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Diet specialization of Olrog's Gull *Larus atlanticus* during the breeding season at Golfo San Jorge, Argentina

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Summary

We studied the diet of breeding Olrog's Gulls *Larus atlanticus* during 1994 at two colonies in Golfo San Jorge, Argentina, through the analysis of 207 regurgitated pellets. The diet at Isla Felipe and Isla Vernaci Sudoeste comprised only a few items (9 vs 7 respectively), of which crabs were the main component. At Isla Felipe, the crabs *Cyrtograpsus altimanus* and *C. angulatus* were present in 91.2% and 89.2% of pellets, respectively, while the percentage contribution of each species was 76.1% and 21.7%, respectively. At Isla Vernaci Sudoeste, the figures were similar (96.2% and 80% of pellets, and percentage contributions 79.4% and 19.5%). All other taxa were present in less than 11% of pellets. No significant differences were found between colonies in the number of prey items, prey individuals per pellet, and consumption of crabs. Percentage contribution of crabs differed significantly between stages of the breeding cycle at Isla Felipe but not at Isla Vernaci Sudoeste. At both colonies, the proportion of male *C. altimanus* in pellets was larger than that of females. The proportion of female *C. angulatus* in pellets at Isla Vernaci Sudoeste was larger than that of males, but no significant differences were found in the consumption of each sex at Isla Felipe. Mean maximum carapace width of male crabs in pellets was not significantly different from that of females at either Isla Felipe or Isla Vernaci. Our study at Golfo San Jorge confirms that Olrog's Gull is fairly specialized, feeding mainly on crabs during the breeding season.

Introduction

Most gulls are feeding generalists, foraging in a wide range of habitats and taking advantage of a great variety of prey, including in many cases food derived from human activities (Mudge and Ferns 1982, Götmark 1984, Burger 1988). However, a few gull species have been suggested to have a specialized diet (Burger and Gochfeld 1996). Among the latter is Olrog's Gull *Larus atlanticus*, an endemic species of the Argentine coast which has a small breeding population restricted to only two nesting areas between 39°12′ and 45°11′S (Yorio *et al.* 1997, Delhey *at al.* 2001a). Olrog's Gull has been described by some authors as a race or subspecies of Belcher's Gull *Larus belcheri*, but the two are currently treated as separate species (Devillers 1977, Burger and Gochfeld 1996). Olrog's Gull is considered Vulnerable to extinction (BirdLife International 2000) or highly threatened (Parker *et al.* 1996). In addition, given that part of the population migrates north to Uruguay and occasionally Brazil during the non-breeding season (Escalante 1984, Collar *et al.* 1992), it has been included in Appendix I of the International Convention for Migratory Species.

Current available information shows that Olrog's Gull has a fairly specialized feeding ecology, preying mainly on crabs (Escalante 1984, Spivak and Sánchez 1992, Copello and Favero 2001, Delhey *et al*. 2001b). Diet studies in winter show that Olrog's Gulls may also forage on mussels, fish, insects and offal (Escalante 1966, Olrog 1967, Jehl and Rumboll 1976, Spivak and Sánchez 1992, Martínez *et al*. 2000). Except for the study conducted by Delhey *et al*. (2001*b*) in southern Buenos Aires, Argentina, most information on the diet of Olrog's Gull has been obtained during the non-breeding period. Knowledge of the feeding ecology during the breeding season of this endemic and threatened species is needed to determine its dependence on particular coastal habitats. Feeding specialists are generally more vulnerable to temporal and spatial variations in prey availability, and thus habitat alterations may result in greater risks to population viability. In this paper we analyse the diet of Olrog's Gull breeding at Golfo San Jorge, Chubut province, Argentina, to confirm whether it is a feeding specialist during the breeding season in the southern part of its range. We compare diet composition at two breeding locations and analyse diet variation throughout the breeding cycle.

Methods

We studied the diet of Olrog's Gull during 1994 at two breeding sites located along the northern coasts of Golfo San Jorge, Chubut province (Fig. 1). Isla Felipe (45°04′S, 66°20′W) is a small island of approximately 1 ha in Bahía Tafor and Isla Vernaci Sudoeste (45°11′S, 66°31′W) is a low island of approximately 6.4 ha located near the mouth of the Caleta Malaspina inlet. The colonies at Isla Felipe and Isla Vernaci

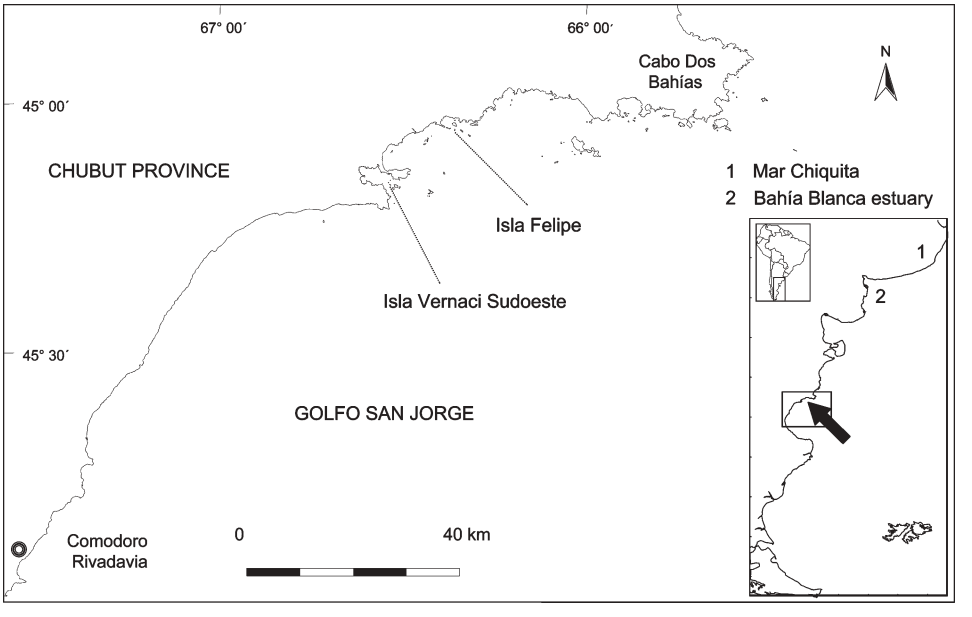

Figure 1. Geographical location of the colonies at Isla Felipe and Isla Vernaci Sudoeste, Golfo San Jorge, Chubut.

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Sudoeste included *c.* 16 and 45 nests, respectively. Several other seabird and shorebird species breed at both Isla Vernaci Sudoeste and Isla Felipe (Yorio *et al.* 1998).

We used regurgitated pellets to study diet. Pellet analysis has been used extensively in gull diet studies as it provides large sample sizes with a minimum disturbance to breeding birds. This method may overemphasize the presence of types of prey with indigestible hard parts, and soft prey may not be well represented (Duffy and Jackson 1986, Brown and Ewins 1996). However, other studies have demonstrated that this method may reflect diet composition (Spaans 1971, Annett and Pierotti 1989) and that it is very valuable for detecting both seasonal changes and differences among locations.

We collected regurgitated pellets in each colony every 2 weeks during the 1994 breeding season, between September and February, both within the nesting area and in the nearby loafing areas. We collected a total of 207 pellets. We broke each pellet in a tray under a zoom binocular microscope (×10 magnification) and identified food remains to the lowest taxonomic level possible, using crustacean shell fragments and chelae, mollusc shell fragments, polychaete mandibles and chetae, fish otoliths and bones. We identified prey with the aid of published guides (Boschi 1964, Boschi *et al.* 1992) and a reference collection obtained in the study area. We classified as "unidentified prey" all parts which were too worn or which were not positively identified. We estimated the importance of each prey species as the frequency of occurrence (%O, the percentage of sampling units containing the prey category) and the percentage contribution (%N, the total percentage of items constituted by each category) (Duffy and Jackson 1986).

During each visit when pellets were collected we noted the general breeding status of nests. We divided the breeding cycle into four stages: pre-laying (second week of September to late October), incubation (November), young chicks up to 4 weeks of age (early December to early January), and old chicks more than a month old (second week of January to first week of February). For the analysis, we grouped pellet collection within these four stages of the breeding cycle. To analyse the variation in prey consumption throughout the season, we also grouped all prey items other than crabs in a single category.

Size (carapace width), weight and sex of crabs in pellets were estimated from linear regressions with maximum length or width of chelae of crabs collected in the study area, following the methods of Spivak and Sánchez (1992). The number of crabs present in each pellet was calculated by considering one crab per two chelae (right and left) which differed by less than 0.1 mm (Spivak and Sánchez 1992). Means are reported ± 1 SE.

Results

The diet of Olrog's Gull in the study area contained only a few taxa, of which crabs were the main component (Table 1). At Isla Felipe, the diet included at least nine different types of prey (Table 1). Mean number of prey items and prey individuals per pellet were 2.0 ± 0.05 and 17.0 ± 1.3 ($n = 102$), respectively. Crabs were the dominant prey; *Cyrtograpsus altimanus* and *C. angulatus* were present in 91.2% and 89.2% of pellets, respectively, while the percentage contribution by each species was 76.1% and 21.7%, respectively. Similarly, the diet of Olrog's Gull at Isla Vernaci Sudoeste

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Table 1. Frequency of occurrence (%O) and numerical frequency (%N) of prey consumed by Olrog's Gull at Isla Felipe and Isla Vernaci Sudoeste, Golfo San Jorge, Argentina, during the 1994 breeding season. Sample size is in parentheses.

Prey taxa	Isla Felipe ($n = 102$)		Isla Vernaci Sudoeste ($n = 105$)	
	%O	%N	%O	%N
Crabs				
Cyrtograpsus altimanus	91.2	76.1	96.2	79.4
Cyrtograpsus angulatus	89.2	21.7	80.0	19.5
Leucipa pentagona	3.9	1.3	0.0	0.0
Peltarion spinosulum	0.0	0.0	1.9	0.1
Molluscs				
Perumitylus purpuratus	2.0	0.2	10.5	0.8
Pareuthria plumbea	1.0	0.1	1.9	0.1
Callochiton puniceus	1.0	0.1	0.9	0.1
Fisurella orians	2.0	0.1	0.9	0.1
Unidentified fish Polychaetes	1.0	0.1	0.0	0.0
Glycera sp.	3.9	0.4	0.0	0.0

included at least seven different types of prey (Table 1). At this colony, mean numbers of prey items and prey individuals per pellet were 1.9 ± 0.05 and 16.7 ± 1.08 ($n = 105$), respectively. Crabs were also the dominant prey; *C. altimanus* and *C. angulatus* were present in 96.2% and 80.0% of pellets, respectively, and percentage contribution was 79.4% and 19.5%, respectively. No significant differences were found in the number of prey items and prey individuals per pellet between colonies (ANOVA $F = 0.15$, $P = 0.70$ and $F = 0.025$, $P = 0.88$, respectively). The consumption of crabs was also similar between colonies ($\chi^2 = 3.2$, df = 1, $P > 0.05$).

Mean number of prey items and prey individuals per pellet at both Isla Felipe and Isla Vernaci Sudoeste did not differ significantly between stages of the breeding cycle (mean number of prey items: ANOVA Isla Felipe $F_{(0.05,3)} = 0.61$, $P = 0.61$, $n = 102$, ANOVA Isla Vernaci Sudoeste $F_{(0.05,3)} = 1.07$, $P = 0.36$, $n = 105$; prey individuals per pellet: ANOVA Isla Felipe $F_{(0.05,3)} = 2.44$, $P = 0.07$, $n = 102$, ANOVA Isla Vernaci Sudoeste $F_{(0.05,3)} = 1.73$, $P = 0.17$, $n = 105$). Both crab species were present and were the numerically most abundant prey throughout the season (Table 2). Percentage contribution of crabs differed significantly between stages of the breeding cycle at Isla Felipe ($\chi^2 = 53.5$, df = 6, $P < 0.05$) but were similar at Isla Vernaci ($\chi^2 = 10.81$, df = 6, $P > 0.05$) (Table 2).

Of the 207 pellets analysed, 139 had chelae which allowed the determination of crab size and sex. At Isla Felipe, male and female individuals of *C. altimanus* showed numerical frequencies of 65% and 35%, respectively ($n = 304$), while percentage contribution of male and female individuals of *C. angulatus* were 44 and 56%, respectively ($n = 52$). At Isla Vernaci Sudoeste, male and female individuals of *C. altimanus* showed numerical frequencies of 67% and 33%, respectively ($n = 351$), while numerical frequencies of each sex of *C. angulatus* were 35% and 65%, respectively ($n = 82$) (Fig. 2). At both colonies, the proportion of male *C. altimanus* in pellets was larger than that of female crabs (Isla Felipe: $\chi^2 = 27.8$, $P < 0.001$; Isla Vernaci Sudoeste: $\chi^2 = 40.3$, $P < 0.001$). The proportion of female *C. angulatus* in pellets at Isla Vernaci Sudoeste was larger than that of male crabs ($\chi^2 = 7.0$, $P < 0.008$), but no significant differences were found in the consumption of each sex at Isla Felipe ($\chi^2 = 0.7$, $P = 0.40$).

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Table 2. Numerical frequency (%N) of prey consumed by Olrog's Gull at Isla Felipe and Isla Vernaci Sudoeste, Golfo San Jorge, Argentina, throughout the stages of the breeding cycle of 1994.

Prey taxa	Isla Felipe				Isla Vernaci Sudoeste			
	PL	IN	YCH	OCH	PL	IN	YCH	OCH
Cyrtograpsus altimanus	81.4	78.1	71.1	69.3	79.7	81.0	80.8	74.9
Cyrtograpsus angulatus	18.1	16.7	27.7	28.2	19.2	18.0	18.9	22.8
Leucipa pentagona		4.2		1.4				
Peltarion spinosulum					0.2	0.2		
Perumitylus purpuratus	0.3			0.3	0.4	0.6	0.3	2.4
Pareuthria plumbea		0.2			0.4			
Callochiton puniceus		0.2			0.2			
Fisurella orians		0.2		0.3		0.2		
Unidentified fish			0.2					
Glycera sp.	0.2	0.2	0.9	0.3				

PL, pre-laying; IN, incubation; YCH, young chicks; OCH, old chicks (see Methods for stage definitions).

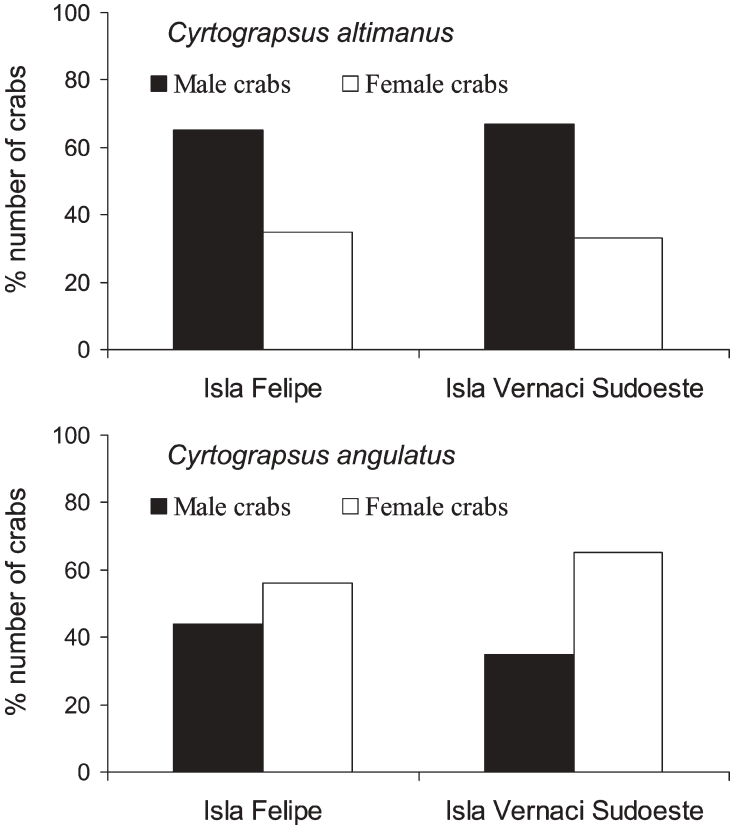

Figure 2. Numerical frequencies of male and female *Cyrtograpsus altimanus* and *C. angulatus* crabs in pellets produced by breeding Olrog's Gull at Isla Felipe and Isla Vernaci Sudoeste, Golfo San Jorge, Chubut.

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For *C. altimanus*, maximum carapace width of males varied between 5.8 and 21.2 mm, with a mean of 10.9 ± 0.13 mm ($n = 436$), while maximum carapace width for females varied between 5.9 and 15.5 mm, with a mean of 10.3 ± 0.11 mm ($n = 217$). Estimated mean weight was 0.9 ± 0.03 g ($n = 436$) for males, and 0.6 ± 0.02 g ($n = 217$) for females. Mean maximum carapace width of males was significantly different from that of females at both Isla Felipe (ANOVA $F_{(0.05,1)} = 4.2$, $P = 0.04$) and Isla Vernaci (ANOVA $F_{(0.05,1)} = 4.6$, $P = 0.03$).

For *C. angulatus*, maximum carapace width of males varied between 10.3 and 46.1 mm, with a mean of 19.9 ± 0.99 mm ($n = 52$), while maximum carapace width for females varied between 11.9 and 36.5 mm, with a mean of 20.4 ± 0.12 mm ($n = 81$). Estimated mean weight was 5.2 ± 1.07 g ($n = 52$) for males, and 4.3 ± 0.56 g ($n = 81$) for females. Mean maximum carapace width of males was not significantly different from that of females at either Isla Felipe (ANOVA $F_{(0.05,1)} = 0.45$, $P = 0.51$) or Isla Vernaci (ANOVA $F_{(0.05,1)} = 0.07$, $P = 0.80$).

Discussion

Our results show that Olrog's Gull has a specialized diet during the breeding season at Golfo San Jorge, Chubut. Although its diet consisted of at least 10 different prey taxa, it fed predominantly on two crab species: *Cyrtograpsus altimanus* and *C. angulatus*. Consumption of these crabs at both study colonies was significantly greater throughout the season than any other prey. These results agree with studies of the diet of Olrog's Gull in southern Buenos Aires, during both the breeding and non-breeding seasons. Observations by Daguerre (1933), Olrog (1967) and Devillers (1977) indicated that this species fed mostly on crabs. More recently, Delhey *et al.* (2001b) showed that during spring and summer at the Bahía Blanca estuary, Buenos Aires, this species fed mostly on the grapsid crab *Chasmagnathus granulata*. Studies of its winter diet in Mar Chiquita, Buenos Aires, have also shown that grapsid crabs (*C. granulata* and *C. angulatus*) are its main prey, although fish, snails, insects, barnacles, or other crab species may occur at low frequencies (Spivak and Sánchez 1992, Copello and Favero 2001, Delhey *et al.* 2001b). The trophic spectrum of prey recorded in this study, however, may represent a minimum, because the method used does not allow the detection of soft-bodied prey with no hard parts which may remain in pellets (Duffy and Jackson 1986).

The proportion of both crab species in the diet of Olrog's Gull was similar throughout the breeding cycle, *C. altimanus* being dominant numerically over *C. angulatus*. However, because the biomass of *C. angulatus* is about 6 times greater than that of *C. altimanus*, the former appears to be the main diet component of Olrog's Gull in the study area. The observed differences in consumption between species may be due, among other things, to differences in crab behaviour, spatial distribution or availability. Crabs show different defence strategies: *C. altimanus* generally retreats under stones or enters a burrow, while *C. angulatus*, particularly smaller individuals, quickly escapes when approached by a potential predator (Scelzo and Lichtschein de Bastida 1978). In addition, studies in coastal habitats in northern Argentina have shown ontogenetic changes in habitat selection and differences in habitat use between grapsid species (Spivak *et al.* 1994). Lack of information on crab population distribution and availability in the study area preclude the identification of factors determining the observed differential predation between crab species.

Olrog's Gull consumed mostly male individuals of *C. altimanus* and female individuals of *C. angulatus*. Sex-biased consumption of crabs has been reported for Olrog's Gull feeding in coastal Buenos Aires (Spivak and Sánchez 1992, Copello and Favero 2001, Delhey *et al*. 2001b). Preferences for female *C. angulatus* by gulls feeding at Mar Chiquita during the winter has been attributed to the more aggressive behaviour of male crabs and to behavioural aspects of breeding females (Spivak and Sánchez 1992). During breeding, female *C. angulatus* show reduced mobility (Scelzo and Lichtschein de Bastida 1978) and spend a higher proportion of time searching for food (Spivak and Sánchez 1992), which could make them more vulnerable to predation. The higher consumption of female than male *C. angulatus* may also be the result of a population bias towards females in larger individuals, as has been recorded in Mar Chiquita (Spivak *et al*. 1994).

Our study at Golfo San Jorge confirms that Olrog's Gull is fairly specialized during the breeding season. Dense assemblages of grapsid crabs, such as those found along the Argentine coast, provide relatively abundant and predictable food sources (Spivak and Sánchez 1992). The characteristics of this food source may have been important in determining the feeding habits of breeding Olrog's Gulls, as specialization is favoured by environmental constancy or resource abundance (Futuyama and Moreno 1988, Sherry 1990, Dall and Cuthill 1997). Delhey *et al*. (2001b) have also suggested that feeding specialization of Olrog's Gull may be the result of interference competition with the larger and behaviourally dominant Kelp Gull *Larus dominicanus*, with which Olrog's Gull is spatially associated throughout its breeding range (Yorio *et al*. 1997). Understanding the relative contributions of factors such as resource abundance patterns or the presence of potential competitors in determining the feeding specialization of Olrog's Gull will require further investigation.

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