SEXUAL SIZE DIMORPHISM AND DETERMINATION OF SEX IN ATLANTIC YELLOW-LEGGED GULLS *LARUS MICHAHELLIS LUSITANIUS* FROM NORTHERN SPAIN

Aitor GALARZA* 1, Jon HIDALGO**, Gorka OCIO** and Pilar RODRÍGUEZ***

**SUMMARY.**—Sexual size dimorphism and determination of sex in Atlantic yellow-legged gulls *Larus michahellis lusitanius* from Northern Spain.

**Aims:** We evaluate sexual size dimorphism in Atlantic yellow-legged gulls *Larus michahellis lusitanius* and provide a discriminant function to sex gulls in hand.

**Location:** Two islands of the Basque Country (Northern Spain).

**Methods:** Incubating gulls were trapped, banded, weighted and measured. A drop of blood was extracted for molecular sexing. After testing for sex differences in body size and weight, discriminant function analyses were performed to identify the best traits for sexing.

**Results:** Body measurements in males were significantly larger than in females. Within each pair, males had larger head length, bill depth, long bill length and body mass. Discriminant analysis indicated than the combination of three measurements (head length, bill depth and wing length) predicted correctly the sex of 98.5 % of individuals.

**Conclusions:** The discriminant function described by Bosch (1996) cannot be used to identify sex properly in Atlantic Iberian yellow-legged gulls because they are significantly smaller than their Mediterranean counterparts. No significant differences were found with yellow-legged gull populations from Western extreme of Cantabrian coast (Galicia). Therefore, we conclude that the developed discriminant function can be applied to other Atlantic yellow-legged gull populations from Northern Iberian Peninsula, thus, providing a highly accurate, inexpensive and fast method for sexing in hand this Iberian gull subspecies.

**Key words:** *Larus michahellis lusitanius*, Iberian Peninsula, discriminant function analysis, sexual dimorphism.

**RESUMEN.**—Dimorfismo sexual y determinación del sexo en gaviotas patiamarillas *Larus michahellis lusitanius* del norte de España.

**Objetivos:** Se evalúa el dimorfismo sexual de una población atlántica de gaviota patiamarilla *Larus michahellis lusitanius* del norte de España y se ofrece una función discriminante para la determinación del sexo.

**Localidad:** Dos islas del País Vasco (Norte de España).

**Métodos:** Se capturaron gaviotas incubadoras que fueron anilladas, pesadas y medidas. Se extrajo una gota de sangre para el sexado molecular. Tras examinar las diferencias entre sexos en medidas corporales y peso, se aplicó análisis discriminante para establecer las mejores medidas de determinación de sexo.

* Servicio de Conservación y Espacios Naturales Protegidos, Departamento de Agricultura, Diputación Foral de Bizkaia, Bilbao, E-48014 Spain.
** Sociedad Ornitológica Lanius, General Salazar, 4-1° dcha, Bilbao, E-48009 Spain.

1 Corresponding author: agalarza@telefonica.net
**INTRODUCTION**

Most gull species have no obvious sexual dimorphism in plumage but males and females differ in size (e.g., Harris & Hope Jones, 1969; Cramp and Simmons, 1983). Several studies have described predictive functions based on external measurements to discriminate between sexes in gulls (Coulson et al., 1983; Migot, 1986; Bosch, 1996; Chochi et al., 2002). These functions are usually specific for each gull species or even for some gull populations within a single species (Evans et al., 1993 and 1995).

Yellow-legged gull (*Larus michahellis*), now considered a separate species from herring gull (*Larus argentatus*) (Yé sou, 1991; Wink et al., 1994; Crochet et al., 2002), shows a great amount of variation among its populations (Liebens et al., 2001; Pons et al., 2004). Although several taxonomic options could be adopted to account the observed variation, two yellow-legged gull subspecies have been commonly accepted: *L. m. atlantis*, inhabiting the Macaronesian archipelagoes and *L. m. michahellis*, breeding in the Mediterranean basin and Atlantic Northern African and Iberian coasts, from Morocco to the Basque Country (Liebers et al., 2001).

Several studies have shown further differences between yellow-legged gulls from Atlantic Morocco and Atlantic Iberia and also that some of the ethologic and phenotypic characteristics of the Atlantic Iberian populations are more similar to Herring gull *Larus argentatus* populations than to the yellow-legged populations breeding in the Mediterranean basin (Teyssèdre, 1983, 1984; Mínguez, 1988; Muñilla, 1997a, 1997b; Beaubrun, 1988). Furthermore, Pons et al. (2004) provided additional evidence to support that Atlantic Iberian yellow-legged gulls are closer to herring gull than to Mediterranean yellow-legged gulls in size and shape. These authors also documented significantly differentiated neutral molecular markers between Atlantic Iberian populations and their Mediterranean counterparts that could be explained by the barrier to current gene flow that the delay in breeding phenology and the isolation by distance may constitute. Taking all this into account, it has been suggested to recognise Atlantic Iberian yellow-legged gull as a distinct subspecies named *Larus michahellis lusitanius* (Joiris, 1978), pending a more complete treatment of genetic and morphologic characters (Bermejo and Mouriño, 2003; Pons et al., 2004).

Yellow-legged gulls from Northern Atlantic Iberia are significantly smaller than yellow-legged gulls from the Mediterranean basin.
(Carrera et al., 1987; Liebers et al., 2001; Pons et al., 2004), therefore the discriminant function described by Bosch (1996) cannot be used to identify sex properly in Atlantic Iberian populations.

The aims of this paper are (1) to evaluate sexual size dimorphism in an Atlantic yellow-legged gull population from Northern Spain and (2) to provide a reliable method for determining the sex of yellow-legged gulls from this population.

**Material and Methods**

During the breeding period of 2005 and 2006, 67 incubating yellow-legged gulls from Izaro Island (43° 25’ N, 02° 41’ W) and 12 from San Nicolás Island (43° 22’ N, 02° 30’ W), (Biscay, Basque Country, Northern Spain) were collected with a drop trap (Mills and Ryder, 1979). All the birds showed complete adult plumage. According to Bermejo and Mouriño (2003) these gulls belong to the Cantabrican population *Larus michahellis lusitanius*. All birds were ringed with a metal and an engraved colour ring, measured, weighted and released. A small blood sample (< 0.1 ml) was taken from the brachial vein for sexing by molecular techniques at the Department of Zoology and Ecology of the University of Navarra, according to the protocol used by Gutiérrez-Corchero et al. (2002).

Nine body variables were measured: flat wing and tail length were measured to the nearest 1 mm using a ruler, head length (distance from the tip of the bill to the posterior ridge formed by the parietal-supraoccipital junction), bill depth (maximum depth of the bill posterior to the nostril), short bill length (distance from the tip of the bill to where rhinoteca meets with the skin), long bill length (distance from the tip of the bill to the corner of the mouth), naloispi (distance from the tip of the bill to the nostril), tarsus length and middle toe length were measured using a digital calliper to the nearest 0.01 mm. Birds were weighted to the nearest 10 g with a hand-held 2,000 g balance.

Variables were checked for normality using the One-Sample Kolmogorov-Smirnov test. We used two-tailed t-test to evaluate intersexual differences for each variable in the population from Izaro Island and to test differences in head length, bill depth and weight between this population and Atlantic yellow-legged gull populations from Galicia (Carrera et al., 1987). We could not compare the variables between sexes because these authors gave statistic values for the whole population.

The percentage of dimorphism between sexes in each measure was calculated as

$$\%D = \frac{X_m - X_f}{X_m}$$

where $X_m$ and $X_f$ are the mean values in males and females respectively. We also compared measurements between the members of each pair in Izaro island to assess how often the male was larger than the female.

Finally, a stepwise discriminant function was calculated using all the measurements of the individuals from Izaro island, entering at each step the variable that best reduce overlapping between the centroids corresponding to the two sexes. The effectiveness of the discriminant function was assessed by a Jacknife - cross validation technique, in which sex classification was estimated using all individuals except the case being classified. We also validated the discriminant function using the sample of individuals from San Nicolás Island (6 males and 6 females). All the analyses were performed with the SPSS 11.0 statistical package.

**Results**

All measurements were significantly larger in males than in females (Table 1). The degree of sexual dimorphism differed depending on the variables; mass being the most dimorphic one and wing the least (Table 1). Paired comparisons of variables between members of the pairs revealed that males were always larg-
Body measurements of female and male yellow-legged gulls from Izaro Island. C.V.: coefficient of variation, \(t\): Student-t statistics, \%D: dimorphism percentage.

[Medidas corporales de hembras y machos de gaviota patiamarilla de la isla de Izaro. C.V.: coeficiente de variación. \(t\): estadístico \(t\) de Student, \%D: porcentaje de dimorfismo.]

### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Females (n = 36)</th>
<th>Males (n = 31)</th>
<th>(t)</th>
<th>(P)</th>
<th>%D</th>
<th>Wilk’s lambda</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean ± SD (range)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head length (mm)</td>
<td>115.51 ± 3.4 (110.2 - 123.6)</td>
<td>128.6 ± 3.1 (119.2 -135.5)</td>
<td>-16.4</td>
<td>&lt; 0.001</td>
<td>10.2</td>
<td>0.19</td>
</tr>
<tr>
<td>Bill depth (mm)</td>
<td>17.6 ± 0.7 (15.9 -18.8)</td>
<td>20.1 ± 0.8 (18.3 - 22.3)</td>
<td>-13.4</td>
<td>&lt; 0.001</td>
<td>12.4</td>
<td>0.26</td>
</tr>
<tr>
<td>Short bill length (mm)</td>
<td>51.9 ± 2.8 (39.9 - 55.9)</td>
<td>58.6 ± 2.1 (52.7 - 62.1)</td>
<td>-10.7</td>
<td>&lt; 0.001</td>
<td>11.4</td>
<td>0.36</td>
</tr>
<tr>
<td>Long bill length (mm)</td>
<td>72.6 ± 2.5 (67.0 - 78.7)</td>
<td>79.9 ± 2.4 (75.0 - 85.3)</td>
<td>-12.2</td>
<td>&lt; 0.001</td>
<td>9.1</td>
<td>0.30</td>
</tr>
<tr>
<td>Nalospi (mm)</td>
<td>22.0 ± 1.7 (18.7 - 25.2)</td>
<td>23.8 ± 1.7 (20.2 - 27.7)</td>
<td>-4.4</td>
<td>&lt; 0.001</td>
<td>8.2</td>
<td>0.77</td>
</tr>
<tr>
<td>Tarsus length (mm)</td>
<td>68.9 ± 2.2 (64.2 - 73.9)</td>
<td>74.2 ± 4.8 (54.8 - 80.5)</td>
<td>-5.5</td>
<td>&lt; 0.001</td>
<td>7.5</td>
<td>0.65</td>
</tr>
<tr>
<td>Middle toe length (mm)</td>
<td>63.7 ± 2.7 (59.6 - 74.1)</td>
<td>68.6 ± 4.7 (47.4 - 74.3)</td>
<td>-5.3</td>
<td>&lt; 0.001</td>
<td>7.1</td>
<td>0.70</td>
</tr>
<tr>
<td>Wing (mm)</td>
<td>417.4 ± 9.1 (399 - 438)</td>
<td>440.0 ± 9.1 (423 - 458)</td>
<td>-10.1</td>
<td>&lt; 0.001</td>
<td>5.1</td>
<td>0.39</td>
</tr>
<tr>
<td>Tail (mm)</td>
<td>166.9 ± 9.1 (151 - 192)</td>
<td>178.9 ± 10.8 (160-211)</td>
<td>-4.9</td>
<td>&lt; 0.001</td>
<td>6.7</td>
<td>0.72</td>
</tr>
<tr>
<td>Mass (g)</td>
<td>803.0 ± 56.2 (670 - 940)</td>
<td>983.8± 71.7 (850-1150)</td>
<td>-11.5</td>
<td>&lt; 0.001</td>
<td>18.3</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Stepwise discriminant analysis incorporated to the function three out of ten body variables. The resulting discriminant function was:

\[
D = 0.206*\text{Head Length} + 0.461*\text{Bill depth} + 0.035*\text{Wing Length} - 48.788
\]

(Wilk’s lambda = 0.153; \(\chi^2 = 119.26\); df = 3; \(P < 0.001\)), where values of D > 0 identified males and values of D < 0 identified females. Function eigenvalue was 5.54, and the value of the function in the centroids for group 1 (females) was -2.152, and 2.499 for group 2 (males). Exact \(F\) test= 116.37 (\(P < 0.001\)) concluded that the function centroids were significantly different. The discriminant function classified correctly the sex of 98.5 % of the original grouped cases as well as 97.0 % of cross-validated grouped cases. Different randomly chosen subsamples were also used to evaluate the validation of the function (Leave one-cut classification in SPSS) resulting in 91.7 % to 100 % of the cases correctly classified. The function also classified correctly 91.6 % of the gulls from San Nicolás Island (one female failed in the prediction among the 12 individuals tested).
No significant differences were found between Basque and Galician populations in head length, bill depth and weight (Table 3). Other morphometric variables were not compared because of the different way of measuring used in both studies.

**DISCUSSION**

As it has been described in other yellow-legged gull populations (Isenmann, 1973; Bosch, 1996; Pons et al., 2004), we found marked sexual differences in body measurements. The accuracy of the discriminant function obtained was similar to those reported for other populations of the *Larus argentatus-cachinnans* group (Shugart, 1977; Fox et al., 1981; Coulson et al., 1983; Migot, 1986; Evans et al., 1995; Bosch, 1996) and predicted correctly the sex of most of yellow-legged gulls from our population. When values of the discriminant function (D) are near zero gulls are less likely to be properly sexed. In such cases, their sex could better be inferred by comparing head length, bill depth, long bill length or body mass with those of their partners if available. The highest accuracy of head length, bill depth and wing length in discriminating sex agree with the results obtained by Bosch (1996) for a Mediterranean yellow-legged colony, although in this case a single measurement (head length) was almost as efficient as the combined function. This variable seems to be the most informative for gull sex prediction since it is included as the most predictive variable in the discriminant function of all the studies mentioned above. The three biometric measurements entering in the function can easily be taken in the field with great accuracy, although bill depth should be used with caution, because it can vary with age (Coulson et al., 1981).

**Table 2**

Percentage of pairs from Izaro Island where males showed higher values than females for each measurement. ($n = 28$).

<table>
<thead>
<tr>
<th>Measurement</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head length</td>
<td>100</td>
</tr>
<tr>
<td>Bill depth</td>
<td>100</td>
</tr>
<tr>
<td>Short bill length</td>
<td>92.3</td>
</tr>
<tr>
<td>Long bill length</td>
<td>100</td>
</tr>
<tr>
<td>Nalospi</td>
<td>83.3</td>
</tr>
<tr>
<td>Tarsus length</td>
<td>92.3</td>
</tr>
<tr>
<td>Middle toe length</td>
<td>96.3</td>
</tr>
<tr>
<td>Wing</td>
<td>83.3</td>
</tr>
<tr>
<td>Tail</td>
<td>72.7</td>
</tr>
<tr>
<td>Body mass</td>
<td>100</td>
</tr>
</tbody>
</table>

**Table 3**

Variation between yellow-legged gulls from Galicia (Carrera et al., 1987) and Izaro Island, Basque Country (present study).

<table>
<thead>
<tr>
<th></th>
<th>Galicia</th>
<th>Basque Country</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head length</td>
<td>122.78 ± 7.37</td>
<td>121.57 ± 7.33</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Bill depth</td>
<td>18.16 ± 1.22</td>
<td>18.73 ± 1.46</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Body mass</td>
<td>853.75 ± 168.39</td>
<td>886.72 ± 110.76</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>
Minguez et al. (1995) suggested the existence of a cline in size of yellow-legged gulls along the Cantabrian coast, being smaller the individuals breeding in the eastern extreme. However, no significant differences were found between Basque (eastern) and Galician (western) populations when head length, bill depth and body mass were compared. Such two gull populations are located in the extremes of the Cantabrian coast, so it can be suggested that no identifiable sexual differences in morphology exist throughout the coast of Northern Atlantic Spain. Therefore, we conclude that the developed discriminant function can be applied to incubating yellow-legged gulls all along Northern Iberian coast, providing a highly accurate, inexpensive and fast method for sexing this gull subspecies in hand which can help us to approach future questions about its ecology.

Acknowledgements.—We are gratefully indebted to Luis Fernando Estéfano, Ignacio García, Miguel de las Heras, Francisco Martínez, Maider Olondo, Yolanda Ozaeta, Pablo Pérez, Elena Sánchez and Begoña Zorrakin for assistance in data collection. We thank the Fishguard of the Basque Government for helping us to access to Izaro Island in 2005. Field work was partially financed by the Biodiversity Office of the Basque Government (Environment Department). Blood analyses were carried out by Mª Ángeles Hernández in the Department of Zoology and Ecology of the University of Navarra. All birds were captured and banded under licence from the corresponding local authority (Diputación Foral de Bizkaia).

Bibliography


[Recibido: 04-09-07]
[Aceptado: 30-06-08]

Aitor Galarza is doctor in biology and works as a gamekeeper in the Biosfera Reserve of Urdaibai. Jon Hidalgo and Gorka Ocio are ringers who developed their interest on seabirds in Lanius Ornithological Society. Pilar Rodriguez is Zoology Professor at University of the Basque Country where she teaches Applied Zoology.