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DIFFERENTIAL USE OF FOOD RESOURCES BETWEEN THE KELP GULL *LARUS DOMINICANUS* AND THE THREATENED OLROG'S GULL *L. ATLANTICUS*

USO DIFERENCIAL DEL RECURSO ALIMENTO ENTRE LA GAVIOTA COCINERA *LARUS DOMINICANUS* Y LA AMENAZADA GAVIOTA DE OLROG *L. ATLANTICUS*

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SUMMARY.—We assessed the potential overlap in diet composition of the kelp gull *Larus dominicanus* and the threatened Olrog's gull *L. atlanticus* breeding syntopically at Bahía San Blas, Argentina, during two breeding seasons (2006 and 2007). Diet was studied using regurgitated pellets (180 per species and year) and chick stomach samples obtained through the water offloading technique (60 per species only in 2007). Kelp gulls fed on at least 18 prey types. Fish was the most important diet component (73.3-85%, depending on breeding stage and year), mainly stripped weakfish *Cynoscion guatucupa* (63.3-75%). Crustaceans were the main prey encountered in Olrog's gull diet, particularly the crabs *Neohelice granulata* and *Cyrtograpsus altimanus*, with frequencies of occurrence of over 98% at all breeding stages. Fish in Olrog's gulls diet were only recorded in the old chick stage and in less than 3.3% of samples, while the occurrence of crustaceans in kelp gull diet throughout the study period was never greater than 13%. The specialised crab-based diet of Olrog's gulls contrasts sharply with the generalist and opportunistic diet of the kelp gull. The characteristics of prey remains and the large size of stripped weakfish found in kelp gull diet samples suggest they were obtained from coastal sport and artisanal fisheries. Future studies should monitor the consumption of fish waste by kelp gulls as a function of changes in fishing effort, and assess the dietary overlap between both gull species in coastal sectors where breeding birds have no access to this human-derived food source.
Key words: coastal fisheries, diet, prey partitioning, seabirds.

RESUMEN.—Evaluamos la potencial superposición en la composición de la dieta de la gaviota cocinera *Larus dominicanus* y la amenazada gaviota de Olrog *L. atlanticus* durante su reproducción sintópica en Bahía San Blas, Argentina, durante dos temporadas de cría (2006 y 2007). La dieta fue estudiada mediante el análisis de egagrópilas (180 por especie y año) y lavados estomacales de pollos

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(60 por especie sólo en 2007). Las gaviotas cocineras se alimentaron de al menos 18 tipos de presa. Los peces fueron el principal componente en la dieta (73,3-85%, dependiendo de la etapa del ciclo reproductivo y año), mayormente la pescadilla de red *Cynoscion guatucupa* (63,3-75%). Los crustáceos fueron las principales presas halladas en la dieta de la gaviota de Olrog, particularmente los cangrejos *Neohelice granulata* y *Cyrtograpsus altimanus*, con frecuencias de ocurrencia de más del 98% en todas las etapas del ciclo reproductivo. Los peces fueron registrados en la dieta de la gaviota de Olrog solamente en la etapa de pollos grandes y en menos del 3,3% de las muestras, mientras que la aparición de crustáceos en la dieta de la gaviota cocinera a lo largo del periodo de estudio nunca fue mayor del 13%. La dieta especializada basada en cangrejos de la gaviota de Olrog contrasta fuertemente con la dieta generalista y oportunista de la gaviota cocinera. Las características de los restos de presas y el gran tamaño de las pescadillas de red encontradas en las muestras de dieta de la gaviota cocinera sugieren que fueron obtenidas de las pesquerías deportivas y artesanales costeras. Estudios futuros deberían monitorear el consumo de residuos de pescado por parte de las gaviotas cocineras en función de los cambios en el esfuerzo de pesca, y evaluar la superposición entre ambas especies de gaviota en sectores costeros donde las aves reproductoras no poseen acceso a esta fuente de alimento derivada de actividades humanas.

Palabras clave: aves marinas, dieta, partición de presas, pesca costera.

Introduction

Several gull populations worldwide have shown significant expansion during the last decades, mostly as a result of increased protection of breeding sites and greater availability of food resulting from human activities such as urban waste and fishery discards (Furness and Monaghan, 1987; Blokpoel and Spaans, 1991; Camphuysen and Garthe, 2000). Gulls often breed in mixed-species colonies and their increase in numbers may result in negative effects on other bird species, including other congeneric species, through predation, competition for breeding space and kleptoparasitism (Quintana and Yorio, 1998; Vidal *et al*., 1998; García *et al*., 2012). Among other effects, coexistence may result in interspecific competition for food (Noordius and Spaans, 1992; González-Solís *et al*., 1997; Rome and Ellis, 2004). Olrog's gull *Larus atlanticus* and the kelp gull *Larus dominicanus* are sympatric breeders in coastal Argentina (Yorio *et al*., 2005). Olrog's gull has a small breeding population (4,800-7,800 pairs) restricted to a relatively small coastal sector in Argentina and is considered globally vulnerable (Yorio *et al*., 2005; BirdLife International, 2012). It has a rather specialised feeding ecology during the breeding season, preying almost exclusively on crabs (Delhey *et al*., 2001; Herrera *et al*., 2005; Suárez *et al*., 2011). In contrast, kelp gull colonies are distributed throughout the southern hemisphere (Burger and Gochfeld, 1996) and this is the most abundant gull species along the coast of Argentina with a breeding population estimated in the 1990s at over 70,000 pairs (Yorio *et al*., 1998). Information on population trends has indicated a significant increase in kelp gull breeding numbers during recent decades (Yorio *et al*., 1998; Lisnizer *et al*., 2011). In Argentina, as in other regions, the kelp gull is a generalist feeder that consumes a wide variety of prey, including urban and fishery waste (see review in Yorio *et al*., 2005).

Kelp gulls breed adjacently to all known Olrog's gull colonies and their breeding cycles largely overlap (García Borboroglu and Yorio, 2007). Thus, knowledge of their trophic interactions should be of great value given the threatened status of Olrog's gull.

Previous studies have shown that in central Patagonia, kelp gulls regularly consume crustaceans, including crab species that are key prey of Olrog's gull (Bertellotti and Yorio, 1999; Herrera *et al*., 2005), suggesting a potential overlap in resource use at syntopic breeding locations. However, little is known about the prey taken by kelp gulls breeding in southern Buenos Aires, the location of the main Olrog's gull nesting grounds. The only study conducted in this coastal sector indicated that kelp gull diet consists mostly of anthropogenic food (Petracci *et al*., 2004) and no studies have yet compared the use of prey resources between both gull species. Dietary information will contribute to the understanding of their trophic requirements and the way these two congeneric and syntopic species partition food resources. In addition, information on prey resource use by these two gull species would help in the identification of factors affecting their population trends, provide baseline information for monitoring programmes and inform natural resource managers of the potential effect of the widely distributed and abundant

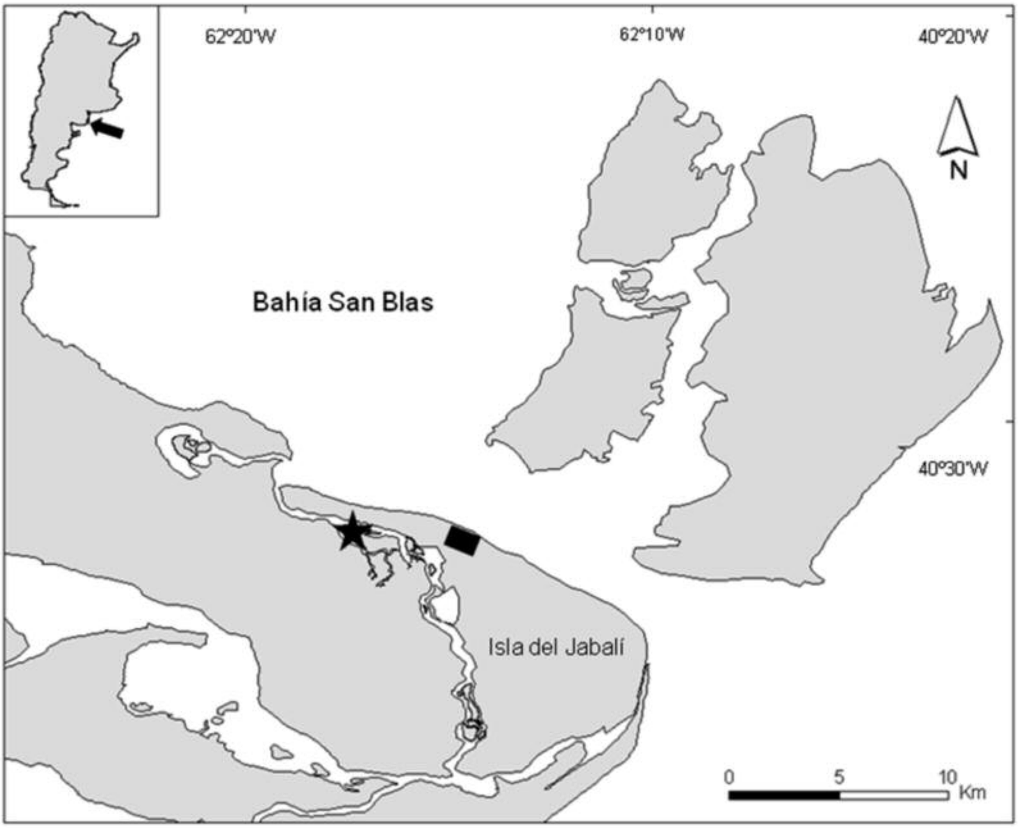

FIG. 1.—Map of the study area showing the location of the Olrog's gull and kelp gull colonies (black star) and the town of San Blas (black box).

[Mapa del área de estudio mostrando la localización de las colonias de gaviotas de Olrog y cocinera (estrella negra) y del pueblo de San Blas (rectángulo negro).]

kelp gull on the threatened Olrog's gull. In this paper we assess the breeding diet of kelp and Olrog's gulls breeding syntopically at Bahía San Blas, southern Buenos Aires Province, Argentina, a coastal area subject to sport and artisanal fishing. We quantify their diet composition during two breeding seasons and evaluate their potential overlap in resource use throughout their breeding cycles. Given the different feeding strategies of the two gull species, we expected a small degree of overlap in diet composition as a result of the fishery waste available to the opportunistic kelp gull.

Material and methods

Study area

Kelp gull and Olrog's gull diets were studied at Islote Arroyo Jabalí Oeste (40° 33' S, 62° 16' W), located in south-western San Blas Bay (Buenos Aires Province) and included within the Bahía San Blas protected area (fig. 1). The coastal sector is characterised by extensive mudflats and marshes of *Spartina* spp. and *Sarcocornia perennis* with crab beds comprised by *Neohelice granulata*, *Cyrtograpsus altimanus* and *Cyrtograpsus angulatus* (Zalba *et al*., 2008). The mixed-species gull colony is five kilometres from the town of San Blas, of about 600 inhabitants. The main economic activities in the area include coastal sport and artisanal fishing (Zalba *et al*., 2008), targetting such species as stripped weakfish *Cynoscion guatucupa*, whitemouth craoker *Micropogonias furnieri*, narrownose smooth-hound *Mustelus schmitti* and silversides *Odontesthes* sp. (Llompart, 2011). The number of kelp gull and Olrog's gull nests were estimated at 770 and 480, respectively (unpubl. data). In the study area, kelp gulls and Olrog's gulls overlap in their breeding cycle and both start laying in late September, eggs start hatching in late October and chicks start fledging in early December. The modal clutch size is three eggs for the kelp gull and two eggs for the Olrog's gull (Yorio *et al*., 2005; La Sala *et al*., 2011). The kelp gull is larger than the Olrog's gull (1 kg v. 0.8 kg; P. Yorio, unpubl. data).

Diet sampling

The composition and temporal variation of the diet of both gull species were studied using regurgitated pellets and stomach samples obtained through the water offloading technique (Wilson, 1984; Duffy and Jackson, 1986; Barrett *et al*., 2007). Pellet analysis may over-emphasise the presence of types of prey with indigestible hard parts and soft prey may not be well represented (Duffy and Jackson, 1986; Barrett *et al*., 2007). However, other studies have demonstrated that the results reflect diet composition (Annett and Pierotti, 1989) and are valuable for detecting seasonal changes (Barrett *et al*., 1990; Johnstone *et al*., 1990). Within a previously determined study area in the colony, pellets were collected from around nests weekly between November and December 2006 (N = 180 for each species) and between October and December 2007 (N = 180 for each species). All pellets found in the study area were collected during each visit, and those found in the first visit were discarded so as to eliminate old pellets from the analysis. Correct assignment of all pellets to each species was possible as kelp and Olrog's gulls nested in discrete colonies adjacent to each other with no nests intermingled. The general breeding status of nests was noted during each visit when diet samples were collected. The breeding cycle was divided into three stages: incubation, young chicks (< 15 days of age), and old chicks (> 15 days of age). Young and old chicks were distinguished by size and the degree of plumage development (unpublished data). Stomach samples were obtained only in 2007 from 30 'young' and 21 'old' kelp gull chicks and 30 'young' and 30 'old' Olrog's gull chicks. Only one chick per nest, the largest in the brood, was sampled. Stomach contents were preserved in 70% alcohol for later analysis.

Back in the laboratory, each pellet and stomach sample was dissected in a tray under a zoom binocular microscope (× 15 magnification) and food remains were identified to the lowest taxonomic level possible, using crustacean shell fragments and chelae, mollusc shell fragments, fish otoliths and cranial bones, and insect remains. Prey items were identified with the aid of published information (Castellanos, 1967; Boschi *et al.*, 1992; Gosztonyi and Kuba, 1996; Deli Antoni *et al.*, 2008). Except for stripped weakfish, most prey individuals were incomplete, or otoliths and diagnostic prey parts were too eroded for subsequent analysis of fish prey sizes. Stripped weakfish otoliths were used to estimate individual prey sizes. Otolith length was measured to the nearest 0.01 mm and the size of each item was calculated applying the equation in Bassoi (1997) that relates otolith length (OL) with total length of individual fish (TL), TL = –70.813 + 30.137 * OL.

Data analysis

Frequency of occurrence (the percentage of sampling units containing a particular prey type) was calculated for each prey type obtained from samples of both gull species (Duffy and Jackson, 1986). Since many prey individuals were incomplete (see Results), and most diagnostic prey parts encountered in kelp gull samples were too eroded for subsequent analysis, the length and mass of prey species could not be estimated. Although the Olrog's gull diet samples allowed the quantification of these variables, only frequencies of occurrence are presented for comparative purposes. For the analysis of the diet of both species, pellets were grouped within the above-defined three stages of the breeding cycle (incubation, young chicks and old chicks), and for part of the comparative analyses prey items were grouped into five categories: fish, molluscs, crustaceans, insects and other (e.g. feathers, chick bones, vegetable material).

We tested for differences in the frequency of occurrence of prey types between species and breeding stages using a multivariate analysis with the PRIMER 6 package (Clarke and Gorley, 2006). First, a similarity matrix of the samples was constructed using the Jaccard similarity coefficient (Clarke and Gorley, 2006). To test for statistical differences, a non-parametric permutation-based procedure compared mean ranks of dissimilarities of samples within and between groups. The ANOSIM test statistic R, varies between –1 and 1, reaching its maximum value when all between-group dissimilarities are greater than all within-group dissimilarities. Statistical significance is determined by comparing the sample R with those produced by randomly assigning samples to groups. The P-value of the test is calculated using the proportion of random arrangements with R-values higher than the sample value (Clarke, 1993). Similarity percentages (SIMPER) were employed to determine the prey species that contributed most to the dissimilarities between groups (Clarke 1993; Clarke and Warwick, 2001).

RESULTS

Pellet analysis indicated that diet composition during the incubation, young chick and old chick stages was similar between years (kelp gull: ANOSIM, Global R = 0.0047, P = 0.072; Olrog's gull: ANOSIM Global R = –0.0059, P = 0.999). Data from both study years were therefore pooled for the analysis of temporal variation and differences between species.

TABLE 1

Frequency of occurrence (%) of prey recorded in pellets at the kelp gull colony of Islote Arroyo Jabalí Oeste, Argentina, during the different stages of the breeding cycle in 2006 and 2007.
[Frecuencias (%) con que se encontraron las presas en egagrópilas de gaviota cocinera en la colonia del Islote Arroyo Jabalí Oeste, Argentina, durante diferentes etapas del ciclo de reproducción en 2006 y 2007.]

Prey	2006			2007		
	Incubation (n = 60)	Young chicks (n = 60)	Old chicks (n = 60)	Incubation (n = 60)	Young chicks (n = 60)	Old chicks (n = 60)
Fish						
Cynoscion guatucupa	68.3	73.3	75.0	68.3	63.3	66.7
Porichthys porosissimus	1.7	0.0	0.0	6.7	10.0	6.7
Triathalassothia argentina	1.7	0.0	0.0	0.0	0.0	0.0
Odonthestes spp.	1.7	1.7	0.0	10.0	3.3	0.0
Molluscs						
Brachidontes rodriguezi	41.7	30.0	36.7	33.3	33.3	35.0
Heleobia australis	3.3	3.3	0.0	1.7	5.0	3.3
Chlamys sp.	1.7	0.0	0.0	0.0	0.0	0.0
Clam	1.7	5.0	5.0	3.3	5.0	1.7
Gastropoda	0.0	0.0	0.0	0.0	1.7	3.3
Polyplacophora	8.3	5.0	11.7	15.0	6.7	11.7
Insects						
Coleoptera, Polyphaga	26.7	13.3	25.0	30.0	36.7	28.3
Coleoptera, Polyphaga, (Buprestidae)	0.0	0.0	2.0	0.0	0.0	0.0
Hymenoptera Apocrita	0.0	2.0	0.0	0.0	0.0	0.0
Solenopsis patagonica (Formicidae)	3.3	0.0	0.0	1.7	0.0	0.0
Acromyrmex striatus (Formicidae)	5.0	0.0	0.0	0.0	0.0	0.0
Orthoptera, Acrididae	2.0	0.0	0.0	2.0	0.0	0.0
Unidentified insects	3.3	11.7	1.7	0.0	0.0	0.0
Crustaceans						
Cyrtograpsus altimanus	1.7	3.3	6.7	1.7	0.0	0.0
Cyrtograpsus angulatus	1.7	3.3	3.3	10.0	1.7	1.7
Neohelice granulata	0.0	1.7	3.3	0.0	1.7	1.7
Platyxanthus patagonicus	1.7	0.0	0.0	0.0	0.0	3.3
Unidentified Decapods	8.3	3.3	3.3	0.0	0.0	0.0
Other						
Vegetable materials	10.0	15.0	31.7	23.3	20.0	23.3
Algae	5.0	1.7	0.0	1.7	0.0	0.0

Kelp gull diet composition

Breeding kelp gulls fed on a wide variety of prey (table 1). Pellet analysis indicated that their diet comprised at least 17 different prey types during 2006 and 16 during 2007. However, 59% and 47% of these prey types during the first and second seasons, respectively, had percentages of occurrence equal to or less than 5%. Fish were the most frequently encountered prey during the three stages of the breeding cycle in both seasons (73.3-75% and 73.3-85% in 2006 and 2007, respectively), followed by molluscs (43.3-56.7% and 51.7-55%). The stripped weakfish was the dominant fish prey (63.3-75%, depending on breeding stage and year), while the mytilid *Brachidontes rodriguezi* was the most frequent mollusc prey. The frequency of occurrence of prey types in kelp gull diet was similar among all stages of the breeding cycle (ANOSIM, Global R = 0.0007, P = 0.363) (table 1). A total of 72 stripped weakfish otoliths were recovered from pellet samples, 20 of which were intact and could be measured. The total length of stripped weakfish found in kelp gull pellets averaged 36.6 ± 4.6 cm (N = 20; range = 30.7-57.3). Although the remaining otoliths could not be measured, they were of similar dimensions to those found whole.

The analysis of stomach samples showed that kelp gull chicks consumed at least 18 different prey types during 2007 (table 2). Fish were also the most frequently identified prey in the young and old chick stages (96.7 and 90.5%, respectively), followed by insects (60 and 42.9%, respectively) and molluscs (30 and 28.6%, respectively). The frequency of occurrence of prey types in chick stomach samples was similar between both chick stages (ANOSIM, Global R = –0.0065, P = 0.528) (table 2). The Argentine anchovy *Engraulis anchoita* was the most frequent fish prey in stomach samples, while *B. rodriguezi* was the most frequent mollusc prey. Most fish remains encountered in the samples consisted of cranial bones and cervical vertebrae, or pieces of flesh and skin in the case of Elasmobranchs. Anchovy individuals were mostly found decapitated.

TABLE 2

Frequency of occurrence (%) of prey recorded in kelp gull chick stomach samples at Islote Arroyo Jabalí Oeste, Argentina, during 2007.
[Frecuencias (%) con que se encontraron las presas en lavados estomacales de pollos de gaviota cocinera en la colonia del Islote Arroyo Jabalí Oeste, Argentina, durante 2007.]

Prey	Young chicks (n = 30)	Old chicks (n = 21)
Fish		
Engraulis anchoita	40.0	24.0
Porichthys porosissimus	26.7	19.0
Cynoscion guatucupa	16.7	5.0
Brevoortia aurea	3.3	14.0
Mustelus schmitti	3.3	14.0
Odontesthes sp.	3.3	0.0
Elasmibranchii	3.3	0.0
Squatinidae	3.3	5.0
Unidentified Osteichthyes	16.7	24.0
Molluscs		
Brachidontes rodriguezi	23.0	19.0
Clam	3.3	5.0
Polyplacophora	3.3	5.0
Insects		
Coleoptera	30.0	33.0
Hymenoptera, Formicidae	26.7	10.0
Diptera	6.7	0.0
Crustaceans		
Neohelice granulata	3.3	5.0
Artemisa longinaris	0.0	5.0
Other		
Larus dominicanus (chick)	0.0	5.0
Vegetable materials	13.3	14.0

Olrog's gull diet composition

Pellet analysis showed that the diet of Olrog's gulls comprised at least five prey items. Crustaceans were the main prey encountered, particularly *N. granulata* and *C. altimanus* (table 3), with frequencies of occurrence of over 98% (fig. 2). Bivalve and insect remains were also present, although in less than 1.5% of samples in both cases. Dietary composition differed significantly among the three stages analysed (ANOSIM, Global R = 0.337, P = 0.001), and also for each of the pair wise comparisons (R < 0.6049, Bonferroni-corrected P < 0.0003). During incubation, *N. granulata* was clearly the crab species with the highest frequency of occurrence (table 3). The relative contribution of *C. altimanus* increased from incubation to the chick stages, and was the main prey during the young and old chick stages (table 3). The analysis of stomach samples also showed that Olrog's gulls provisioned offspring almost exclusively with crabs during both chick stages (table 4). Fish were the only other prey item recorded, although in less than 3.3% of total samples and only at the old chick stage. The frequency of occurrence of prey types in chick stomach samples was similar between both chick stages (ANOSIM, Global R = 0.04497, P = 0.053) (table 4).

Comparison of diet composition between kelp and Olrog's gulls

The pellet analyses showed significant differences between the dietary composition of kelp and Olrog's gulls at all stages of the breeding cycle (Incubation: ANOSIM, Global R = 0.747, P = 0.001; Young chicks: ANOSIM, Global R = 0.706, P = 0.001; Old chicks: ANOSIM, Global R = 0.673, P = 0.001). The prey type designated by SIMPER as contributing most to the observed difference in diet composition between the

TABLE 3

Frequency of occurrence (%) of prey recorded in pellets at the Olrog's gull colony of Islote Arroyo Jabalí Oeste, Argentina, during the different stages of the breeding cycle in 2006 and 2007.
[Frecuencias (%) con que se encontraron las presas en egagrópilas de gaviota de Olrog en la colonia del Islote Arroyo Jabalí Oeste, Argentina, durante diferentes etapas del ciclo de reproducción en 2006 y 2007.]

Prey	2006			2007		
	Incubation (n = 60)	Young chicks (n = 60)	Old chicks (n = 60)	Incubation (n = 60)	Young chicks (n = 60)	Old chicks (n = 60)
Crustaceans						
Neohelice granulata	98.2	27.9	57.6	95.2	23.7	52.4
Cyrtograpsus altimanus	16.8	83.4	64.1	18.2	90.0	70.9
Cyrtograpsus angulatus	13.8	65.9	31.2	16.4	75.7	37.2
Molluscs						
Brachidontes rodriguezi	0.0	1.2	0.0	0.0	0.0	0.0
Insects	0.6	0.0	0.0	0.6	0.0	0.0

TABLE 4

Frequency of occurrence (%) of prey recorded in Olrog's gull chick stomach samples at Islote Arroyo Jabalí Oeste, Argentina, during 2007.
[Frecuencias (%) con que se encontraron las presas en lavados estomacales de pollos de gaviota de Olrog en la colonia del Islote Arroyo Jabalí Oeste, Argentina, durante 2007.]

Prey	Young chicks (n = 30)	Old chicks (n = 30)
Crustaceans		
Neohelice granulata	24.5	60.5
Cyrtograpsus altimanus	91.0	77.3
Cyrtograpsus angulatus	50.5	32.2
Fish	0.0	3.3

gull species were *C. altimanus*, stripped weakfish and *C. angulatus* during the incubation and young chick stages (accounting in both cases for 65% of the observed differences), and stripped weakfish, *C. altimanus* and *N. granulata* during the old chick stage, accounting for about 61% of the observed differences. Fish were the most frequent prey in kelp gull diet with frequencies of occurrence never less than 73%, but they were not recorded in Olrog's gulls pellet samples (fig. 2a). Olrog's gulls consumed crabs almost exclusively, these making an overall dietary contribution of over 98%, while the frequencies of occurrence of crustaceans in kelp gull diet samples were never greater than 13% (fig. 2b).

Differences were also found in the frequency of occurrence of prey between kelp and Olrog's gull chick stomach samples (Young chicks: ANOSIM, Global R = 0.629, P = 0.001; Old chicks: ANOSIM, Global R = 0.635, P = 0.001). Fish were the dominant prey in kelp gull chick stomach samples, mainly *E. anchoita* and *Porichthys porosissimus*, while over 99% of prey in Olrog's gull chick stomach samples were crabs. The prey type designated by SIMPER as contributing most to the observed differences were *C. altimanus* and *E. anchoita* during the young chick stage (38.2% of the observed differences) and *C. altimanus* and *N. granulata* during the old chick stage (39.3% of the observed differences).

DISCUSSION

Our results show that kelp gulls breeding at Bahía San Blas fed on a wide variety of prey species, in agreement with previous studies elsewhere in coastal Argentina that indicated their generalist and opportunistic feeding habits (Bertellotti and Yorio, 1999; Petracci *et al*., 2004; González-Zevallos, 2010). Fish was the most important component of the kelp gull diet throughout the breeding cycle, the stripped weakfish being the main recorded fish prey. This fish is one of the most abundant species in coastal fish assemblages along the coasts of Buenos Aires province (Jaureguizar *et al*., 2006; Llompart, 2011), which could partly explain its frequency of occurrence in kelp gull diet. However, the characteristics of prey remains (the presence of elasmobranch flesh and skin and headless argentine anchovies) and particularly the large size of stripped weakfish found in samples, unlikely to be directly captured by gulls, suggest they were also obtained from coastal sport and artisanal fisheries. The stripped weakfish is one of the main target species of the coastal sport fishery and it is a secondary target of artisanal fisheries operating in the Bahía San Blas area (Zalba *et al*., 2008; Llompart, 2011). For example, 70,000 and 56,000 kg of stripped weakfish were captured by sport fisheries at Bahía San Blas during November and December of 2008 and 2009, respec-

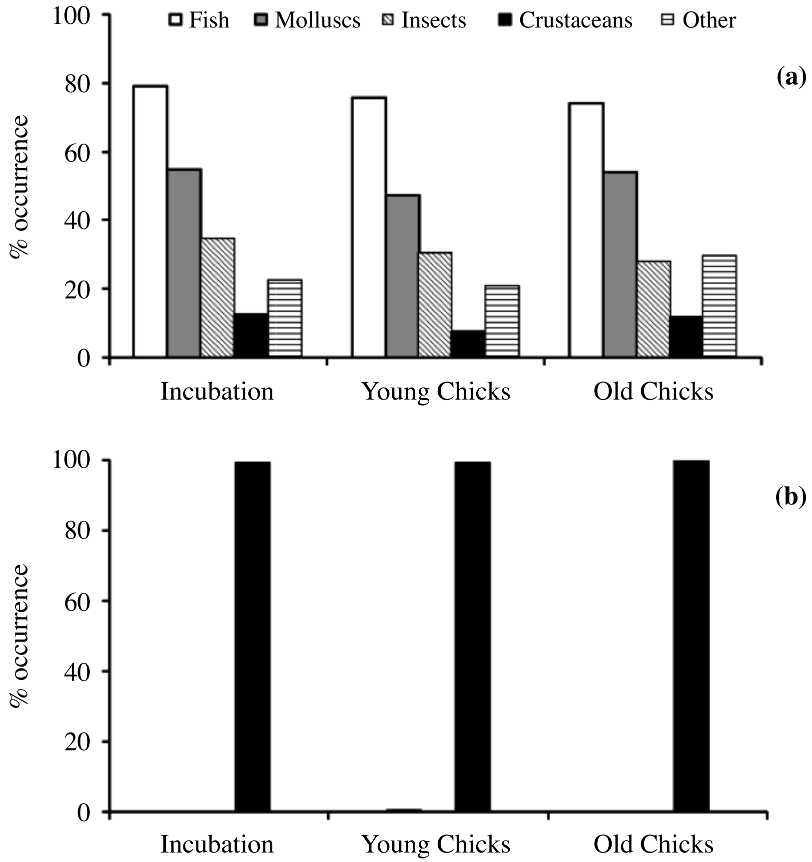

FIG. 2.—Main food categories recorded in pellets (% occurrence) of (a) kelp gulls and (b) Olrog's gulls breeding at Islote Arroyo Jabalí Oeste, Argentina, during 2006 and 2007. Sample sizes: N = 180 pellets for each species (60 per breeding stage).

[Principales categorías del alimento registradas (% de ocurrencia) en las egagrópilas de las gaviotas cocinera (a) y de Olrog (b) nidificando en el Islote Arroyo Jabalí Oeste, Argentina, durante 2006 y 2007. Tamaños muestrales: N = 180 egagrópilas para cada especie (60 por etapa del ciclo de reproducción).]

tively (Llompart, 2011), providing significant amounts of waste resulting from their processing to opportunistic species such as the kelp gull. In addition, the stripped weakfish is also commonly used as fish bait, together with the argentine anchovy, the shrimp *Artemisa longinaris* and the silversides, which were also found in diet samples. In confirmation, kelp gulls were regularly observed feeding on remains of recently processed fish along the coastline during fishing activities or on fish scraps at the local refuse tip located 4 km away from the colony. Kelp gulls regularly take advantage of fish waste provided by fishing activities elsewhere in coastal Argentina (see review in Yorio *et al.*, 2005; Silva *et al.*, 2005, Marinao and Yorio, 2011; Seco-Pon *et al.*, 2012) and throughout their southern hemispheric distribution (e.g. Abrams, 1983; Coulson and

Coulson, 1993; Branco, 2001; Ludynia *et al.*, 2005), showing their foraging plasticity and ability to take advantage of food resources provided by human activities. The contribution of fish waste to kelp gull diet in Bahía San Blas very probably reflects the closeness of colonies to sport and artisanal fishing grounds.

The diet of Olrog's gull at Islote Arroyo Jabalí Oeste consisted almost exclusively of crabs throughout the breeding cycle, as has been reported for other breeding locations in southern Buenos Aires and Chubut provinces (Delhey *et al.*, 2001; Herrera *et al.*, 2005). The contribution of the three crab species recorded in food samples varied among breeding stages, which has been suggested to reflect prey size restrictions imposed by the requirements of small chicks (Suárez *et al.*, 2011). This specialised crab-based diet contrasts sharply with the generalist diet of the kelp gull. In addition, the high contribution of crabs in their diet clearly differs from that observed in breeding kelp gulls. Previous studies have reported that crustaceans are an important component in the diet of kelp gulls breeding in some Patagonian colonies (Bertellotti and Yorio, 1999), and the consumption of *Cyrtograpsus* crabs has been reported in Golfo San Jorge (González-Zevallos, 2010). Despite the availability of crabs in the study area (Zalba *et al.*, 2008; Suárez *et al.*, 2012), they were poorly represented in kelp gull diet, very probably because of the regular availability throughout the breeding cycle of higher quality food in terms of fishery waste. Fish is considered to be of higher quality than invertebrates (i.e. Pierotti and Annett, 1987; Massinas and Becker, 1990). Similarly, Petracci *et al.* (2004) reported that breeding kelp gulls did not include crabs in their diet in an area also characterised by large beds of *Neohelice* and *Cyrtograpsus* crabs (Iribarne *et al.*, 2003). Conversely, it is interesting that despite the availability and easy access of higher quality food such as fish waste, Olrog's gulls did not take advantage of this resource in the study area. Although Olrog's gulls have been reported as food specialists during the breeding season (Delhey *et al.*, 2001; Herrera *et al.*, 2005; Suárez *et al.*, 2011), they often take advantage during the non-breeding season of fish discarded by sport fishers and from coastal trawl vessels (Martínez *et al.*, 2000; Copello and Favero, 2001; Berón *et al.*, 2007; Berón and Favero, 2010, Seco-Pon *et al.*, 2012). Delhey *et al.* (2001) have suggested that Olrog's gulls do not feed on alternative food resources as a result of interference competition with the larger and more aggressive kelp gull, although both gull species use fish waste during the non-breeding season in coastal Buenos Aires (Berón *et al.*, 2007; Silva *et al.*, 2005). Future studies should assess potential interspecific behavioural interactions at their feeding grounds.

Many seabird studies have shown that a difference in prey selection is one of the mechanisms that may allow coexistence of different species at the same breeding location (e.g. Diamond, 1984; Wiens, 1989; Croxall *et al.*, 1997). Several gull species breeding in mixed-species colonies show some differences in their diet (Noordhuis and Spaans, 1992; Garthe *et al.*, 1999; Kubetski and Garthe, 2003; Kim and Monaghan, 2006; Steenweg *et al.*, 2011), although significant overlap in resource use may be also observed (Rome and Ellis, 2004; Gwiazda *et al.*, 2011). In other regions where kelp gulls breed sympatrically with different gull species, comparative dietary studies have shown that some differences exist in prey composition, although there is a considerable overlap in their use of food resources. For example, kelp gulls fed less on crabs and more on urban waste than the sympatric pacific gull *Larus pacificus* in Australia (Coulson and Coulson, 1993), and fed on more diverse and larger prey than Hartlaub's gull *Larus hartlaubii* in South Africa (Steele, 1992). The differences in diet composition between kelp and Olrog's gulls observed at Bahía San Blas are much more extreme than those recorded between syntopic gulls in other studies.

Kelp gull chick stomach samples showed a higher representation of fish prey and a differential contribution of prey species, particularly the argentine anchovy, in comparison with pellet samples. This may have resulted from more complete digestion of fish remains in pellets in comparison to stomach samples, and the relatively higher digestive erosion of the argentine anchovy's diagnostic parts and the lack of otoliths in pellet remains due to the consumption of headless individuals used as fish bait. In addition, it should be considered that fish may be under-represented in pellets (Brown and Ewins, 1986; Johnstone *et al*., 1990). Several gull diet studies have recently shown the value of using stable isotope analysis (Ramos *et al*., 2009; Navarro *et al*., 2010; Moreno *et al*., 2010; Steenweg *et al*., 2011), and it has been found that the analysis of pellets and food remains often underestimated the contribution of fish relative to stable isotope estimates (Weiser and Powell, 2011). Future studies using stable isotope analysis should confirm the observed dietary patterns in these sympatric gull species, although the differences in the use of resources between both species was so obvious that our conclusions on their food partitioning based on conventional methods are very likely to be valid.

The use of new supplementary food sources has been suggested as one of the main factors contributing to the population expansion of opportunistic foragers, such as many *Larus* gulls (Harris, 1970; Blokpoel and Spaans, 1991; Oro *et al*., 2004). Kelp gull populations have expanded in coastal Argentina (Yorio *et al*., 1998), and it has been suggested that kelp gull demography in Patagonia is affected by the provision of fishery waste (Lisnizer *et al*., 2011). Unfortunately, there is no available information on the trend in kelp gull numbers in the study area, but the consumption of fishery waste by breeding kelp gulls in Bahía San Blas should in any case be a matter of concern, given the potential negative effect of the kelp gull population increase on the threatened Olrog's gull. Kelp and Olrog's gulls share several nesting microhabitat characteristics, so an increase in the area occupied by kelp gulls or in their nesting density as a result of their increase in numbers could affect the availability of adequate nesting habitats for Olrog's gulls (García Borboroglu and Yorio, 2007). Future studies should monitor the consumption of fish waste by gulls as a function of changes in fishing effort, and assess the dietary overlap between both gull species in coastal sectors where breeding birds have no access to this human-derived food source.

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