SEXING RING-BILLED GULLS EXTERNALLY

By John P. Ryder

This paper describes a simple, tested method for sexing live Ring-billed Gulls (*Larus delawarensis*) externally, using Discriminant Function Analysis (D.F.A.). The paper also discusses possible statistical bias in studies that used D.F.A. to sex gulls externally (Mills, 1971 for Silver Gulls, *L. novaehollandiae scopulinus* and Shugart, 1977 for Herring Gulls, *L. argentatus* and Ring-billed Gulls).

The objective of the D.F.A. is to classify objects, by a set of independent variables, into one of two or more mutually exclusive categories (Morrison, 1969). Two categories discussed here are male and female Ring-billed Gulls.

Inherent within the analytical procedure of the D.F.A. are two sources of bias (Frank et al., 1965). The first bias is from sampling error. Internally the D.F.A. maximizes the proportion of cases that are correctly categorized in the sample without reference to the population from which the sample was taken. The result is that the separative powers of the discriminant function are biased upward (Cooley and Lohnes, 1971).

The second form of bias is known as search bias (Frank et al., 1965). This enters into most research wherein the investigator seeks a variable or variables which best fit the investigation. Those chosen may well fit into the sample taken but do not necessarily apply to other data from the population with equal separative capability.

The method of eliminating both forms of bias from the D.F.A. involves using only part of the data (analysis sample) and comparing predictions obtained using these data against the remainder of the data (validation sample). This procedure is known as the V_1 validation (Frank et al., 1965). Previous investigators (Mills, 1971; Shugart, 1977) did not correct their discriminant functions for either bias. Thus their discriminant functions may give a separation capability greater than can be expected from subsequent samples from the population. In this paper, I categorize Ring-billed Gulls as male or female by D.F.A. with and without the V_1 validation procedure.

STUDY AREA AND METHODS

The study was conducted on Granite Island (48°43′N, 88°29′W), Black Bay, northern Lake Superior, Ontario. Ryder and Somppi (1977) recently described the area. As part of a long-term project dealing with the biology of breeding Ring-billed Gulls, I collected 48 males and 51 females, all in adult plumage (see Ryder, 1975), from 10 May to 14 June 1977. Within one hour after collection I took the measurements listed in Table 1, following the definitions in Baldwin et al. (1931). Body weight was recorded to the nearest 5 g on Pesola hand-held 500-g and 1,000-g spring scales. All other measurements were taken with vernier calipers to 0.01 mm. I determined the sex of each individual by dissection.

Data were transferred to computer cards for the RAO-V analysis of the subprogram DISCRIMINANT as outlined by Klecka (1975). The RAO-V analysis is a stepwise D.F.A. which eliminates less useful variables before performing the actual D.F.A. The criterion for eliminating a variable is Wilks' lambda, a statistic that indicates the discriminatory power of a variable. Wilks' lambda is associated inversely with Chi-square and can be tested for significance.

TABLE 1

Standard body measurements of freshly-collected breeding Ring-billed Gulls from Granite Island, 1977.

	Male (n = 48)		Female (n = 51)		Probability values (Student's *t*-test between means)
Measurement	Mean (mm)[1]	SD (mm)	Mean (mm)	SD (mm)	
Body weight	566	42	471	46	$P < 0.001$
Length of bill from gape	65.2	2.0	59.1	1.9	$P < 0.001$
Length of exposed culmen	41.9	1.6	37.7	1.4	$P < 0.001$
Depth of bill at angle of gonys	13.8	0.6	12.4	0.4	$P < 0.001$
Tarsus length	66.2	2.4	61.4	2.2	$P < 0.001$
Midtoe length	41.2	1.9	38.3	1.5	$P < 0.001$
Length of middle claw	8.3	1.3	7.6	0.6	$P < 0.010$
Tail length	138.1	4.5	131.0	5.6	$P < 0.001$

[1] Except body weight (in g).

RESULTS

Table 1 gives the standard body measurements. In all cases male measurements were significantly larger than those of females. Alone, these data cannot be used to separate the sexes because, as Shugart (1977) points out, the *t*-test shows only to what degree each part measured differs between the sexes. The data also do not lend themselves to determination of overall group differences because variables from individuals can markedly affect the calculated significance levels of the means (Shugart, 1977).

Five of the original eight variables were selected by the RAO-V program as having maximum separation ability based on their Wilks' lambda values. The variables were: depth of bill at angle of gonys, length of bill from gape, length of middle claw, length of tail, and total body weight. I chose the depth of bill at angle of gonys (hereafter called gonys) and length of bill from gape (hereafter called bill length) for further D.F.A. analysis because the RAO-V analysis allows any number of variables, over one, to be tested for their separative capability. The gonys and bill length are easily, rapidly, and accurately measured with vernier calipers while a single investigator holds a live, often struggling bird. Both variables are non-arbitrary characters that are easily identified by different investigators, thus eliminating the often problematic situation of where a structure begins and ends. The length of middle claw and length of tail each vary seasonally (Mills, 1971), as does body weight, and are of little use for discriminating sex throughout the year.

Data for gonys and bill length for the 99 specimens were processed through the D.F.A. The resulting discriminant function (A) was:

$$(\text{bill length} \times 0.18154) + (\text{gonys} \times 0.45484) = 17.20850.$$

Male values are above and female values below the discrimination at 17.20850. Wilks' lambda = 0.2416 for the function with a corresponding $\chi^2 = 136.354$, df = 2, $P < 0.001$.

Although the above function sexed correctly 96.0% (95/99) of the gulls from the total sample, the actual capability of the function to separate sexes in future samples cannot be tested. This is because all the available data were used to calculate the discriminant function. This sampling error (Frank et al., 1965) thus gives only the maximum proportion of cases correctly categorized as male or female.

To calculate a discriminant function that could be tested for actual separative capability (V_1 validation procedure), 60% of the data (analysis sample) were randomly selected, by the computer (see Nie et al., 1975), and processed through the D.F.A. The resulting discriminant function (B), based on 26 males and 33 females was:

$$(\text{bill length} \times 0.14651) + (\text{gonys} \times 0.58560) = 16.71336.$$

Male and female values are respectively above and below the discrimination at 16.71336. Wilks' lambda = 0.2542, $\chi^2 = 76.705$, df = 2, $P < 0.001$.

The above function correctly sexed 98.3% (58/59) of the Ring-billed Gulls from the analysis sample.

The remaining data (the validation sample) on gonys and bill length from 22 males and 18 females were used as a test to determine the actual predictive power of the discriminant function (B). The result was 95.0% (38/40) of the gulls were correctly sexed. With a 99% confidence interval, 89.7% (26/29) of the gulls in the validation sample, having measurements within the range of overlap, were sexed correctly using the discriminant function (B). All gulls with measurements outside the region of overlap were correctly identified. Additionally males and females were correctly identified equally with the function ($\chi^2 = 2.36$, df = 1, $0.1 < P < 0.5$).

The V_1 validation procedure showed that the overall actual predictive power of the calculated discriminant function (B) was 3.3% lower than

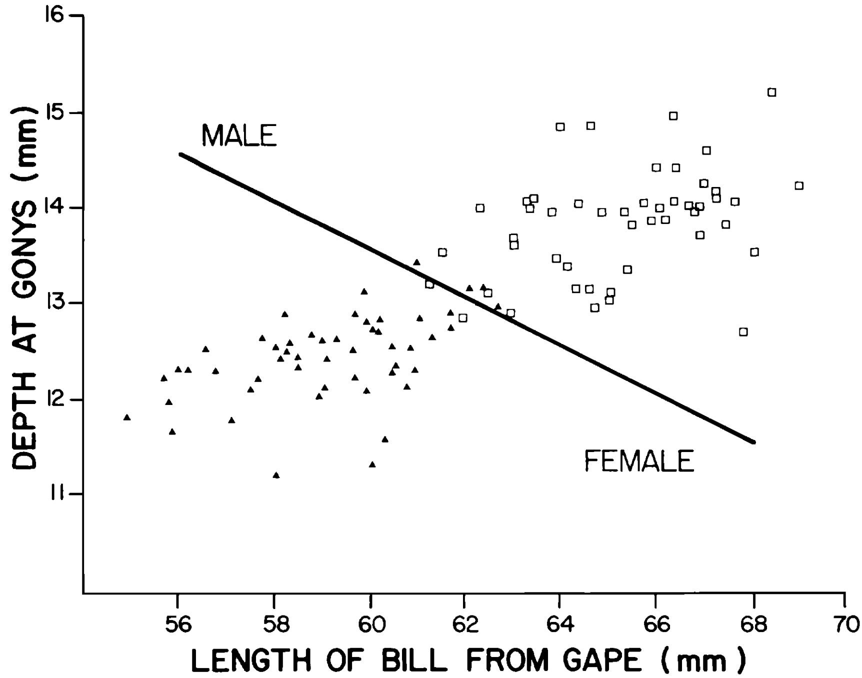

FIGURE 1. Relationship between the depth of bill at angle of gonys and length of bill from gape in 51 female and 48 male Ring-billed Gulls from Granite Island, 1977. The line represents the best separation between males and females (see text).

the capability calculated from the analysis sample. More importantly, within the region of overlap, the separative capability dropped by 8.6% from the analysis sample prediction.

Figure 1 illustrates the relationship between the bill length and gonys. The line that best separates males and females in the figure was calculated by substituting measurements into the discriminant function (B). The points on the figure include all 99 specimens.

The discriminant function is easy and rapid to use in the field with a pocket calculator. For example, the sex of a Ring-billed Gull with a bill length of 65.20 mm and gonys of 13.80 mm is determined by substituting measurements into the single function from the analysis sample:

$$(65.20 \times 0.14651) + (13.80 \times 0.58560) = 17.63$$
(rounded off to 2 places).

Since the discriminant score of $17.63 > 16.71$, the bird is a male.

DISCUSSION

The use of the bill length and gonys to sex accurately Ring-billed Gulls is illustrated by the percentage similarity between gulls sexed correctly from the analysis sample (98.3%) and validation sample (95.0%). Mills (1971) and Shugart (1977) did not test their discriminant functions' ability to separate males and females from data other than those used to calculate the discriminant function. In the absence of the V_1 validation, it is difficult to judge how reliable a given discriminant function is, especially in the region where measurements overlap.

In addition to being useful in determining the sex of live Ring-billed Gulls, the gonys and bill length minimize handling time, hence overall disturbance. During the course of our studies we have measured many gonys and bill lengths in less than 30 sec per bird.

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