birds we obtained color data for was banded before 1 July, so we do not know how quickly the gray area changes during the molt.

The white bib of ASY phoebes is a conspicuous part of what is otherwise a rather dull gray plumage. Further research is needed to determine if the white area of a Phoebe's breast serves any social function, such as a signal of status. It seems unlikely that the decrease of gray with age could be related to female mate choice, because the amount of gray did not differ between the sexes within age classes. With the exception of the Scissor-tailed Flycatcher (*Tyrannus forficatus*), in which subadults of both sexes have plumage subtly different from adult birds, we are unaware of documented examples of age-related differences between subadult and adult plumages among other North American flycatchers. Further study of age-related plumage differences in Eastern Phoebes and other flycatchers could provide enlightening contrasts with species that display sex-specific delayed plumage maturation (e.g., Black-headed Grosbeaks, [*Pheucticus melanocephalus*], Hill 1988).

The group classification function from our DFA did mis-classify 15% of our sample, and we note that these functions have not been validated with an independent data set. Furthermore, the population sampled comes from only one site near the north-eastern extreme of the rather extensive range of Eastern Phoebes. Samples from throughout the range need to be studied. For the time being, the DFA results do serve to emphasize the fact that, despite their similar appearance, male Eastern Phoebes are larger than females, at least in the parameters we measured. There is considerable overlap of wing, tarsal, and vent–tail lengths between the sexes, but the size difference holds in both SY and ASY birds. In addition to being a potential method for sexing non-breeding birds, this difference in size could also influence behavioral interactions.

ACKNOWLEDGMENTS

We thank Jennifer Magwood, Saul Schneider, and Lorraine Standing for assistance in the field. Comments from T. B. Herman, N. K. Johnson, C. Thompson, K. G. Beal, and P. Pyle improved the manuscript. This research was supported by a Natural Sciences and Engineering Research Council Scholarship and a Sigma Xi Grant-In-Aid to KFC, and by an NSERC operating grant to RJR. We are very grateful to the cottagers and landowners along the shores of Lake Opinicon, Ontario, for their assistance and cooperation with this project.

LITERATURE CITED

ALATALO, R. V., L. GUSTAFSSON, AND A. LUNDBERG. 1984. High frequency of cuckoldry in pied and collared flycatchers. Oikos 42:41–47.

HILL, G. E. 1988. The function of delayed plumage maturation in male Black-headed Grosbeaks. Auk 105:1–10.

KLAAS, E. E. 1975. Cowbird parasitism and nesting success of the eastern phoebe. Occas. Pap. Mus. Nat. Hist. Univ. Kans. 41:1–18.

MIDDLETON, D. S. AND B. J. JOHNSON. 1956. The Michigan Audubon Society phoebe study (part I): a study of the phoebe in Macomb County. Jack-Pine Warbler 34:63–66.

PYLE, P., S. N. G. HOWELL, R. P. YUNICK, AND D. F. DESANTE. 1987. Identification guide to North American passerines. Slate Creek Press, Bolinas, California.

SMITH, H. G., H. KÄLLANDER, K. FONTELL, AND M. LJUNGSTRÖM. 1988. Feeding frequency and parental division of labour in the double-brooded great tit *Parus major*. Effects of manipulating brood size. Behav. Ecol. Sociobiol. 22:447–453.

SMITH, W. J. 1969. Displays of *Sayornis phoebe* (Aves, Tyrannidae), Behavior 33:283–322.

SOKAL, R. R. AND J. ROHLF. 1981. Biometry (2nd ed.). W. H. Freeman and Company, San Francisco, California.

WILKINSON, L. 1990. Systat: the system for statistics. Systat Inc., Evanston, Illinois.