

Winter diet of striated caracara *Phalacrocorax australis* (Aves, Polyborinae) at a farm settlement on the Falkland Islands

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Abstract Striated caracaras occur only on the Falkland Islands and the outer islands of southern Chile and Argentina. In summer, the species associates with seabirds and seals and depends heavily upon them for food. The winter diet is less well understood. We studied the diet of 90–130 mainly juvenile and sub-adult striated caracaras overwintering at a farm on Saunders Island, Falkland Islands, in mid-winter (July–August) 2011. Direct observations of feeding and regurgitation pellets collected at a roost indicate that the winter diet of the striated caracaras at the site is mainly native geese, beetles and other invertebrates, and the carcasses of domestic sheep. This study illustrates seasonal shifts in the diet of this near-threatened South Atlantic endemic and suggests an important nutritional link between juvenile and subadult caracara survival in winter and traditional human activities at sheep farms.

Keywords Caracaras · Regurgitation pellets · Food stress · Marine subsidy · Human subsidy · Falkland Islands

Introduction

The sub-Antarctic ecosystems of the Falkland Islands and Fuegian Islands of southernmost Chile and Argentina have more diverse scavenging bird communities than islands closer to the Antarctic Polar Front (Woods and Woods

1997; Shirihai and Jarrett 2012). Five species of scavenging Falconiformes that are not found farther south (Ferguson-Lees and Christie 2001) occur in Tierra del Fuego and the Falkland Islands, including the regionally endemic and globally near-threatened striated caracara *Phalacrocorax australis* (BirdLife International 2011).

The striated caracara is a relatively large, stocky, and inquisitive scavenging bird of prey that breeds in association with seabird colonies, where it feeds upon eggs, chicks, and both dead and dying marine birds (Strange 1996; Ferguson-Lees and Christie 2001; Marin et al. 2006). An opportunistic predator, kleptoparasite, and social scavenger, caracaras sometimes attack nestling and fully grown seabirds and land birds (Strange 1996; Ferguson-Lees and Christie 2001; Quillfeldt et al. 2007; Catry et al. 2008). They also displace and take food being fed upon by turkey vultures *Cathartes aura* (Strange 1996; Catry et al. 2008), variable hawks *Buteo polyosoma* (Bildstein, pers. observation), and subantarctic skuas *Stercorarius antarcticus* (Catry et al. 2008) and also feed upon the placentas, faeces, and carrion of seals (Catry et al. 2008).

The world population of striated caracaras is estimated at between 1,000 and 2,500 adults (BirdLife International 2011). The species has been little studied outside of the austral-summer breeding season (cf. Strange 1996; Catry et al. 2008). Most of the world population is thought to occur on the Falklands (BirdLife International 2011), where breeding occurs on islands off the coasts of East and West Falkland (Woods and Woods 1997; Woods 2007). In winter, many juveniles and sub-adults evacuate feeding sites near largely inactive seabird colonies and travel to farm settlements (Strange 1996; Woods 2007), where they secure food associated with human activity at a time when little food is available in more natural landscapes.

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Striated caracaras appear to have been more common on the Falklands (Barnard 1836; Darwin 1845; Strange 1996; Woods 2007) before human persecution in the nineteenth and twentieth centuries (Strange 1996; Woods and Woods 1997; Woods 2007). The population is believed to have been stable since the 1980s (Woods 2007), although numbers have increased on New Island, which became a private nature reserve in 1972–1973 (Catry et al. 2008). Recent estimates of breeding success suggest that caracaras should be increasing throughout the Falklands (Strange 1996; Woods and Woods 1997), when in fact they are not (Woods 2007). Why they are not doing so remains unclear. Several authors have suggested that the species, and in particular juveniles and sub-adults, may be nutritionally hard-pressed in winter since many of the seabirds they feed upon winter at sea (Strange 1996; Woods 2007).

Striated caracaras occur on the main and settled islands of the Falklands, as well as on the more remote and largely unpopulated islands there. The extent to which the presence of people and domesticated animals affects the availability of food items for this species, especially in winter, presents an interesting ecological non-native aberration as well as an opportunity to understand how striated caracaras survive the winter season when seabirds, seals, and sea lions are not breeding. This is particularly so on the Falklands where conflict exists or has existed with sheep farmers who believe that striated caracaras prey on healthy lambs and adult sheep (Woods 2007).

Striated caracaras generally have been studied on islands where domestic stocks are not found and where people live only during specific and short periods of the year. We set out to study the general biology of the species on an island with both breeding seabirds, seals, and sea lions and a sheep farm with permanently residing farmers. This on-going study, which began in late 2010, aims to understand the movement and feeding ecology of the species in such circumstances as well as to determine the fitness consequences of variations in individual behaviour. The study involves capture and colour marking of individual caracaras, detailed observations of their behaviour, including their movements, and the collection of regurgitation pellets.

As is true of many diurnal birds of prey (Marti et al. 2007) and seabirds (Duffy and Jackson 1986), striated caracaras regurgitate mucous-covered pellets of the less digestible remains of their food. Pellets typically are regurgitated around dawn at or near the birds' evening roosts (Houston and Duke 2007). Although quantitative analyses of pellets can underestimate dietary input from large carcasses, faecal materials, or organisms that lack hard body parts (Duffy and Jackson 1986; Marti et al. 2007), pellet examination is useful for assessing dietary breadth (cf. Fisher 1893; Carss et al. 1997; Barrett et al. 2007; Marti et al. 2007; Malzof and Quintana 2008).

This short note provides the first account of the winter diet of the species. Conclusions are provided, together with some of the as yet unpublished data from the other aspects of the research programme, to support several of the hypotheses presented.

Materials and methods

Study site and fauna

Saunders Island (51.37°S 60.09°W) is a 12,500-ha-sized island off the north coast of West Falkland Island. It is home to four species of penguins, king *Aptenodytes patagonicus*, gentoo *Pygoscelis papua*, rockhopper *Eudyptes chrysocome*, and magellanic *Spheniscus magellanicus*; two species of shags, rock *Phalacrocorax magellanicus* and imperial *P. atriceps*; and several colonies of black-browed albatrosses *Thalassarche melanophrys*. Upland *Chloephaga picta* and ruddy-headed geese *C. rubidiceps* occur on the island, particularly at and near the settlement study area. Southern sea lions *Otaria flavescens* and southern elephant seals *Mirounga leonina* breed on the island (Summers 2005). In addition to a wintering population of striated caracaras that is estimated at 90–130 based on resightings of colour-banded birds, smaller numbers of scavenging turkey vultures and mainly predatory variable hawks, southern crested caracaras *Caracara plancus*, and peregrine falcons *Falco peregrinus* also occur on the island.

Saunders Island is operated as a livestock farm by Suzan and David Pole-Evans and four to six co-workers. Livestock in 2010–2011 included 6,500 sheep, 300 dairy and beef cattle, 70 goats, 30 horses, 170 chickens, 90 domestic ducks and geese, and 20 working dogs. Most of the island is hilly and undulating plain covered with dry heath (Summers 2005).

Observation efforts

We observed caracaras for approximately 6–8 h daily on 23 days between 18 July and 12 August 2011. Observations occurred at and near the farm settlement and the adjacent beach at Sealer Cove. We established a 2.7-km-long loop trail that meandered through and around the settlement and beach that we walked several times daily while looking for caracaras and observing their feeding behaviour. We also made daily observations of caracaras feeding on upland geese being fed to a resident pig, as well as the caracaras that fed on three upland geese that we offered to them. During our observations, we noted what the birds were feeding upon, whether or not they left food uneaten, and whether or not they attempted to displace or

did displace other caracaras feeding with them. We also searched for recent carcasses of livestock and geese at and around the settlement and noted whether caracaras fed upon them.

In August 2012, one of us (KLB) visited Carcass Island, 13 km east of Saunders Island where we observed caracaras feeding at a farm settlement for 8 h across three days.

Diet analysis

We collected 67 regurgitation pellets between 6 and 8 August on a tidally inundated rock platform at the base of a 10- to 25-m communal cliff roost site overlooking Sealer Cove, 1.5 km north of the centre of the settlement. Based on five evening roost entry and six morning roost departure counts of caracaras between 6 and 12 August, we estimated that the roost was used by approximately 65 striated caracaras each evening, most of which were juveniles or sub-adults (i.e. 1–4 years old) (cf. Strange 1996). At least six adults also used the roost. To ensure that pellets represented the winter diet of striated caracaras, we only collected and analysed “fresh” pellets (i.e. largely entire and still moist). Bleached and desiccated pellets were excluded from the sample, as were partly decomposed and disintegrating pellets. The rock platforms where we collected pellets were scoured by spring tides, further reducing the likelihood of our including older pellets in the sample. Although turkey vultures, variable hawks, and southern caracaras also regurgitate pellets, none of these birds was seen roosting at the roost site. This, together with the fact that raptors typically regurgitate pellets at dawn before leaving their evening roost (Houston and Duke 2007), leads us to conclude that the regurgitation pellets we collected came from striated caracaras.

Pellets were dried thoroughly for 48 h, and then microwaved for 20 s to reduce the likelihood of bacterial decomposition. The length and width of each pellet were determined to the nearest mm. Pellets were wrapped in tissue paper and stored in cardboard boxes in a dry room until their contents were dissected and identified. Each pellet was opened by hand and its contents separated under a dissecting microscope. Vegetation, the remains of terrestrial and marine invertebrates, birds, mammals, and fishes (including scales, chitinous parts, bird feathers, and mammalian hair), were identified to species when possible (cf. Marti et al. 2007) using a small reference collection, the Falklands Conservation herbarium and other resources (Strange 1992; Broughton et al. 2000; Wilson and McAdam 2000; Jones 2004; Liddle 2007; Häussermann and Försterra 2009; Neely and Brickle 2011). We also noted the occurrence of soil, peat lumps, and human refuse, along with the presence of sand (<2 mm), grit (2–5 mm), and small stones or pebbles (5–15 mm).

Results are expressed as the frequency of occurrence, calculated as % occurrence = $n_f/N \times 100$, where n_f is the number of pellets with food item f and N is the total number of pellets.

Results and discussion

Based on individually marked birds, we estimated that 90–130 different striated caracaras fed at the settlement during the course of our observations. Caracaras typically fed in groups or “gangs” (sensu Catry et al. 2008) of 2–15 or more birds (Fig. 1). Individuals fed feverishly and competitively, taking numerous small bits of food from both small and large food items. Most caracaras were juvenile and sub-adult individuals, and most appeared ravenous at carcasses, with individually marked birds routinely displacing other birds and subsequently being displaced by yet others. Behavioural observations of more than 50 striated caracaras at a farm settlement on Carcass Island during three days in August 2012 indicated similar ravenous and competitive feeding behaviour among individually marked birds there (K. L. Bildstein, unpubl. observations).

Whole pellets averaged 56 ± 2 mm (mean \pm SE) long and 23 ± 1 mm wide and were off-white to dark gray in colour. Most contained both plant and animal material (Table 1). Plants, including terrestrial (e.g. Ericaceae and Gramineae) and marine (Ulvaceae and Lessoniaceae) forms, may have been consumed accidentally when the birds were picking at and through animal material. That said behavioural observations indicated that caracaras routinely took dried *Empetrum rubrum* berries from bushes. Efforts by caracaras to scavenge washed up limpets and chitons were largely unsuccessful as birds usually were unable to open them.



Fig. 1 Striated caracaras waiting to feed on an upland goose being consumed by a variable hawk (Photo by Kalinka Rexer-Huber)

Table 1 Frequency of occurrence of prey in striated caracara pellets ($N = 67$) collected at a communal cliff roost site at the outskirts of the Saunders Island farm settlement in winter (early August) 2011

Class	Order	Family	Common name, <i>Species</i>	Occurrence (%)
Ulvophyceae	Ulvales	Ulvaceae	<i>Ulva</i> sp.	6
Phaeophyceae	Laminariales	Lessoniaceae	Tree kelp <i>Lessonia</i> sp.	3
			Unidentified algae	1.5
Lichens			Lichen	4.5
Ascomycota				
Mosses Bryophyta			Moss	14.9
Plants		Hard ferns Blechnaceae	<i>Blechnum</i>	4.5
		Grasses Gramineae	Unidentified grass	71.6
		Daisies Asteraceae	Christmas bush, <i>Baccharis</i>	13.4
		Daisies Asteraceae	Clubmoss cudweed, <i>Chevreulia</i>	1.5
		Daisies Asteraceae	Fachine, <i>Chilotrimum</i>	3
		Bedstraws Rubiaceae	Bead plant, <i>Nertera</i>	10.4
		Crowberries Ericaceae	Diddle-dee, <i>Empetrum</i>	76.1
		Crowberries Ericaceae	<i>Gaultheria</i>	9
		Fabaceae	Clover, <i>Trifolium</i>	1.5
		Giant rhubarbs Gunneraceae	Pig vine, <i>Gunnera</i>	22.4
		Myrtles Myrtaceae	Teaberry, <i>Myrteola</i>	3
			Unidentified seed	10.4
			Wood	1.5
Polyplacophora			Chiton	3
Bivalvia	Mytiloidea	Mytilidae	Mussel, <i>Mytilus</i> sp.	6
Bivalvia	Mytiloidea	Mytilidae	Mytilid pearl	6
Bivalvia	Veneroidea	Veneridae	Striped clam <i>Eurhomalea exalbida</i>	6
Gastropoda		Fissurellidae	<i>Fissurella</i> , sp.	7.5
Gastropoda		Trochidae	Trochid	7.5
Gastropoda	Neogastropoda	Muricidae	<i>Trophon</i> , sp.	6
Crustacea	Decapoda	Munididae	Lobster-krill, <i>Munida</i> sp.	4.5
Crustacea	Decapoda	Inachidae	Crab, <i>Eurypodius</i> sp.	1.5
Crustacea	Decapoda		Unidentified crab	1.5
Crustacea	Sandhoppers Amphipoda		Amphipod	1.5
Insecta	Coleoptera	Ground beetles Carabidae	<i>Lissopterus, quadrinotatus</i>	1.5
	Coleoptera	Ground beetles Carabidae	<i>Metius blanda</i>	9
	Coleoptera	Rove beetles Staphylinidae	<i>Crymus antarcticus</i>	11.9
	Coleoptera	Rove beetles Staphylinidae	<i>Quedius mesomelinus</i>	3
	Coleoptera	Darkling beetles Tenebrionidae	<i>Parahelops haversii</i>	4.5
	Coleoptera	Narrow-waisted beetles Salpingidae	<i>Poophylax falklandica</i>	1.5
	Coleoptera	Weevils Curculionidae	<i>Antarctobius falklandicus</i>	7.5
	Coleoptera	Weevils Curculionidae	<i>Antarctobius vulsus</i>	19.4
	Coleoptera	Weevils Curculionidae	<i>Malvinus compressiventris</i>	23.9
Arachnida			Mite	1.5
Fish	Perciformes	Nototheniidae	<i>Patagonotothen</i> sp.	1.5
Birds	Pelecaniformes	Phalacrocoracidae	Shag <i>Phalacrocorax</i> sp.	1.5
	Anseriformes	Anatidae	Upland goose, <i>Chloephaga picta</i>	52.2
	Anseriformes	Anatidae	Ruddy-headed goose, <i>Chloephaga rubidiceps</i>	47.8
			eggshell	1.5

Table 1 continued

Class	Order	Family	Common name, <i>Species</i>	Occurrence (%)
Mammals			Horse, <i>Equus</i> sp.	1.5
			Goat, <i>Capra</i> sp.	6
			Sheep, <i>Ovis</i> sp.	26.9
			Fat lumps, (most likely sheep)	3
(Inorganic)			Pebbles, 5–15 mm	40.3
			Sand <2 mm	19.4
			Soil	14.9
			Grit 2–5 mm	10.4
			Peat lumps	9
			Plastic	4.5

Remains of up to nine species of beetles (Coleoptera)—the most common of which were weevils (Curculionidae)—were identified in 49.3 % of the pellets. Non-insect invertebrates, including arachnids, snails, bivalves, chitons, and crustaceans, occurred in 40.3 % of the pellets. Fishes occurred in 1.5 % of all pellets; birds, especially remains of geese *Chloephaga* spp., occurred in 92.5 % of the pellets; remains of sheep and other livestock occurred in 34.3 % of the pellets. Sand, soil, grit, and lumps of peat occurred in 65.7 % of the pellets, and plastic in 4.5 % of the pellets. Plastics may have been consumed from settlement refuse and detrital wracks along the shoreline.

Caracaras approached and attempted to consume many types of food items. As such, they appear to be a classic “open program” species (*sensu* Mayr 1974). Such species, like the kea *Nestor notabilis* (Diamond and Bond 1999) and the northern raven *Corvus corax* (Heinrich 2007), leave their nests largely naive and initially show limited ability to distinguish edible from non-edible items, as well as benign from potentially dangerous organisms in their environments. In such species, juveniles spend a considerable part of their early lives experimenting with and testing their environments while determining, among other things, what is and what is not suitable food. Doing so in groups may limit the amount of food secured by an individual, but at the same time may quicken an individual’s learning curve.

Caracaras appeared food stressed, a characteristic of their winter condition that others have noted (Strange 1996; Woods 2007). Indeed, we rarely saw birds exhibit any signs of satiation or “slowing down” while eating, with most feeding attempts stopping only when the bird in question had clearly consumed all edible parts of an item, or was chased from a carcass by another caracara. Ten individually marked birds captured in the austral summers of 2010–2011 or 2011–2012 as well as in the austral winter of 2011 weighed less during winter than during summer,

having lost an average of 14 % of their summer body mass in winter (K. L. Bildstein, unpubl. data).

Goose feathers, presumably from carrion as we never saw a caracara approach or attempt to take a live goose, occurred in most pellets. Caracaras gained access to geese three ways: as the result of natural deaths, when a goose carcass was fed to farm animals and caracaras took some of it while the farm animal was attempting to feed upon it, and when the uneaten parts of geese killed by variable hawks became available (Fig. 1). Although variable hawks dominate over caracaras at goose carcasses (Dwyer and Cockwell 2011), we observed a sub-adult caracara carrying part of a goose while it was being pursued by a male variable hawk. Caracaras, especially when feeding in groups (Fig. 1), often secured food via kleptoparasitism from feeding hawks largely by swarming and numerically overwhelming the hawk.

The high percentage of *Chloephaga* spp. geese remains in caracara pellets probably reflects the fact that geese congregate in winter in large numbers at settlements to feed in grassy areas created by heavy livestock grazing there (*cf.* Summers and McAdam 1993). The high density of geese results in high numbers of variable hawks, which provide more geese carrion for the caracaras. Seabird remains were limited to one pellet in which shag *Phalacrocorax* spp. feathers were found. The only other seabird that overwinters in large numbers on the island is the gentoo penguin whose nearest colony is more than 3 km from the settlement.

Caracaras were not seen feeding on fish, and generally avoided contact with salt water (*cf.* Strange 1996). That said the relative scarcity of fish remains in pellets may, in part, reflect the fact that pellets sometimes under-represent fish in diets while over-representing birds when compared with direct observations (Votier et al. 2003).

The hair of domestic sheep, goat, and horse occurred in about one-third of all pellets (Table 1), presumably from

carrion. These high percentages most likely reflect the high densities of these species near the settlement. The remains of rodents, which occur on the Island, were not found in any pellets. Catry et al. (2008) noted that striated caracaras on New Island refused to feed upon the fresh corpses of rats *Rattus rattus* and mice *Mus musculus* that were offered to them.

Pebbles, sand, grit, vegetation, and soil, which occurred frequently in pellets (Table 1), may have accumulated in the digestive tracts of caracaras when they were inadvertently swallowed along with food items by ravenously feeding birds. Such items also occur in the pellets of skuas *Stercorarius* spp. (Malzof and Quintana 2008). Vegetation and substrate may have been ingested purposely, as sometimes occurs in other scavenging birds of prey feeding on large carcasses, where consumption of such material helps create sufficient volume and mass of a pellet for peristaltic action to eject it (cf. Houston et al. 2007). Another possibility is that nutritionally stressed individuals consumed such items, particularly vegetation, which occurred in 91 % of all pellets, in hopes of retrieving some nutritional value from them (cf. Houston et al. 2007).

The only other study on diet in striated caracaras based on pellet contents that we know of involved the summer diet of individuals on New Island (Catry et al. 2008), about 90 km southwest of our study area, and which contains no sheep, but is occupied by two species of rats, rabbits, and feral cats, as well as a handful of scientists during the summer months. On New Island, caracaras had a summer diet overwhelmingly dominated by seabirds, including adult thin-billed prions *Pachyptila belcheri*, penguins Spheniscidae spp., nestling prions, nestling black-browed albatrosses, and other birds, together with rabbits *Syvilagus* spp. and beetles (Catry et al. 2008), confirming what many have suggested for caracaras in summer: a diet rich in breeding seabirds and their young. Our study presents a stark contrast to this, with a winter diet rich in terrestrial waterfowl and mammalian carrion that is decidedly less directly connected to a “marine subsidy” (sensu Polis et al. 1997; Rose and Polis 1998) than is the summer diet.

Traditional farming, which has replaced the historical abundance of winter pinniped populations on the Falklands (Strange 1996), appears to be a significant nutritional resource for at least some populations of this globally near-threatened species. The new information presented in this short note documents the importance of this winter-time “human subsidy” for the species, at least on islands where livestock is managed by farmers tolerant of the birds. Additional new information on the movement and feeding ecology of striated caracaras, as well as on their conservation status on the Falklands, is likely to result from our on-going work there.

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