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SEXUAL SIZE DIMORPHISM AND DETERMINATION OF SEX IN YELLOW-LEGGED GULLS

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Abstract.—This paper evaluates sexual size dimorphism in the Yellow-legged Gull (*Larus cachinnans*) from a colony in northeast Spain and provides a reliable method for predicting the sex of measured individuals. Males were significantly larger than females in all body measurements. Predictive functions using two to four measurements correctly sexed 100% of the sampled individuals, although one measurement (head length) was almost as accurate (99.4%). Other authors reported no differences between the measurements taken from gulls in this colony and those taken from gulls in colonies as far away as the Moroccan coast. Thus, the discriminant functions described in this paper might be applicable to other colonies of Yellow-legged Gulls.

DIMORFISMO SEXUAL DE TAMAÑO Y DETERMINACIÓN DEL SEXO EN GAVIOTAS PATIAMARILLAS

Sinopsis.—El presente artículo evalua el dimorfismo sexual en el tamaño de la Gaviota Patiamarilla (*Larus cachinnans*) en una colonia del Noreste de España, y ofrece métodos eficaces para predecir su sexo. Los machos fueron significativamente mayores que las hembras en todas las medidas corporales. Funciones predictivas que combinaron de 2 a 4 medidas sexaron correctamente el 100% de los individuos muestreados, aunque una sola medida por separado (longitud de la cabeza) fue casi tan precisa en predecir el sexo (99.4%). Otros autores han mostrado la ausencia de diferencias en las medidas corporales de las gaviotas de la colonia estudiada con las de gaviotas de colonias tan alejadas como la costa de Marruecos. De este modo, las funciones discriminantes descritas en este articulo podrían ser aplicables a otras colonias de Gaviotas Patiamarillas.

Because male and female gulls usually differ in size but not plumage (Cramp and Simmons 1983, Ingolfsson 1969), many studies have described predictive functions based on external measurements to discriminate between the sexes. These functions are specific for each species and, in some cases, each population within a species (Evans et al. 1993). The Yellow-legged Gull (*Larus cachinnans*), formerly classified as a subspecies of the Herring Gull, is now generally considered to form a separate species (Wilds and Czaplak 1994, Wink et al. 1994, Yésou 1991). Although it is the most common seabird in the Mediterranean region (Beaubrun 1993, Bourne 1993), few papers deal with its morphometric characteristics, and the scarce information about its sexual size dimorphism does not include any discriminant function.

Discriminant functions described by Coulson et al. (1983) and Migot (1986) for European populations of Herring Gulls (from England and France, respectively) incorrectly classified 50.7% and 85.7%, respectively, of female Yellow-legged Gulls as males in a population from northeast Spain (possibly because Yellow-legged Gulls have a longer, heavier bill and bulkier head and body than Herring Gulls; Mierauskas et al. 1991, Wilds and Czaplak 1994). Therefore, the objectives of this paper are (1) to evaluate sexual size dimorphism in a population of Yellow-legged Gulls and (2) to offer a reliable method for determining the sex of Yellow-legged Gulls.

METHODS

During April 1993 and 1994, adult Yellow-legged Gulls (>4-yr-old based on plumage) from the Medes Islands colony, northeast Spain (42°0′N, 3°13′E), were collected as part of a government culling program. The gulls belonged to the subspecies *Larus cachinnans michahellis.* Birds were labeled, weighed with a hand-held 1500-g Pesola (±10 g) and then frozen for later examination.

Ten body measurements were taken: head length (distance from the tip of the bill to the posterior ridge formed by the parietal-supraoccipital junction), bill depth (minimum depth of the bill posterior to the gonys), short bill length (length of the culmen from the tip of the upper mandible to where rhinotheca meets with the skin), long bill length (distance from the tip of the upper mandible to the corner of the mouth), nalospi (distance from the tip of the bill to the nostril), flat wing, tail, tarsus length (tarsometatarsus length), foot length (distance from the distal end of tarsometatarsus to the base of the nail on the middle toe of the flattened foot), and middle toe length (distance from the first scale of the middle toe to the base of the nail on this toe) (Fig. 1). Because all ten measurements involved a low percentage of fleshy tissue, shrinkage from freezing should be minimal. To confirm this, I compared the length of eight tarsi before and after freezing using a paired *t*-test. No significant differences were found ($t = 0.77$; df = 7; $P = 0.232$). Most measurements were taken using a digital caliper (±0.01 mm); foot, wing, and tail length were measured with a ruler (±1 mm).

Subsequent to being measured, all birds were dissected to determine their sex. The measurements of 181 sexed gulls (104 males and 77 females) were used to evaluate sexual size dimorphism and to obtain several discriminant functions. Significant intersexual differences for each measurement were tested with a two-tailed, two-sample *t*-test. Stepwise discriminant function analysis (BMDP:P7M, Dixon et al. 1985) was performed on all measurements, entering at each step the measurement that added the most separation between the two sexes. To validate the discriminant functions, I used 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., Amat et al. 1993, Chardine and Morris 1989). This method produces an unbiased estimate of the success rate of the discriminant functions (Dixon et al. 1985, Seber 1984).

RESULTS

Males were significantly larger than females in all body measurements (Table 1). Head length (with 124.54 mm as a point of inter-sex separa-

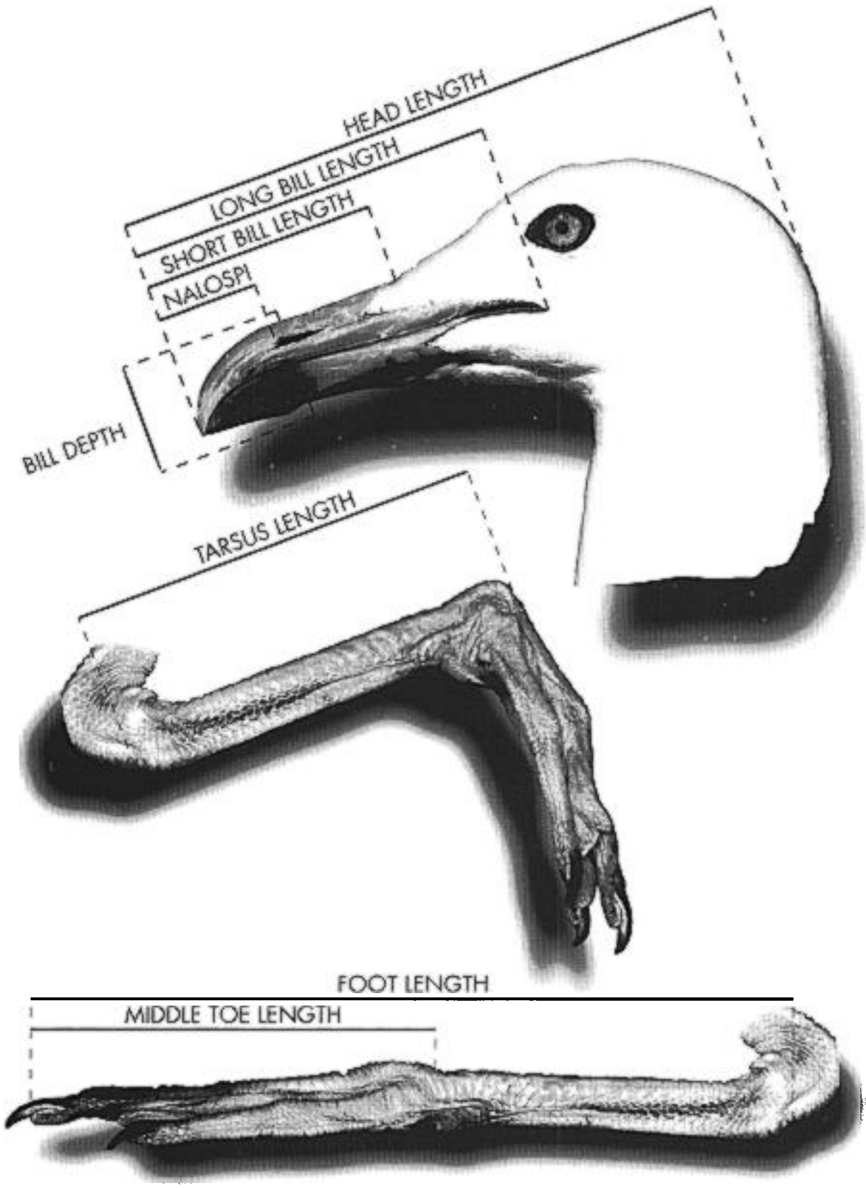

FIGURE 1. Variables measured (excluding wing and tail) to sex Yellow-legged Gulls.

TABLE 1. Body measurements (mm or g) of male and female Yellow-legged Gulls from the Medes Island colony, Spain.

	Sexes							
	Males (n = 104)			Females (n = 77)				
	Mean ± SD	Range	C.V.	Mean ± SD	Range	C.V.	t	P
Head length	130.1 ± 2.6	124.4–136.6	2.0	119.0 ± 2.4	112.3–124.4	2.1	29.6	<0.001
Bill depth	19.0 ± 0.6	17.3–20.4	3.1	17.1 ± 0.5	16.0–18.2	2.8	24.0	<0.001
Short bill length	59.9 ± 2.6	51.5–69.9	4.3	53.3 ± 1.9	49.5–58.6	3.6	18.9	<0.001
Long bill length	91.4 ± 3.0	83.4–98.2	3.2	83.3 ± 2.9	76.6–89.3	3.4	18.4	<0.001
Nalospi	26.2 ± 1.0	23.6–29.5	3.8	23.7 ± 1.1	21.4–26.0	4.7	15.8	<0.001
Tarsus length	71.0 ± 2.0	66.1–76.3	2.9	65.1 ± 2.2	57.7–69.2	3.4	18.6	<0.001
Foot length	132.8 ± 3.6	123–141	2.7	122.5 ± 3.4	114–129	2.8	19.7	<0.001
Middle toe length	68.4 ± 2.4	58.5–73.8	3.4	63.8 ± 2.2	58.2–67.7	3.4	13.3	<0.001
Wing	458.6 ± 13.1	434–561	2.9	434.2 ± 9.4	410–454	2.2	13.9	<0.001
Tail	178.6 ± 4.1	168–190	2.3	168.8 ± 4.1	158–180	2.5	15.8	<0.001
Mass	1157.0 ± 83.9	940–1420	7.3	966.4 ± 61.9	830–1110	6.4	16.8	<0.001

tion) was the most useful single measurement in discriminating between the sexes, correctly identifying 99.4% of sampled individuals (Table 2). Stepwise analysis chose four of the eleven measurements. The resulting combined function was: $D_1 = 1.430*HL + 5.135*BD + 0.114*W + 0.262*T - 366.988$; where values of $D_1 > 0$ identified males and values < 0 identified females. This function correctly identified the sex of 100% of cases. Because a function requiring four different measurements is of little practical value in field studies, the functions with highest discriminatory power using two and three measurements were determined. These functions had only slightly lower discriminatory power (expressed by the Wilks' lambda) and also correctly identified 100% of cases (Table 2).

DISCUSSION

Sexual differences in body measurements were marked (as in other Yellow-legged Gull colonies; Isenmann 1973, Launay 1984, Mierauskas et al. 1991), and single measurements were accurate predictors of sex. Some of the measurements with the highest accuracy in sexing (bill lengths, foot length) were not selected in the stepwise discriminant function while other measurements with lower accuracy were (wing and tail). Because the stepwise analysis does not select measurements carrying redundant information (i.e., those whose inclusion in the function does not improve the accuracy of the function), the absence of some of the most accurate measurements may be explained by the presence in the function of another measurement which was both more accurate and closely correlated. For instance, the presence of head length in the discriminant function may be the reason why bill lengths were not included.

The highest accuracy of head length and bill depth in discriminating sex coincides with the results obtained in other gull species (Fox et al. 1981, Hanners and Patton 1985, Migot 1986). Furthermore, head length was almost as efficient in determining the sex as any of the combined functions (Coulson et al. 1983). Thus, for some field studies, recording only this measurement may be sufficient for sexing Yellow-legged Gulls accurately (>99%). To improve the degree of accuracy (though only slightly), the combined function with head length and bill depth can be used. However, it should be used with caution because bill depth can vary with age (Coulson et al. 1981).

There is considerable movement of Yellow-legged Gulls among colonies of the eastern Spanish (including Medes Islands) and French Mediterranean coasts (Carrera 1987, Carrera and Vilagrasa 1984, Carrera et al. 1993). Because of this movement, marked morphometric differences between gulls from different colonies in this region are not expected. Measurements of gulls of the Medes Islands do not significantly differ from those taken from gulls at colonies as far away as the Chafarinas Islands (on the Moroccan coast) (Carrera et al. 1987). This absence of intercolony variation is in contrast to other gull species in which such differences have been found (Evans et al. 1993, Monaghan et al. 1983, Threlfall and Jewer 1978). Thus, the discriminant functions described in this paper for

TABLE 2. Accuracy of sexing Yellow-legged Gulls obtained by discriminant analysis using single measurements or combined functions.

Variable	Wilks' Lambda	Cases correctly separated: Males	Cases correctly separated: Females
Head length (HL)	0.170	99.0% (103/104)	100% (77/77)
Bill depth (BD)	0.237	95.2% (99/104)	97.4% (75/77)
Short bill length	0.334	94.2% (98/104)	94.8% (73/77)
Long bill length	0.346	93.3% (97/104)	90.9% (70/77)
Nalospi	0.419	93.3% (97/104)	87.0% (67/77)
Tarsus length	0.340	92.3% (96/104)	90.9% (70/77)
Foot length	0.317	90.4% (94/104)	93.5% (72/77)
Middle toe length	0.502	88.5% (92/104)	80.5% (62/77)
Wing (W)	0.481	94.2% (98/104)	92.2% (71/77)
Tail (T)	0.417	92.3% (96/104)	89.6% (69/77)
Weight	0.387	87.5% (91/104)	93.5% (72/77)
Combined functions			
$D_1 = 1.430*HL \pm 5.135*BD \pm 0.114*W \pm 0.262*T - 366.988$	0.114	100% (104/104)	100% (77/77)
$D_2 = 1.472*HL \pm 5.231*BD \pm 0.154*W - 346.582$	0.117	100% (104/104)	100% (77/77)
$D_3 = 1.539*HL \pm 5.130*BD - 284.174$	0.129	100% (104/104)	100% (77/77)

the Medes Islands colony might be applicable to other colonies of Yellow-legged Gulls.

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