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Population growth and density, diet and breeding success of striated caracaras *Phalcoboenus australis* on New Island, Falkland Islands

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Abstract The striated caracara is a rare and specialised raptor, with a distribution restricted to outer islands of southern South America and the Falklands, where it lives in a unique obligate association with seabirds and seals. Despite its tameness, interesting adaptations and the fact that it is classified as near-threatened, there is virtually no published quantitative information on its demography, ecology and behaviour. We carried out a study on New Island, West Falklands, where the species was eradicated due to heavy persecution up to the 1960s. Recolonisation started after 1972 and presently there are an estimated 85 adult territorial pairs plus ca. 130 non-territorial immatures, representing an overall density of 15.5 striated caracaras per km^2. The population is estimated to have increased by 15% per year over the past 3 decades, with the result that New Island now harbours the largest known breeding aggregation on a single island in the entire breeding range of the species. The spring and summer diet of striated caracaras on New Island is dominated by one small seabird, the thin-billed prion *Pachyptila belcheri*. An estimated 25,000 adult and sub-adult prions are consumed every year, but this possibly represents less than 1% of the local population. The diet of different pairs displayed significant differences, which were probably related to differences in the availability of prey types between territories. Breeding success in recent years was very high, suggesting that conditions are good and the population may not yet have reached the island's carrying capacity.

Keywords Pachyptila · Predation · Seabird · *Buteo polyosoma*

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Introduction

The striated caracara *Phalcoboenus australis* has the southernmost overall breeding distribution of any bird of prey in the world, with a restricted range confined to islands in southern South America and the Falklands (Del Hoyo et al. 1994; Marín et al. 2006). Its global population is thought to be small and the species is classified as near-threatened (BirdLife International 2004). Besides a few broad accounts with little detailed data (reviewed, for example, in Brown and Amadon 1968; Del Hoyo et al. 1994; Woods and Woods 1997), there are virtually no studies (but see Strange 1996 for a detailed qualitative description) concerning the ecology and behaviour of this highly specialised raptor that seems to be an obligate inhabitant of islands with populations of seals or seabirds (Fig. 1). The species has probably undergone a massive historical decline in its Falkland Islands stronghold, which has been linked to heavy persecution (Strange 1996; Woods and Woods 1997) and could also have been aggravated by catastrophic historical declines of some seabirds and seals (e.g. Pütz et al. 2003; Thompson et al. 2005), on which the species feeds. Recent protection has allowed some population recovery in the Falklands, although the data are sparse.

In this paper we present the results from a study carried out on New Island, West Falkland, which is one of the main

Fig. 1 Striated caracara face to face with rockhopper penguin. Seabird colonies provide much of the feeding resources needed by this specialised bird of prey

known nesting grounds for the species and has the particularity of also harbouring the largest know seabird nesting population in the archipelago (Strange et al. 2007). Striated caracaras were extirpated from New Island in the 1960s, although a few pairs survived in neighbouring islets (I. J. Strange, personal observation). The management of New Island as a private Nature Reserve since 1972 allowed the caracara population to recover. In this paper, we present data on present caracara numbers and density, diet and breeding success of this important population.

Methods

This study took place at New Island (51°43′S, 61°18′W), West Falkland. The island covers an area of approximately 1,970 ha and has a perimeter of 56,300 m (measured in a GIS from digitalised map with a 1:25,000 scale). The ground is hilly (highest point 226 m above sea level), with high cliffs on the west and low ground on the eastern side of the island. The whole island is now run as a private nature reserve. Restoration of the site commenced in the summer of 1972–1973, when cattle and pigs were removed plus 50% of the sheep. All the sheep were removed from a major section of the island in 1976 and the last few sheep were taken away in 2005 (Strange et al. 2007). Most of the terrain is covered with short grasses or feldmark-type vegetation (see Catry et al. 2003; Strange et al. 2007 for a more detailed description of the vegetation types). Tussock grass *Parodiochloa flabellata* forms dense stands locally but, overall, covers only less than 5% of the surface of the island. Seabirds are numerous, with an estimated population of ca. 2 million pairs of thin-billed prions *Pachyptila belcheri* (Catry et al. 2003) and a few thousand pairs of each of the following species: black-browed albatrosses *Thalassarche melanophris*, imperial shags *Phalacrocorax atriceps*, gentoo *Pygoscelis papua*, rockhopper *Eudyptes chrysocome* and Magellanic penguins *Spheniscus magellanicus*. Waterfowl are well represented too, particularly with a population of many hundred upland geese *Chloephaga picta*. There are two South American furseal *Arctocephalus australis* rookeries, where one often finds more than one thousand seals hauled on the rocks and hundreds of pups are born every year (Strange et al. 2007).

A complete census of the striated caracara population was carried out in the summer season of 2006–2007. Previous to this, from 2004, partial censuses were carried out and many nests and territories were located and, in the 2006–2007 season, we opportunistically (during other field activities) worked about two-thirds of the coast-line during incubation and early chick rearing (from October to December), confirming known nests and territorial pairs, which made the final work easier and more accurate. Finally, in the second week of January, we walked along the entire coastline and recorded all adult birds, recently fledged young and nests. At this time of the year, caracaras are particularly conspicuous, as adults spend most of the day perched along the cliffs or foraging on the ground nearby and young birds are permanently calling and attempting the first flights in the neighbourhood of their nest. Failed and non-breeding pairs remain in their territories until at least the end of January, and very often male and female perch side by side. While working along the coast, when coming across an adult bird or pair, it was generally possible to look back and confirm that the previous birds were still in view and there was no double counting. If, despite these precautions, errors happened, we regard it as more likely that pairs were missed than double counted. Hence, our results possibly represent a slight underestimation of the reality. During these surveys, nest contents were recorded as well as the number of newly fledged young when they were still in the immediate vicinity of the nest. However, in the high cliffs of the West Coast of New Island, there were a number of situations where a nest could not be seen, despite the fact that a territorial pair was obviously present and sometimes calling chicks could be heard. The overall final survey in January represented 9 man-days of fieldwork.

Immature (generally non-territorial) birds were easy to recognise, due to their distinctive plumage and the habit of flocking. During the breeding season, we never saw individuals in full adult plumage joining immature flocks. Estimating immature numbers was, contrarily to the census of adults, difficult, due to their mobility. However, as most individuals gathered in some areas where they flocked (up to 65 birds seen together), it was possible, by walking all over the island (in November 2006) and recording numbers seen, to give a crude estimate for the population present on New Island during the breeding season.

During the 2005–2006 summer season, we collected pellets under nests and known roosting sites from December (including pellets cast in the previous couple of months) to late February, hence covering the whole striated caracara breeding season. Pellets originated from seven different territories and from a roosting area used by a group of ca. 8 immatures. During this same period, pellets from two known perches of red-backed hawk *Buteo polyosoma* and two territories of crested caracaras *Caracara plancus* were also collected. Pellets were opened and contents identified using a small purpose-made reference collection.

Estimating the numbers of prions eaten by caracaras

To crudely estimate the number of prions taken by striated caracaras we used a simple model based on the following assumptions.

Mean body-mass of adult striated caracaras on New Island is 1,390 ± 176 g ($N = 11$; data taken from Strange 1996), which is very similar to the 1,414 g of Scandinavian female goshawks *Accipiter gentilis* (Cramp and Simmons 1980). Scandinavian female goshawks are known to consume ca. 190 g of meat per day (Kenward et al. 1981 in Rutz 2003). We assume food consumption by striated caracaras to be similar to female goshawks, given that, for a given body-mass, there do not seem to be large differences in food consumption and digestive efficiency by Accipitriformes and Falconiformes (Barton and Houston 1993).

However, knowing that the calorific content of seabird meat is very high (e.g. 1.75 times superior than rabbit meat, for example; see Votier et al. 2004) and that a large part (ca. 80%, see "Results") of the diet of caracaras consists of seabird meat, we estimate that the daily meat consumption of an adult/immature caracara is approximately $(190/1.75) \times 0.80 + 190 \times 0.2 = 125$ g.

Prions are available in large numbers at least from mid September (prions were numerous in pellets collected in late September). From mid January, most prions eaten by caracaras are chicks taken from burrows. Hence, we assumed a period of adult and sub-adult prion predation of 4 months (15 September–15 January) or 120 days (see also Strange 1980).

We also assumed that striated caracara chicks need ca. 5,000 g of mammal meat from hatching to fledging, based on data from a similarly sized raptor, the ferruginous hawk *Buteo regalis* (calculated from data in Olendorff 1974). Correcting for the higher energetic content of seabird meat, as above, we have $(5{,}000/1.75) \times 0.8 + 5{,}000 \times 0.2 = 3{,}286$ g of food.

Following Phillips et al. (1999) and Votier et al. (2004) we considered that only 65% of one prion carcass would be available for caracaras as digestible matter. Prions have a mean body mass of 154 g, and thus each adult prion would have provided 100 g of digestible matter.

Results

Population

In 2006–2007 there were 85 pairs of territorial striated caracaras (excluding three pairs where at least one of the birds showed an immature plumage) on New Island (Fig. 2), which gives a density of 4.3 territorial pairs per km^2. Including three territorial pairs with one immature plus a (roughly) estimated 130 non-territorial immatures, the overall population of fledged individuals (excluding young fledged in January 2007) would have been ca. 306 individuals, an overall density of 15.5 striated caracaras per km^2. Most pairs nested on the coast and the density of coastal territories defended by adult pairs was 1.4 per km of shoreline.

When IJS bought New Island and started observations on its natural history, in 1972–1973, no striated caracaras nested on New Island, although small numbers were known to be present in uninhabited islets lying within a few hundred metres from New Island itself, where caracaras still nest today, and on North Island (just 3 km from New

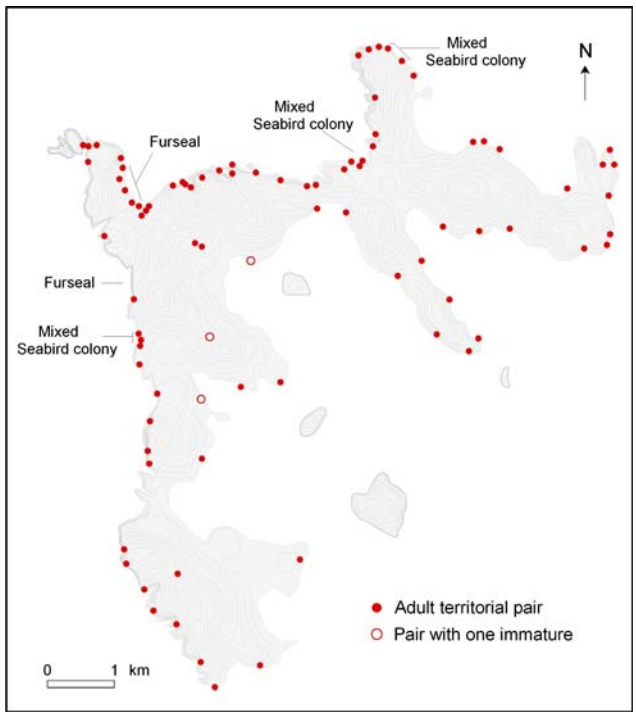

Fig. 2 Distribution of territorial striated caracara pairs on New Island in the breeding season of 2006–2007. Also shown are the locations of furseal rookeries and the main seabird mixed colonies (with large number of imperial shag, black-browed albatross and rockhopper penguin nests)

Island). New Island must have been recolonised from those islets or from North Island soon after striated caracaras were granted protection. Assuming that New Island would have been recolonised by one pair in 1974–1975, this gives a population growth of 15% per year until 2006–2007. The population on New Island in 1996 was estimated at seven pairs (Strange 1996), but this may have been an underestimate, as a population growth of 28.5% per year would have been required to reach the present-day 85 pairs. Observations in the past 3 years indicate than new territories and nesting sites are still being established, suggesting the population is still growing.

Breeding success

Of 18 pairs with a breeding attempt with a known successful outcome in 2005–2006, 9 raised 2 fledglings and 9 raised 3, or 2.5 ± 0.5 fledglings per successful pair ($N = 18$). Of 36 pairs with a known successful outcome in 2006–2007, 2 raised 1 chick, 19 raised 2 and 15 raised 3, or 2.4 ± 0.6 fledglings per successful pair ($N = 36$). Knowing that the species normally does not lay more than three eggs (Strange 1996), this is a very high breeding output. However, it should be noted that some pairs were known to have either skipped reproduction or failed at an early stage. The importance of these pairs in the population is unknown to us (no nests were systematically followed from laying to fledging), but breeding output per territorial pair must be considerably less than what was recorded by us. Some failures may have been weather related, as storms with heavy rain and high winds are rather frequent during the nesting season.

Diet

Striated caracara diet in spring and summer was largely dominated by birds, which were present on 92.6% of the 406 analysed pellets. Thin-billed prions were by far the most frequently taken species, occurring in 59.3% of the pellets (Table 1). Our observations indicate that adults and sub-adults were hunted in the open, during the night, or taken out from nest burrows when incubating, during the day. Large chicks were probably the main prey when they became available in February. Other seabirds were mostly taken as carrion or as prey stolen from Falkland skuas *Stercorarius antarctica*. Striated caracaras were very seldom seen attempting to take eggs or chicks of large seabirds, such as penguins, cormorants or albatrosses, apparently preferring to wait for opportunities created by skuas or by nest failures. Gangs of immatures, however, were seen attacking and killing almost fully-grown imperial shag chicks, and half-grown albatross chicks, when unattended by their parents. Other large birds, such as upland geese, were taken as carrion.

Table 1 Frequency of occurrence of different striated caracara prey in pellets ($N = 406$) collected in eight different areas/territories during spring and summer (late September to March) 2005–2006 and 2006–2007, on New Island, Falkland Islands

Class	Common name	Scientific name	Frequency of occurrence (%)
Birds	Penguin[a]	Spheniscidae[a]	15.3
	Thin-billed prion (adult)	*Pachyptila belcheri*	54.4
	Thin-billed prion (chick)	*Pachyptila belcheri*	4.9
	Black-browed albatross (chick)	*Thalassarche melanophris*	4.2
	Imperial shag	*Phalacrocorax atriceps*	3.7
	Upland goose	*Chloephaga picta*	7.7
	Unidentified goose or duck	Anatidae	1.5
	Magellanic oystercatcher	*Haematopus leucopodos*	0.2
	Austral thrush	*Turdus falklandii*	0.5
	Unidentified bird		5.2
	Egg		1.7
Mammals	Rabbit	*Sylvilagus* sp.	6.7
Insects	Beetle	Coleoptera[b]	17.4
Molluscs	Unidentified marine shell	Gastropoda/Bivalvia	1.2
	Squid	Cephalopoda	1.0
Sea squirts	Unidentified colonial species	Ascidiacea	0.5

Note that the number of prion chicks taken is likely to have been underestimated, as some well grown chicks are likely to have been erroneously classified as adults

[a] Mostly rockhopper *Eudyptes chrysocome* and Magellanic *Spheniscus magellanicus*, and to a smaller extent gentoo penguin *Pygoscelis papua*

[b] Generally Curculionidae and Carabidae

There were differences in the diet, as revealed by the pellets, between pairs nesting in different areas (Table 2). Comparing the proportion of prions in the sampled pellets of different breeding pairs, one finds that differences are highly significant ($\chi^2_6 = 112.1$, $P < 0.001$; Table 2).

Prion consumption by striated caracaras

Given the results of the pellet analyses (Tables 1, 2) and the uncertainty of the contribution of diet items (mostly furseal) that generally do not leave identifiable remains in pellets, we admit that broadly ca. 50% of the caracara food intake is provided by prions (excluding prion chicks).

The 306 adult/immature caracaras present on New Island during the breeding season should consume 38,250 g of meat per day, and 4,590,000 g during the 120 days that adult/immature prions are readily available as prey on New Island. If half of this is provided by prions, we have a consumption of 22,950 prions per season.

Applying the same calculations to chicks, we have that each chick fledged will have required $3{,}286 \times 0.5 =$ 1,643 g of prion meat, which equals to 16.4 prions. We know that successful striated caracara pairs raise on average 2.5 chicks on New Island. We set the unknown proportion of unsuccessful pairs at 1/3, which gives 1.67 chicks raised per territorial pair. This gives an estimated 142 chicks raised on New Island on 2006–2007 and a total prion consumption by chicks of the order of 2,329 individuals.

Adding adults, immatures and chicks, we get an estimate of 25,279 adult and sub-adult prions consumed by the striated caracaras during the nesting season.

Relationships with other birds of prey

Other diurnal birds of prey nesting on New Island include small numbers of crested caracara *Caracara plancus* (3–4 pairs in 2006–2007), red-backed hawk *Buteo polyosoma* (ca. 3–5 pairs), peregrine falcons *Falco peregrinus* (ca. 7 pairs) and turkey vultures *Cathartes aura* (common, but far less numerous than striated caracaras). We have no data on peregrine diet, other than to say that they take prions and terrestrial birds. Vultures feed on all types of carrion, competing with caracaras for large bird corpses (mostly penguins and upland geese) and for seal placentas, corpses and excreta. Adult vultures are dominant over caracaras and on several occasions we have found the caracaras waiting while a vulture feeds; when the vulture flew away due to our presence (vultures are much shyer in relation to humans) caracaras took their place. However, on occasion, a pair of adult caracaras was also seen displacing a vulture (particularly immatures). Also, when a large flock of young caracaras is present, the vultures often are unable to monopolise the corpse of a large bird such as an upland goose.

Data on the diet of crested caracaras and red-backed hawks are presented in Table 3. Sample sizes are small and the limited evidence suggests little segregation by diet between the two caracaras, at least during spring and summer. Striated caracaras seem to eat prions more often than their larger counterparts, but the difference is not statistically significant (Fisher exact text, $P = 0.76$). On the other hand, there is a very clear dietary difference with red-backed hawks, which prey much more often on mammals than striated caracaras do (Fisher exact test, $P < 0.001$). We have seen striated caracaras attempting to kleptoparasite red-backed hawks, sometimes with success.

Moult

During our census in mid-January we noticed that the vast majority of the adult territorial birds (both active and failed pairs) were moulting the central pair of tail feathers, which were almost fully-grown in some individuals, and up to 2 pairs of primaries. Birds moulting rectrices and primaries included some that still had chicks on the nest (fully grown and ready to fledge).

Table 2 Main diet traits of seven adult territorial pairs and one group of immature birds in 2005–2006 and 2006–2007

	Prions (%)	Other seabirds (%)	Other birds (%)	Rabbit (%)	Insect (%)	Total number of pellets
Pair 1	42	17	16	9	16	130
Pair 2	81		16	3		38
Pair 3	83	4	9	4		23
Pair 4	92		4	4		27
Pair 5	90	5	5			20
Pair 6	78		20	2		46
Pair 7	17	68	1		14	88
Immatures	94		3	3		34
Mean	72	12	9	3	4	406

Each cell represents the proportion of pellets collected which were mostly constituted by the relevant prey type

Table 3 Frequency of occurrence of prey in crested caracara *Caracara plancus* and in red-backed hawk *Buteo polyosoma* pellets collected in spring and summer 2005–2006, in two distinct territories of each of these birds of prey

Class	Prey type	Frequency of occurrence (%) in crested caracara pellets ($N = 17$)	Frequency of occurrence (%) in red-backed hawk pellets ($N = 46$)
Birds	Penguin	11.8	
	Thin-billed prion	35.3	21.7
	King cormorant	5.9	
	Upland goose	17.6	15.2
	Meadowlark *Sturnella loyca*		2.2
	Unidentified bird	29.4	6.5
Mammals	Rabbit	17.6	41.3
	Mouse *Mus musculus*		16.7
	Ship rat *Rattus rattus*		6.5
Insects	Beetle	5.9	
Molluscs	Unidentified marine shell	5.9	

Discussion

Striated caracaras are so exceedingly tame that many individuals (particularly juveniles) can be easily caught with a hand net. Hence, it is not surprising that, when heavily persecuted, they can be exterminated from whole islands, as has happened on New Island up until 1972. After the creation of a private reserve and benefiting from effective protection, the population started its recovery. Thirty-three years later, the island holds a dense and apparently healthy growing population, but the previous and current carrying capacity of the site is unknown. It is known that there have been important population recoveries at other sites where protection has been afforded as a result of changes of people's attitudes. Nevertheless, a recent partial survey of the Falkland Islands suggests that the population levels might be, on the whole, stable (Woods 2007). The species is not free of concerns, as its reliance on seal and seabird populations make it susceptible to changes in the marine ecosystem, which have been threatening some marine predators (e.g. Pütz et al. 2003; Thompson et al. 2005).

According to the results of several surveys (Woods and Smith 1999; Marín et al. 2006; Woods 2007) and the present study, New Island harbours the largest known single-island population of striated caracaras in the world. However, it should be noted the survey effort on New Island has been more intense than elsewhere in the Falklands (or at other sites in South America), particularly because censuses at other islands have mostly taken place during incubation, when striated caracaras have a much more discrete behaviour and are harder to locate. Incidentally, Saddle Island, which lies only ca. 2 km from New Island and was surveyed at the most appropriate time of the year, was found to have at least 19 breeding pairs (only successful nests/pairs were counted) in January 2007 (Woods 2007), which represents a density (54 territorial pairs per km^2) even higher than we found on New Island.

The present population survey suggests that, on New Island, striated caracaras have a mostly coastal distribution (Fig. 2), which can be easily explained by the availability of potential nest sites along the sea-cliffs, particularly on the west and the north coast. On the other hand, the higher population density on the northern part of the island is harder to understand. Caracaras are generally more abundant near seal rookeries and mixed seabird colonies, but the relationship is inconsistent, with very few pairs around the large furseal rookery situated on the west coast (Fig. 2). It is also possible that the higher population density in the north reflects (re)colonisation patterns, given that the most important potential sources of recruits are situated north of New Island.

Censuses in 1997 and 1998, complemented by further data obtained in 2006, suggest a national Falkland Islands striated caracara population of ca. 500 pairs (Woods and Smith 1999; Woods 2007). In this context, the population of New Island can be regarded as very important, representing more than 10% of the total. We note, however, that it is likely that more detailed surveys elsewhere will result in upward revisions of the Falklands population estimate.

Breeding success on New Island appears to be high. The only other data on breeding success for this species come from Smith and Prince (1985) who visited Beauchêne Island (Falklands) in December 1980. They report that out of 27 nests with chicks, 8 had only one chick, 9 had two and 10 had three (an average of 2.1 chicks per nest), which is fewer than reported here.

Moult and breeding are two activities that are often segregated in the life-cycle of birds (e.g. Payne 1972), although there are a number of exceptions (e.g. Newton and Rothery 2005). The fact that striated caracaras were able to start tail and wing feather moult while meeting

the high energetic demands of almost fully-grown chicks suggests that food supplies are plenty in mid-summer and the caracaras make the most of it before resources dwindle to the lowest levels in mid-winter (see Strange 1996).

On New Island, during spring and summer, striated caracaras rely heavily on the abundant thin-billed prions for food. Nevertheless, it is clear that diet varies from one territory to another, undoubtedly due to differences in prey abundance but maybe also due to feeding specialisations. It should also be noted that some dietary items are unlikely to be detected in the pellets. Furseal carrion and placentas, in particular, are regularly consumed by caracaras on New Island (personal observation), but were never recorded in pellets, and we were unable to sample pairs that nest right by the furseal rookeries. However, it must be stressed that only a minority of the adult breeding pairs (and probably of the immatures) had access to and fed on those rookeries during the breeding season. Furthermore, at these sites they faced competition from turkey vultures and crested caracaras. Marine invertebrates, which have been suspected to be locally important at other sites or times (Strange 1996; Marín et al. 2006) were rare in the summer diet on New Island, and only occasionally we did notice caracaras feeding on intertidal areas.

It is interesting to note that, in contrast to other local predators, such as buzzards, or feral cats (Matias and Catry 2008), striated caracaras show little reliance on introduced rabbits and seem to completely avoid eating rats and mice. The avoidance of rodents is particularly intriguing; a few individuals that got used to be hand-fed invariably refused taking fresh corpses of rats *Rattus rattus* or mice *Mus musculus*. On the other hand, it is possible that rabbits and rodents are consumed more frequently in winter, when other food resources are scarce.

Striated caracaras, particularly the young, are notoriously inquisitive and playful, traits that probably favour their survival in the harsh and resource-depleted winter environment of outlying islands. Their ability to hunt by night and to dig and extract prions out of burrows, for example, is probably unmatched by the crested caracara, which, as we have shown, eat fewer prions and have a small population and probably a low breeding success on New Island, despite being socially dominant over the striated caracara and hence probably having an advantage when competing for carrion, for example.

The estimate of ca. 25,000 adult and sub-adult prions taken by striated caracaras per season must be taken cautiously, as there are a number of uncertainties in our model. In particular, it is likely that striated caracaras are slightly more efficient than goshawks at digesting food (Barton and Houston 1993), and hence may have a slightly lower food consumption. On the other hand, striated caracaras live in a very challenging environment, with frequent strong winds and low temperatures, which may imply greater food consumption. On the whole, there are no reasons to believe that errors involved in the estimate of prion consumption are important and the figure gives an idea of the likely order of magnitude of the numbers taken. Admitting that the estimate of 2,000,000 pairs of breeding prions on New Island (Catry et al. 2003) is still valid, and knowing that very large numbers of immature non-breeders are usually present at any petrel colony, it appears that the total kill by striated caracaras affects less than 1% of the local prion population. It is also likely that caracaras take relatively less breeding adults than immature birds, as the latter usually spend more time in exposed situations above the ground (see Warham 1990). Despite the predation by caracaras and other local predators (including feral cats, rats, skuas and several birds of prey), thin-billed prions keep reproducing successfully on New Island, the population is still very large (Catry et al. 2003, 2007) and there are no obvious signs of a decline. Nevertheless, with this level of predation, striated caracaras can potentially play a role in regulating prion numbers, particularly if the predator population keeps increasing and if oceanographic factors reduce prion numbers.

Historically, Falklands striated caracaras probably nested in an environment with tremendously abundant food resources during the breeding season (when large populations of seabirds and seals were present), but likely with much fewer resources during winter (virtually no seabirds reproduce in the Falklands during winter and most are migratory and leave the islands. Seals are also less plentiful in winter and reproduction does not take place in this season). Man introduced abundant mammal prey that is present year-round (mostly sheep, that can be consumed as carrion), but also fiercely persecuted striated caracaras. Persecution is now mostly something of the past. With ample winter food supply in most of the Falklands, striated caracara populations can potentially expand (but see Woods 2007). Whether or not they have the potential to impact significantly on other species is something that will have to be assessed in the future. At the moment, we know of no evidence that this might be the case.

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References

Barton NWH, Houston DC (1993) A comparison of digestive efficiency in birds of prey. Ibis 135:363–371

BirdLife International (2004) Threatened birds of the world 2004. CD-Rom, Cambridge UK: BirdLife International

Brown L, Amadon D (1968) Eagles, Hawks and Falcons of the World. Country Life Books, Feltham

Catry P, Campos A, Segurado P, Silva M, Strange I (2003) Population census and nesting habitat selection of thin-billed prion *Pachyptila belcheri* on New Island, Falkland Islands. Polar Biol 26:202–207

Catry P, Silva MC, MacKay S, Campos A, Masello J, Quillfeldt P, Strange IJ (2007) Can thin-billed prions *Pachyptila belcheri* breed successfully on an island with introduced rats, mice and cats? The case of New Island, Falkland Islands. Polar Biol 30:391–394

Cramp S, Simmons KEL (1980) The Birds of the Western Palearctic, vol II. Oxford University Press, Oxford

Del Hoyo J, Elliot A, Sargatal J (eds) (1994) Handbook of the birds of the world, vol II. Lynx Edicions, Barcelona

Kenward RE, Marcstrom V, Karlbom M (1981) Goshawk winter ecology in Swedish pheasant habitats. J Wildl Manag 45:397–408

Marín M, Kusch A, Oehler D, Driechman S (2006) Distribution, breeding and status of the striated caracara *Phalcoboenus australis* (Gmelin 1788) in Southern Chile. An Inst Patagonia (Chile) 34:65–74

Matias R, Catry P (2008) The diet of feral cats at New Island, Falkland Islands, and possible impact on breeding seabirds. Polar Biol 31:609–616

Newton I, Rothery P (2005) The timing, duration and pattern of moult and its relationship to breeding in a population of the European greenfinch *Carduelis chloris*. Ibis 147:667–679

Olendorff RR (1974) Some quantitative aspects of growth in three species of Buteos. Condor 76:466–468

Payne RB (1972) Mechanisms and control of moult. In: Farner DS, King JR (eds) Avian biology, vol 2. Academic Press, New York, pp 103–155

Phillips RA, Thompson DR, Hamer KC (1999) The impact of great skua predation on seabird populations at St Kilda: a bioenergetics model. J Appl Ecol 36:218–232

Pütz K, Clausen AP, Huin N, Croxall JP (2003) Re-evaluation of historical rockhopper penguin population data in the Falkland islands. Waterbirds 26:169–175

Rutz C (2003) Assessing the breeding season diet of goshawks *Accipiter gentilis*: biases of plucking analysis quantified by means of continuous radio-monitoring. J Zool Lond 259:209–217

Smith RIL, Prince PA (1985) The natural history of Beauchêne Island. Biol J Linn Soc 24:233–283

Strange IJ (1980) The thin-billed prion *Pachyptila belcheri*, at New Island, Falkland Islands. Gerfaut 70:411–445

Strange IJ (1996) The striated caracara *Phalcoboenus australis* in the Falkland Islands. Author's Edition, Falkland Islands

Strange IJ, Catry P, Strange G, Quillfeldt P (2007) New Island, Falkland Islands. A South Atlantic Wildlife Sanctuary for Conservation Management. New Island Conservation Trust, London. 152 pp

Thompson D, Strange IJ, Riddy M, Duck CD (2005) The size and status of the population of southern sea lions *Otaria flavescens* in the Falkland Islands. Biol Conserv 121:357–367

Votier SC, Bearhop S, Ratcliffe N, Phillips RA, Furness RW (2004) Predation by great skuas at a large Shetland seabird colony. J Appl Ecol 41:1117–1128

Warham J (1990) The petrels. Their ecology and breeding systems. Academic Press, London

Woods RW (2007) The distribution and abundance of the striated caracara *Phalcoboenus australis* in the Falklands, 2006. Falklands Conservation, Stanley

Woods RW, Woods A (1997) Atlas of the breeding birds of the Falkland Islands. Anthony Nelson, Oswestry

Woods RW, Smith JG (1999) The distribution and abundance of the striated caracara *Phalcoboenus australis* in the Falklands, 1997–1998. Falklands Conservation, Stanley