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IDENTIFYING THE SEX OF MASSACHUSETTS HERRING GULLS BY LINEAR MEASUREMENTS

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Abstract.—Discriminant functions capable of determining sex are lacking for Herring Gull (*Larus argentatus*) populations in the northeastern United States. A new discriminant function, based on culmen and tarsus lengths, that correctly classified the sex of 94% of gulls collected in Massachusetts was derived. This function is applicable to nesting populations of Massachusetts Herring Gulls, but should be tested against the morphometrics of known-sex gulls before being applied to other populations.

IDENTIFICACIÓN DEL SEXO EN *LARUS ARGENTATUS* MEDIANTE EL USO DE MEDIDAS LINEARES

Sinopsis.—Al presente no se ha hecho uso de funciones discriminativas para determinar el sexo de individuos de *Larus argentatus* en las poblaciones del noreste de los Estados Unidos. En este trabajo presentamos una función discriminativa, basada en el largo del culmen y largo del tarso, que permitió clasificar correctamente el sexo del 94% de los individuos estudiados en Massachusetts. Aunque la función es aplicable a la población de gaviotas de Massachusetts, ésta debe ser puesta a pruebas (con la morfometría de gaviotas de sexo conocido) previo a ser utilizada en el estudio de otras poblaciones del ave.

Discriminant functions derived from morphometric data are commonly used to sex a variety of avian species. Within species, geographic variation (e.g., Coulson et al. 1983, Evans et al. 1993, Threlfall and Jewer 1978) and differences between captive and wild populations (e.g., Smith and Wiemeyer 1992) may reduce a function's applicability. For these reasons, functions should be applied only to the populations from which they were derived (e.g., Evans et al. 1993, Smith and Wiemeyer 1992).

Numerous functions have been derived to discriminate between the sexes of Herring Gulls (*Larus argentatus*). Functions have been derived for populations in Michigan (Shugart 1977), Ontario (Fox et al. 1981), Newfoundland (Coulson et al. 1983), and Great Britain (Coulson et al. 1983, Threlfall and Jewer 1978). As Herring Gulls vary geographically (e.g., Monaghan et al. 1983, Threlfall and Jewer 1978), and may vary clinally between Maine and New York (Threlfall and Jewer 1978), existing

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discriminant functions may not be applicable to gulls in the northeastern United States.

Roseate Tern (*Sterna dougallii*) recovery efforts in Massachusetts resulted in the death of a large sample of Herring Gulls from a single breeding colony (Blodget and Henze 1992). This sample provided an opportunity to gather morphological data on the Massachusetts population. Here we present this information and provide a discriminant analysis formula that can accurately sex Massachusetts Herring Gulls.

METHODS

We measured 444 Herring Gulls collected on and around Ram Island, Mattapoisett, Massachusetts (41°37′N, 70°48′W) following application of the avicide DRC-1339 on 15 May 1990. All but two gulls are believed to have died as a result of ingesting DRC-1339.

We measured culmen length, tarsus length, wing-chord (flattened) and mass of each gull. All linear measurements were taken on the right side of the body, unless the structure to be measured was absent or damaged. Culmen and tarsus lengths were measured with calipers to the nearest 1 mm, wing-chord was measured with a ruler to the nearest 1 mm, and mass was measured with a 4000-g electronic balance (Metler Instrument Co., Hightstown, New Jersey) to the nearest 0.1 g. Gulls were then dissected and their sexes determined on the basis of internal morphology. Only adult gulls (i.e., those showing full adult plumage) were included in our analysis; this resulted in the exclusion of 22 birds from our data set. We used a two-tailed, two-sample, *t*-test (SYSTAT, Wilkinson 1991) to test for significant ($P \leq 0.025$) intersexual differences in size and mass.

A discriminant function was developed following the guidelines of Frank et al. (1965) as described by Fox et al. (1981) for the V1 validation method. The measured gulls were divided into two samples, the analysis sample and the validation sample. We derived a base discriminant function from all four variables using the MGLH program in SYSTAT (Wilkinson 1991). The combination of measurements that best discriminated between sexes was selected from our base function. We then derived our first discriminant function using the analysis sample ($n = 316$, 75%), and tested the function for accuracy using the validation sample ($n = 106$, 25%). This process was performed to determine the level of bias in our sample. Once minimal bias was established, a second function was derived by combining analysis and validation samples ($n = 422$).

RESULTS

Massachusetts Herring Gulls exhibited significant inter- and little intrasexual morphological variation. Males were significantly larger than females for all measurements ($P = 0.001$, Table 1). Culmen, tarsus and wing-chord lengths varied little within sexes (CV = 2.3–3.7%), whereas mass was more variable (CV = 6.8–10.4%, Table 1).

Herring Gulls could be reliably sexed using only two measurements. From our base discriminant function, the combined measurements of

TABLE 1. Measurements of male and female Herring Gulls from Ram Island, Mattapoisett, Massachusetts.

Variable	Males			Females				
	n	Mean ± SD (range)	CV	*n*	Mean ± SD (range)	CV	*t*	*P*
Culmen (mm)	169	56.0 ± 2.3 (56–70)	3.7	253	57.2 ± 1.9 (52–62)	3.4	−28.5	0.001
Tarsus (mm)	169	71.1 ± 2.2 (65–76)	3.1	253	66.0 ± 2.0 (60–73)	3.1	−24.0	0.001
Wing chord (mm)	169	429 ± 10.3 (400–460)	2.4	253	408 ± 9.6 (384–447)	2.3	−20.8	0.001
Mass (g)	169	1147 ± 77.7 (973–1143)	6.8	246	1023 ± 106 (718–1385)	10.4	−13.7	0.001

culmen (CL) and tarsus (TL) lengths were the most discriminating factors in classifying the sex of Herring Gulls (Wilk's lambda = 0.261, χ^2 = 418.836, df = 2, $P < 0.001$). The classification function:

$$(CL \times 0.853) + (TL \times 0.736) = 101.843$$

correctly classified 95% of the Herring Gulls in the analysis sample. If the function value was greater than 101.843, the gull was classified as a male; gulls with values less than or equal to the function value were classified as females. This function correctly classified 187 of 192 females (97%) and 113 of 124 males (91%). Using the validation sample, the function correctly classified 56 of 61 females (92%), and 42 of 45 males (93%), providing an overall accuracy of 92%. The similarity of our classification accuracy derived from the analysis sample (n = 316, 95%) to that derived from the validation sample (n = 106, 92%) suggests minimal sampling bias.

Our second classification function, derived from combined analysis and validation samples, also accurately discriminated between the sexes (Wilk's lambda = 0.273, χ^2 = 542.634, df = 2, $P < 0.001$). The classification function:

$$(CL \times 0.882) + (TL \times 0.730) = 103.178$$

correctly classified 94% of the Herring Gulls. This function should be used when sexing Herring Gulls from Massachusetts because of its high accuracy and minimal bias, due to its larger sample size.

DISCUSSION

Body-mass values for Massachusetts gulls were influenced by the use of avicide. Decino et al. (1966) reported that European Starlings (*Sturnus vulgaris*) poisoned with DRC-1339 doubled their water consumption 4–8 h after ingestion and experienced hemorrhaging and congestion in their kidneys that reduced their ability to excrete toxic compounds. Additionally, they reported fat-like accumulations of uric acid in the body cavity.

We observed similar accumulations, as well as accumulations of fluids, while dissecting Massachusetts gulls and believe these materials affected our body-mass values. Therefore, masses reported in this study are not directly comparable to values reported in previous studies (i.e., those involving non-poisoned gulls), nor were they considered for incorporation into our discriminant function.

The accuracy of our discriminant function was similar to those reported for other populations of Herring Gulls. Shugart (1977) reported that a discriminant function based on combined head and bill length, and wing-chord, correctly sexed 98.15% of the Michigan Herring Gulls tested. A function based on seven variables (wing length, mass, tarsus length, culmen depth, culmen length, tail length, and the product of culmen depth by length) correctly identified the sex of 91.3% of British and 97.7% of Newfoundland gulls tested (Threlfall and Jewer 1978). Fox et al. (1981) derived two functions to determine the sex of Herring Gulls in Ontario. The first function, based on head and foot lengths, correctly identified the sex of 94.9% of gulls tested; the second function, based on head length and bill depth, correctly identified the sex of 96.5% of gulls tested. Coulson et al. (1983) reported accuracies of 95.8–96.7%, depending on whether one (combined head and bill length) or five (combined head and bill length, body-mass, bill depth, bill length, and wing length) variables were used to derive the function. Our function's accuracy falls within the range of values reported previously. Although based on different variables, the high levels of accuracy reported in these studies suggest identifiable sexual differences in morphology exist throughout the Herring Gull's range. Determination of which function is appropriate depends on the population under investigation.

Our discriminant function was developed from, and intended to be applied to, nesting populations of Massachusetts Herring Gulls. We recommend that those considering applying this function to other populations first test the morphometrics of known sex gulls against our equation (e.g., Evans et al. 1993) to determine if it can correctly classify birds from other populations.

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