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MORPHOMETRIC ASSESSMENT OF SEXUAL DIMORPHISM IN SKELETAL ELEMENTS OF CALIFORNIA GULLS

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ABSTRACT.—Using univariate and multivariate techniques, we evaluated sexual dimorphism in four external and 51 skeletal measures taken from 66 California Gulls (*Larus californicus*). Based on analyses of variance, all characters showed statistically significant sexual dimorphism. Skeletal measures of head and pectoral regions were closely correlated but—with elimination of geographic, temporal, and ontogenetic influences—we noted considerable independent variation among characters. Differences between sexes were greatest in the head region (average of 8.03%), with mandible depth being the most dimorphic head character. Differences in the wing region were somewhat less (averaging 6.98%), although still greater than the overall size difference between sexes (i.e., 6.10%; based on the cube root of body weight). Principal components analysis of skeletal characters standardized on the basis of pooled, within-sex standard deviations provided complete separation of males and females. Four skeletal measures (i.e., skull width, mandible length, keel depth, and minimum synsacral width), when used in combination in a stepwise discriminant function, correctly identified to sex all specimens that we used and, it is expected, will do so for most other specimens of this species. Classification functions were developed from the total suite of characters to assign unknown specimens to one or the other sex. Most males and females could also be separated by using combinations of characteristics taken from only one of the five body regions studied (i.e., head, pectoral, wing, pelvic, and leg regions), indicating the widespread nature of sexual dimorphism in California Gulls.

Sexual dimorphism in size and shape is almost universal in birds, and numerous theoretical constructs have been developed to explain its ecological and evolutionary significance (e.g., Verner and Willson 1966, Orians 1969, Selander 1972, Ralls 1977). Darwinian sexual selection is likely the most important single cause that generates dimorphism, but other influences also have been considered to be significant. For instance, Selander (1966) presented a case for a relationship between sexual dimorphism and differential niche utilization in birds (i.e., the niche segregation theory) and suggested reasons why such dimorphism would develop. In a number of cases, this explanation has been promoted (e.g., Earhart and Johnson 1970; Robins 1971, Williamson 1971, Wallace 1974); in others, workers have found it necessary to consider alternative hypotheses that take into account bioenergetic pressures, predation pressures, non-monogamous mating systems, or various combinations of these factors (see Sigurjónsdóttir 1981 and references therein). The evolutionary significance of sexual dimorphism is still being actively debated.

In a variety of studies, there are practical as well as theoretical reasons for wanting to elucidate sexual differences. For instance, gull species are frequent subjects of ethological investigations because gulls are highly colonial, have stereotyped displays, and are relatively easy to observe. Most gulls, however, are monomorphic in plumage, and investigators have difficulty in determining the sex of individual birds. Consequently, a series of works has appeared that provide the basis of identification to sex by using external morphometric characteristics. Studies of this type have been completed for Great Black-backed Gulls (*Larus marinus*; Harris 1964), Lesser Black-backed Gulls (*L. fuscus*; Harris and Hope Jones 1969), Herring Gulls (*L. argentatus*; Harris and Hope Jones 1969, Shugart 1977, Threlfall and Jewer 1978, Fox et al. 1981), Red-billed Gulls (*L. scopulinus*; Mills 1971), Ring-billed Gulls (*L. delawarensis*; Shugart 1977, Ryder 1978), Silver Gulls (*L. novaehollandiae*; Wooller and Dunlop 1981), and Kelp or Southern Black-backed Gulls (*L. dominicanus*; Nugent 1982).

Ingolfsson (1969), in a related but more detailed analysis, compared the degree of sexual dimorphism in five species of large gulls, in-

cluding Great Black-backed Gulls, Lesser Black-backed Gulls, Iceland Gulls (*L. glaucoides*), Glaucous Gulls (*L. hyperboreus*), and Herring/Glaucous Gull hybrids. He indicated that sexual dimorphism is usually greater in bill dimensions than in other body parts and is always more pronounced than the overall difference in general size. While stomach contents revealed marked differences among species, no intersexual differences were found. Based on these and other findings, Ingolfsson (1969) concluded that sexual dimorphism in gulls is related to sex recognition, territory defense, or some other factor that is unrelated to feeding habit.

We have evaluated in detail the differences in skeletal dimensions between the sexes of California Gulls (*L. californicus*), a typical, medium-sized gull that has not been subjected to an in-depth analysis of sexual dimorphism. Behle and Selander (1953) found no differences in plumage or soft-part coloration between males and females. As in almost all gulls, however, males are significantly larger than females (the former averaging about 21.5% heavier and 3.76–9.48% larger than the latter in external measurements). A multivariate approach, employing a series of 51 skeletal measures, enabled us to more comprehensively investigate the relative degree of sexual differences in various body regions, as well as those within particular body parts. First, we identified the best skeletal measures for discriminating between males and females. Second, we asked whether sexual size dimorphism appears in all body regions and, if so, whether it is more pronounced in a particular region. Third, we assessed the degree of character covariation.

MATERIALS AND METHODS

A total of 66 California Gulls (27 males and 39 females) was collected in May, June, and September of 1968, near Salt Lake City, Utah (i.e., 28 May and 14 September, Salt Lake City dump, 5 mi W Salt Lake City Center, Salt Lake County; 13 June, Farmington Bay Waterfowl Management Area, 14 mi NW of Salt Lake City Center, Davis County, Utah). Based on plumage characteristics, all birds were at least three years of age (Dwight 1925, Behle and Selander 1953). Skeletons were prepared by using dermestids, and the 51 skeletal measurements that are listed in Table 1 were taken. Characters were described in detail by Schnell (1970a). We also recorded weight (about two weeks after collection and after the birds had been frozen), wing chord, tail length, and exposed culmen length—external measures that were not used in multivariate analyses.

Damaged specimens that would not yield nearly every measurement were excluded from the sample. As a result, very few values were missing in the original data (eight of 1,377 measures in males, or 0.58%; 16 of 1,989 in females, or 0.80%). The missing values were estimated from the other specimens of the same sex by linear regression onto the character that explained the greatest proportion of the variance for the character under consideration ("Missing Data Estimator" computer program developed by D. M. Power).

We calculated arithmetic means and standard deviations for each sex and used an analysis of variance (ANOVA) to assess sexual differences for each character. Correlations were calculated among skeletal characters that were based on all specimens. We summarized correlations among characters by clustering with the unweighted pair-group method that made use of arithmetic averages (UPGMA; Sneath and Sokal 1973). The cophenetic correlation coefficient was calculated to determine the degree to which the resulting dendrogram summarized the inter-associations indicated in the original character correlation matrix.

Principal components (Sneath and Sokal 1973) were extracted from the variance-covariance matrix of skeletal characters that were standardized on the basis of pooled within-sex standard deviations. As pointed out by Rohwer and Kilgore (1973), this modification of the usual method for standardization has advantages when one is attempting to discriminate between known groups. More emphasis is given to characters with a relatively low ratio of within-group variance to total variance. Character loadings (i.e., correlations of characters with components) were calculated, and specimens were projected onto component axes.

We also used stepwise discriminant analysis (Program P7M of BMDP-79; Dixon and Brown 1979) to determine which of the 51 measurements (in combination) provided maximum discrimination between males and females with respect to the amount of variability within each sex. Specimens were then projected onto the resulting discriminant axis. Classification functions were calculated and could be used to assign a specimen of unknown gender to one or the other sex, based on the likelihood of membership in two groups. The technique was applied first to the total suite of characters and then to those representing particular body regions (i.e., 14 head, 11 pectoral girdle, 12 wing, 11 pelvic girdle, nine leg).

For the discriminant analysis, we entered variables into a function one at a time, with the order of entry being determined by an anal-

TABLE 1. Character names, arithmetic means, standard deviations, principal component loadings, *F*-ratios, and percentage differences for male and female California Gulls.[a]

Character number and name[b]	Mean (mm)		Standard deviation (mm)		Principal component		*F*-ratio[c]	Percentage difference[d]
	Male	Female	Male	Female	I	II		
Head								
1 Premaxilla l.	55.47	50.54	1.88	1.03	0.917	−0.107	186.8	9.29
2 Premaxilla l. (f.n.o.)	15.39	14.18	0.80	0.60	0.713	−0.006	49.6	8.21
3 Premaxilla d.	6.09	5.63	0.30	0.39	0.583	0.535	27.2	7.93
4 Internarial w.	4.28	3.87	0.23	0.21	0.786	0.250	56.1	9.91
5 Nasal bone w.	10.47	9.71	0.41	0.37	0.751	0.064	59.9	7.47
6 Interorbital w.	10.31	9.35	0.58	0.54	0.722	−0.084	47.5	9.73
7 Postorbital w.	36.25	33.67	0.76	0.70	0.891	−0.020	204.6	7.38
8 Skull w.	32.35	29.69	0.63	0.59	0.943	0.031	307.8	8.59
9 Occipital d.	7.24	6.76	0.52	0.53	0.495	0.420	12.8	6.76
10 Skull d.	23.34	22.52	0.52	0.49	0.683	0.018	41.6	3.55
11 Skull l.	103.64	95.80	2.76	1.37	0.953	−0.089	233.2	7.86
12 Mandible l.	91.59	83.54	2.39	1.54	0.948	−0.116	278.0	9.20
13 Min. mandible l.	8.46	8.04	0.59	0.55	0.388	−0.209	8.6	5.03
14 Mandible d.	12.68	11.31	0.54	0.34	0.921	0.030	160.8	11.45
Pectoral								
15 Coracoid w.	4.56	4.27	0.20	0.25	0.577	0.307	24.8	6.55
16 Coracoid l.	45.05	42.02	1.00	0.94	0.934	−0.056	156.9	6.96
17 Scapula l.	59.66	55.74	1.60	1.60	0.912	−0.094	95.7	6.80
18 Scapula w.	10.07	9.22	0.37	0.35	0.786	0.313	89.2	8.83
19 Furcular process l.[e]	6.66	5.98	0.50	0.69	0.526	−0.303	19.0	10.67
20 Furcula l.	43.67	40.57	1.30	1.16	0.902	−0.113	102.5	7.35
21 Sternum l.	68.36	64.16	1.85	1.83	0.841	−0.011	83.0	6.33
22 Keel l.	70.37	65.45	2.05	1.92	0.876	−0.051	99.1	7.24
23 Sternum w.	43.02	39.26	1.29	1.41	0.842	−0.024	121.6	9.15
24 Keel d.	30.26	28.46	0.93	0.76	0.878	−0.169	73.7	6.13
25 Costal margin of sternum	16.04	14.94	0.99	0.71	0.611	0.063	27.3	7.06
Wing								
40 Humerus trochanter l.	31.79	29.35	0.90	0.83	0.914	0.000	127.8	7.96
41 Deltoid crest d.	11.69	10.90	0.39	0.40	0.766	0.071	63.2	6.98
42 Humerus dist. end w.	14.94	13.83	0.30	0.34	0.946	−0.020	190.6	7.72
43 Humerus l.	117.42	109.92	3.23	3.01	0.881	−0.134	93.2	6.60
44 Radius l.	129.58	120.73	3.84	3.25	0.907	−0.237	102.2	7.07
45 Ulna l.	133.88	125.20	3.93	2.82	0.929	−0.245	109.4	6.70
46 Ulna w.	4.72	4.40	0.18	0.13	0.779	0.051	74.7	7.17
47 Carpometacarpus l.	65.24	60.93	1.89	1.38	0.935	−0.207	114.9	6.84
48 Carpometacarpus d.	7.49	6.99	0.21	0.20	0.821	0.008	91.8	6.81
49 Phalanx l.[f]	27.42	25.57	0.89	0.66	0.891	−0.193	93.4	6.95
50 Phalanx d.[f]	8.28	7.83	0.19	0.22	0.724	−0.107	75.7	5.59
51 Pollex l.	28.60	26.56	0.94	0.94	0.799	−0.089	75.2	7.40
Pelvic								
26 Synsacrum d.	11.93	10.89	0.54	0.54	0.778	0.185	59.4	9.14
27 Posterior synsacrum l.	12.44	11.67	1.10	0.86	0.575	−0.131	10.3	6.43
28 Anterior synsacrum l.	38.22	35.92	1.20	1.07	0.808	−0.077	66.6	6.20
29 Synsacrum w.	25.94	23.83	0.89	1.21	0.738	0.309	59.7	8.48
30 Synsacrum min. w.	20.64	18.93	0.64	0.51	0.855	0.104	144.9	8.61
Leg								
31 Femur prox. end w.	9.09	8.30	0.28	0.27	0.891	0.219	133.8	9.18
32 Femur min. w.	4.17	3.86	0.21	0.16	0.660	0.310	45.7	7.77
33 Femur dist. end w.	9.32	8.63	0.21	0.21	0.905	0.200	174.1	7.73
34 Femur l.	49.91	46.54	1.07	1.06	0.933	−0.068	160.9	6.99
35 Tibiotarsus w.	3.77	3.49	0.24	0.17	0.655	0.189	32.0	7.80
36 Tibiotarsus l.	92.35	87.33	2.24	2.13	0.872	−0.295	85.1	5.58
37 Tarsometatarsus l.	59.48	55.10	1.32	1.51	0.906	−0.164	148.1	7.64
38 Tarsometatarsus w.	3.36	3.07	0.20	0.17	0.637	0.129	39.0	9.04
39 Tarsometatarsus dist. end w.	8.86	8.34	0.26	0.23	0.771	0.178	75.0	6.03

[a] Measures based on 27 males and 39 females.
[b] Character numbers and names from Schnell (1970a) with corrections indicated in Schnell (1970b:302). Abbreviations as follows: d. = depth; dist. = distal; f.n.o. = from narial opening; l. = length; min. = minimum; prox. = proximal; w. = width.
[c] Between-sex variance divided by within-sex variance. Comparisons 13 and 27 are highly significant ($P < 0.01$); others are very highly significant ($P < 0.001$).
[d] The difference between sexes (males minus females) multiplied by 100, with the resulting value divided by the average of the male and female means.
[e] Length of hypocleideum.
[f] Basal phalanx of digit II.

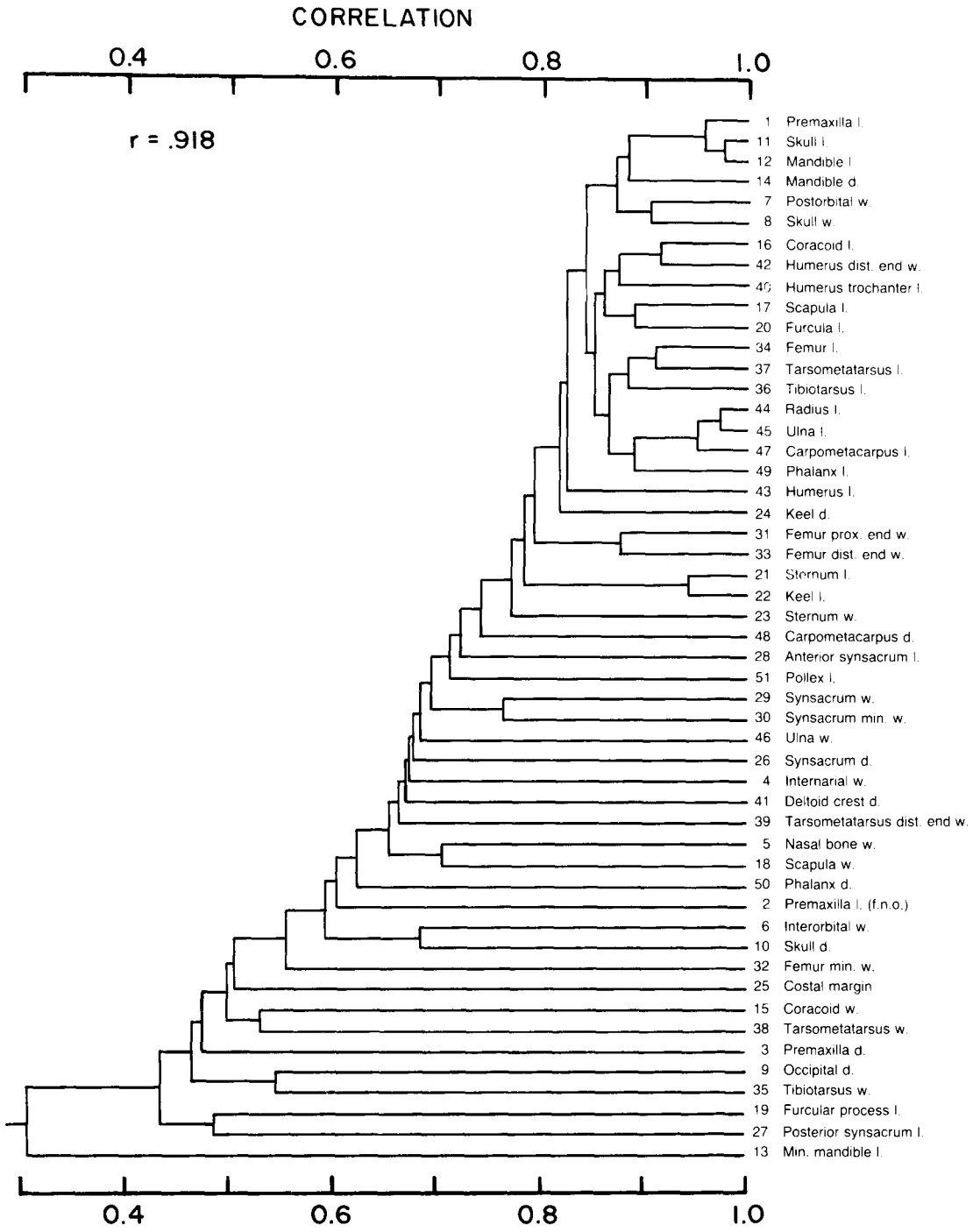

FIGURE 1. Dendrogram summarizing correlations among characters, based on 66 California Gulls. UPGMA clustering was used, and the cophenetic correlation (r) is indicated.

ysis of variance F-statistic (i.e., F-to-enter). The computed F-to-enter values are conditioned on the variables already present in the function (in a way similar to an analysis of covariance). After a variable is added, the function is re-computed to include the new variable, so as to maximize the separation between the known groups (in our case, the two sexes). The F-to-enter value indicates the contribution of a particular character to the overall separation of the predetermined groups. We set a minimum F-to-enter value of 4.0 for this analysis (i.e., a variable was not added to the classification function unless it provided this degree of separation).

Two of us (Schnell and Worthen) were in-

TABLE 2. Mean external measurements (SD in parentheses) for 27 male and 39 female California Gulls.

Measure	Male		Female	
Weight (g)	671.6	(54.40)	558.8	(37.92)
Cube root of weight ($g^{1/3}$)[a]	8.75	(0.236)	8.23	(0.186)
Wing chord (mm)	382.0	(13.93)	361.5	(11.77)
Tail length (mm)	149.1	(5.96)	145.4	(5.14)
Exposed culmen length (mm)	46.1	(2.39)	41.8	(2.32)

[a] For comparison with linear measures.

volved in specimen preparation and initial analyses. Schnell and Douglas conducted additional statistical analyses and developed the initial draft of the manuscript.

RESULTS

CHARACTER COVARIATION AND DEGREE OF DIMORPHISM

All correlations among the 51 characters were positive, ranging from 0.167 (minimum mandible length and anterior synsacrum length) to 0.976 (skull and mandible lengths). Character associations are summarized in Figure 1. The cophenetic correlation of this dendrogram is relatively high (0.918), indicating that the diagram accurately portrays the original character correlations. At the top of the dendrogram, a relatively closely linked group of six measurements of the head (from premaxilla length through skull width) joins another set of 12 characters that includes mostly appendage lengths. While we found a few additional close associations—for instance, the correlation of proximal and distal end widths of the femur, as well as that for sternum and keel lengths—most of the other characters were not closely correlated with one another. The most divergent character was minimum mandible length, which is relatively short in California Gulls. The dendrogram suggests that, overall, there is considerable independent variation among skeletal measures in this species.

External measures for the 27 male and 39 female gulls are summarized in Table 2. Percent differences between males and females for these characters were: weight, 18.33%; cube root of weight, 6.10%; wing chord, 5.52%; tail length, 2.54%; exposed culmen length, 9.63%.

The results of the principal components

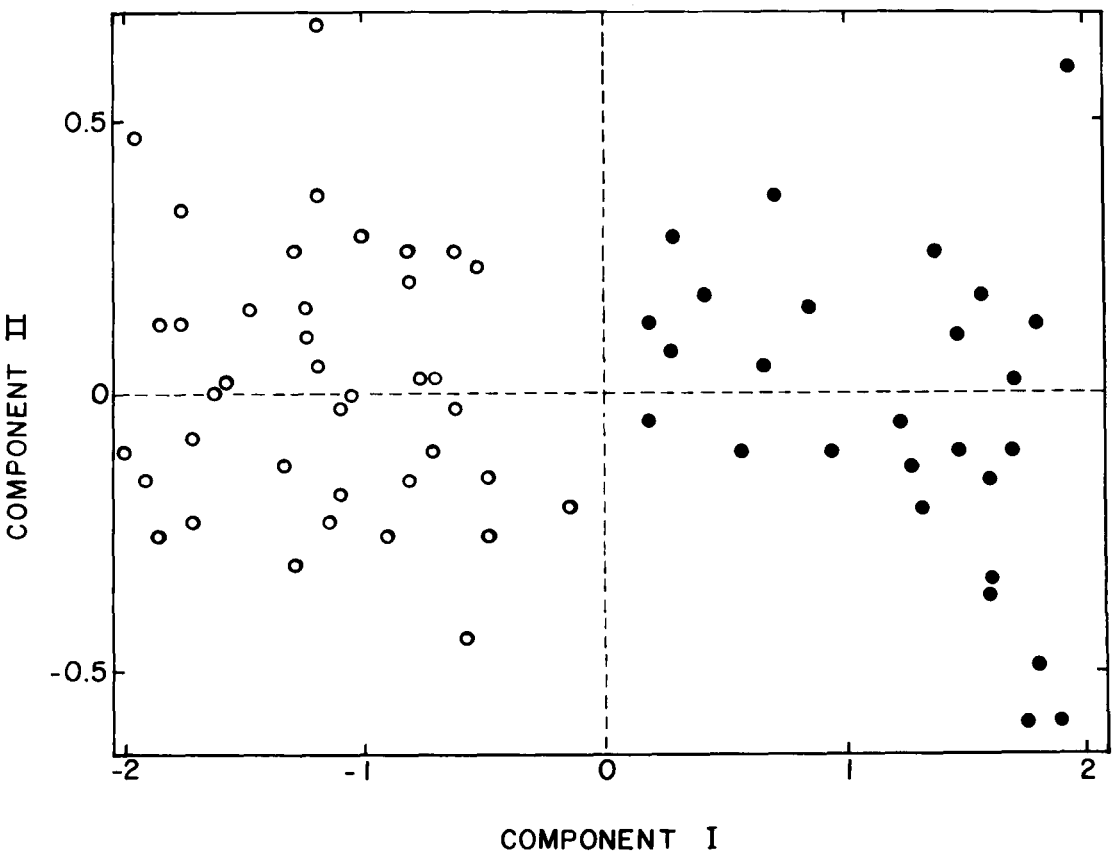

FIGURE 2. California Gulls plotted with respect to the first two principal components, based on 51 skeletal measurements. Characters were standardized on the basis of within-sex variances. The 27 males are represented by darkened circles and the 39 females by open circles.

TABLE 3. Statistics for stepwise discriminant analyses of male and female California Gulls, based on all characters, as well as on character subsets.

Character	*F*-value to enter	Order of entry	Coefficients[a]	Classification functions[b]	
				Male	Female
All characters (51)					
8 Skull w.	307.85	1	0.9853	63.656	57.773
12 Mandible l.	17.55	2	0.4113	21.131	18.675
24 Keel d.	7.65	3	−0.7410	−23.731	−19.307
39 Synsacrum min. w.	11.29	4	0.8016	48.731	43.945
Constant			−60.1401	−2,141.936	−1,779.571
Head (14)					
8 Skull w.	307.85	1	1.0374	66.720	61.451
12 Mandible l.	17.55	2	0.2872	15.669	14.211
Constant			−56.8674	−1,797.546	−1,506.410
Pectoral (11)					
16 Coracoid l.	156.88	1	0.4925	36.584	34.642
18 Scapula w.	13.03	2	1.3255	53.892	48.664
23 Sternum w.	10.62	3	0.3513	11.416	10.030
Constant			−48.3157	−1,341.638	−1,149.659
Wing (12)					
42 Humerus dist. end w.	190.62	1	2.2829	116.604	107.522
50 Phalanx d.	10.31	2	1.7784	149.441	142.366
51 Pollex l.	4.24	3	0.3147	16.347	15.095
Constant			−55.4882	−1,724.271	−1,502.075
Pelvic (5)					
26 Synsacrum d.	13.34	2	0.8988	35.081	31.986
30 Synsacrum min. w.	144.93	1	1.4712	61.572	56.506
Constant			−39.0491	−845.280	−709.737
Leg (9)					
33 Femur dist. end w.	174.06	1	3.2073	172.560	159.669
37 Tarsometatarsus l.	22.15	2	0.4097	22.465	20.818
Constant			−51.890	−1,473.090	−1,263.062

[a] For canonical variable, which in the two-group case is equivalent to the discriminant function.
[b] Used with original measurements. Add products of measurements and corresponding function values to constant; classify as male or female depending on which results in the higher value for classification function.

analysis of skeletal measures indicated general trends in variation. Loadings for the first two components are given in Table 1, and the individual specimens are projected onto these components in Figure 2. The first component, which explained 65.4% of the total character variation, provided complete separation between males and females (Fig. 2). It had high correlations with essentially all characters (Table 1), suggesting that the component represents a general size factor that is associated with differences between sexes. The largest animals are depicted to the right on Figure 2. The second component statistically explained relatively little variability (3.4%) and, except for premaxilla depth (0.535) and occipital depth (0.420), characters vary independently relative to this component. Birds that are large for these two characters are near the top of the diagram (Fig. 2), while the smaller ones are near the bottom. We found no indication of any association of variation in this component with differences owing to age (i.e., among three-year-olds, four-year-olds, and older) or other obvious factors.

All characters showed statistically significant differences between the sexes, with males being larger (Table 1). The *F*-ratios from ANOVAs ranged from 8.6 (minimum mandible length) to 307.8 (skull width). The percent difference between males and females for the 51 characters averaged 7.56%, with the smallest difference being 3.55% (skull depth) and the largest 11.45% (mandible depth). Average percentage differences for characters from different body regions were: head, 8.03%; pectoral, 7.55%; wing, 6.98%; pelvic, 7.77%; and leg, 7.53%.

DISCRIMINANT ANALYSES

When all characters were evaluated simultaneously, the resulting function included four characters (top of Table 3). It reflected, as indicated in the ANOVAs for single characters (Table 1), that the best character for separating the sexes was skull width. The combination of this character with a head length character, as well as one each from the pectoral and pelvic regions, resulted in complete separation of males and females (Fig. 3A). Coefficients that

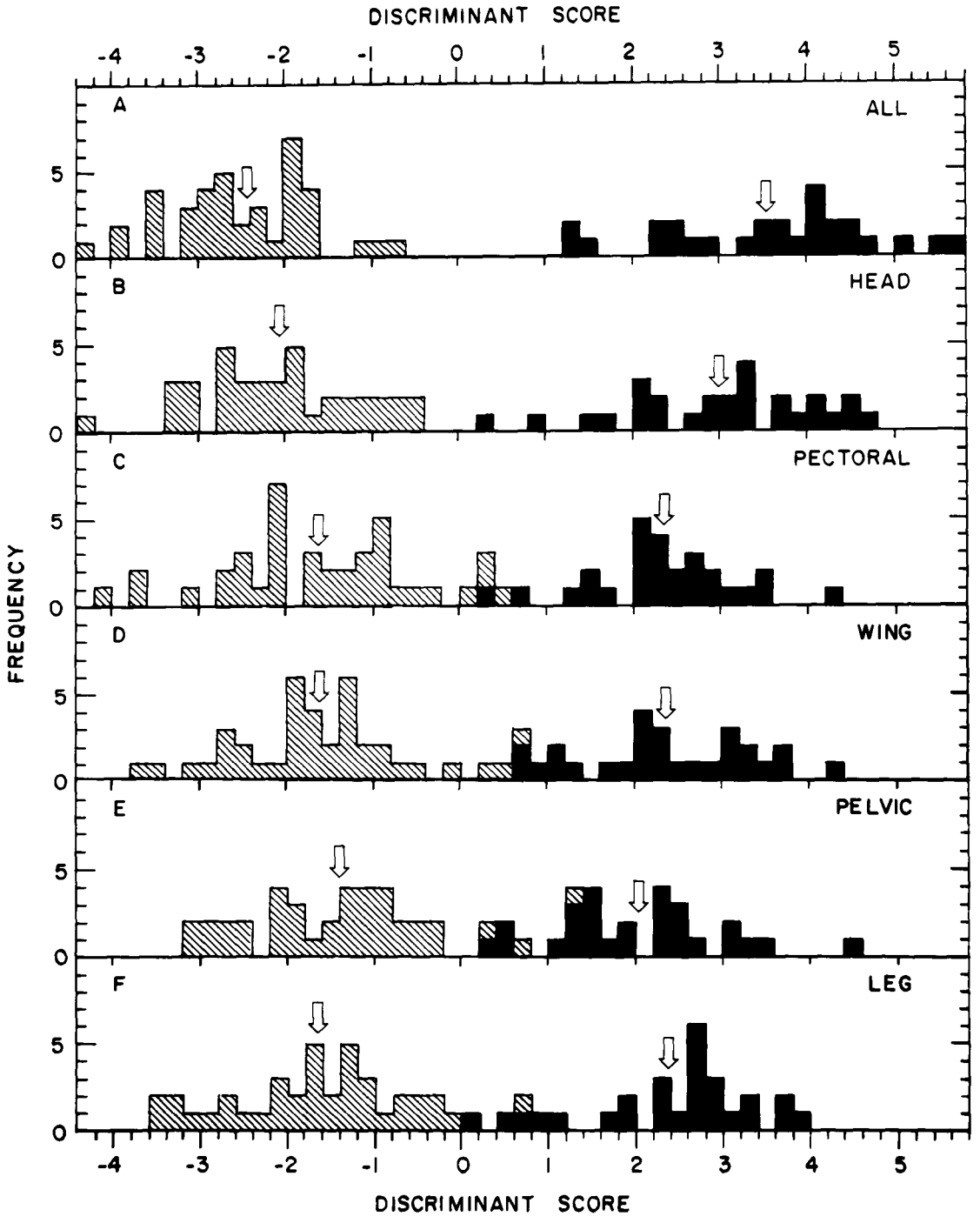

FIGURE 3. Projections of 27 male (solid bars) and 39 female (lined bars) California Gulls onto discriminant function axes that are designed to separate the sexes. Discriminant plots are based on: (A) all 51 measurements; (B) 14 head characters; (C) 11 pectoral characters; (D) 12 wing characters; (E) five pelvic characters; and (F) nine leg characters. These provide the maximum separation of males and females that can be achieved by using skeletal measurements of the whole body, as well as those of separate body regions. Arrows indicate mean projection values for each sex.

can be used to place specimens of unknown gender onto the discriminant axis are provided in Table 3, along with coefficients for the two classification functions.

The classification functions are based on an equal probability of a particular specimen being a male or female. Measurement values for the characters are multiplied by the indicated coefficients, and the resulting products are added to the constant. This calculation is completed

TABLE 4. Percentage of original specimens (27 males and 39 females), correctly identified as to sex, using classification functions (based on all specimens as well as jackknifed procedure) that were derived from characters that represented different body regions.

Body region	Regular procedure			Jackknifed procedure		
	Male	Female	Total	Male	Female	Total
All	100.0	100.0	100.0	100.0	100.0	100.0
Head	96.3	100.0	98.5	96.3	100.0	98.5
Pectoral	100.0	94.9	97.0	96.3	94.9	95.5
Wing	100.0	92.3	95.5	100.0	89.7	93.9
Pelvic	100.0	94.9	97.0	96.3	94.9	95.5
Leg	96.3	97.4	97.0	92.6	97.4	95.5

for both functions, and a specimen is assigned to that sex for which the resulting classification value is the greatest.

Of the 27 males and 39 females in the analysis, all were correctly identified by using the classification function (Table 4). This was also the case when we used a pseudo-jackknifed classification procedure (see Dixon and Brown 1979), which effectively leaves out the individual specimen being considered, re-computes the coefficients of the functions, and then evaluates the specimen; typically, this procedure gives a better indication of the future behavior of functions on new specimens.

As expected, given the results in the overall analysis, the discriminant function that was based on only the 14 head characters incorporated skull width and mandible length (Table 3). While this function resulted in complete separation of males and females (Fig. 3B), the classification functions misclassified one of the males as a female, whether the regular or jackknifed procedure was used.

For the pectoral and wing regions that were considered separately, we selected three characters as part of the respective discriminant functions (Table 3). While most specimens were separated by sex (Fig. 3C, D), there was slight overlap. The classification functions correctly identified a higher proportion of the males than females by using characters from these regions (Table 4), with over 93% of the total specimens being correctly identified with the regular and jackknifed procedures.

Similar percentages of correct identification were achieved by using the classification functions for the pelvic region and those for the leg region (Table 4). The discriminant functions for these two body regions incorporated two variables each (Table 3), and most specimens were separated into the appropriate male or female group (Fig. 3E, D).

DISCUSSION

In our evaluation of character covariation, we minimized the influence of geographic and temporal variation by collecting specimens within a short time span and from a relatively small geographic area. We also largely eliminated variation due to age in our sample by selecting only adult specimens (i.e., those at least three years of age). Intercorrelations between many of the characters were relatively low, often less than 0.80. This level of covariation suggests that, while some birds are bigger than others, there are some proportional and shape differences among the birds as well.

The range of 3.76–9.48% difference between male and female California Gulls reported by Behle and Selander (1953:249) for external measures is about the same as the range we found for these characteristics. It is also similar to the 3.55–11.45% differences found for our suite of 51 skeletal measures. The birds used in their and our studies are from essentially the same locality, but were taken 15 to 17 years apart (1950–1952, and 1968).

Ingolfsson (1969) noted that sexual dimorphism in gulls is remarkably constant among species, with the males averaging 1.04–1.09 times as large as the females. He used the male/female ratio of cube roots of body weights, rather than the difference divided by the average male-female weights. Thus, his measure yields a somewhat higher proportional (or percentage) difference than the one obtained with the coefficient we employed. In our sample, based on the cube root of body weight, males were 6.10% larger than females (or 1.063, using Ingolfsson's measure) indicating that, with respect to inter-sex differences, the California Gull is a typical larine. In most monogamous birds, males are slightly larger than females.

Selander (1966, 1972) pointed out that many species are more dimorphic in bill dimensions than in those from other body parts. He cited some particularly striking examples, including that for American White and Brown pelicans (*Pelecanus erythrorhynchos* and *P. occidentalis*), where the percentage sexual dimorphism in bill length (16% in the former and 8–10% in the latter) is about twice that of wing or tarsus length. Ingolfsson (1969) stated that, in the gulls he studied, sexual dimorphism in bill

dimensions was invariably greater than it was in other body parts and was greater than the dimorphism in general size. Furthermore, he found dimorphism almost always greater in bill depth than in culmen length. The relatively greater bill depth in males is probably related to the importance and prominent use of the bill in courtship displays and territorial defense.

The relative differences that we found for various body parts of male and female California Gulls support the findings of previous investigators, although the differences are not marked. On the average, the greatest intersexual differences occurred in the head (8.03%), while the wing was the least variable (6.98%). Within the head region, the mandible depth clearly was the most dimorphic of the measures taken (11.45%; Table 1). It is the lower part of the bill that was the major contributor to the relatively large difference in overall bill depth, since dimorphism in premaxilla depth (7.93%) was similar to that of other skull dimensions. The greater depth difference on the head was restricted to the bill; the difference between males and females in skull depth was only 3.55% (Table 1).

The degree of sexual dimorphism was relatively uniform in characters from the pectoral, pelvic, and leg regions, although there are some exceptions (Table 1). For instance, the difference between sexes in the length of the furcular process (hypocleideum) was particularly marked (10.67%); the significance of this difference, if any, is unclear. It has been suggested (P. Stettenheim, pers. comm.) that the larger size of this process in males may be related to more or louder vocalizing by male gulls. The interclavicular air sac has a role as a resonating chamber for the syrinx, which it encloses. Since the furcular process (hypocleideum) crosses this sac, larger size of the process may reflect a larger resonating chamber.

Differences in wing length seem to be less marked than those for other linear measures. Ingolfsson (1969) reported that, for several gull species, the difference in wing length between sexes was less than that predicted on the basis of overall size. For the California Gull, the 6.98% average difference in wing dimensions was actually greater than we found for the cube root of body weight (6.10%). Wing length is likely to be closely linked with wing loading and other wing-body considerations that are related to aerodynamic properties. Thus, it is likely that selective and other constraints on wing dimensions are considerably different than those influencing other body regions.

We were able to separate and easily identify to sex all of the specimens that were employed in our study with the use of four characteristics (two skull, one pectoral, and one pelvic) taken from the total of 51. Our analyses indicate that most, if not all, individual California Gulls can be identified to sex through this combination of skeletal characters. Nearly as complete a separation is achieved with measures from only one body region, because dimorphism pervades all skeletal elements in California Gulls.

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RECENT PUBLICATIONS

Neotropical ornithology.—Edited by P. A. Buckley, Mercedes S. Foster, Eugene S. Morton, Robert S. Ridgely, and Francine G. Buckley. 1985. Ornithological Monographs No. 36. American Ornithologists' Union, Washington, DC. 1041 p. $70.00. Source: Frank R. Moore, Assistant to the Treasurer, A.O.U., Department of Biology, University of Southern Mississippi, Southern Station Box 5018, Hattiesburg, MS 39406. All orders must be prepaid and include a $1.00 handling charge. This volume is a collection of invited papers, prepared as a memorial to Eugene Eisenmann, one of the most influential and surely the most warmly esteemed worker on neotropical birds. It opens with a biographical sketch of Eisenmann by Thomas Howell and closes with an overview of the collection—with regard to the field itself—by Kenneth Parkes. In between are 61 papers grouped as to new taxa, zoogeography and distribution, systematics, evolution, community and population ecology, evolutionary and behavioral ecology, breeding biology, and conservation. Commendably, they reflect the editors' efforts to obtain longer synthesizing review papers as well as shorter reports on significant new research. Thus, they tend to show a broader perspective and to contain more material of lasting value than is customary in assembled volumes. The papers are each furnished with abstracts in English and Spanish, illustrations, and a list of references. Eight color plates (by various artists) depict new or reanalyzed taxa, or features of taxonomic significance. Despite the shortcomings in the scope of the volume, acknowledged by the editors, this is the most inclusive monograph on neotropical ornithology ever published. It brings honor to its authors and editors, as well as its dedicatee. Index.

Primer symposio de ornithologia neotropical.—Edited by F. Gary Stiles and Pedro G. Aguilar F. 1985. Asociación Peruana para Conservación de la Naturaleya, Lima, Peru. 126 p. Paper cover. No price given. Source: Pacific Press S.A., Los Negocios 219, Lima 34, Peru. This volume contains the proceedings of the first symposium on neotropical ornithology, held in October, 1983 at Arequipa, Peru. The 13 papers and 19 summaries of other presentations deal with a variety of species and ornithological problems in Latin America but do not focus on a common theme. They are written in Spanish, and the papers have summaries in English. In closing are recommendations for the investigation and protection of birds and their habitats in Latin America. A landmark publication. Illustrations, references.

Nidificacion de las aves argentinas (Dendrocolaptidae y Furnariidae).—S. Narosky, R. Fraga, and M. de la Peña. 1983. Asociación Ornithologica del Plata [Buenos Aires]. 98 p. Paper cover. $8.00. Source: Asociación Ornithologica del Plata, 25 de May 749, 2° Piso, (1002) Buenos Aires, Argentina. This is a report, in Spanish, on the nesting habits of Argentine woodcreepers and ovenbirds. For each of 77 species, data on the nest and eggs are given, taken from the literature and original observations; comments on the validity of certain published records or on taxonomic implications are appended. Many of the accounts are illustrated with drawings that show the placement and structure of the nests. Basic information of this kind is hard to come by, yet is essential for sound research in systematics and ecology. Monochrome photographs, references, index.