Seasonal and Regional Variation in the Diet of the Kelp Gull in Northern Chile

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Abstract.—The feeding ecology of the Kelp Gull (*Larus dominicanus*) was studied during the 2002-03 breeding season at Coquimbo, northern Chile. Food composition was studied by analyzing pellets regurgitated by Kelp Gulls living in different habitats. Birds breeding or resting near fishing ports used these as their main feeding grounds. Birds breeding on offshore islands fed mainly on intertidal organisms and olives. A comparison between the food of breeders and non-breeding birds during the breeding season showed a difference in diet composition of breeders, who fed more on fish of high energy density while non-breeding birds continued feeding on a wide range of organisms and waste. Observations in a fishing harbor and at sea demonstrated that fisheries waste was an important food source for the birds. The inshore distribution at sea was related to the location of fishing ports and breeding colonies. *Received 17 May 2004, accepted 18 February 2005.*

Key words.—Diet, foraging ecology, Kelp Gull, *Larus dominicanus*, pellets, Chile.

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Gulls are known to be feeding generalists (Cramp and Simmons 1983; Vauk and Prüter 1987; Burger 1988). This behavior includes the use of anthropogenic food sources such as refuse tips and discards or offal from fisheries (Burger 1988; Furness *et al.* 1992) as well as natural prey found in offshore or intertidal areas (Götmark 1984; Kubetzki and Garthe 2003). Besides determining food composition and feeding habitats, diet studies can also provide valuable information about differences in the feeding ecology of breeding and non-breeding birds. For example, it has been shown that gulls can change their diet during breeding and chick rearing (Annett and Pierotti 1989) and thus improve their breeding success (Bukacinska *et al.* 1996).

The Kelp Gull (*Larus dominicanus*) has a wide distribution in the southern hemisphere (Murphy 1936; Harrison 1985). It is common along the coast of northern Chile (Jehl 1973; Schlatter 1984; Simeone *et al.* 2003). Until now, few studies have investigated the feeding ecology of the Kelp Gull in Chile (Bahamondes and Castilla 1986; Martinez Araneda 1998), and most of these were occasional observations (Meichßner 2001; Ruiz and Simeone 2001; Weichler *et al.* 2004).

To determine the composition of food of Kelp Gulls in anthropogenic and natural habitats and to find out whether dietary differences occurred during the breeding period, regurgitated pellets were collected throughout the breeding season, from October to February 2002-03, at an urban breeding colony, at an urban resting site and at several natural breeding colonies on islands along the coast, and subsequently analyzed.

Study Area and Methods

Pellets from Kelp Gulls were collected in Coquimbo, northern Chile, during the breeding season between October 2002 and February 2003 (see Fig. 1 for the study area). One breeding colony was located on the roof of buildings of the local university, close to a small fishing harbor (referred to subsequently as the urban colony). An urban resting site for the Kelp Gulls on a mining ramp, also close to the fishing harbor, was searched for pellets. Birds there were assumed to be non-breeders since breeding birds were observed returning to the colony directly after feeding while this was not the case for birds resting on the mining ramp. Several birds present at the resting place were not in adult plumage. Birds apparently in adult plumage but remaining at the resting site might be intermittent breeders, a common phenomenon in gulls (Calladine and Harris 1997). Both groups of birds had direct access to fisheries discard and to human waste at a nearby refuse tip. Both sampling sites were cleared of pellets before the first samples were taken, in order to guarantee the freshness of the samples. Three breeding colonies were sampled at Damas Island, Pajaros Island and Chañaral Island (Fig. 1). All three islands have little or no human influence and are at least 40 km away from large towns. The breeding season was divided into pre-incubation, incubation and chick-rearing periods.

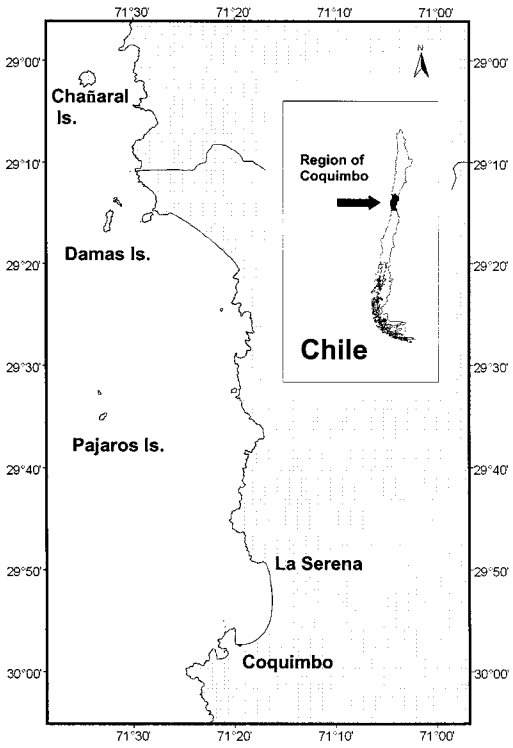

Figure 1. Study area in northern Chile. The urban breeding area and resting site of the Kelp Gull, and the fishing harbor located in the city of Coquimbo.

Pellets were collected and contents were identified in the laboratory. Prey items were grouped into the following categories: fish, bivalve mollusks, gastropods mollusks, crustaceans, echinoderms, cephalopods, insects, waste, birds and mammals and plants and algae. Identification to the lowest possible taxonomic level was made using identification guides and reference collections (Retamal 1981; Falabella *et al.* 1995; Zagal and Hermosilla 2001). Possible bias has to be taken into account when using pellets for diet studies since easily digestible prey might be underestimated (Duffy and Jackson 1986; González-Solís *et al.* 1997). Studies on gulls have shown a accurate reflection of prey composition by using pellets (Spaans 1971; Annett and Pierotti 1989), especially when targeting trends in diet (Duffy and Jackson 1986; Furness and Monaghan 1987; Kubetzki and Garthe 2003).

The composition of the pellets is shown as the percentage of all pellets that contained a certain prey category at the respective site and season. Since some pellets contained more than one prey category, the sum of the percentages over the categories is higher than 100%. In addition, a semi-quantitative analysis was carried out by assessing the main prey item(s) from each pellet, thereby taking into account their digestibility, energy content and biomass (and thus reducing bias). Prey categories were further grouped into (a) fisheries discards (fish and cephalopods), (b) invertebrates (bivalves, gastropods, crustaceans, echinoderms and insects), (c) waste and (d) others (birds and mammals and plants such as seeds and fruits). Each pellet was given a value of one, and this value was split into equal parts if there was more than one component (e.g. invertebrates = 0.5, waste = 0.5). Traces and minor components were excluded from that analysis.

The proportions of pellets containing fish were compared between the three stages of the breeding cycle and breeders vs. non-breeders using the procedure for non-orthogonal contingency tables having two crossed predictor variables (stage of breeding cycle and breeder vs. non-breeder) and two frequencies of occurrence (pellets with an without fish) as the response variable described in Bortz *et al.* (1990). In essence, this procedure is comparable to an ANOVA, and it gives F-values (and corresponding degrees of freedom) for the total contingency as well as for the two predictor variables and their interaction, separately. The same procedure was used to compare the frequencies of occurrence of pellets with and without waste between the two groups of subjects and the three stages of the breeding cycle. In addition, we used a χ-test for linear trends (Zar 1996).

Data for each of the three islands was collected once during the breeding season (see Table 1).

RESULTS

Seasonal Variation

Urban colony site. At the colony, the number of food categories found in the pellets decreased from eight in the pre-incubation period to three during chick rearing (only considering categories with frequencies over 5%). Fish was the most frequent prey category in all three periods, reaching a maximum of 89% during chick-rearing. Cephalopods ranked second while all other categories occurred at minor percentages only (Table 1; Fig. 2).

Non-breeder site. During all breeding periods several food categories were present in pellets from the resting site at the harbor. The prey categories found most often differed between the periods; waste dominated during pre-incubation, fish during incubation and waste again during chick rearing. Several other categories were found regularly during all breeding stages (Table 1; Fig. 2).

There was a linear trend at the colony site with increasing frequencies of fish and decreasing frequencies of waste over the breeding season ($\chi_2 = 32.5$, $P<0.001$ and $\chi_2 = 22.1$, $P < 0.001$, respectively) whereas non-breeding birds did not show such trend in their food composition (fish: $\chi^2_2 = 0.32$, n.s.; waste: $\chi^2_2 = 0.60$, n.s.; Fig. 3, Table 2). The composi-

Table 1. Composition of Kelp Gull pellets collected during the pre-incubation, incubation and chick-rearing period in the study area in northern Chile during the breeding season 2002/03. (N = numbers of pellets containing category, % = frequency of occurrence).

	Urban colony (Breeders)						Urban resting place (Non-breeders)						Damas Is.		Pajaros Is.		Chañaral Is.	
	Pre-Incubation		Incubation		Chick rearing		Pre-Incubation		Incubation		Chick rearing		Pre-Incubation		Incubation		Chick rearing	
Number of pellets	116		48		184		67		61		129		23		77		59	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Fish	70	60	36	75	163	89	32	48	43	71	61	47	8	35	33	43	3	5
Bivalves	8	7	2	4	—	—	27	40	6	10	9	7	6	26	23	30	—	—
Gastropods	—	—	—	—	3	2	1	2	—	—	3	2	—	0	1	1	—	—
Crustaceans	8	7	1	2	1	1	16	24	1	2	15	12	17	74	4	5	6	10
Echinoderms	1	1	—	—	1	1	3	5	1	2	1	1	—	—	—	—	—	—
Cephalopods	25	22	13	27	11	6	3	5	2	3	1	1	—	—	1	1	—	—
Insects	1	1	—	—	—	—	4	6	—	—	—	—	10	43	8	10	—	—
Waste	24	12	3	6	7	4	39	58	19	31	63	49	—	—	36	47	—	—
Stones	15	13	2	4	—	—	28	42	8	13	11	9	5	22	34	44	—	—
Birds & mammals	21	18	5	10	—	—	36	54	17	28	30	23	—	—	33	43	50	86
Plants	22	19	1	2	—	—	37	55	13	21	21	16	—	—	33	43	50	86
Algae	3	3	—	—	—	—	2	3	—	—	1	1	1	4	2	3	—	—

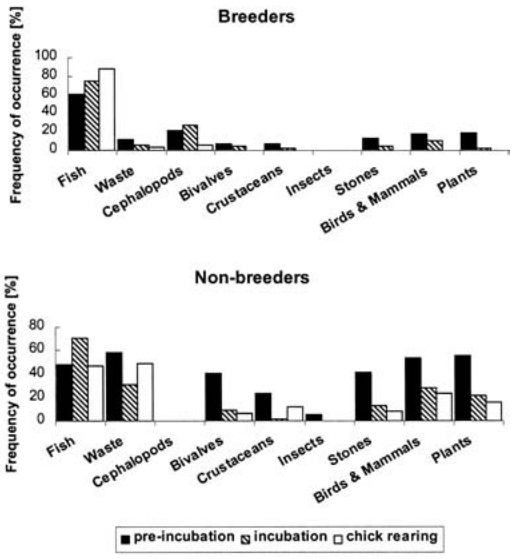

Figure 2. Composition (as frequency of occurrence in percentages) of Kelp Gull pellets collected at the urban breeding colony (breeders) and the urban resting place (non-breeders).

tion of pellets differed significantly between the three breeding stages (fish: $F_{2,599} = 7.46$, $P < 0.001$; waste: $F_{2,599} = 10.7$, $P < 0.001$, respectively) and between breeders and non-breeders (fish: $F_{1,599} = 23.5$, $P<0.001$; waste: $F_{1,599} = 103.9$, $P < 0.001$, respectively).

Regional Variation

Pellet composition varied greatly among the three islands (Damas, Pajaros and Chañaral). Pajaros Island, located closest to larger towns such as Coquimbo and La Serena, exhibited a high percentage of waste in the pellets (47%). Fish was also common, being mostly commercially exploited species such as *Merluccius gayi* and *Trachurus murphyi*. Other categories found here were remains of birds and mammals (the island has breeding colonies of the Peruvian Booby (*Sula variegata*) and Humboldt Penguins (*Spheniscus humboldti*), as well as large numbers of rats) and plants (Table 1; Fig. 4). On Damas Island, waste was not found in the diet of Kelp Gulls. Crustaceans were most numerous (74%), and insects were also frequent. Fish vertebrae in the pellets indicate that birds on Damas Island fed on small schooling fish. Birds on Chañaral Island had a totally different food composition, with 86% of all pellets containing olive seeds, presumably taken from a plantation about 10 km away (Table 1). Other items found were crustaceans and fish, probably captured in the sea. Food composition differed significantly between the three islands ($\chi^2_6 = 101$, $P < 0.001$).

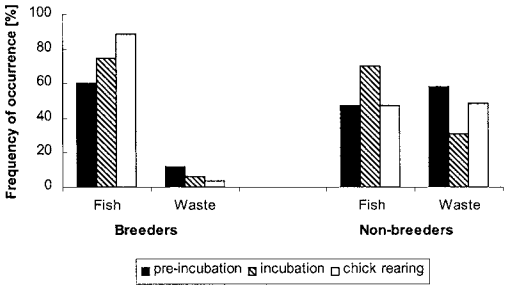

Figure 3. Comparison of pellet compositions of urban breeders and non-breeding Kelp Gulls with regard to fish and waste.

DISCUSSION

Our results demonstrate that Kelp Gulls in northern Chile feed on a large variety of prey. Both regional and seasonal aspects may influence prey availability and prey selection in this species. The results from the urban colony indicate that breeding Kelp Gulls specialize in their food spectrum during the breeding season. An increase of fish and a decreasing percentage of waste consumed show a nutritional change during the breeding period. Annett and Pierotti (1989) found such a change in the Western Gull (*Larus occidentalis*), which switched from waste to mainly fish after chick hatching. As was the case in the study by Annett and Pierotti (1989), prey availability cannot have been the principal reason for this change since non-breeding birds feeding in the same area did not show such behavior. Why the gulls did not feed on fishery discards during the entire study period is not understood. A higher cost of foraging on fish, as stated by Annett and Pierotti (1989), is not true for this study, as fish were readily available in the harbor (although this is valid only for the birds breeding in the urban site). Hockey

Table 2. Statistical tests for Figure 3.

	Number of pellets			Chi-square for linear trends		
Breeders	Pre-incubation	Incubation	Chick rearing	χ^2_t	df	P
Fish	70	36	163	32.5	2	0.001
Waste	24	3	7	22.1	2	0.001
Non-breeders						
Fish	32	43	61	0.32	2	0.85
Waste	39	19	63	0.60	2	0.74

and Steele (1990) and Steele and Hockey (1990) found that gulls feed their chicks with food of high energy density such as fish, but that the adult birds kept on feeding on waste. A distinction between adult and chick pellets was not possible in this study, and further observations are necessary to determine if differences exist in adult and chick food.

Identification of the remains of fish in the pellets showed that mainly *Trachurus murphyi* and *Merluccius gayi* were consumed by Kelp Gulls. Both species are caught and landed by local fisherman. Other species found in the diet were also available as discards at the fishing harbor. Regular counts at the fishing harbor near the breeding colony and seabird at sea counts (pers. obs.) corroborated the importance of fishery waste for the Kelp Gulls, especially at the fish markets in many ports along the coast. The use of discards is common among several gull species worldwide (Buckley 1990; Camphuysen 1993; Garthe 1999). Yorio and Caille (1999), Bertollotti and Yorio (2000) and Weichler *et al.* (2004) observed Kelp Gulls attending fishing vessels in Chilean and Argentinean waters.

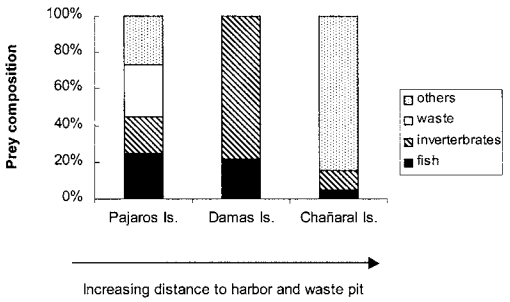

Figure 4. Composition of Kelp Gull pellets collected at the three islands Pajaros, Damas and Chañaral.

The use of refuse tips has been observed in several gull species and in many cases an increase in numbers is related to this habit (Fordham 1967; Yorio *et al.* 1998). Some types of waste have a relatively high energy density (Hunt 1972; Pierotti and Annett 1991) compared to invertebrates (Cummins and Wuycheck 1971; Hunt 1972; Pierotti and Annett 1991), and edible waste was easily accessible in this case. Untreated waste attracted larger numbers of (mainly adult) gulls (Monaghan *et al.* 1986), and the amount of edible components seemed to make waste an important food source for Kelp Gulls in urban areas in this study.

The very different food composition found in pellets from the three breeding colonies on Pajaros, Damas and Chañaral Island could be, in part, due to seasonal differences as each island was only sampled once and at different stages of the breeding period. However, the very obvious differences are probably due to prey availability. Pajaros Island is located closest to large towns with fish markets (harbors) and refuse tips. Although the distance is about 50 km, birds seem to use those feeding grounds on a regular basis, and gulls at sea were seen commuting directly between island and mainland feeding grounds. The energy gained by the consumption of fishery discards and waste is presumably higher than the costs of flying, as has been calculated for the Lesser Black-backed Gull (*Larus fuscus*) and Herring Gull (*L. argentatus*), flying large distances in order to consume fisheries discard and waste (Camphuysen 1995). In contrast, Kelp Gulls on Damas Island seem to forage exclusively on natural prey from the intertidal zone and on terrestrial prey such

as insects, the latter possibly being a result of a good food availability at the time of sampling (spring, "desierto florido").

Kelp Gulls from Chañaral Island exhibited a typical prey composition. More than 80% of pellets contained olive seeds. An olive plantation is located on the mainland about 10 km away. Olives have a relatively low energy density (Holland *et al.* 1995) compared to fish. However, feeding on fruits is known in other gulls. The Common (Mew) Gull (*Larus canus*) feeds to a considerable extent on cherries in northern Germany (Kubetzki *et al.* 1999), and the Glaucous Gull (*Larus hyperboreus*) feeds on berries in the Canadian Arctic (Barry and Barry 1990).

The results of this study compare closely with other observations on the feeding ecology of Kelp Gulls. It has been shown that Kelp Gulls feed on intertidal organisms (Bahamondes and Castilla 1986; Hockey and Steele 1990; Steele and Hockey 1995; Bertollotti and Yorio 1999), on birds and other vertebrates near breeding colonies (Fordham and Cormack 1970; Burger and Gochfeld 1981; Emslie *et al.* 1995; Yorio and Quintana 1997; Meichßner 2001; Ruiz and Simeone 2001) and at increasing percentage on fisheries discard and waste (Fordham 1967; Yorio *et al.* 1998). Concerns have been raised in the study area because of increasing conflicts between human interests and birds (e.g. roosting habits and fouling buildings, cars and trees). Whether the use of discard and waste is the cause of increasing numbers of Kelp Gulls in that region has to be determined by further studies, as well as the effects on the birds of a different discard and refuse policy. A decrease of the food supply could be a good alternative before the application of any control program aimed at population reduction.

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