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THE UNEXPECTED DIET OF BREEDING IMPERIAL SHAGS (*PHALACROCORAX ATRICEPS*) AT THE NAHUEL HUAPI LAKE, PATAGONIA: IMPLICATIONS ON POPULATION TRENDS?

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La inesperada composición de la dieta del Cormorán Imperial (*Phalacrocorax atriceps*) durante el período reproductivo en el Lago Nahuel Huapi, Patagonia: ¿implicancias sobre la tendencia poblacional?

Key words: Imperial Shag, *Phalacrocorax atriceps*, breeding diet, Crustaceans, Patagonia, threatened populations.

INTRODUCTION

The Imperial Shag *Phalacrocorax atriceps* is widely distributed along the coast of South America and in Malvinas/Falkland Islands (Orta 1992). This shag is marine in most its range and forages predominantly on fish, although invertebrates were frequently reported as present in the diet (e.g., Punta *et al.* 2003, Ferrari *et al.* 2004, Bulgarella *et al.* 2008).

Reynolds (1934) reported the presence of the Imperial Shag breeding at Yehuin Lake, Tierra del Fuego, and later on Pereyra (1945, quoted in Navas 1970), Chebez & Gómez (1988) and Rasmussen *et al.* (1992) reported the existence of the only other three populations of this shag breeding in freshwater environments, the Nahuel Huapi (NHL), Fagnano, and Vintter lakes, respectively. Despite the potential interest in studying these populations, few studies provided infor-

mation on the biology of this shag species. Although not globally threatened, the Imperial Shag at NHL is locally endangered and between the summers of 1990 (Rasmussen *et al.* 1993) and 2005 (Pastore *et al.* 2005) the total number of individuals decreased in 68%.

Thus, the aim of this study is provide the first information on the diet of the Imperial Shag breeding at NHL to improve the knowledge of the foraging behavior of this species as well as to explore the linkage between diet composition and the reported declining trend of this population.

MATERIAL AND METHODS

A total of 59 pellets of the Imperial Shag were collected around active nests during 21 November (24 pellets, incubating–early rearing) and 26 December (17 pellets, mid rearing) 2007 and 17 January 2008 (18 pellets, late rearing–fledging) at the colony in Punta Sur (eight nests, 41°01.253'S–71°30.312'W), NHL, Nahuel Huapi National Park, Patagonia, Argentina (Fig. 1). The pellets were collected in separated polythene bags and processed according to the methodology described in Casaux *et al.* (1995). Otoliths evidenced the presence of fish in the diet and the number, size, and mass of the specimens ingested were estimated following the procedure and applying the equations in Casaux *et al.* (2009).

Chelas, gastroliths, and exoskeleton remains evidenced the presence of the decapods Freshwater Crayfish *Samastacus spinifrons* and *Aegla* sp. in the diet. To estimate the number of individuals ingested chelas were separated into right and left, the most abundant being considered as the number of individuals per sample, whereas for such purpose the total number of gastroliths present in the sample (only in the Freshwater Crayfish) was divided by two. The higher of these two estimations was considered as the number of specimens per sample. The total length and mass of the Freshwater Crayfish and *Aegla* sp. individuals were estimated from chela and gastrolith lengths using the equations in Alarcón (2010). Twenty nine percent of the Freshwater Crayfish sampled by Alarcón (2010) were molting and did not bear gastroliths. Thus, considering the fraction of field-caught individuals bearing gastroliths we compensated the estimation of the number and mass of individuals of this species represented in the samples.

RESULTS

The Freshwater Crayfish was largely the most frequent and numerous prey, followed by *Aegla* sp. (Table 1). That crustacean also predominated by mass throughout the study period whereas the Rainbow Trout *Oncorhynchus mykiss* and the Brown Trout *Salmo trutta* followed in importance. Although fish were the second prey in importance by mass, they were scarcely represented in the samples (mainly during incubating-early rearing) and only exotic species were identified.

DISCUSSION

Fish are the main, and sometimes the only, component of the diet of shags (Orta 1992). Despite this strong feeding pattern, some studies carried out in the southern hemisphere indicated that non-fish preys may be an important component in the diet of non-breeding "blue-eyed shags" (Espitalier-Noel *et al.* 1988, Green *et al.* 1990). Similarly, the analysis of three stomach contents collected at Puerto Mercedes, NHL (15 km far from our study site), indicated that fish were absent from the diet of the non-breeding Imperial Shag, being the Freshwater Crayfish and *Aegla* sp. the only prey represented in the samples (Rasmussen *et al.* 1993). Although fish were

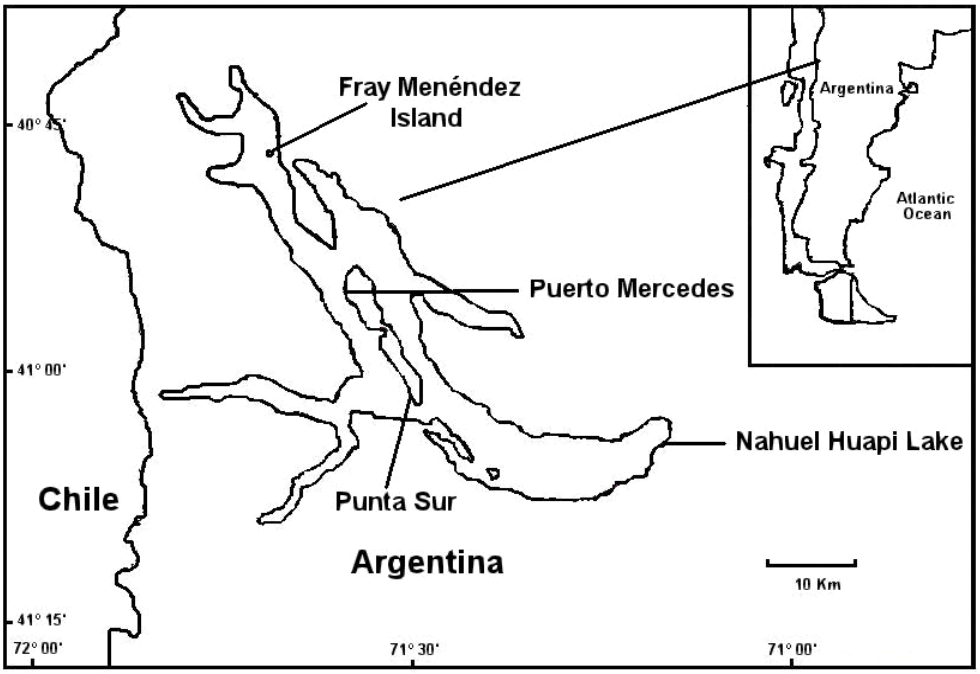

FIG. 1. Map showing the location of the colony of the Imperial Shag under study at the Nahuel Huapi Lake, Northwest Patagonia, Argentina.

presented in our samples, our results are in line with those provided by Rasmussen *et al.* (1993) and this is the first study indicating that breeding shags forage almost exclusively on invertebrates.

The Imperial Shag at NHL is locally endangered and between the summers of 1990 (331 individuals, Rasmussen *et al.* 1993) and 2005 (106, Pastore *et al.* 2005) the total number of individuals decreased in a 68%. There is no previous information on the breeding output of these shags at NHL, but at the beginning of the 2007/08 breeding season only eight and two chicks were observed in the colonies at Punta Sur (this study) and Fray Menéndez Island (D. Mujica pers. com.), respectively, and only three of them (all from Punta Sur) survived. During the 2008/09 breeding season only seven pairs attempted to breed at Punta Sur but no chicks were emancipated. Two reasons were enunciated to explain the current critical situation of the Imperial Shag at this locality: (1) increasing predation pressure and (2) decreasing food availability (Navas 1970, Frixione 2008). No attempts of predation on eggs or chicks were reported but potential predators were observed in (the Crested Caracara *Polyborus plancus*, Rasmussen *et al.* 1993, and the Kelp Gull *Larus dominicanus*, Frixione 2008) or close (the American Mink *Mustela vison*, C. Chehebar pers. com.) the colonies. In our visits to Punta Sur, four of the five chicks death there (3–30 days old, mean age 10.8 days) were close to the nests without evidence of predation. If occurring, predation is not the only factor determining the decrease in the population of the Imperial Shag at NHL. The ages of the chicks found death, whose energy requirements were low, evidence a severe problem in chick food provisioning and support the alternative (2).

TABLE 1. Diet of the Imperial Shag breeding at Victoria Island, northwest Patagonia, as reflected by the analysis of 59 pellets collected on 21 November 2007 (Day 1), 26 December 2007 (Day 2), and 17 January 2008 (Day 3) (number of pellets analyzed in parentheses). Percentage frequencies of occurrence (F%), importance by number (N%) and mass (M%), and mean total length (TL in cm ± SD) and length range of prey represented in the samples.

Date		Decapods		Coleopterans	Gastropods	Fish		
		S. spinifrons	*Aegla* sp.			*O. mykiss*	*S. trutta*	Unidentif.
Day 1	F%	100	-	4.2	4.2	8.3	4.2	8.3
(24)	N%	98.1	-	0.1	0.1	0.8	0.3	0.6
	M%	81.9	-			17.1	1.0	
	TL ± SD	6.4 ± 1.4	-			24.2 ± 2.9	12.1 ± 0.1	
	Range	1.9–10.8	-			19.2–26.7	12.0–12.2	
Day 2	F%	100	11.7	-	-	-	-	-
(17)	N%	99.4	0.6	-	-	-	-	-
	M%	99.9	0.1	-	-	-	-	-
	TL ± SD	6.9 ± 1.6	3.3 ± 0.3	-	-	-	-	-
	Range	2.1–12.5	3.1–3.9	-	-	-	-	-
Day 3	F%	100	16.7	-	-	-	-	5.6
(18)	N%	99.2	0.6	-	-	-	-	0.2
	M%	99.9	0.1	-	-	-	-	
	TL ± SD	6.9 ± 1.4	3.2 ± 0.3	-	-	-	-	
	Range	3.0–12.6	3.0–3.6	-	-	-	-	
Overall	F%	100	8.5	1.7	1.7	3.4	1.7	5.1
(59)	N%	99.0	0.4	0.1	0.1	0.2	0.1	0.1
	M%	93.7	0.1			5.9	0.3	
	TL ± SD	6.7 ± 1.5	3.3 ± 3.0			24.2 ± 2.9	12.1 ± 0.1	
	Range	2.1–12.6	3.0–3.9			19.2–26.7	12.0–12.2	

The breeding Imperial Shag at NHL preyed almost exclusively on Freshwater Crayfish. The marked piscivory reported for phalacrocoraciids (Orta 1992) let us speculate that shags forage on crustaceans due to the low availability (in quantity, distance, or depth) of fish. It is believed that the salmonids introduced in Patagonia since the early 1900's negatively affected native fish, altering the abundance, structure and distribution of their populations (Pascual *et al.* 2002). This is also the case of the NHL where the fish community is currently dominated by salmonids (Vigliano *et al.* 2005). Although salmonids are present and abundant, the Imperial Shag at the Vintter Lake, Patagonia, foraged exclusively on the demersal native fish Inanga *Galaxias maculatus* (Rasmussen *et al.* 1992). Despite of the local high abundance of exotic species (Baigún 2001), at two localities of Patagonia the Neotropic Cormorant *Phalacrocorax olivaceus* foraged predominantly on native fish (Casaux *et al.* 2008, 2009). In the 1960s, native fish and crustaceans were the main prey of shags at NHL and salmonids were scarcely represented in the diet (A. Anziano, quoted in Navas 1970). This suggests that, as observed in other localities and species in west Patagonia (see above), the Imperial Shag at NHL positively selects native fish when present and abundant. Under such scenario, an increasing alteration in the abundance or distribution of native fish might results in decreasing fish consumption.

To cover their own energy requirements (according to estimations by Casaux *et al.* (1995) for a close related species like the Antarctic Shag *Phalacrocorax bransfieldensis*, 2800 $Kj*day^{-1}$), foraging on specimens of sizes similar to the represented in the samples each shag have to consume daily four fish (considering a mean energy content of 5.4 $Kj*g^{-1}$, Ciancio *et al.* 2007, and an assimilation efficiency of 75%, Wiens 1984). Assuming an assimilation efficiency similar to the reported for fish and an energy density of 3.9 $Kj*g^{-1}$ (Ciancio *et al.* 2007), shags foraging on Freshwater Crayfish of sizes similar to the sampling data have to consume daily 143 specimens. Compared to fish, the Freshwater Crayfish might be a more predictable prey with a lower escape capacity. However, considering the number of individuals to be caught, it is due to expect that if shags have to forage on this cryptic prey due to a reduced targeted fish availability they must invest more time in foraging activities (not only in those related to prey location and ingestion but also in the digestive process) which negatively affect the overall time and energy budget. Although speculative, the arguments above let us assume that low targeted fish availability at NHL might affect the rate of energy intake and, consequently, chick food provisioning, both factors negatively affecting the Imperial Shag's population trend.

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