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ADAPTABILITY OF GREAT CORMORANTS *PHALACROCORAX CARBO* IN A COASTAL ENVIRONMENT DEMONSTRATED BY THEIR EXPLOITATION OF INTRODUCED PREY SPECIES AND USE OF ARTIFICIAL BREEDING SITES

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An analysis of the contents of regurgitations of great cormorant *Phalacrocorax carbo* chicks at two coastal colonies in South Africa, one on an offhore island (St Croix) and the other at a saltworks in an estuary (Swartkops), revealed that the diet was dominated by introduced freshwater and estuarine fish. Most other prey species were indigenous euryhaline fish, and from the size ranges of the estuary-dependent species it was clear that they had been obtained in estuaries. Great cormorants in this coastal environment have learned to exploit introduced fish species, but use offshore islands as safe breeding sites, unless suitably safe artificial sites are created near their preferred foraging areas.

Key words: chick regurgitations, diet, St Croix Island, Swartkops River

The great cormorant *Phalacrocorax carbo* is widely distributed in South Africa in marine, estuarine and freshwater habitats. Early observers concluded that it was essentially a coastal species in South Africa (Hustler and Underhill 1997). It is still more abundant in coastal areas (Brooke *et al.* 1982, Hustler and Underhill 1997), but inland populations appear to have increased, probably because of its adaptability and ability to exploit impoundments, introduced prey species and artificial breeding sites (Williams and Randall 1995).

Preliminary results based on ring recoveries led to speculation that the marine and inland populations of great cormorants in southern Africa were ecologically separated (Jarvis 1970). Subsequently, as more ring recoveries of banded nestlings were reported, it became apparent that interchange between coastal and inland populations was not uncommon (Skead 1980, Underhill *et al.* 1999). Interestingly, phenotypic differences were believed to exist between coastal and inland populations, the former being markedly heavier and longer-legged (Brooke *et al.* 1982).

Dietary studies have demonstrated that South African great cormorants consume a wide range of fish species (Rand 1960, Whitfield and Blaber 1979, Jackson 1984, Whitfield 1986, Kopij 1998). During studies on seabirds on islands in Algoa Bay and on estuarine birds in the nearby Swartkops River estuary, the diet of great cormorants was investigated at two colonies in very different breeding habitats. The main aim of this study was to gain an insight into possible ecological separation and breeding site selection of the species through analysis of its diet.

MATERIAL AND METHODS

The colony in a marine environment was on St Croix Island, Algoa Bay (Fig. 1). It consisted of about 45 pairs breeding on the crest of the island, which is an important breeding site for several seabird species (Randall *et al.* 1981). St Croix is a rocky island 12 ha in extent, which shelves off steeply to a depth of 20 m and is located 4 km from the nearest point on the mainland.

The colony in an estuarine environment was in the Swartkops River. It consisted of about 210 pairs breeding on small, artificial low-sand "islands" in a settling pond in a saltworks constructed in the flood plain (Martin and Randall 1987). The shortest distance between the Swartkops and St Croix Island colonies is 20 km.

The colony at St Croix Island was visited once a year in May or June from 1979 to 1985 to count the nests accurately and to ring the chicks. Visits were delayed until shortly before the chicks fledged so as to prevent kelp gulls *Larus dominicanus* preying on eggs and small chicks. The chicks frequently regurgitated food when approached or handled and the regurgitations were collected and stored separately for

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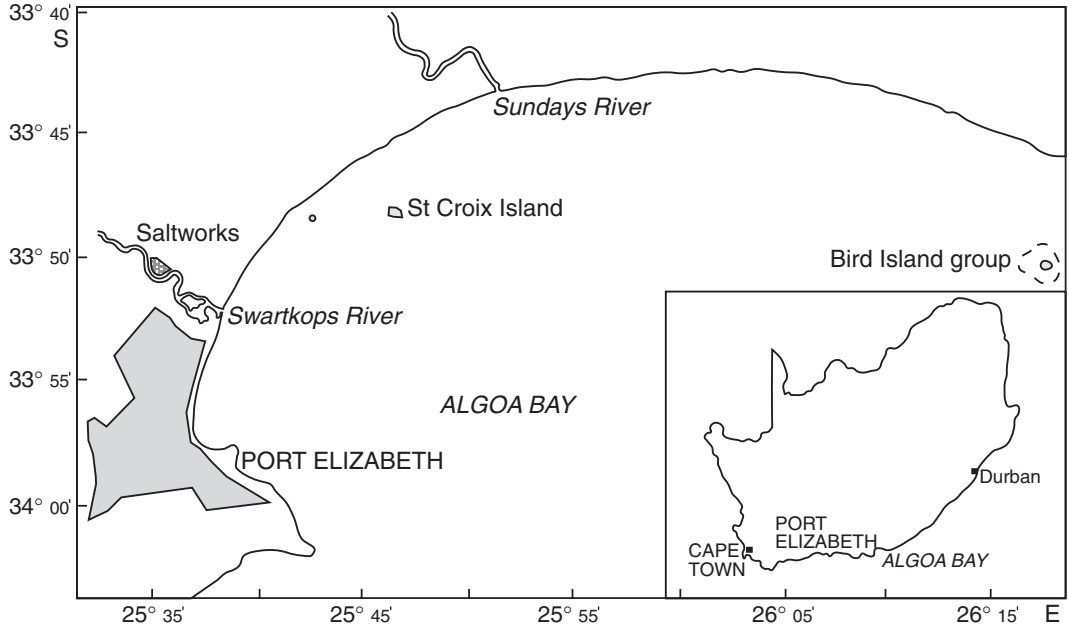

Fig. 1: Map of Algoa Bay, South Africa, showing the positions of the great cormorant breeding colonies and other places mentioned in the text

analysis.

The colony in the Swartkops River estuary was visited in March, April and May in 1985 and 1986. The colony was more densely packed than at the island and it proved difficult to separate samples from individual chicks. As a result, most samples contained the regurgitations of more than one chick.

Whole fish in the regurgitations were removed, identified and measured. Teeth were used to identify mullet to species level (Marais 1980). Identifiable partly digested fish were removed and their lengths estimated by comparison with fish of a similar size retrieved from the regurgitations or from a reference collection. Reconstituted wet mass was calculated using length:mass regressions (Marais and Baird 1980).

The presence of prey species in the regurgitations was expressed as frequency of occurrence (*%F*), relative number of individual items (*%N*), and relative contribution to total reconstituted mass (*%M*). The dietary importance of each food item was calculated using the "index of relative importance" (*IRI*) of Hyslop (1980):

$$IRI = (\%N + \%M) \times (\%F) \quad .$$

RESULTS

The regurgitations of great cormorants from the two sites contained 16 species of fish: 15 from St Croix Island and three from the Swartkops River estuary, of which two were common to both (Table I).

Carp *Cyprinus carpio* dominated the diet at both localities, and the Moçambique tilapia *Oreochromis mossambicus* was also an important prey species. Of roughly equal importance at St Croix Island were two mullet species, the freshwater mullet *Myxus capensis* and the flat-headed mullet *Mugil cephalus*. Three other species (groovy mullet *Liza dumerilii*, strepie *Sarpa salpa* and blacktail *Diplodus sargus*) were of lesser importance and the remaining eight species can be regarded as trace items (Table I).

Fish recorded in the regurgitations ranged from freshwater fish, through euryhaline species, with various degrees of dependence on estuaries, to a fully marine species. Freshwater and euryhaline fish dominated the diet of great cormorants at both colonies (Table I). Of particular note was the importance of introduced freshwater species in the diet, especially at

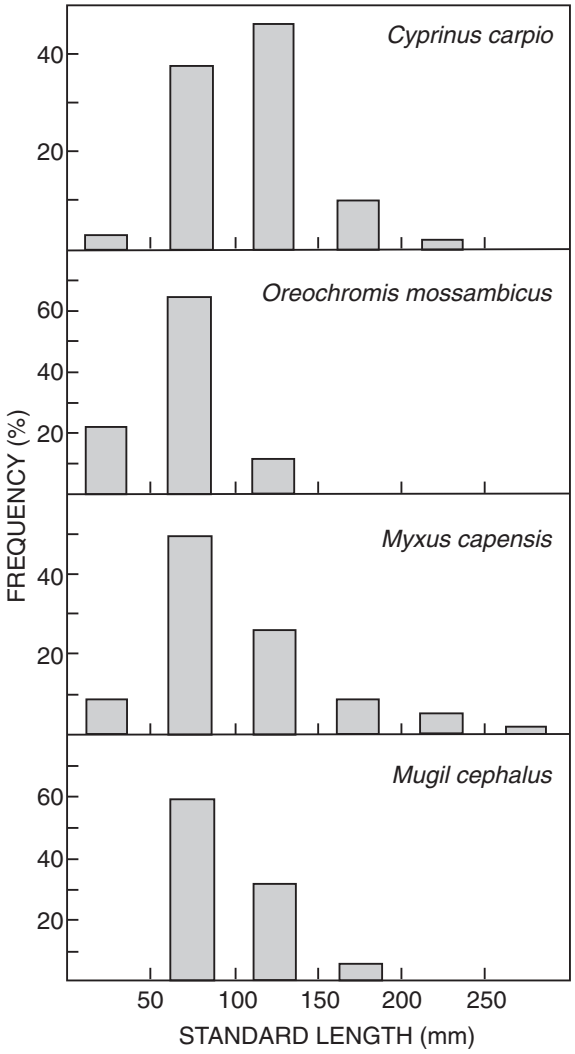

Fig. 2: Length frequency of the four most abundant prey species recovered from regurgitations of great cormorants chicks at the St Croix Island and Swartkops colonies

Swartkops, where the diet was composed almost exclusively of these species. Apart from the only truly marine species (i.e. koester *Acanthistius sebastoides*) and the freshwater species, the rest either have an estuarine phase in their life cycle or occur in estuaries.

The fish in the regurgitations varied greatly in size, from the smallest, a Moçambique tilapia of 28 mm standard length (*SL*), to the largest, a freshwater mullet of 265 mm *SL*. Three of the four most common prey species had the same modal size-class (51–100 mm *SL*; Fig. 2). Carp (median = 111 mm *SL*) were generally the largest of the four common prey species, followed by the two similar-sized mullet species, flat-headed mullet (median = 96 mm *SL*) and freshwater mullet (median = 90 mm *SL*), with Moçambique tilapia (median = 64 mm *SL*) the smallest.

DISCUSSION

The results of the analysis of the diet of great cormorant chicks at St Croix Island was not altogether surprising, considering how seldom they were seen feeding at sea. Despite spending many hours at sea in Algoa Bay, the present authors have never encountered great cormorants in the water away from the islands. A similar observation was made by Rand (1960), who noted how few great cormorants were seen at sea and that those he encountered were at reefs or close inshore. The stomach contents of the cormorants examined by Rand (1960) contained reef fish and it is assumed here that great cormorants diving in the immediate vicinity of the island were preying on reef fish. However, on many occasions during the present study they were seen diving for nest material, such as sea fans *Leptogorgia palma*. They were, however, recorded flying over the sea, apparently on their way to mainland waterbodies (Randall and Randall 1984).

Carp is an alien species that is essentially a bottom-dwelling freshwater fish of dams and slow-flowing rivers (Skelton 1993). It has a low salinity tolerance, but it has been recorded in the upper reaches of the Swartkops River estuary (Jubb 1965, Baird *et al.* 1986) and Sundays River estuary (Marais 1981, Beckley 1984). The Moçambique tilapia is a translocated indigenous species and is basically a freshwater fish, but it has a higher salinity tolerance than carp and therefore a wider distribution in estuaries (Skelton 1993, De Moor and Bruton 1988). There are a few records for the species in the Swartkops system (Baird *et al.* 1986) and it has been recorded in low numbers from the lower, middle and upper reaches of the Sundays Estuary (Beckley 1984). The first recorded introduction of Moçambique tilapia in the Port Elizabeth area took place at North End Lake in 1961, and of particular interest is that there was an influx of piscivorous birds, notably great cormorants, soon afterwards (De Moor and Bruton 1988). It therefore appears as if great cormorants from the St Croix Island and Swartkops

Table I: Contents of regurgitations obtained from chicks of great cormorants on St Croix Island and Swartkops Estuary expressed as percentage frequency of occurrence (%*F*), relative number of prey items (%*N*), percentage mass of prey (%*M*) and index of relative importance (*IRI*). Habitat denotes whether the prey species occur exclusively or predominantly in marine (m), estuarine (e) or freshwater (f) – Whitfield (1994). Totals represent the number of regurgitations (*F*), number of prey items (*N*) and reconstituted mass of prey (*M*, g)

Prey species	Habitat	%*F*	%*N*	%*M*	*IRI*
		St Croix Island			
*Cyprinus carpio**	f	48.3	28.8	27.0	2 690.72
*Oreochromis mossambicus***	f (e)	12.1	12.0	7.5	236.09
Myxus capensis	e (f,m)	19.0	18.5	22.6	779.36
Mugil cephalus	e (f,m)	20.7	18.0	14.5	673.58
Liza dumerilii	e (m)	6.9	3.0	10.5	92.82
Sarpa salpa	m (e)	8.6	3.0	6.8	84.84
Diplodus sargus	m (e)	3.4	11.6	4.4	55.03
Monodactylus falciformis	e (m,f)	3.4	1.7	1.1	9.65
Lithognathus mormyrus	m (e)	1.7	0.4	0.2	1.06
Heteromycteris capensis	e (m)	1.7	0.4	0.6	1.73
Terapon jarbua	e (m,f)	1.7	0.4	0.2	1.13
Rhabdosargus holubi	e (m)	1.7	0.9	1.1	3.44
Pomadysus olivaceum	m (e)	1.7	0.4	0.1	0.88
Acanthistius sebastoides	m	1.7	0.4	2.8	5.53
Argyrosomus japonicus	e (m)	1.7	0.4	0.6	1.73
Totals		58	233	8 673	
		Swartkops Estuary			
*Cyprinus carpio**	f	80.0	75.5	93.7	13 533.91
*Oreochromis mossambicus***	f (e)	26.7	23.5	5.2	765.23
Liza tricuspidens	e (m)	6.7	1.0	1.1	14.20
Totals		15	102	3 749	

* Alien species
** Translocated indigenous species

colonies could have exploited impoundments, rivers or estuaries to obtain these prey species.

Of the remainder of the species recovered from the regurgitations, all except one (koester) have been recorded in the Swartkops Estuary (Baird *et al.* 1986) and the Sundays Estuary (Marais 1981, Beckley 1984). Although they have marine phases in their lives, an indication that cormorants obtained most of their prey in estuaries is provided by the fact that most of the fish in the regurgitations were juveniles.

During surveys of the distribution and abundance of birds in the Swartkops Estuary, great cormorants were recorded from the mouth to the upper limit of tidal influence (Martin and Baird 1987). Of particular interest was that high-tide counts of cormorants were 11 times higher than low-tide counts, which was attributed to cormorants moving into the estuary at high tide (Martin and Baird 1987).

The eggs of great cormorants from St Croix Island contained residue levels of pollutants, such as organochlorine insecticides and polychlorinated biphenyls, which were among the highest measured in coastal birds in the Port Elizabeth area (De Kock and Randall 1984). The levels were not high enough to cause reproductive impairment, but relative to seabirds on the offshore islands it appeared that great cormorants were feeding in a more polluted environment. This conclusion is supported by the findings of the diet study.

The St Croix Island colony was smaller during the study period than it had been in the 1950s (Rand 1963) and early 1970s (Randall *et al*. 1981). The date of establishment of the Swartkops colony is unknown. However, it could not have been before the 1960s because the "islands" in the salt works were constructed between 1961 and 1962 (Martin and Randall 1987). It seems likely that, once the Swartkops colony was established, it started drawing cormorants off the islands and presumably the attraction was the proximity to the foraging areas. During the 1990s, following attacks by feral dogs and people removing eggs, most of the cormorants deserted the Swartkops colony (APM unpublished data). Some settled at a safer site in a saltworks in the Sundays Estuary (APM

pers. obs.), whereas others appear to have gone to St Croix Island, where the population increased and numbered 117 pairs in March 1999 (R. J. M. Crawford, Marine & Coastal Management, pers. comm.).

In other studies of the diet of great cormorants in South Africa, the prey species reflected what was available in the immediate vicinity, regardless of whether the cormorants were sampled in freshwater dams (Kopij 1998), coastal lakes (Whitfield 1986), estuaries (Whitfield and Blaber 1979, Jackson 1984), or at sea (Rand 1960). Clearly, it must have been energetically beneficial for the cormorants from St Croix Island to undertake foraging trips of 40 km or more when marine species were potentially available within 200 m of the colony. The processes involved in prey selection remain speculation, but the reason the cormorants undertake the flights can be attributed to their need for secure breeding sites; offshore islands serve this purpose (Williams and Randall 1995).

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