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SEX DETERMINATION OF GREAT BLACK-BACKED GULLS USING MORPHOMETRIC CHARACTERS

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Abstract.—We evaluated sexual size dimorphism of Great Black-backed Gulls (*Larus marinus*) from a breeding colony in the Bay of Fundy and provide a reliable method for predicting the sex of measured individuals. Males were significantly larger than females in all body measurements. A predictive function using only three linear measurements (head length, bill depth and wing length) was more accurate than any single linear measure and correctly sexed 99–100% of the individuals.

DETERMINACIÓN DEL SEXO EN INDIVIDUOS DE LA GAVIOTA *LARUS MAXIMUS* UTILIZANDO MORFOMETRÍA

Sinopsis.—Evaluamos el dimorfismo sexual de individuos de la gaviota *Larus maximus* utilizando morfometría. Se provee en este trabajo de un método confiable para determinar el sexo en éstas aves. El trabajo se llevó a cabo con individuos de una colonia presente en la bahía de Fundy. Los machos resultaron ser significativamente de mayor tamaño que las hembras, en todas las medidas morfométricas. Una función predecible utilizando tan solo tres medidas lineares (largo de la cabeza, profundidad del pico y largo del ala) resultó ser más exacta que cualquier medida linear individual y permitió sexar correctamente entre el 99–100% de los individuos.

In ecological and behavioral studies, it is often important to know the sex of individuals. In sexually monomorphic species such as Larids, researchers have developed predictive models based on the relationship between body size and sex for samples of known individuals (Fox et al. 1981, Hanners and Patton 1985, Bosch 1996). Discriminant functions derived from morphometric data are commonly used. However, these functions can be applied only to the populations from which they were derived because geographic variation within a species (Threlfall and Jewer 1978, Coulson et al. 1983, Evans et al. 1993) may limit a function's generality.

Great Black-backed Gulls (*Larus marinus*) have expanded their range and numbers along the eastern coast of North America since the early 1920s (Drury 1973, 1974) and have become quite common. However, little is known about their ecology in this region, and no studies have investigated sexual size dimorphism and geographic variation. Gull control programs on a breeding colony in the Bay of Fundy provided a large sample of Great Black-backed Gulls (Mawhinney and Diamond, unpubl. data) and we used the opportunity to gather morphological data on the specimens. The objectives of this paper were to (1) quantify sexual size dimorphism in Great Black-backed Gulls and (2) offer a reliable method for determining the sex of Great Black-backed Gulls.

STUDY AREA

Spruce and Flatpot Island are two islands within the Wolves Archipelago (44°56′N, 66°44′W), 12 km offshore from Beaver Harbour, New Brunswick, Canada. The dominant vegetation on the islands is balsam fir (*Abies balsamea*) and spruce (*Picea* spp.). Breeding seabirds on the two islands include Great Black-backed Gulls, Herring Gulls (*Larus argentatus*), Common Eiders (*Somateria mollissima*) and Black Guillemots (*Cepphus grylle*).

METHODS

In mid-April to early May Great Black-backed Gulls were removed from Spruce and Flatpot Island in New Brunswick in 1996 (Canadian Wildlife Service Scientific Kill Permit No. SK196) through a combination of shooting and nest trapping. Gulls captured on the nest (sea bird traps, Mills and Ryder 1979) were killed by cervical dislocation. Each bird was weighed to the nearest 25 g with a spring balance and six measures of structural size were recorded: (1) head and bill (HL), the maximum distance from the bill tip to the posterior extremity of the occipital process; (2) bill length (BL), from the bill tip to the posterior extremity of the lateral side of the bill; (3) culmen (C), from the bill tip to the posterior extremity of the culmen; (4) bill depth (BD), vertical height of the bill with the mandibles closed, from the gonys; (5) wing length (WL), distance from the wrist to the tip of the wing with the wing flattened and flexed at the wrist; (6) tarsus length (TL), from the pit at the posterior junction of the tibiotarsus and the tarsometatarsus to the anterior distal end of the tibiotarsus. All measurements were taken to the nearest 1 mm with callipers except wing length, which was measured to the nearest mm with a flat ruler. All birds were sexed by dissection.

Morphometric analyses were performed using $\log_{10}$ transformed data. Multivariate analyses of variance (MANOVA) were used to determine whether overall external morphology varied with sex (SAS Institute 1990) and discriminant function analyses (DFA) were used to explore the nature of this variation. Gulls were analysed with a stepwise DFA of transformed morphometric measurements, entering at each step the measurement that added the most separation between the two sexes (Bosch 1996). Results were considered to be significant at $\alpha = 0.05$. The data of the discriminant functions were validated using a jackknife statistical procedure (also called Leave-one-out; Lachenbruch and Mickey 1968) in which each individual was classified using a function derived from the total sample less the individual being classified (e.g., Chardine and Morris 1989, Amat et al. 1993). This method produces an unbiased estimate of the success rate of the discriminant functions (Seber 1984).

RESULTS

Male gulls were larger than females in all body measurements in both breeding populations (Ps < 0.001, Table 1). Head length was the most useful single measurement in discriminating between sexes, correctly

TABLE 1. Means (±SD) of linear measurements (mm) taken from adult Great Black-backed Gulls collected from their breeding territory on the Wolves Archipelago, New Brunswick, 1996.

	New Brunswick		MANOVA	
Measurement	Females (n = 108)	Males (n = 78)	F	P
Head length	136.4 ± 3.4	149.2 ± 3.6	610.788	<0.001
Bill length	90.2 ± 5.1	98.9 ± 4.9	121.492	<0.001
Culmen	61.3 ± 3.5	67.8 ± 3.6	144.020	<0.001
Bill depth	24.1 ± 1.0	26.5 ± 1.6	167.076	<0.001
Wing length	468.4 ± 1.4	495.9 ± 1.3	188.037	<0.001
Tarsus length	77.2 ± 3.1	82.7 ± 4.3	96.260	<0.001

identifying 97% of females and 99% of males (Table 2). Stepwise DFA found that the combined function using head length, bill depth and wing length correctly identified the sex of 99% of all females and 100% of all males. The resulting function was:

$$D_1 = 73.46 \log_{10}HL + 18.64 \log_{10}BD + 32.97 \log_{10}WL - 3.31 \log_{10}BL - 233.51 \quad (P = 0.001, R^2 = 0.907); \quad (1)$$

where values of $D_1 < 0$ identified females and values of $D_1 > 0$ identified males. Because head length and bill depth are common measurements recorded for gulls we derived a function based on these measurements. The resulting function was:

$$D_2 = 82.69 \log_{10}HL + 18.03 \log_{10}BD - 203.06 \quad (P = 0.001, R^2 = 0.879). \quad (2)$$

This function had slightly less discriminatory power but was able to correctly classify 97% of the jackknifed classifications.

TABLE 2. Accuracy of sexing Great Black-backed Gulls in New Brunswick by discriminant analysis using single measurements or combined functions.

		Jackknifed classifications (n = 186)	
Variable	R^2	Females	Males
Head length (HL)	0.877	97% (105/108)	99% (77/78)
Bill length (BL)	0.631	87% (94/108)	86% (67/78)
Culmen (C)	0.663	87% (94/108)	83% (65/78)
Bill depth (BD)	0.690	94% (101/108)	85% (66/78)
Wing length (WL)	0.711	82% (89/108)	90% (70/78)
Tarsus length (TL)	0.586	83% (90/108)	88% (68/78)
$D_1 = 70.26 \log_{10}$ HL + 18.53 $\log_{10}$ BD + 31.91 $\log_{10}$ WL − 230.66	0.906	99% (107/108)	100% (78/78)
$D_2 = 82.69 \log_{10}$ HL + 18.03 $\log_{10}$ BD − 203.06	0.893	97% (105/108)	97% (76/78)

DISCUSSION

As in other gull species (Monaghan et al. 1983, Evans et al. 1993, Bosch 1996) male Great Black-backed Gulls were larger than females. The predictive function, using three linear measurements relatively easy to record in the field, was more accurate than any single linear measure. Despite the relative ability of some linear measurements (bill lengths and tarsus) to predict sex accurately, some were not selected in the stepwise DFA because their inclusion in the function did not improve its accuracy. The absence of some of the more accurate measurements (e.g., bill lengths) may be explained by the presence in the function of another measurement which was both more accurate and closely correlated with bill lengths (i.e., head length).

Wing length is the most difficult of the three measurements to take on adult Great Black-backed Gulls in the field. Therefore a function requiring only the two important head measurements was determined (Table 2). While this function had slightly less discriminatory power it was able to classify correctly 100% of the jackknifed classifications. The power of head length and bill depth to discriminate sex agrees with studies of other gull species (Fox et al. 1981, Hanners and Patton 1985, Bosch 1996). However, it should be used with caution as bill depth can vary with age (Coulson et al. 1981). To improve the degree of accuracy, the combined function using three measurements should be used.

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LITERATURE CITED

AMAT, J. A., J. VINÚELA, AND M. FERRER. 1993. Sexing Chinstrap Penguins (*Pygoscelis antarctica*) by morphological measurements. Colon. Waterbirds 16:213–215.

BOSCH, M. 1996. Sexual size dimorphism and determination of sex in Yellow-legged Gulls. J. Field Ornithol. 67:534–541.

CHARDINE, J. W., AND R. D. MORRIS. 1989. Sexual size dimorphism and assortative mating in the Brown Noddy. Condor 91:868–874.

COULSON, J. C. S., S. THOMAS, J. E. L. BUTTERFIELD, N. DUNCAN, P. MONAGHAN, AND C. SHEDDEN. 1983. The use of head and bill length to sex live gulls Laridae. Ibis 125:549–557.

DRURY, W. H. 1973. Population changes in New England seabirds. Bird Banding 44:267–313.

———. 1974. Population changes in New England seabirds. Bird Banding. 45:1–92.

EVANS, D. R., E. M. HOOPES, AND C. R. GRIFFIN. 1993. Discriminating the sex of Laughing Gulls by linear measurements. J. Field Ornithol. 64:472–476.

FOX, G. A., C. R. COOPER, AND J. P. RYDER. 1981. Predicting the sex of Herring Gulls by using external measurements. J. Field Ornithol. 52:1–9.

HANNERS, L. A., AND S. R. PATTON. 1985. Sexing Laughing Gulls using external measurements and discriminant analysis. J. Field Ornithol. 52:1–9.

LACHENBRUCH, P. A., AND M. R. MICKEY. 1968. Estimation of error rates in discriminant analysis. Technometrics 10:1–11.

MILLS, J. A., AND J. P. RYDER. 1979. Trap for capturing shore and seabirds. Bird Banding. 50: 121–123.

MONAGHAN, P., J. C. COULSON, N. DUNCAN, R. W. FURNESS, C. B. SHEDDEN, AND C. THOMAS. 1983. The geographic variation of the Herring Gull *Larus argentatus* within Britain and in northern Europe; a biometrical approach. Ibis 125:412–417.

SAS/STAT INSTITUTE. 1990. SAS/STAT User's guide, Version 6. 4th ed., vol. 1. SAS Inst. Inc, Cary, North Carolina.

SEBER, G. A. F. 1984. Multivariate observations. John Wiley and Sons, New York, New York, 686 pp.

THRELFALL, W., AND D. JEWER. 1978. Notes on the standard body measurements of two populations of Herring Gulls (*Larus argentatus*). Auk 95:749–753.

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