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Short Communication

A recently established Kelp Gull colony in a freshwater environment supported by an inland refuse dump in Patagonia

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Abstract. Populations of several species of gull are increasing worldwide as a result of a plentiful supply of anthropogenic food in urbanised environments. In light of this, we decided to examine the importance of anthropogenic food in the diet of a recently established colony of Kelp Gulls (*Larus dominicanus*). We collected 241 regurgitated pellets of the Kelp Gull during the 2008–09 breeding season at the colony in the De La Guardia Islands, Nahuel Huapi Lake, Argentina. In terms of percentage frequency of occurrence in pellets, human refuse (65.6%) was the most frequently recorded item, followed by insects (42.3%; mostly coleopterans) and fish (21.2%). In terms of the percentage number of total prey items, insects (62.1%) and human refuse (21.3%) were the most abundant items. The consumption of insects decreased and that of human refuse increased during chick-rearing. Human refuse was recorded in samples from most nests (97.3%). We compare our results with those obtained for other localities and discuss the consequences of the management of urban refuse. Our results suggest that the Kelp Gull breeding colony in the De La Guardia Islands is sustained by the availability of food from the rubbish tip of Villa la Angostura. This is the first dietary study of the Kelp Gull in a continental freshwater ecosystem and one more example of a gull colony supported by anthropogenic sources of food.

Additional keywords: diet, human refuse, *Larus dominicanus*, rubbish tip.

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Introduction

The Kelp Gull (*Larus dominicanus*) is widely distributed in the southern hemisphere (Watson 1975; Burger and Gochfeld 1996) and expansion of the population of this species is a matter of concern in several areas of Argentina, South Africa and Australia (Coulson and Coulson 1993; Yorio *et al*. 1998; Whittington *et al*. 2006; Lisnizer *et al*. 2011). The Kelp Gull is an opportunistic and generalist feeder and is also considered to be an aggressive predator that takes a variety of prey (Coulson and Coulson 1993; Bertellotti and Yorio 1999; Bertellotti *et al*. 2003). It also exploits human refuse and fishery discards (Giaccardi *et al*. 1997; Bertellotti and Yorio 1999; Bertellotti *et al*. 2001; Petracci *et al*. 2004). There have been several studies of the foraging behaviour of the Kelp Gull in Patagonia (Bertellotti and Yorio 1999; Yorio and Bertellotti 2002; Bertellotti *et al*. 2003; Petracci *et al*. 2004) but all were conducted in coastal marine environments and there is no information available on Kelp Gulls foraging in freshwater ecosystems.

Populations of Kelp Gulls are increasing along the Argentinean coast (Yorio *et al*. 1998; Lisnizer *et al*. 2011). Through food competition, kleptoparasitism and predation on eggs or chicks, the increasing numbers of Kelp Gulls has had a negative affect on other species of bird and, consequently, the dynamics of the related ecosystems (Yorio and Quintana 1997; Quintana and Yorio 1999; Silva 2006). Further, populations of Kelp Gulls have been implicated in human health issues (Frere *et al*. 2000; Albarnaz *et al*. 2007; Pereda *et al*. 2008). For example, the helminth *Diphyllobothrium latum*, which produces diphyllobothriasis disease in humans, was observed in faeces of Kelp Gulls at Nahuel Huapi Lake (Kreiter and Semenas 1997) (Fig. 1).

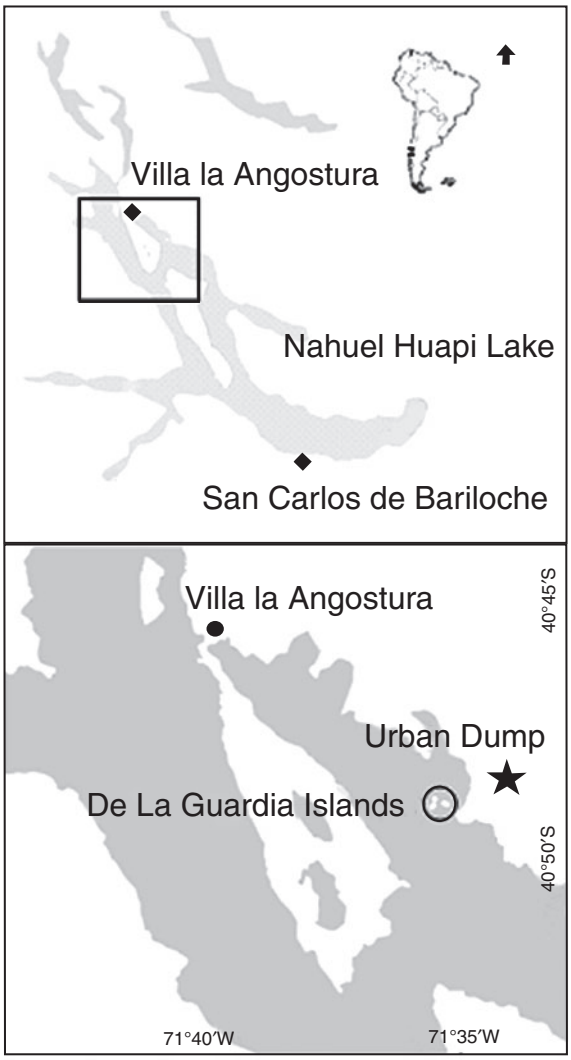

Fig. 1. Location of De La Guardia Islands colony in the Nahuel Huapi National Park, Patagonia, Argentina.

The expansion of Kelp Gulls populations observed on the northern Patagonian coast (Lisnizer *et al*. 2011) appears also to be occurring in continental ecosystems. A colony of Kelp Gulls in the De La Guardia Islands, in Nahuel Huapi Lake, was first noted by fishermen of the area in 2002, close to the urban rubbish tip of Villa la Angostura.

The aim of this study is to provide the first information on the feeding habits of the Kelp Gull in a Patagonian freshwater environment, as well as analyse such information in relation to the reported increasing numbers of gulls at the Nahuel Huapi Lake. We tested the hypothesis that the breeding colony of the De La Guardia Island is supported by its proximity to the rubbish tip of the nearby town.

Materials and methods

The study was conducted in a Kelp Gull breeding colony in the northern part of the Nahuel Huapi Lake (NHL), Nahuel Huapi National Park, Argentina (40°49′S, 71°35′W; Fig. 1). The colony is 1.5 km from the urban rubbish tip of Villa la Angostura, a growing town in Los Lagos, which had a human population growth of 107% in the 1990s (INDEC 2001). Regurgitated pellets of the Kelp Gull were collected weekly at the De La Guardia Islands colony from 46 of the 50 nests observed, between the second week of November and the last week of December 2008.

Analysis of pellets may overestimate the presence of prey with hard parts, and underestimate the occurrence of soft-bodied prey (Duffy and Jackson 1986; Brown and Ewins 1996; Barrett *et al*. 2007). However, this method has been extensively used in studies of the diet of gulls because it provides large sample sizes with a minimum disturbance to breeding birds and has shown to be a valuable tool for detecting seasonal changes in the diet (Herrera *et al*. 2005). Sampling started during the laying period (94% of the nests were active) and finished when the oldest chicks were 47 days old. The colony was cleared of old pellets before sampling started. Samples found <1.5 m from a nest were assigned to that nest. Pellets were frozen at −20°C, dissected under a stereomicroscope (20× magnification) and prey-classes were identified to the lowest taxonomic level possible. Invertebrates were classified by the presence of claws, mandibles and shell fragments (Rudolph 2002). Otoliths and bones (vertebrae, maxillae and spines) were used for identification of fish (Liotta 2005). Bones were used to classify other vertebrates (i.e. small mammals; Pearson 1995). Only organic urban refuse was counted (bones of poultry, beef meat, etc.) and inorganic items were not included in the analysis. Of plant material, only seeds were counted.

In order to detect changes in the composition of the diet through the breeding season, the samples were separated into four subsamples corresponding to: laying (10–19 November, $n = 62$), hatching (20 November–6 December, $n = 59$), early chick-rearing (7–23 December, $n = 80$) and late chick-rearing (24–29 December, $n = 40$). We calculated percentage frequency of occurrence (%*f*) and percentage number (%*n*) for the breeding season and for each breeding stage.

To determine the use of the rubbish tip of Villa la Angostura as a foraging area, we conducted 18 censuses at the tip at the concurrently with the collection of pellets. We visited the waste tip at a randomly selected time between 0900 and 1900 hours, and during each visit conducted a point count for 10 min and within a radius of 70 m. Individuals observed were classed as immatures or adults based on plumage and colour of bill and legs.

Statistical analysis

In order to compare the proportion of items (expressed as the number of items in each category of prey by the total number of pellets for each stage) found in pellets throughout the stages of breeding, we fitted a generalise linear model (GLM) with a gamma distribution for the response variable, and the inverse as the link function. As the gamma distribution only allows positive values, we added 0.1 to all the values to correct for zero values. Tukey's *post hoc* test was used for comparisons among stages; results were considered statistically significant at $P < 0.05$.

Counts of Gulls at the rubbish tip were tested by a GLM with a Poisson distribution. After detecting overdispersion, we corrected the standard errors using a quasi-GLM model where the variance is given by $\varphi \times \mu$, where φ is the dispersion parameter

and μ is the mean (Zuur *et al*. 2009). We used R version 2.9.1 (R Development Core Team 2009) for all statistical analysis.

Results

Overall dietary composition

A total of 810 prey items was identified in the 241 pellets collected in the colony of the De La Guardia Islands. Human organic refuse (mostly chicken necks and wings and beef cutlets) was the most frequently recorded item in pellets (percentage frequency of occurrence, %*f*, in pellets, 65.6%), followed by insects (42.3%; mainly terrestrial coleopterans), fish (21.2%), crustaceans (mainly *Aegla abtao riolimayana* and *Samastacus spinifrons*) (13.7%) and the gastropod (*Pseudosuccinela columella*) (2%) (Fig. 2). As a proportion of the total numbers of prey recorded in the pellets of Kelp Gulls, insects were the most abundant (62.1%, mostly terrestrial coleopterans), followed by human organic refuse (21.3%) and fish (6.5%) (Fig. 3). Most fish in the samples were not identified to species; those that could be identified were Inanga (*Galaxias maculatus*), perch (*Percichtys* sp.) and unidentified salmonids. Although most of the remains of fish could not be accurately measured, the size range of hard remains suggests that some would have only been available to Gulls through human fishing activity. Of interest, we identified the jaw of an individual chiropteran bat.

Of the 241 pellets collected, 237 were positively assigned to 38 of the 46 nests sampled in the colony. Human refuse was present in pellets from 37 of the 38 nests (97.3%); insects were recorded from 81.5% of nests, fish 63%, crustaceans 53.6% and young chicks of other species 23.6%.

Changes in the diet through the breeding season

Human refuse was the most frequently occurring item through the study period, followed by insects, fish and crustaceans (Fig. 2). Insects (mainly coleopterans) were the most numerous alimentary item through the study, followed by human refuse, fish and crustaceans (Fig. 3). The consumption of insects increased towards the end of the breeding season and human refuse decreased (Fig. 3).

The proportion of prey items found in the pellets varied between the stages of breeding ($\chi^2 = 0.82$, d.f. = 3, $P = 0.0015$). Unfortunately, testing the interaction between factors was not possible, owing to overparameterisation (i.e. having more parameters than can be estimated from the data) and small sample sizes. The variance explained by the model was 97.16%. During laying and hatching the proportion of prey items found in pellets was similar ($t = 8.3$, $P = 0.35$), but differed from those observed during early ($t = 3.1$, $P = 0.004$) and late chick-rearing stages ($t = 2.44$, $P = 0.02$). During laying and hatching, Kelp Gulls ingested a greater proportion of insects, whereas during chick-rearing (both early and late), they reduced the intake of insects and increased the intake of refuse (Fig. 3).

Counts of Kelp Gulls

Kelp Gulls were present at the rubbish tip in 17 of the 18 counts (94.4%; Fig. 4), with an overall mean of 21.4 individuals per census (s.d. 21.3, range 0–88). Most birds were adults (mean 20.3 individuals, s.d. 20.8, range 0–84), with the rest juveniles and subadults (1.1 individuals, s.d. 1.25, range 0–4). Although the

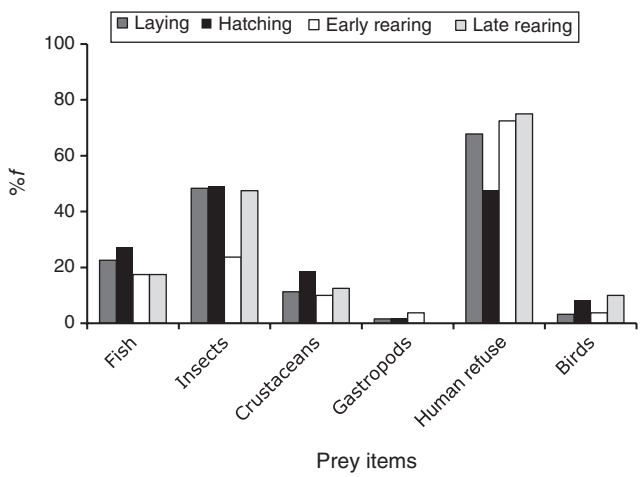

Fig. 2. Changes in the frequency of occurrence (%*f*) of food items in pellets of Kelp Gulls collected at a breeding colony in the De La Guardia Islands during November and December 2008.

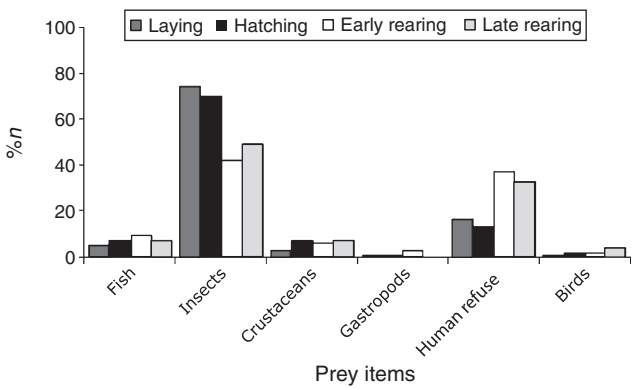

Fig. 3. Changes in the percentage number (%*n*) of food items in pellets of Kelp Gulls collected at a breeding colony in the De La Guardia Islands during November and December 2008.

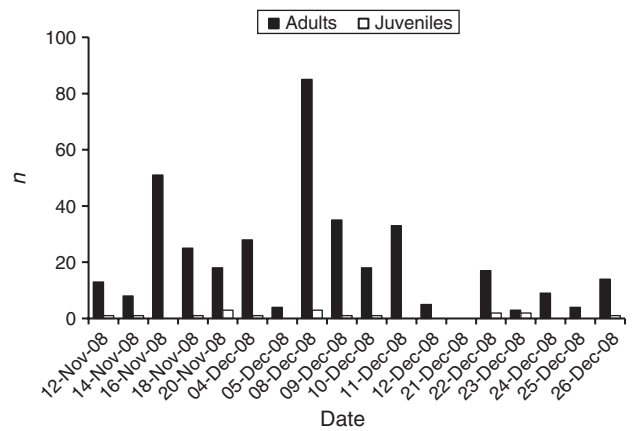

Fig. 4. Numbers (*n*) of Kelp Gulls observed at the urban rubbish tip of the town of Villa la Angostura during November and December 2008.

numbers of Gulls varied between 0 and 88, with peaks of >50 on two occasions, there was no overall significant variation in the abundance of Gulls through the season ($\chi^2 = 23.352$, d.f. = 1, $P = 0.3015$, $\varphi = 21.88$, S.E. = 0.015).

Discussion

In terms of the percentage number of total prey items, insects were the most numerous item in the diet, although the importance of hard-bodied prey items such as insects could be overestimated as they are readily detected in pellets. In terms of percentage frequency of occurrence in pellets, human refuse was the most frequently recorded item throughout the breeding season. Nevertheless, the importance of human refuse was likely to have been underestimated because soft items, such as fat, animal viscera and the like, are usually not detected in pellets. The limitations of pellet analysis as a method for determining diet (Barrett *et al*. 2007) might explain the high relative abundance of small taxa of low biomass found in this study; and it is likely that human refuse is much more important in the composition of biomass in the diet than shown in this study.

Our results differ markedly from those obtained in Patagonia (Yorio and Bertellotti 2002; Bertellotti *et al*. 2003), Buenos Aires and Antarctica (Silva *et al*. 2000, 2001; Silva 2006) where marine invertebrates and fish were the most frequently occurring prey items. However, as with this present study, Petracci *et al*. (2004) reported human refuse as an important component of the diet of Kelp Gulls in Buenos Aires. The trophic spectrum in the De La Guardia Islands is reduced compared with those reported for marine environments (Yorio and Bertellotti 2002; Bertellotti *et al*. 2003; Petracci *et al*. 2004; Silva 2006), which might reflect differences in the availability of food. This would be consistent with the feeding plasticity of this opportunistic and generalist species. Although we would expect aquatic prey to predominate in the diet of a gull, we found that most of the insects in the pellets were terrestrial coleopterans, which shows that the birds were foraging in a terrestrial environment, and ingestion of such species may have been associated with the rubbish tip. Interestingly, this is the first study reporting the presence of a bat (order Chiroptera) in the diet of Kelp Gulls. The presence of other vertebrates in pellets, such as young chicks, highlights the negative effect Kelp Gulls can have on other birds in terms of predation on eggs or chicks, as well as competition for food and kleptoparasitism (Quintana and Yorio 1998; Bertellotti and Yorio 1999; Silva 2006; Sanz-Aguilar *et al*. 2009; Ramos *et al*. 2009).

The contribution of human refuse and insects to the diet varied throughout the breeding season. Several studies have reported an increase of small prey in the diet of several species of gulls soon after chicks hatch (Annett and Pierotti 1989; Pierotti and Annett 1991; Smith and Carlile 1993; Ramos *et al*. 2009), as well as a decrease in the contribution of refuse and decomposed items in the diet of Kelp Gulls of coastal Patagonia at the same point in the breeding period (Annett and Pierotti 1989; Bertellotti and Yorio 1999). Annett and Pierotti (1989) suggested that this pattern is related to the fact that such small prey are more easily handled and swallowed by recently hatched chicks than larger prey, as we found in the NHL colony where abundance of insects in the diet was higher during laying and hatching and then decreased during the rearing stages (Fig. 3).

The presence of Kelp Gulls foraging in the urban rubbish tip is consistent with the diet reported from pellets. The colony of the De La Guardia Islands has established close to the urban rubbish tip of the town of Villa la Angostura (~1.5 km between the colony and the tip). This rubbish tip uses an 'open dump' processing method, leaving large quantities of organic refuse permanently available for Gulls, and thus supporting the establishment and maintenance of this colony. Such dumps are usually present and intensively used where populations of Gulls are expanding (Smith and Carlile 1993; Coulson and Coulson 1998; Bertellotti *et al*. 2001; Whittington *et al*. 2006). As seen with the Silver Gull (*Larus novaehollandiae*) in Australia, the availability of a non-natural food can improve breeding performance of individuals by increasing mass and body condition (Auman *et al*. 2008). In consequence, population dynamics could be changed by improving adult and chick survival. The nearest neighbouring colony in the area is an older colony 40 km south in the NHL ($n = 350$ nests, J. P. Alarcón, pers. comm.) and close to the city of San Carlos de Bariloche. We suggest that future research should examine the flux of individuals between the two colonies as well as the relationship between the colonies and the urban rubbish tips.

As shown by the composition of the diet of the Kelp Gulls and their frequent use of the waste tip in this study, the abundance and predictability of human refuse plays an important role in providing food for this colony. In light of this, we suggest it is necessary to reformulate the treatment of human refuse at the localities surrounding the NHL to minimise the effects of refuse on the fitness and breeding success of Gulls and the subsequent effects on other components of this protected area.

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