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Wilson Bull., 103(3), 1991, pp. 497–500

Body measurements of Boreal Owls in Idaho and a discriminant model to determine sex of live specimens.—The recognized distribution of Boreal Owls (*Aegolius funereus*) in North America has expanded significantly in the past seven years (Palmer and Ryder 1984, Hayward et al. 1987, O'Connell 1987, Stahlecker and Rawinski 1990). As interest in the Boreal Owls of the western United States increases and population studies become important in assessing species status, reliable identification of sex and age will be useful. Here we report the body measurements of 58 adult Boreal Owls captured in Idaho and describe a discriminate model for sexing the birds.

During studies of Boreal Owl habitat use in 1980–1987, we captured and measured 14 male and 11 female Boreal Owls in Chamberlain Basin of the Frank Church—River of No Return Wilderness of central Idaho. We captured the owls at night, on bal-chatri traps or in mist nets at calling sites during winter and spring. We recaptured and remeasured some individuals when their radio-transmitters needed replacing. During an associated investigation evaluating nest boxes as a tool to monitor Boreal Owl populations, we captured and measured eight males and 24 females at nest boxes near McCall, Idaho from 1988–1990. We captured an additional female at a nest box in northern Idaho in 1989.

Because the owls at Chamberlain Basin were radio marked, we could observe their behavior during courtship and nesting and thereby determine each bird's sex. Owls observed singing the staccato song (Bondrup-Nielsen 1984) and/or seen delivering prey to a nest cavity occupied by another Boreal Owl were classified as males. Owls that incubated eggs, brooded young, or otherwise occupied a cavity day and night for at least a week were classified as females (Mikkola 1983). Similarly, owls captured during the nest box study were classified by behavior.

We weighed owls with a 300-g Pesola scale to the nearest g. A wing tracing was made without overextending the wing and its area was measured using a planimeter. We recorded wing length (wing chord) as the distance from the carpal region of the bent wing to the tip

TABLE 1

BODY MEASUREMENTS OF BOREAL OWLS IN IDAHO. SAMPLE INCLUDES 58 INDIVIDUALS WITH REPEATED MEASURES OF SOME BIRDS CAPTURED MORE THAN ONCE OVER FIVE YEARS

Variable	Male				Female			
	Mean	SE	Range	N	Mean	SE	Range	N
Weight (g)	117.3	1.39	93–139	(50)	166.8	2.46	132–215	(53)
Bill (mm)	12.7	0.112	11.2–14.0	(40)	13.5	0.094	11.8–14.6	(42)
Wing area (cm^2)	237.2	2.92	199–272	(35)	269.3	3.58	229–299	(28)
Wing loading (g/cm^2)	0.50	0.011	0.36–0.66	(33)	0.62	0.011	0.49–0.75	(28)
Wing length (mm)	172.5	0.58	163–179	(41)	183.6	0.72	174–198	(49)
Eighth primary (mm)	134.4	0.57	127–141	(35)	142.9	0.56	134–150	(43)
Alula (mm)	48.6	0.41	41–53	(41)	52.5	0.56	41–60	(48)
Tail (mm)	99.9	0.54	91–107	(44)	106.0	0.69	95–117	(45)
Foot (mm)	34.0	0.15	32–35	(22)	36.7	0.34	33–39	(23)

of the longest primary without flattening the wing (Pettingill 1970:448). We measured the tail, alula, and eighth primary (the longest) by slipping a ruler under the feather to its base. We did not flatten the eighth primary but did for the alula and tail. Bill was measured with calipers from the tip to the top of the nostril. We did not measure to the cere (Pettingill 1970:447) because that measurement varied due to injuries. We measured feet by stretching diagonal toes open and measuring from the tips of the pads (i.e., talon excluded).

Boreal Owls are one of the most dimorphic owls (Earhart and Johnson 1970, Mueller 1986, Norberg 1987). Our results confirm substantial differences in body measurements between sexes (Table 1). Mean mass, bill length, alula, eighth primary, wing length, wing area, tail length, and foot length for females exceeded those for males (t-test, $P < 0.0005$ for all measures). We did not find a difference in mean weight of male or female owls between summer and winter seasons (t-tests, $P = 0.15$, male; $P = 0.324$ female). Here we define summer as 1 May–1 November.

Our measurements fall within the ranges reported by other authors, although we found significant differences in mean values for some morphological measurements (measures of variance were not published in many cases, so tests of differences are not possible in all cases). Korpimaki (1981) reported tail lengths. His averages were 105.3 mm for males (N = 27) and 109.6 mm for females (N = 106) which were larger than ours (t-test, $P < 0.0001$, $P = 0.006$, respectively). Dement'ev and Gladkov (1954) reported wing lengths but not standard deviations for four Russian subspecies. Males averaged 163 mm (*A. f. funereus*) (N = 21), 166.2 mm (*A. f. sibiricus*) (N = 19), 180 mm (*A. f. magnus*) (N = 6), and 165 mm (*A. f. pallens*) (N = 3). Females averaged 174.7 mm (N = 34), 176.1 mm (N = 23), 187 mm (N = 3), and 167 mm (N = 3) for the respective subspecies. Earhart and Johnson (1970) reported wing lengths of museum specimens for North American Boreal Owls which averaged 161.5 mm for males (N = 10) and 174.4 mm for females (N = 5). Our wing lengths were larger than those of Earhart and Johnson ($P < 0.0001$ for both sexes), however, the difference could be due to shrinkage of museum specimens (Mueller 1986). Finnish Boreal Owls captured at nests also had shorter wing lengths (male $\bar{x} = 168.3$, N = 27; female $\bar{x} = 175.5$, N = 106; Korpimaki 1981) than the Idaho population ($P < 0.0001$ for both sexes).

Male weights reported by other authors are: 116 g (*A. f. funereus*) (N = 1) and 109 g (*A.

f. magnus (N = 1) from the Soviet Union (Dement'ev and Gladkov 1954); 116–133 g from Europe (Geroudet in Mikkola 1983); 92–115 g ($\bar{x}$ = 102.1 g, N = 28) from Finland (Korpimaki 1981); and 85–119 g ($\bar{x}$ = 101.6 g, N = 5) for North America (Earhart and Johnson 1970). Female weights from other populations are 177 g and 197 g (*A. f. funereus*) (Dement'ev and Gladkov 1954); 150–197 g (Geroudet in Mikkola 1983); $\bar{x}$ = 170.3 g (N = 157) (Korpimaki 1981); and $\bar{x}$ = 139.5 g (N = 4) (Earhart and Johnson 1970). The weights reported by Earhart and Johnson (1970) are significantly less than mean weights for Idaho male and female Boreal Owls (*t*-test, $P = 0.0006$, $P = 0.0012$, respectively). Weights of female owls in Finland, however, were similar to the Idaho population (*t*-test, $P = 0.2428$), while Finnish males were smaller than the Idaho population (*t*-test, $P < 0.001$).

To develop an objective classification of Boreal Owl sex, we performed a discriminant analysis (Johnson and Wichern 1982). To define the initial discriminant function, we included one set of measurements for each owl captured at Chamberlain Basin (N = 25) and a random sample of half the owls caught during the nest box studies (N = 16). Two data sets were used to assess the performance of the discriminant function in classifying the sex of Boreal Owls. One test data set (Test I) included the original sample used to form the discriminant model. The second test data set (Test II) included the remaining Boreal Owls captured at nest boxes near McCall, Idaho (N = 16) and repeated measures of owls captured at Chamberlain Basin (N = 22). We feel the repeat measurements from owls at Chamberlin add valuable data to the test. Although these data were not completely independent of the initial classification data, they did incorporate measurement variation, which although frequently ignored as a source of error, is quite large (Mueller 1986). Furthermore, many of these owls were recaptured in different years, and variation between measurements on individual owls was similar to variation among owls. For example, tail length of one female ranged from 100 to 112 mm, a large proportion of the range for all females 95–117 mm.

Wing area, foot length, and eighth primary length were the most difficult measures to take from live birds. Therefore, we excluded these measures from the model. Because weight can vary with time of day, prey population conditions, and weather conditions, we felt the best classification system should also exclude weight. A male measured twice in 14 days lost 23 g, illustrating the degree of fluctuation in this measurement.

No single variable or combination of two or three variables (excluding weight) produced a satisfactory classification. Using wing length (wing), bill length (bill), alula length (alula), and tail length (tail), a linear discriminant model correctly classified all but one owl in both Test I and Test II. Both individuals were males. Because the model correctly classified >95% of the test owls, including 96.9% of the observations which were not used to develop the discriminant model (Test II), we considered the model satisfactory.

The linear equations used to identify sex based on this model are: female discriminant score (DS) = (16.12wing) + (6.78tail) + (39.11bill) + (4.25alula) − 2198.64; male DS = (15.35wing) + (6.25tail) + (36.83bill) + (3.98alula) − 1965.11. The higher score represents the sexual classification.

The classification model described above requires body measurements which may not have been taken for Boreal Owls in other studies. We therefore offer a second model based on three common measurements. This model must be used with caution because it includes owl weight as a variable.

The linear equations used to identify sex based on this model are: female DS = (1.82weight) + (15.46wing) + (30.06bill) − 1766.45; male: DS = (1.52weight) + (14.41wing) + (27.97bill) − 1510.91. The higher score identifies the owl's sex. This model achieved 100% correct classification of both test data sets, and separation between groups (generalized squared distance = 27.4) was very high.

Because our discriminant classifications are based on only two populations, they must be used with caution at increasing distances from our study site. Molting birds cannot be sexed using these functions, so biologists should carefully examine birds captured in late summer and autumn.

Acknowledgments.—We thank L. Flaccus, P. Heekin, A. Wright, and D. Zebley for assistance capturing owls, and J. Duncan, D. Holt, C. Marti, and anonymous reviewers for comments on the manuscript. This is contribution No. 574 of the Idaho Forest, Wildlife, and Range Experiment Station, funded in part by Max McGraw Wildlife Foundation, a McIntire-Stennis grant, Idaho Dept. of Fish and Game, Intermountain Forest and Range Experiment Station, and the North American Bluebird Society.

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