THE DIET AND FORAGING BEHAVIOUR OF TWO PATAGONIAN CORMORANTS

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Received 11 June 1992, accepted 2 December 1992

SUMMARY

PUNTA, G.E., SARAVIA, J.R.C. & YORIO, P.M. 1993. The diet and foraging behaviour of two Patagonian cormorants. *Marine Ornithology* 21: 27-36.

The diet and foraging behaviour of the Imperial Cormorant *Phalacrocorax atriceps* and the Rock Shag *P. magellanicus* were studied at Bahías Bustamante and Melo, Argentina, during 1989 to 1991. Both species fed on a wide variety of fish and invertebrates. Rock Shags preyed mainly on rock cods *Notothenia* spp., which were present in 87% of regurgitation pellets during the breeding season and in 91% of pellets during the winter. Rock Shags foraged solitarily, in strictly coastal areas, and mainly on the bottom. The main prey of the Imperial Cormorant during the breeding season was anchovy *Engraulis anchoita* (43% by mass). Imperial Cormorants foraged both solitarily and in groups, and fed similarly on bottom and midwater prey during the breeding season.

INTRODUCTION

Many studies have analyzed cormorant diet and feeding ecology (e.g. Bartholomew 1942, Jordán 1959, Robertson 1974, Williams & Burger 1978, Ainley *et al.* 1981, Cooper 1985a,b, 1986, Duffy *et al.* 1987, Wilson & Wilson 1988). The particular emphasis of these studies was partly based on the view that cormorants compete with commercial fisheries (Schreiber & Clapp 1987), and that the quantity of prey taken by these species may sometimes represent an important proportion of fish stocks (Murphy 1954, Rand 1960). On the other hand, evidence suggests that overfishing combined with changing oceanic conditions may adversely affect cormorant populations (Potts *et al.* 1980, Crawford & Shelton 1981, Furness 1982, Duffy 1983).

The Imperial Cormorant *Phalacrocorax atriceps* and the Rock Shag *P. magellanicus* are widely distributed along the Patagonian coast of Argentina and are sympatric at many locations. Our study population consisted totally of the former *P. albiventer* ("albiventer" colour morph, sensu Siegel-Causey 1986). The relationship between *P. atriceps* and *P. albiventer* is still a matter of discussion and in this study we follow Devillers & Terschuren's (1978) treatment until clarification of the taxonomic status of the species.

Several studies have described aspects of Imperial Cormorant and Rock Shag ecology and behaviour (Murphy 1936, Humphrey *et al.* 1970, Devillers & Terschuren 1978, Malacalza 1984a,b, Siegel-Causey 1986, Rasmussen 1987, Punta 1989). However, little is known about their diet and foraging

behaviour in Patagonia. The existing information on the diet of *P. atriceps* comes from studies of Antarctic and sub-Antarctic populations (Schlatter & Moreno 1976, Blankley 1981, Brothers 1985, Espitalier-Noel *et al.* 1988, Green *et al.* 1990). We lack information on Rock Shag diet throughout its range, and published information on foraging behaviour in this species refers only to diving patterns (Wanless & Harris 1991).

Given the current growth of the fishing industry along the Patagonian coast (Dirección de Intereses Marítimos del Chubut, unpubl. data), knowledge of an overlap between cormorant feeding requirements and commercial fisheries may be important in the design of management plans and conservation strategies. In this study we present information on the diet and foraging behaviour of the Imperial Cormorant and Rock Shag in southern Chubut, Argentina.

METHODS

We conducted this study from 1989 to 1992 in Bahía Bustamante (45 05S, 66 28W) and Bahía Melo, (45 03S, 65 50W) (Fig. 1). Imperial Cormorants and Rock Shags breed on Islas Isabel (450 and 30 breeding pairs, respectively) and Islas Escobar (750 and 280 breeding pairs, respectively) and can be found throughout the year near these localities.

Analysis of diets are based on 276 regirgitation pellets, 114 from Rock Shags and 162 from Imperial Cormorants. Additionally, 16 regurgitations of stomach contents were obtained from Imperial Cormorants when captured or while we approached their nests. Rock Shags were never observed to regurgitate when approached. We divided the samples into the breeding season and winter. During the breeding season, pellets were gathered between the last week of October and the third week of December. During the winter we obtained monthly samples between May and August.

During the 1991-92 breeding season we examined the seasonal variation in Imperial Cormorant diet. For analysis, samples were divided among three stages of the breeding cycle: pre-laying, incubation and chick-rearing. Prey items were divided into prey categories corresponding to five major taxa: fish, crustaceans, molluscs, echiurids and polychaetes.

Prey items were identified with a 21x binocular microscope through the use of fish otoliths, polychaete mouth parts, cephalopod beaks, and crustacean and echiurid remains. We included food items that were too damaged for identification in an "unidentified" category. We analyzed prey size from prey items obtained from the regurgitations. Prey total length and mass were measured with dial calipers and an analytical balance, and estimated to the nearest 0.5 mm and 0.1 g, respectively.

During the 1991-92 breeding season we identified a new fish species *Ribeiroclinus eingenmani*, apparenty overlooked in the previous years' samples. This species was included with notothenid fish in the analysis of Rock Shag and Imperial Cormorant pellets. However, we discriminated this species in the analysis of Imperial Cormorant regurgitations.

We conducted observations on foraging behaviour in Bahía Bustamante from the coast and from inflatable boats, using 22x telescopes and 8x30 binoculars. We conducted under-water observations of Rock Shag foraging habitat by means of SCUBA diving. Data on foraging depths were obtained from nautical charts (Charts 12 and 13, Servicio de Hidrografía Naval Argentina) and corrected for the tidal height at the time of the observations.

RESULTS

Rock Shag diet and foraging behaviour

Rock Shags fed on a wide variety of prey species (Table 1). Their main prey species were rock cods *Notothenia* spp.. These were present in 87.4% of the pellets collected during the breeding season and in 90.9% of pellets collected during the winter

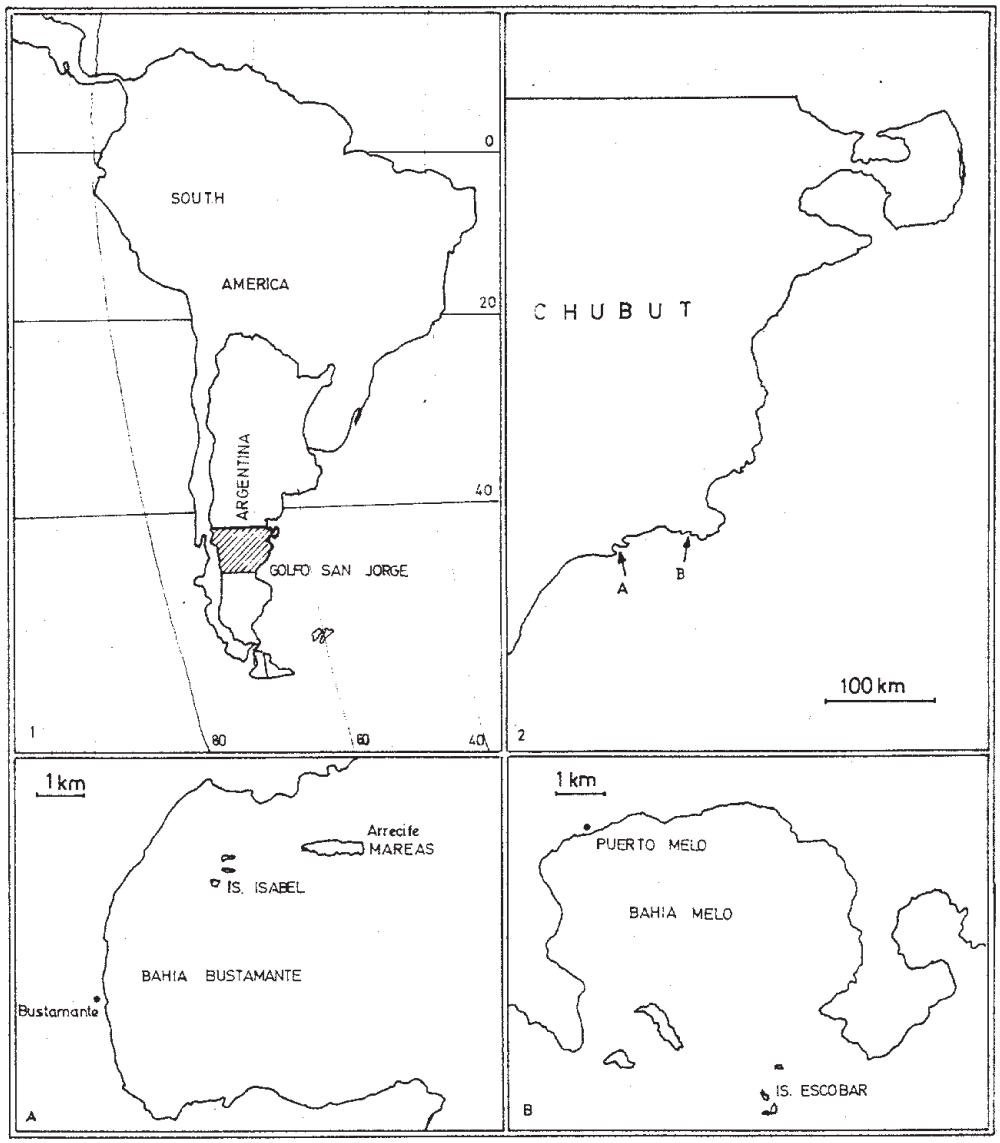

Figure 1

Location of the study areas in Bahía Bustamante and Bahía Melo, and Imperial Cormorant and Rock Shag colonies on Islas Isabel and Escobar.

TABLE 1

FOOD OF THE ROCK SHAG IN BAHIA BUSTAMANTE AND PUERTO MELO DURING THE 1989 TO 1991 BREEDING SEASONS (N = 103) AND THE WINTER OF 1989 (N = 11), EXPRESSED AS FREQUENCY OF OCCURRENCE AS DETERMINED BY PELLET ANALYSIS

Prey		Breeding season %	Winter %
Fish			
Rock Cods	*Notothenia* spp.	87.4	90.9
Anchovy	*Engraulis anchoita*	24.3	0.0
Unidentified fish		2.9	0.0
Crustaceans			
Crab	*Peltarion* sp. and *Coenoptalmus* sp.	32.0	27.3
Shrimp	*Austropandalus grayi*	59.2	36.4
Cephalopods			
Octopus	*Octopus* sp.	21.4	0.0
Squid	*Loligo gahi*	10.7	0.0
Echiurid	*Urechis chilensis*	43.7	18.2
Polychaete	*Eunice* spp.	60.2	45.5
Unidentified		13.6	36.4

(Table 1). During the 1991-92 breeding season we identified the fish *R. eigenmani*. This species was present in 42.9% of pellets, and was associated with *Notothenia* spp. in 82% of pellets. Because it was included with notothenid fish in the analysis, the percentage of such fishes presented in Table 1 is very likely an overestimation.

Of 93 days of field observations during the three study years, all Rock Shags observed foraged individually and at distances between 50 m and 2 km from the coast. When foraging outside the bays, they did it at distances of less than 200 m from the shore and among kelp *Macrocystis pyrifera* beds. The maximum depth in Bahía Bustamante is approximately 18 m (Chart 13, Servicio de Hidrografía Naval Argentino). Rock Shags foraged in areas with algae and where maximum depth was between 2 and 12 m. Rock Shags foraged on the bottom throughout the year, but were occasionally observed foraging also at midwater during the breeding season.

Imperial Cormorant diet and foraging behaviour

Imperial Cormorants fed on a wide variety of prey species, especially during the breeding season (Table 2). The species' main prey during the breeding season was anchovy *Engraulis anchoita* (Table 3). During the 1991-92 breeding season we also found *R. eigenmani* in Imperial Cormorant pellets and regurgitations. During 1991-92, *R. eigenmani* was present in 30.1% of pellets, and was associated with notothenid fish in 92.9% of cases. As it was included with notothenid fish in the analysis, the percentage of such fishes presented in Table 2 is very likely an overestimation. Imperial Cormorants preyed mainly on fish (72.5%) during the 1991-92

TABLE 2

FOOD OF THE IMPERIAL CORMORANT IN BAHIA BUSTAMANTE AND PUERTO MELO DURING THE 1989 TO 1991 BREEDING SEASONS (N = 140) AND THE WINTER OF 1989 (N = 22), EXPRESSED AS FREQUENCY OF OCCURRENCE AS DETERMINED BY PELLET ANALYSIS

Prey		Breeding season %	Winter %
Fish			
Rock cods	*Notothenia* spp.	57.1	68.2
Anchovy	*Engraulis anchoita*	56.4	0.0
Codfish	*Genypterus blacodes*	10.7	0.0
Hake	*Merluccius hubbsi*	0.7	0.0
Silverfish	*Odontestes* spp.	3.6	4.6
Unidentified fish		5.0	0.0
Crustaceans			
Crab	*Peltarion* sp. and		
	Coenophtalmus sp.	36.4	45.5
Shrimp	*Pleoticus muelleri*	5.7	0.0
	Austropandalus grayi	35.0	9.1
Cephalopods			
Octopus	*Octopus* sp.	41.4	13.6
Squid	*Loligo gahi*	17.9	18.2
Echiurid	*Urechis chilensis*	44.3	9.1
Polychaete	*Eunice* spp.	52.1	27.3
Unidentified		36.4	27.3

breeding season (Table 3).

The relative contribution of each prey group varied as the breeding season progressed (Fig. 2). We observed an increase in the occurrence of fish and echiurid prey and a decrease in crustacean prey.

Anchovy mean total length was 151 mm (sd = 0.94, range = 137-165 mm, n= 11) and mean mass was 20.2 g (sd = 4.6, range = 15-29 g, n = 11). All codfish individuals were juveniles, with a maximum total length of less than 360 mm. Imperial Cormorants captured both juvenile and adult shrimps *Pleoticus muelleri* with a maximum total length of 120 mm. Prey classified according to habitat indicates a similar proportion of bottom and midwater prey during the breeding season, namely 42.5% benthic, 52.1% midwater prey. The rest remained unclassified.

Imperial Cormorants foraged both solitarily and in groups. During the 1991-92 breeding season, group foraging accounted for 24.3% of observations (n = 37), and group size varied between *c.* 100-500 individuals. During both 1990 and 1991, we started to observe group foraging at approximately the same time that anchovy started to be recorded in Imperial Cormorant diet. At Bahía Bustamante, we observed Imperial Cormorants foraging at distances between 50 m and 3 km from the shore. Outside Bahías

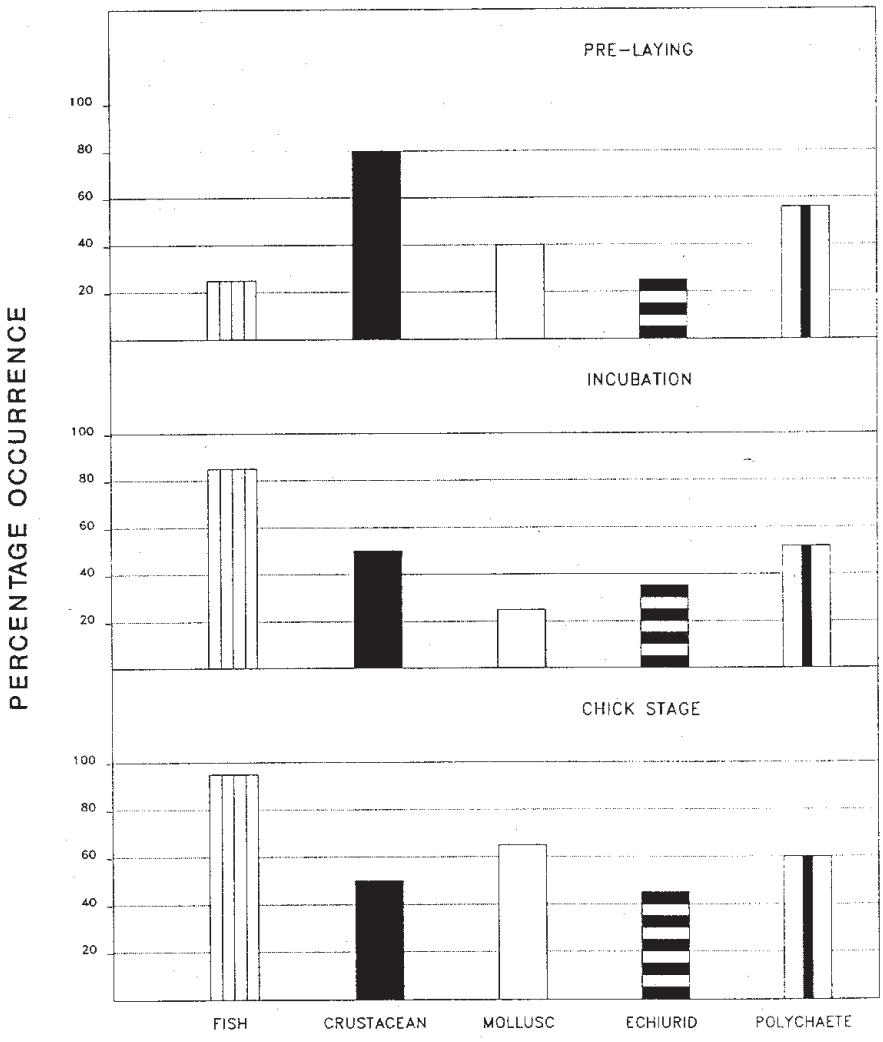

Figure 2

Seasonal variation of major prey groups in pellets of Imperial Cormorants in Bahía Bustamante during the 1991-92 breeding season.

TABLE 3

FOOD OF THE IMPERIAL CORMORANT IN BAHIA BUSTAMANTE DURING THE 1991-92 BREEDING SEASON (N = 16), EXPRESSED AS PERCENTAGE MASS AS DETERMINED BY REGURGITATION ANALYSIS

	Prey	%
Fish		
Rock Cods	*Notothenia* spp.	13.4
Ribeiroclinus	*Ribeiroclinus eigenmanni*	8.3
Anchovy	*Engraulis anchoita*	42.5
Codfish	*Genypterus blacodes*	5.1
Silverfish	*Odontesthes* spp.	1.3
Unidentified fish		1.9
Crustaceans		
Shrimp	*Austropandalus grayi*	2.0
Cephalopods		
Octopus	*Octopus* sp.	6.0
Squid	*Loligo gahi*	3.8
Echiurid	*Urechis chilensis*	6.0
Polychaete	*Eunice* spp.	6.8
Unidentified		2.9

Bustamante and Melo, we observed cormorants feeding 4 km from the coast. Both inside and outside these bays, Imperial Cormorants foraged in areas where maximum depth varied between 2 and 18 m.

DISCUSSION

Both species of cormorants shared most of the identified prey items, although during the breeding season Imperial Cormorants fed on a wider variety of prey species than did the Rock Shag. Whereas during the breeding season Rock Shags fed mainly on the bottom, Imperial Cormorants fed in similar proportions on bottom and midwater prey species. Additionally, Rock Shags foraged closer to the shore than did Imperial Cormorants.

Imperial Cormorants and Rock Shags nest in association at many locations along the Chubut coast (Punta 1989). The differences in diet composition and foraging behaviour observed between both species during the breeding season, and a difference of approximately three weeks in their timing of breeding (G.E. Punta & J.R.C. Saravia unpubl. data), appear to be important factors in the ecological segregation of these two sympatric cormorant species.

Our analysis of the seasonal variation in Imperial Cormorant diet composition shows an increase in consumption of fish, mainly anchovy and nototheniid fish, after the start of the incubation period and an increase in cephalopods during the chick-rearing stage. Anchovy schools around our

study area apparently get closer to cormorant breeding sites during November and December (R.R. Fondacaro pers. comm.), suggesting that changes in the composition of Imperial Cormorant diet may in part be determined by changes in prey availability.

The information we present on Imperial Cormorant winter diet corresponds only to the resident population in our study area. Most of the population disperses northward during the winter, and less than 10% of individuals remain near the breeding areas (G.E. Punta unpubl. data). Interestingly, the resighting and recovery of banded Imperial Cormorants at distances of up to 400 km from the breeding sites where they were banded (Punta in press), coincides with the migratory movements of anchovy (Angelescu & Cousseau 1967), one of their main prey species during the breeding season. Thus, it is likely that this prey species is included in the Imperial Cormorant's winter diet north of the study area.

The different populations of Imperial Cormorants are considered to be mainly piscivorous, with a preponderance of benthic fish in their diet (Blankley 1981, Brothers 1985, Espitalier-Noel *et al.* 1988). Even though the Chubut population also feeds on benthic fish, one of their main prey during the breeding season is the anchovy, which is a meso-pelagic species. This greater use of meso-pelagic prey might explain the higher incidence of group foraging in the Chubut Imperial Cormorants than in sub-Antarctic populations (Williams & Burger 1979, Brothers 1985).

Of the prey species found in the diet of Imperial Cormorants and Rock Shags in Patagonia, only codfish and shrimp *P. muelleri* are of commercial value near the study areas. However, whereas cormorants prey on juvenile codfish, the fishing fleet catches mainly adult individuals. On the other hand, an overlap exists between fisheries and Imperial Cormorants during the spring and summer months, because the fishing fleet catches both juvenile and adult shrimp.

The present data suggest that the overlap between fisheries and diets of the two cormorant species is currently low. However, although the Imperial Cormorant preys on juvenile codfish with a total length smaller than those caught commercially, we lack information on how the removal of adult codfish affects the potential availability of juvenile individuals to this cormorant. Additionally, juvenile codfish form part of the fishery's bycatch and are subsequently discarded (J.R.C. Saravia pers. obs.). Attention should also be paid to the development of the anchovy fishery in the Province of Chubut since this study has indicated that Imperial Cormorants depend on anchovy for at least part of the year.

ACKNOWLEDGEMENTS

We thank Gonzalo Herrera, Eduardo Hofinger, Juan Carlos Quintriqueo and Carlos Perez for assistance in the field, Guillermo Caille, Sonia Laurenti and Zulma Lizarralde for their assistance in prey species identification, and Viviana Malacalza for helpful comments on earlier drafts of this paper. We also thank Soriano S.A. and Patagonia Comercial S.R.L., and their personnel, for accommodations and logistic support during field work. Special thanks go to Antonio De Nichilo and the Dirección de Intereses Marítimos y Pesca Continental. We are grateful to an anonymous referee for valuable comments on the manuscript. Research was partially funded by Wildlife Conservation International, a division of the New York Zoological Society.

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