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DIFFERENTIAL AGE-RELATED PHENOLOGY IN LESSER BLACK-BACKED GULL *LARUS FUSCUS* WINTERING IN THE MALAGA AREA

FENOLOGÍA DIFERENCIAL RELACIONADA CON LA EDAD EN LA GAVIOTA SOMBRÍA *LARUS FUSCUS* DESDE EL ÁREA DE INVERNADA DE MÁLAGA

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Summary.—We aimed to identify the existence of age-classes groups that shared similar seasonal patterns in migration movements for the lesser black-backed gull *Larus fuscus*. The gull age-classes groups were defined as sets of age-classes that were present in the harbour of Malaga (South of Spain) simultaneously during the wintering season. We distinguished ten groups of age-classes, which can be subsequently lumped into four big age-class groups: (i) immature stage-class, (ii) young breeders, (iii) age-classes from 6 to 11 years old, and (iv) age-classes older than 11 years old. Our present results supported the 'dominance and arrival time model'.

Resumen.—Se pretendía identificar la existencia de grupos de clases de edad con un patrón estacional similar en la gaviota sombría *Larus fuscus*. Los grupos se definieron como conjuntos de clases de edad que estuvieron presentes de forma simultánea siguiendo un mismo patrón temporal en el puerto de Málaga durante la temporada de invernada. Se distinguieron diez grupos de clases de edad, los cuales a su vez pueden agruparse en cuatro grandes grupos: (i) inmaduros, (ii) jóvenes reproductores, (iii) clases de edad de 6 a 11 años y (iv) clases de aves mayores de 11 años. Nuestros resultados apoyan la teoría de la 'posición dominante y el modelo de la hora de llegada'.

The existence of differential age-related migration patterns is well known, for example, mature birds should leave the wintering grounds earlier due to constraints on the timing of breeding. This theory is named 'dominance and arrival time model' (e.g. Ellegren, 1991; Pérez-Tris and Tellería, 2001). An interesting question, thereby, is

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to understand how bird species from different populations, sex or taxa meet per age groups, coinciding in the wintering areas, because this is the basis of the avian migration phenology (Marques *et al*., 2009).

The lesser black-backed gull *Larus fuscus* is considered a common migratory species with a wide geographical distribution, breeding in colonies along the coast and some inland sites in North and West Europe, from the White Sea to Iceland; and in South Europe, up to the North of the Iberian Peninsula. It winters in wide areas along the Atlantic coasts of Europe and North Africa, as well as in the Mediterranean (*L. f. graellsii* and *L. f. intermedius*) and Central Africa (nominate *L. f. fuscus*). For this reason it is considered a suitable model for the study of migration (e.g. Marques *et al*., 2009).

The aim of this study was to test the existence of differential age-related phenology in the lesser black-backed gull in a wintering hotspot, using a statistical method for distinguishing different gull age-class groups.

The study was carried out in Malaga (Andalusia, S Spain), where ring monitoring has been conducted on a regular basis since 2007 by a single observer (S.G.B.). The local wintering population includes individuals from at least 55 different breeding colonies distributed throughout 8 different countries (comprising both *L. f. intermedius* and *L. f. graellsii*). Sightings were made using a 20-60x telescope of 80 mm in the harbour of Malaga during non-working days, in three winter seasons (2007-2008 to 2009-2010), from November to February (for details see García-Barcelona, 2009). Only gulls ringed as chicks in their breeding colonies were used in the analysis (n = 281 different individuals).

In a first step we defined gull age-class groups (GAGs thereafter) as sets of age-classes that were present together in the harbour of Malaga during the wintering season.

Real *et al*. (1992) developed a probabilistic procedure to recognize chorotypes (defined as the pool of species that share a similar geographic distribution, but whose ranges are significantly different from those of other species). Following a similar approach, we obtained a matrix of age-class similarities between the association of each pair of ages *a* and *b* using the Baroni-Urbani and Buser's (1976) index (BUB):

$$BUB = \frac{\sqrt{(C * D)} + C}{\sqrt{(C * D)} + A + B - C}$$

where A is the number of days when individuals of age *a* were observed, B is the number of days when individuals of age *b* were observed, C is the number of days when both ages *a* and *b* were observed, and D is the number of days when both ages were absent. To group the ages into GAGs, we used UPGMA (Unweighted Pair-Group Method using the Arithmetic Averages; Sneath and Sokal, 1973). Using the critical values in Baroni-Urbani and Buser (1976), the similarity matrix was transformed into a matrix of significant similarities, in which each value of the BUB index was transformed to '+', '–' or '0', depending on whether the values of BUB were higher than, lower than, or similar to that expected at random, respectively (Real *et al*., 1992, 2008). We considered GAGs to be those clusters that best combined the following characteristics: a high proportion of significant similarities (+) within the cluster; a low proportion of significant dissimilarities (–) within the cluster; and a low proportion of significant similarities (+) between the distribution of the cluster and the distribution of its most similar cluster. The degree to which a distribution cluster M combines these conditions is provided by the parameter DW (M × M). For the mathematical expansion of this parameter see Real *et al*. (1992, 2008), who used it to discriminate biogeographic areas rather than chorotypes. In this way, we computed the DW (M × M) values for every branch of the dendrogram. A cluster was considered a GAG either if: (i) DW (M × M) = 1 (i.e. the maximum possible value of internal homogeneity); or (ii) DW (M × M) was positive, higher than those of the other clusters included in the distributions involved, and if a *G*-test of independence (Sokal and Rohlf, 1995), which yielded the parameter GW (M × M), showed that the proportion of the '+' signs within the cluster was significantly higher than that between

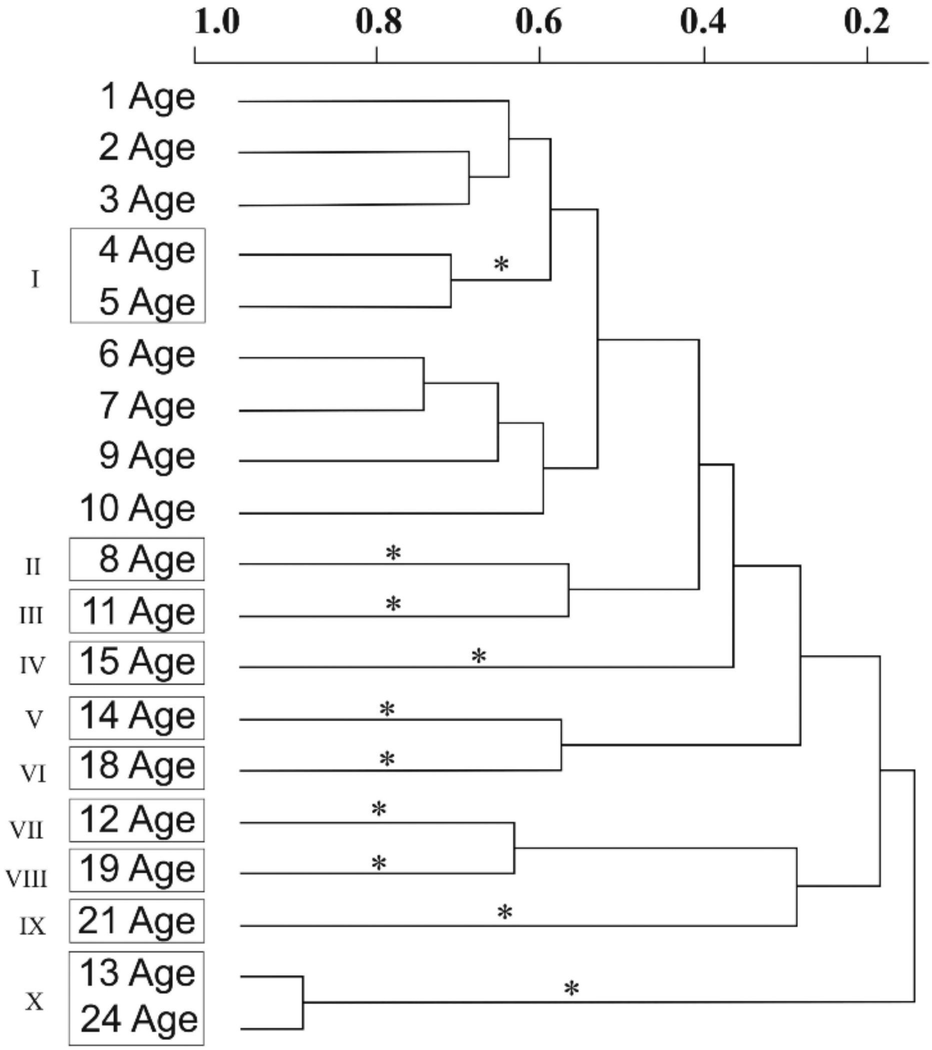

FIG. 1.—Classification analysis of the age-classes during the winter seasons observed. Asterisks mark significant differences between nodes. Scale indicates similarity level.
[Análisis de clasificación de las clases de edad observadas durante las estaciones de invierno. Los asteriscos marcan diferencias significativas entre nodos. La escala indica el nivel de similitud.]

it and its most similar cluster. The distributions that did not fulfil these conditions were considered ungrouped, and so they were considered to follow a continuous pattern of gradual substitutions in time.

Once the GAGs were defined, these were re-grouped into big gull age-classes groups (B-GAGs) comprised of correlated age-classes. We tested for inter-winter differences in the occurrence of these B-GAGs, considering three sub-periods (García-Barcelona, 2009): (i) post-breeding migration (November); (ii) mid winter (December-January); and pre-breeding migration (February), using the χ^2 test (e.g. Sokal and Rohlf, 1995). Expected values for the χ^2 test were calculated according to the number of birds per day of observation for each period and between the total days of observation.

A total of 10 different GAGs with maximum internal homogeneity, comprising 12 age-classes, were obtained (figure 1). Eight of these groups only comprised 1 age-class (age-classes 8, 11, 12, 14, 15, 18, 19 and 21), whereas two GAGs included two age classes (4-5 and 13-24 years). We distinguished four B-GAGs:

i) Inmature stage-classes, these were the most abundant age-classes, with diverse geographical origins, and they were present in every wintering season.
ii) Young potential breeders, age-classes from 4 to 5 years old, comprising one GAG.
iii) Age-classes from 6 to 11 years old, which did not associate in any GAG (except age classes 8 and 11).
iv) Age-classes older than 11 years old.

TABLE 1

Observed and expected frequency of individuals per big gull age-classes groups (B-GAGs) in the three periods considered in the study: (i) post-breeding migration (November); (ii) mid winter (December-January); and pre-breeding migration (February). We show the values of the chi-square test (χ^2), and P-values for d.f. = 2. Significant differences are marked with an asterisk.
[Frecuencia de individuos observada y esperada por grandes grupos de clases de edad para la gaviota sombría (B-GAGs) en los tres periodos considerados en el estudio: (i) migración post-reproductora (noviembre); (ii) invierno (diciembre-enero); y migración pre-reproductora (febrero). Se muestran los valores del test de chi-cuadrado (χ^2) y los valores de significación para dos grados de libertad. Las diferencias significativas se marcan con un asterisco.]

B-GAGs	November	Mid winter	February	χ^2	P
Immatures	Observed = 13 Expected = 11.59	Observed = 64 Expected = 66.64	Observed = 36 Expected = 34.77	0.319	0.852
Young breeders	Observed = 5 Expected = 6.15	Observed = 46 Expected = 35.38	Observed = 9 Expected = 18.46	8.25	0.0162*
Into 6-11	Observed = 4 Expected = 8.62	Observed = 64 Expected = 49.54	Observed = 16 Expected = 25.85	10.45	0.0054*
> 11 years	Observed = 1 Expected = 20	Observed = 17 Expected = 20	Observed = 6 Expected = 4	1.7045	0.427

Young breeders and birds from 6 to 11 years old showed significant differences between the three winter sub-periods, being less frequent than expected both in early and late winter (migration periods); the other B-GAGs did not show significant differences (table 1, figure 2). Birds from 4 to 11 years old could form the bulk of breeders, and thus arrive in the wintering area later and leave earlier, while immature and older birds would remain for longer periods in the wintering areas. However, we did not observe many individuals older than 11 years old, for this reason it is difficult to draw conclusions about these GAGs. Our present results supported the 'dominance and arrival time model', because the mature GAGs were really scarce during February by which time the breeding migration has begun.

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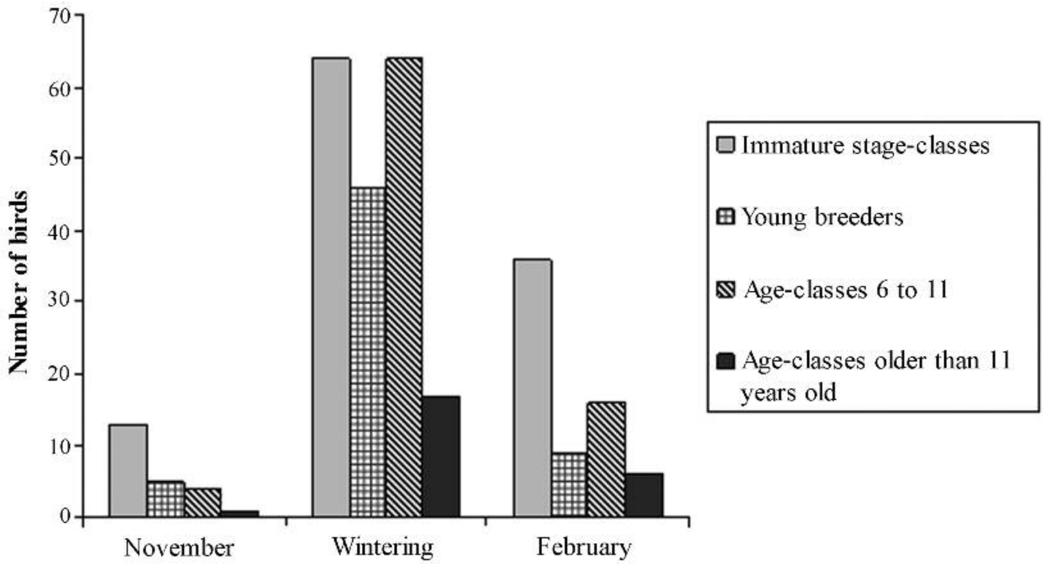

FIG. 2.—Observed frequency of individuals per age-class in the three periods considered in the study: November, arrival of birds; February, beginning of the breeding migration; Wintering, rest of wintering season.

[Frecuencia de individuos observada por clase de edad en los tres periodos considerados en el estudio: noviembre, llegada de las aves marinas; febrero, comienzo de la migración reproductora; invernada, resto de la estación de invierno.]

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