DOES ACCESS TO HIGH-QUALITY PELAGIC PREY INCREASE THE BREEDING SUCCESS OF KELP GULLS *LARUS DOMINICANUS* IN THE ANTARCTIC PENINSULA?

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SUMMARY

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An analysis of the diet of the Kelp Gull *Larus dominicanus* during the chick-rearing period at a colony in northern Gerlache Strait, Antarctic Peninsula showed that Antarctic Krill *Euphausia superba* made up 20% by mass of the diet of the adults and 66% by mass of the chicks' diet. Fish constituted a low proportion of total prey, both in pellets and chick regurgitations, whereas the importance of limpets in adult pellets was similar to results from other studies in Antarctica. Chick regurgitations show substantial differences in the diet at the study site with other localities. Our data on breeding success were in accordance with localities farther south in Antarctica where Kelp Gull chicks are fed offshore prey. Antarctic Krill may represent a substantial resource for Kelp Gulls in some localities as those reported here; the abundance of this resource during the chick-rearing period, associated with low levels of predation by skuas and with favourable local climatic conditions, could be linked with very high reproductive success in the study area.

Keywords: Kelp Gull, *Larus dominicanus,* Antarctica, diet, breeding success

INTRODUCTION

Antarctic Krill *Euphausia superba* is one of the main food resources for many seabirds and marine mammals in the Southern Ocean (Croxall *et al.* 1988, 1999). Despite the bulk of the diet of adult and chick Kelp Gulls *Larus dominicanus* at these latitudes during the chick-rearing period being mainly composed of limpets, amphipods, krill and fish, the relative importance of these items varies from one locality to other. Whereas limpets and other intertidal fauna, together with scavenged prey at penguin colonies, constitute the main components of the diets at the South Shetland Islands and northern Antarctic Peninsula (Favero *et al*. 1997, Favero & Silva 1998, Silva & Favero 1998), studies from the southern Antarctic Peninsula region show that Kelp Gulls consume, in 'good' summers, large amounts of pelagic fish during the chick-rearing period (Maxson & Bernstein 1984, Fraser 1989). These differences were attributed to the abundance of pelagic resources in the southernmost localities, and/or the presence of more extensive intertidal foraging areas in the South Shetland Islands (Favero & Silva 1998). No previous studies have identified Antarctic Krill as an important prey of Kelp Gulls at sites in the northern Gerlache Strait region (Antarctic Peninsula), but some studies have linked high reproductive success to an abundance of pelagic prey in the diet (see Maxson & Bernstein 1984, Fraser 1989).

In this paper we present data on the diet of Kelp Gulls at a study site in the northern Gerlache Strait region, Antarctic Peninsula, and test the hypothesis that abundance of pelagic prey is linked to reproductive success.

METHODS

The study was conducted from 20 December 1997 to 25 February 1998 during the chick-rearing period of Kelp Gulls near the northern extent of Gerlache Strait, Antarctic Peninsula (64°09'S, 60°57'W). At least 583 breeding pairs were present in the study area, scattered in four large colonies (>50 pairs) and in several smaller groups (M. Favero *et al*. unpubl. data).

Diet was assessed by the analysis of 470 pellets and 42 handling-induced chick regurgitations collected in breeding territories. In the laboratory the samples were dissected and prey remains identified with a stereo microscope. Contents were sorted into limpets, krill, snails, fish, amphipods, squid, penguins and flying birds. The number of individuals belonging to each prey taxon represented in every sample was estimated by counting intact specimens and undigested prey remains (e.g. krill eyes, fish otoliths and eye-lenses and squid beaks). The otoliths recovered from the

samples were assigned to species using Hecht (1987) and Reid (1996). Otoliths belonging to each species were assigned as 'right' and 'left', and the most abundant being considered as the minimum number of individuals from that prey species in the diet sample. The lengths and masses of the individuals identified were estimated from otolith lengths using the equations from local reference material (R. Casaux & E. Barrera-Oro unpubl. data), and Hecht (1987). The lengths of intact krill (rostrum tip to telson tip) were measured to the nearest 0.01 mm.

Breeding success of Kelp Gulls was estimated by checking, at the time of hatching, the nest contents of 50 active nests in three colonies (Cierva Point, Sucia Point and Moss Island) and by counts of fledged (or near-fledged) chicks at the end of the season. Pre-fledging mortality of large chicks was assumed to be negligible (Favero & Silva 1998).

RESULTS

Pellet and regurgitation analysis showed that the Antarctic limpet *Nacella concinna* and Antarctic Krill constituted the bulk of the diet of adult Kelp Gulls, together accounting for 84% by number and 88% by mass (Table 1). Fish constituted a low proportion of the total prey recovered from pellets: from 65 containing fish remains, only 36 individual fish were identified, belonging to seven large *Nototheniops nudifrons*, 25 small nototheniids (mainly *Pleuragramma antarcticum*) and four myctophids (*Electrona antarctica*). Another 18 fish were classified as juvenile nototheniids.

Table 1

Frequency of occurrence (F%), and importance by number (N%) and by mass (W%) of prey items found in Kelp Gull pellets and chick regurgitations

	Pellets			Chick regurgitations		
Food item	**F%**	**N%**	**W%**	**F%**	**N%**	**W%**
Molluscs						
Limpet	99.1	48.1	70.2	26.2	1.7	12.8
Snail	3.7	0.6	0.2	2.4	0.3	tr
Cephalopods						
Squid	0.2	tr	0.1	2.4	tr	2.7
Crustaceans						
Krill	31.2	36.0	17.8	88.1	76.3	65.6
Amphipod	20.2	13.73	1.6	4.8	20.9	1.0
Isopod	0.6	tr	0.2	–	–	–
Fish						
Fish	14.0	0.8	6.4	14.3	0.6	14.3
Birds						
Penguin	2.4	0.1	1.0	4.8	0.1	2.8
Flying birds	3.0	0.2	1.8	2.4	tr	0.1
Mammals						
Seal	0.9	0.1	0.5	–	–	–
Algae	2.8	0.2	0.1	4.8	0.1	0.2

Krill was the main prey item in the diets of chicks, being four and five times the importance by mass of fish and limpets, respectively (Table 1). The identified fish specimens were *N. nudifrons* (total length [TL] = 115.4 mm, n = 1), *P. antarcticum* (TL = 139.7–176.0 mm, n = 6), *E. antarctica* (standard length [SL] = 33.1–73.1 mm), *Protomyctophum normani* (SL = 33.1 mm), *Chionodraco rastrospinosus* and *Trematomus* sp. Almost all fish came from samples obtained late in the breeding season and from chicks near to fledging. The mean size of krill brought by adult gulls to their chicks was 38.2±4.0 mm (modal class 38–40 mm, range 21.6–57.0 mm, n = 586).

The dietary composition as reflected in the analysis of adult pellets and chick regurgitations showed significant differences in the occurrence and importance by number and by mass of the main prey types ($\chi^2 > 71.1$, df = 4, $P < 0.0001$ in all comparisons).

The fledging success obtained in the 50 nests was 1.7 chicks/pair, reaching the maximum of two chicks per pair in a subcolony of 15 nests located at Cierva Point.

DISCUSSION

Our study shows that Antarctic Krill was the main component in the diets of chicks, comprising 66% of the total mass, whereas limpets constituted the bulk (70% by mass) of the diet of adult gulls. The information obtained from chick regurgitations show substantial differences from studies reported elsewhere in Antarctica, although the importance of prey items in adult pellets was similar to that reported for other Antarctic localities (Table 2, Fraser 1989, Favero *et al.* 1997, Silva & Favero 1998, Silva *et al.* 1999). Whereas prey brought by adults to their chicks at northern localities (e.g. South Shetland Islands and northern Antarctic Peninsula) comes mainly from coastal feeding territories (i.e. intertidal and penguin colonies: Favero & Silva 1998, MPS unpubl. data), chicks from southern areas such as Anvers Island and the northern Gerlache Strait are fed mostly on pelagic prey, at least during 'good' summers (Maxson & Bernstein 1984, Fraser 1989, this study).

Many factors could be linked with the observed importance of krill in the diet of gulls in the northern Gerlache Strait. Recent studies of krill distribution and abundance off the west coast of the Antarctic Peninsula have reported biomass at the inner shelf region, reaching values of 180 $g.m^{-2}$ (Lascara *et al*. 1999). These high biomass densities of krill could be available to southern gulls. Circumstantial evidence supporting the idea of large abundance of krill during the study period existed in the high proportion of krill in the diets of other seabird species in the area (such as Southern Giant Petrels *Macronectes giganteus*, N.R. Coria unpubl. data) and in the high abundance of other krill predators such as Humpback Whales *Megaptera novaeangliae* seen feeding daily during samplings and Leopard Seals *Hydrurga leptonyx* resting on small icebergs containing pink faeces (i.e. mainly krill-constituted, MF pers. obs.).

Further, we observed Chinstrap Penguins *Pygoscelis antarctica* foraging near the coast (*c.* 500 to 2000 m offshore) and large flocks of Kelp Gulls (up to 120 individuals) feeding in close association with other flying birds (MF & N.R. Coria unpubl. data). Seabird foraging associations with other marine vertebrates

have been widely reported, where diving predators drive prey to the surface, making it available to other species (Evans 1982, Burger 1988, Pitman 1993, Verheyden 1993). Preliminary data on foraging aggregations of birds observed during samplings suggest an increase of prey availability near the surface for flying birds, due to the upward movements of krill avoiding predation by penguins. This is supported by literature reporting Chinstrap Penguins attacking krill aggregations from the sides or from underneath (Zamon *et al.* 1996). In the observed associations, Kelp Gulls were the most abundant species, accounting for 60% of total birds (MF & N.R. Coria unpubl. data).

Evidence from several bird species in the Antarctic supports the link between high reproductive performance and high prey availability (see Pierotti & Annett 1990). In the Antarctic, Kelp Gulls show the highest breeding success when chicks were fed with offshore prey (i.e. fish or krill), whereas intermediate or low reproductive performances were reported when food come from other sources (Table 2). However, other factors should be taken into account, as the extremely good weather conditions in the study area during the chick-rearing period (very occasional storms and low wind intensities) may have contributed towards high breeding success. An increase in the intake of alternative resources have been reported for other gull species during stormy years, when offshore prey were hard to capture (Pierotti 1982). Such a situation could be representative for localities in Antarctica where unfavourable weather conditions would lead Kelp Gulls switching from a diet of fish or krill to preying on intertidal or terrestrial food.

Another factor that contributed to the high breeding performance was the very low level of predation by South Polar Skuas *Catharacta maccormicki* at the gull colonies. The skuas forage mainly on offshore fish (i.e. over 79% of their diet by mass, Peter *et al.* 1990). The opposite was observed during several previous years in the South Shetland Islands where Subantarctic Skuas *C. antarctica* were the main species, and high predation rates on penguin and other bird colonies were observed (MF unpubl. data, see also Peter *et al.* 1990).

Here we have presented evidence that Antarctic Krill can be a substantial resource for Kelp Gulls at some localities in the Antarctic. The abundance of this resource during the study period, allied with low levels of predation and favorable local weather conditions, may have resulted in the very high reproductive performances found in the area. Further studies may confirm whether these conditions represent the norm at these localities or, as observed at more southerly localities, variations of prey (especially krill) availability lead to inter-annual variation in the reproductive success of Kelp Gulls.

TABLE 2

Diets of Kelp Gulls and their breeding success from different localities in Antarctica. SOI: South Orkney Islands, SSI: South Shetland Islands, AP: Antarctic Peninsula

Locality		Season	Diet			Breeding success	Reference
			FT[1]	Fish[2]	Krill		
Davies Point (SOI)	60°46'S, 44°42'W	1996–97	+++	o	o	0.92	M.P. Silva, unpubl. data
Admiralty Bay (SSI)	62°10'S, 58°27'W	1985	+++	?	?	0.68	Jablonski 1986
Stranger Point (SSI)	62°16'S, 58°37'W	1992–93	++	o	+	0.30	Silva & Favero 1998
Stranger Point (SSI)	62°16'S, 58°37'W	1993–94	+++	o	o	0.50	Silva & Favero 1998
Duthoit Point (SSI)	62°19'S, 58°48'W	1994–95	++	+	+	<1.00	Silva & Favero 1998
Harmony Point (SSI)	62°18'S, 59°14'W	1995–96	+++	+	+	1.45	Favero & Silva 1998[(cr)]
Hope Bay (AP)	62°23'S, 54°00'W	1996–97	+++	+	o	<1.00	M.P. Silva, unpubl. data
Cierva Point (AP)	64°09'S, 60°57'W	1997–98	+	+	+++	2.00	This study[(cr)]
Sucia Point (AP)	64°10'S, 60°57'W	1997–98	+	+	+++	1.28	This study[(cr)]
Moss Island (AP)	64°10'S, 61°02'W	1997–98	o	+	+++	1.80	This study[(cr)]
Anvers Island (AP)	64°49'S, 63°47'W	1974–75	?	+++[2]	?	1.91	Maxson & Bernstein 1984[(dc)]
Anvers Island (AP)	64°49'S, 63°47'W	1975–76	?	+++[2]	?	1.80	Maxson & Bernstein 1984[(dc)]
Anvers Island (AP)	64°49'S, 63°47'W	1978–79	+++	o/+	o/+	0.40	Maxson & Bernstein 1984[(dc)]
Anvers Island (AP)	64°49'S, 63°47'W	1979–80	+++	o/+	o/+	0.60	Maxson & Bernstein 1984[(dc)]

[1] Food from feeding territories, mainly intertidal prey (limpets, amphipods) and penguin colonies (by predation or scavenging)
[2] Mainly *Pleuragramma antarcticum*
o: Food not recorded to occur or very scarce in the area
+: Food occasionally recorded
++: Food frequently recorded
+++: Food very frequently recorded
[cr] Chick regurgitations
[dc] Food delivered to chicks

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