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Diet of the Southern Caracara in a near-shore insular system in southern Patagonia, Argentina

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ABSTRACT

The Southern Caracara (*Caracara plancus*) diet is little known in continental areas, but nothing is known about its diet in insular areas. We reported the food habits of Southern Caracaras in four near-shore islands located in Chubut province, southern Argentina. Between March 2013 and February 2017 we collected pellets (N = 306) on three islands (Leones, Tova and Galfrascoli) and disaggregated food remains (N = 146) on one island (Tovita). We measured the importance level of each food item by calculating the percentage of total food item (%TP) and percentage of occurrences (%OC). Southern caracaras consumed a variety of animal food including vertebrates and invertebrates. The most frequent food items in the pellets were the Magellanic penguin (*Spheniscus magellanicus*) and insects, whose importance level showed some variation among islands (penguins: %TP = 26.1–38.5%, OC = 83.7–95.3; insects: TP = 1.3–25.9, OC = 2.9–76.1). In the pellets collected in Tova island, we also found a great proportion of South American sea lion (*Otaria flavescens*; %TP = 22.9, %OC = 50.7). In the food remains, the most frequent animal food items were the Magellanic penguin (%TP = 28.8) and European rabbit (*Oryctolagus cuniculus*) (%TP = 44.7). Apparently, the large-sized animals (penguins, sea lions and adult rabbits) were taken as carrion. Because all these animal species are common on islands, we think that caracaras taken them opportunistically. In agreement with previous studies, our results show that the Southern Caracara on islands is also an opportunistic, scavenger and insect-eating species.

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1. Introduction

The Southern Caracara (*Caracara plancus*) is a common and widespread raptor species in South America inhabiting a variety of habitats such as steppes and prairies with trees, agricultural lands, open forests, marshes and marine coasts (White et al., 1994, Narosky and Yzurieta, 2010). The Southern Caracara is described as an opportunistic predator and facultative scavenger (Bó et al., 2007). According to published information, it consumes a wide variety of animal food including small mammals, lagomorphs, birds, reptiles, arthropods and carrion (Whitacre et al.,

1982; Rodríguez-Estrella and Rivera-Rodríguez, 1997; Travaini et al., 1998, 2001; Vargas et al., 2007; Figueroa and Corales, 2015). Southern Caracaras also practice the piracy by stealing eggs from other birds' nests and preys captured by other avian predators. However, Bó et al. (2007) included it into the insect-eating guild due to insects were the main prey consumed by Caracaras. Diet composition of Southern Caracara also appears to depend on the age of individuals, season and habitat characteristics (e.g., Engh et al., 1997; Travaini et al., 1998; Lambertucci et al., 2009a).

In Argentina, in particular, quantitative data about the diet of the Southern Caracara are scarce and restricted to the central region of the country (Vargas et al., 2007; Idoeta and Roesler, 2012) and northwestern area of Patagonia (Travaini et al., 2001). Here, we quantitatively described the Southern Caracara's diet on near shore islands. Our objectives were (i) to determine the importance level of each consumed food item, (ii) to evaluate the differences in diet among caracaras inhabiting different islands and (iii) to compare the diet composition among insular and continental caracaras.

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2. Material and method

We studied the diet of the Southern Caracara in four islands located north of San Jorge Gulf, Chubut province, southern Argentina (Fig. 1). This set of islands is within the Parque Interjurisdiccional Marino Costero Patagonia Austral (132,124 ha, Fig. 1). This marine protected area is characterized by the presence of multiples islands, sheltered bays, inlets with shallow water and a coastline with sandy and rocky/gravel bottom intertidal zones (Yorio, 2001; Crespo, 2014). The islands sampled varied in size and distance from the mainland. Leones island covers an area of 414.7 ha and is located at a distance less than 1 km from the mainland. It is characterized by the presence of large colonies of sea-birds, especially Magellanic Penguins (*Spheniscus magellanicus*) as well as colonies of gulls (*Larus* spp.), cormorants (*Phalacrocorax* spp.), and seagulls (*Sterna* spp. and *Thalasseus* spp.). Tova and Tovita islands are located at a distance of ~6 km from the mainland and cover an area of 549.8 ha and 152.8 ha, respectively. Most of the area of both islands is occupied by nests of Magellanic Penguins. Galfrascoli island, which covers an area of 20.3 ha, is located at ~1 km from the mainland and is connected with it during low tide (Fig. 1).

The islands and part of the mainland coast are composed mainly of volcanic rock covered by an accumulation of pyroclastic conglomerates, sand, silt, and shell fragments from the coast as well as from the sea-bottom (Lema et al., 2001). Climate is temperate and semi-arid, with an average annual temperature of 13 °C, an average annual precipitation rate of 200 mm, and strong winds from the west.

We determined the diet of Southern Caracara on the basis of pellets and food remains collected between March 2013 and February 2017 under communal roost and perches. We collected pellets in Leones, Tova, and Galfrascoli islands, and food remains in Tovita island. We collected the samples from each island only on one date, excepting Tova island where we collected the material on two dates (Table 1). In the case of Tovita island, we only found food remains. We think that these remains were generated by an accumulation of unconsumed parts of animals more than disintegrated pellets since the size of some bone structures (mainly skulls) were too big to be swallowed whole and later regurgitated. In the laboratory, pellets were disaggregated by

hand and one by one by using hot water. The content was carefully extracted and separated according to the food type [e.g., feathers, hairs, chitin pieces (such as, elytra, mandibles and feet), bones, skulls, mandibles]. The use of hot water allows disaggregating pellets more easily than using cold water. Furthermore, when pellets contained abundant feathers or hair, we dissolved the organic material in a sodium hydroxide solution (5% concentration) to recover any small bone fragment which could have been left into the remaining material during hand picking (Marti et al., 2007). Food items were identified to the lowest taxonomic level by comparing anatomical pieces found in pellets and food remains with references collection housed at Instituto Patagónico para el Estudio de los Ecosistemas Continentales (IPEEC) – CCT CONICET – CENPAT (Puerto Madryn, Chubut, Argentina), and on the basis of our own knowledge.

Because many pellets contained only feather or hair remains, we were unable to estimate the minimum number of consumed individuals per sample, and thereby, we could not estimate the consumed biomass nor the food-niche metrics (Travaini et al., 2001; Marti et al., 2007; Lambertucci et al., 2009b). For these reasons, we expressed results as percentage of occurrence (%OC) and percentage of total food items (%TP).

The percentage of occurrence express the number of times a food item occurs in relation to the total number of pellets and we calculated it as follows: $\%OC = nf/N * 100$, where n is the number of pellets with food item f and N is the total number of pellets. The percentage of total food item express the number of times each food item is encountered in relation to the overall number of items in all pellets and we calculated it as follows: $\%TP = \text{number of times a food item occurred} / \text{total number of food items} * 100$ (Marti et al., 2007).

Complementarily, we evaluated the diet variation among Southern caracara inhabiting different islands by performing a Correspondence Analysis (Legendre and Legendre, 1998). This multivariate statistical technique permits to detect ecological association among sampling sites by ordering of elements in common in two-dimensional graphical form. Following Borcard et al. (2011), we entered the frequency data without pre-transformation. The analysis was performed by using R version 3.3.3 (R Core Team, 2017) and FactoMineR package (Lê et al., 2008).

3. Results

The Southern Caracara in the studied islands consumed a wide variety of animal food. We identified a total of 958 food item in 306 pellets from Leones, Galfrascoli, and Tova islands and among food item remains from Tovita island (Table 1). The food items found belonged to three classes of vertebrates and to six classes of invertebrates.

In the three islands where we studied the diet on the basis of pellets, the most frequent food item was birds, and among these, the Magellanic Penguin. In this regard, it is noteworthy that the importance level of avian food item in general, and penguins, in particular, (both by %TP and %OC) were very similar among the islands. Even though eggs occurred in a low frequency, our results show that Southern Caracara predated on bird eggs as well. In terms of food item importance, birds were followed by insects, particularly in Leones and Galfrascoli islands (Table 1). While in Tova island and 2014 year (Table 1) mammals followed birds in order of importance. Other food items, such as fish, mollusks, scorpions and crabs were also found in the diet but with a low frequency of occurrence (Table 1).

In Tovita island, mammals constituted almost the half of all food items found in food remains being the European rabbit (*Oryctolagus cuniculus*) the most consumed species (Table 1). Pen-

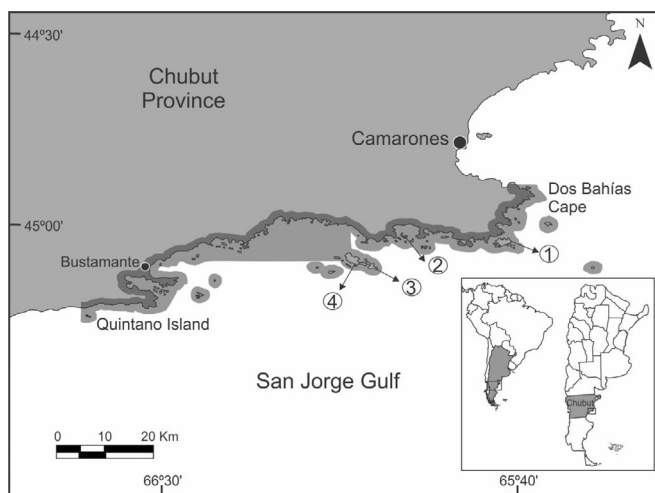


Fig. 1. Location of islands where the diet of the Southern Caracara was studied. The dark gray area indicates the limits of the Parque Interjurisdiccional Marino Costero Patagonia Austral, and numbers within a circle indicate the islands: 1) Leones, 2) Galfrascoli, 3) Tovita, and 4) Tova. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1

Diet of the Southern Caracara (*Caracara plancus*) in a nearshore insular system of southern Patagonia, Argentina. %TP = percentage of total food item, %CO = percentage of occurrences (in some cases, this percentage could sum more than 100%, due to it was calculated on total number of pellets and one pellet may content more than one food item).

	LEONES		GALFRASCOLI		TOVA 2014		TOVA 2016		TOVITA
	% TP	%OC	% TP	%OC	% TP	%OC	% TP	%OC	% TP
Birds	31.20	91.3	39.15	118.6	41.21	91.04	43.77	95.33	47.95
<i>Haematopus</i> sp.			0.72						
<i>Larus</i> sp.			0.72						9.59
<i>Macronectes</i> sp.									1.37
<i>Phalacrocorax</i> sp.									2.05
<i>Podiceps major</i>			0.72						3.42
<i>Spheniscus magellanicus</i>	28.90	84.78	26.12	83.72	38.51	85.07	36.61	95.33	28.77
<i>Sterna</i> sp.									1.37
<i>Tachyeres</i> sp.									1.37
Unidentified birds			8.70	27.90	2.70	5.97	5.11	13.37	
Eggshells	2.30	6.52	2.17	6.98			2.05	5.33	
Mammals	5.93	17.39	5.06	13.95	23.65	52.24	8.70	22.67	49.32
<i>Eligmodontia</i> sp.			0.72						
<i>Eubalaena australis</i>							1.02	2.67	0.68
<i>Microcavia australis</i>									
<i>Oryctolagus cuniculus</i>					0.68	1.49	0.77	2.00	44.52
<i>Otaria flavescens</i>	5.93	17.39	3.62	11.63	22.97	50.75	6.91	18.00	0.68
<i>Zaedyus pichi</i>									3.42
Unidentified mammals			0.72	2.33					
Unidentified birds or mammals	9.70	28.26	14.49	44.19	27.03	59.70	32.97	86.00	
Fishes			3.62	11.63			0.77	2.00	1.37
Molluscs	7.43	21.74	5.80	16.28	0.68	1.49	1.02	2.67	
Class Bivalvia	5.94	17.39	5.80	16.28	0.68	1.49	0.51	1.33	
Class Gastropoda	0.75	2.17							
Class Cephalopoda/Order Octopoda	0.74	2.17					0.51	1.33	
Arthropods	28.92	84.78	20.29	62.79	2.03	4.48	5.12	13.33	1.37
Class Insecta	25.94	76.09	19.57	60.47	1.35	2.99	3.84	10.00	
Class Arachnida/Order Scorpiones	0.75	2.17	0.72	2.33					
Class Malacostraca	2.23	6.52			0.68	1.49	1.28	3.33	1.37
Other remains	16.82	47.83	11.59	37.21	5.41	11.94	7.66	20.01	
Inorganic material	9.40	26.09	7.25	23.26	5.41	11.94	4.35	11.34	
Vegetal material	7.42	21.74	2.17	6.98			2.54	6.67	
Unidentified remains			2.17	6.98			0.77	2.00	
Pellets	46		43		67		150		–
Food items	135		138		148		391		146
Date	3 March 2013		6 February 2017		March 2014		18 January 2016		14 January 2016

guins were also an important food item (Table 1) and its importance level was similar to than found in pellets from the other island. Comparing with the findings from pellets, the importance of %TP of penguins in Tovita island was similar to the rest of the islands while the importance of other food items was very low (Table 1).

In the Correspondence Analysis, the two main axes accounted for 83.3% of the variance (Fig. 2). Axis I accounted for 61.4% of variance and separated the vertebrate species into two groups: the majority of birds and rabbits located in the positive area of the diagram whereas penguins and sea lions located in the negative area of the diagram. Axis II accounted for 21.9% of variance and located the most invertebrates in the positive region. Tovita was the most distant island from the origin in the Correspondence Analysis map being located in the positive region of axis I and II. Possibly, this could be reflecting a potential bias due that collected material in the island was food remains and not pellets. The Galfrascoli and Leones islands were located in the negative region of the axis I and the positive area of axis II, being very close to each other. Finally, the two samples collected from Tova island were located the negative region of both axes, being relative close to each other. It is interesting to note that all island labels are close to the origin of the Correspondence Analysis plot, reflecting so similarity regarding the food items consumed by caracaras (Fig. 2).

4. Discussion

In agreement with findings from previous studies (Travaini et al., 2001; Bó et al., 2007; Vargas et al., 2007), our study shows that the Southern Caracara is an opportunistic, scavenger and insect eater species.

The high proportion of Magellanic penguins, European rabbits, and South American sea lions in the pellets and food remains of Southern Caracara in our study area suggest that this raptor species strongly bases its diet on these animal species. We presumed that caracaras consumed these three animal species as carrion, particularly the South American sea lion, which is a large-sized species (170 kg for females and 300–350 kg for males, Cardenas-Alayza, 2018). In the case of penguins and rabbits, previous studies show that Southern Caracara consumed them mainly as carrion (Travaini et al., 2001; Vargas et al., 2007; Figueroa and Corales, 2015). In fact, the presence of large stable colonies of penguins and sea lions in the studied islands make carrion a permanently available food resource to caracaras. However, it is possible that a few juvenile individuals of penguins and rabbits were taken by caracaras as live prey (Rodríguez-Estrella and Rivera-Rodríguez, 1997; Travaini et al., 2001; Vargas et al., 2007; Idoeta and Roesler, 2012) and probably as an occasional event.

We must highlight that the Southern Caracara is the prime scavenger species on the islands studied. Other potential scavenger

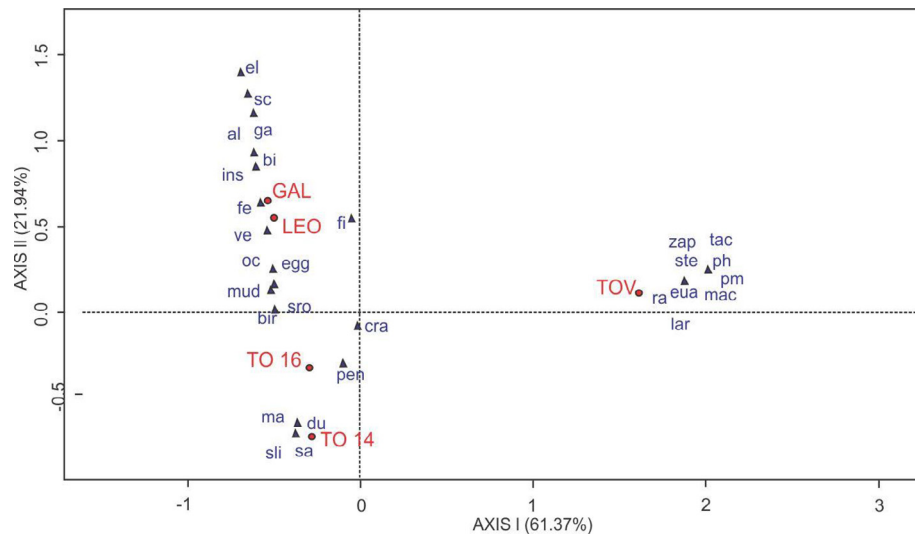


Fig. 2. Association between food item consumed by Southern Caracaras and near-shore islands in Argentine Patagonia as evaluated by a Correspondence Analysis. Capital letters indicate islands, **LEO**: Leones, **GAL**: Galfrascoli, **TOV**: Tovita, **TO 14**: Tova sample of the year 2014, and **TO 16**: Tova sample of the year 2016. Food items are indicated in lowercase letters, **al**: algae, **ga**: gastropoda, **el**: *Eligmodontia* sp., **sc**: scorpions, **bi**: bivalve, **ins**: insecta, **ve**: vegetation, **fi**: fish, **oc**: octopus, **fe**: feathers, **mud**: mud, **sro**: small rocks, **egg**: egg shell, **bir**: birds, **cra**: crabs, **pen**: penguins, **sli**: sea lion, **sa**: sand, **ma**: *Microcavia australis*, **du**: dung, **ra**: rabbits, **zap**: *Zaedyus pichiy*, **pm**: *Podiceps major*, **ph**: *Phalacrocorax* sp., **tac**: *Tachyeres* sp., **eua**: *Eubalaena australis*, **mac**: *Macroneustes* sp., **ste**: *Sterna* sp., **lar**: *Larus* sp.

species are the Black Rat (*Rattus norvegicus*) and Large-hairy Armadillo (*Chaetophractus villosus*), but they occur in Leones island (Udrizar Sauthier et al., 2017). In this way, the caracaras can play a particular functional role in our study site by cleaning the islands of dead animals.

The apparent high consumption of rabbits by caracaras in Tovita island is consistent with their local availability. The European rabbit is an allochthonous species whose populations are still in expansion in Argentina, causing several alterations in the environments, damaging crops and facilities, altering native biodiversity, competing with native species and changing soil properties, among others (Bonino and Soriguer, 2004; Guichón et al., 2016). During the 20th-century algae collectors and fishermen introduced this species in Tova and Tovita islands, and now it is a common species in the latter. In Tovita island, European rabbits are one of the main food resources of Southern Caracara consuming them mostly as carrion, and probably capturing some juvenile individuals as well. The absence of rabbit remains in the pellets collected in Leones and Galfrascoli islands is explainable due to this species is not present on these islands (Udrizar Sauthier et al., 2017; S. Alderete, unpublished data).

In two of the islands, Leones and Galfrascoli, we found a high occurrence of insects in the pellets. Usually, Southern Caracara forages opportunistically on the food resources available in the environment. Thus, they possibly took advantage of the high abundance of insects in those islands. It is also possible that Southern Caracara had compensated the absence of rabbits consuming much more insects. The low proportion of insects in the pellets collected in Tova Island and food item remains from Tovita Island is intriguing because the insect availability in the field was similarly high among all the islands (Cheli et al., 2016). It is possible the absence of insects in food remains may be an artifact of this type of food sample. Generally, diet analysis based on food remains (~ prey remains) tend to overestimate the representation of the large animal items and to underestimate the small animal items (e.g., Simmons et al., 1991; Oro and Tella, 1995; Redpath et al., 2001). For this reason, we could not discard a higher consumption of insects by Southern caracaras on this island.

In agreement with previous studies elsewhere, the insects appear to constitute one of the most frequent food items in the diet

of Southern Caracara in the islands we visited. For example, Zotta (1940) reported a high proportion of insects in the stomach content of Southern Caracara collected in Bragado, Buenos Aires province, although this author did not explain how he precisely estimated the percentage of insects. Engh et al. (1997) reported a high insects consumption by Southern Caracara in Chilean Patagonia (frequency of occurrence = 57%). Travaini et al. (2001) found that insects constituted almost the half of consumed animal food in Argentine Patagonia. Vargas et al. (2007) documented a high frequency of insects in the Southern Caracara pellets (almost 70% of all prey items) in Mar Chiquita Biosphere reserve, Argentina.

According to Travaini et al. (2001), the juvenile caracaras appear to make a higher consumption of insects than adult caracaras. Generally, adult individuals displace immature individuals from their breeding territories, limiting access to more profitable food resource such as vertebrates, and therefore forcing them to feed on small-sized animals such as insects. Unfortunately, we were unable to distinguish the pellets/food remains from adults and juvenile individuals, and therefore we could not know if consumption of insects on islands visited is related to age class. However, we think that the high consumption of insects on islands could be related to the fact that we collected the pellets during the summer when insects are more abundant. It is also possible that caracaras had taken a fraction of insects while eating carrion (Vargas et al., 2007).

An interesting finding of our study is that diet composition of Southern Caracara tended to be similar among islands where we collected pellets. Even though we did not evaluate the availability of food resources, most consumed animal species by the caracaras are common in almost all the islands. Our study provides a first description of the diet of Southern Caracara in a near-shore islands system in southern Patagonia, and it contributes to a better understanding of how caracaras use available food sources. Further studies are needed to elucidate to what extent Southern Caracara consume animals as carrion or as live prey, and if they take food resources according to the field abundance or selectively.

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Declarations of interest

None.

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