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SPATIAL AND TEMPORAL PATTERNS OF DIET IN THE CAPE CORMORANT OFF SOUTHERN AFRICA[1]

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Abstract. Diets of Cape Cormorant (*Phalacrocorax capensis*) were sampled from 1981 to 1985, between Mercury (25°43'S) and Dyer (34°41'S) islands of the Benguela upwelling ecosystem off Namibia and South Africa. Over 99% of identifiable prey items were pelagic fish: cape anchovy (*Engraulis japonicus capensis*), 46%; pelagic goby (*Sufflogobius bibarbatus*), 34%; and maasbanker (*Trachurus trachurus*), 14%. Daily, monthly, and regional variation in diet was three to four times that of annual variation, suggesting that environmental variability in the Benguela ecosystem is greatest at time intervals shorter than 1 year and that caution is necessary when inferring diets of Cape Cormorants from limited sampling.

Key words: *Anchovy; Benguela; cormorant; diet; variability.*

INTRODUCTION

Seabird diets are being increasingly used to assess the population dynamics and behavior of marine fish (e.g., Crawford and Shelton 1978, 1981; Anderson et al. 1980; Wilson 1985a; Duffy et al. 1985). Cape Cormorant (*Phalacrocorax capensis*) diets have been used for such assessments in the Benguela upwelling ecosystem of southern Africa (e.g., Crawford and Shelton 1981; Burger and Cooper 1984; Cooper 1984, 1985; Duffy et al. 1984, 1985; Crawford et al. 1985). Many of these studies relied on data collected over short periods or even single days. However, variability in diets may occur spatially, between colonies, and temporally, between days, seasons, and years, so that sampling may provide misleading information, if its variability is not considered.

We examined variability in the diets of Cape Cormorants in Namibian and South African waters using regurgitates (pellets) of indigestible matter produced by the birds (Duffy and Laurenson 1983). These pellets contain fish otoliths, eye crystals, crustacean exoskeletons, and cephalopod beaks.

METHODS

Between November 1981 and November 1985, shortly after sunrise to avoid loss of pellets to scavenging Hartlaub's Gulls (*Larus hartlaubi*) and Sacred Ibis (*Threskiornis aethiopicus*), we attempted to collect at least 20 pellets from overnight roosts of Cape Cormorants during 66 sampling periods. Samples were taken from eight localities from November 1981 to November 1985 (see Appendix).

Each pellet was sun-dried in the field, wrapped in tissue paper, and then oven-dried in the laboratory at approximately 50°C for 12 hr. For analysis, we moistened the samples then teased them apart with dissecting needles under a 10× binocular microscope. Where possible, all otoliths and cephalopod upper-beaks were identified to lowest possible taxon and counted. We did not attempt to pair otoliths because digestive erosion makes size determination unreliable (Duffy and Laurenson 1983) and otoliths were sometimes very numerous. Percentage data were arc-sin transformed to calculate means and standard deviations.

RESULTS

A total of 33,612 digestion-resistant hard parts of prey was extracted from 1,108 pellets (901 with contents other than stones) of Cape Cormorant pellets. Only 12.5% of the otoliths were too eroded for identification. Over 99% of the remaining 29,398 prey objects were otoliths from pelagic school fish. Cape anchovy (*Engraulis ja-*

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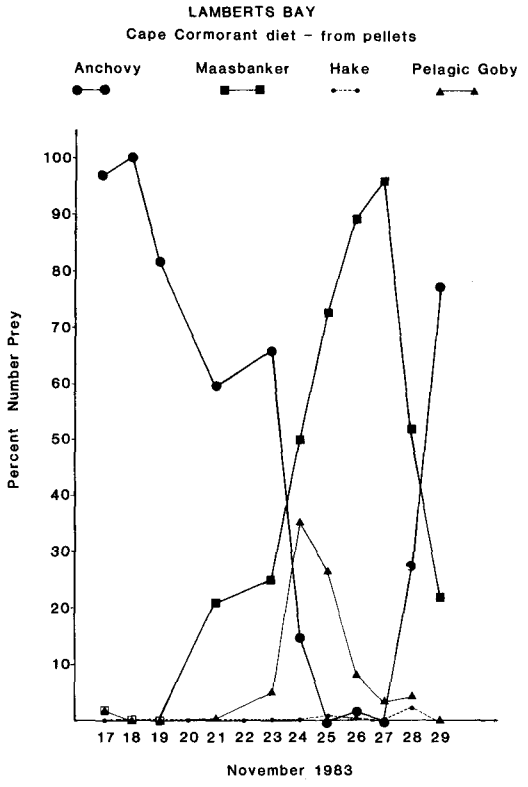

FIGURE 1. Daily variation in the diets of Cape Cormorants at Bird Island: 17 to 29 November 1983.

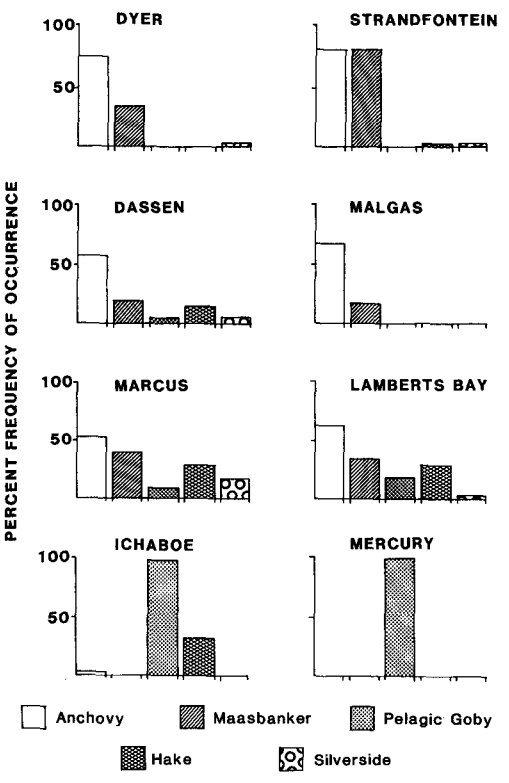

FIGURE 2. Regional variation, based on frequency of occurrence, of Cape Cormorant diets in Namibia and South Africa.

ponicus [*capensis*]), pelagic goby (*Sufflogobius bibarbatus*), and maasbanker (*Trachurus trachurus*) were the most important prey species (Table 1). Although hake (*Merluccius* spp.) accounted for only 3% of the identifiable prey remains by number, their otoliths occurred in 20% of the pellets.

The between-day variation in pellet composition was high. During November 1983 at Bird Island, the relative abundance of anchovy in pellets ranged from 0 to 100% ($\bar{x}$ = 74.5%; SD = 19.8%; Fig. 1). When anchovy were scarce in pellets, these were composed almost entirely of maasbanker and hake otoliths.

Regionally, prey composition also varied (Figs. 2, 3). In the southwestern and southern Cape, between Dyer Island and Bird Island, Lambert's Bay, anchovy accounted for more than 59% of all prey items, and anchovy otoliths were the most frequent prey remains in pellets. Maasbanker accounted for most of the remaining major prey and was the second-most common prey,

TABLE 1. Principal prey species, percentage relative abundance (of otoliths, upper cephalopod beaks, and crustacean exoskeletons; n = 29,398) and frequency of occurrence (n = 901 pellets with contents), of the Cape Cormorant as determined by pellet analysis.

	Relative abundance (%)	Frequency of occurrence (%)
Anchovy (*Engraulis capensis*)	45.77	58.4
Pelagic goby (*Sufflogobius bibarbatus*)	34.20	19.6
Maasbanker (*Trachurus trachurus*)	14.42	37.0
Hake (*Merluccius* spp.)	3.11	19.5
Silverside (*Aetherina breviceps*)	2.02	4.4
Squid (*Loligo* spp.)	0.18	3.4
Stomatopod (*Squilla armata*)	0.14	4.0
Redeye (*Etrumeus teres*)	0.05	0.6
Pipefish (*Syngnathus acus*)	0.03	0.1
Pilchard (*Sardinops ocellata*)	0.02	0.3
Other	0.06	1.8

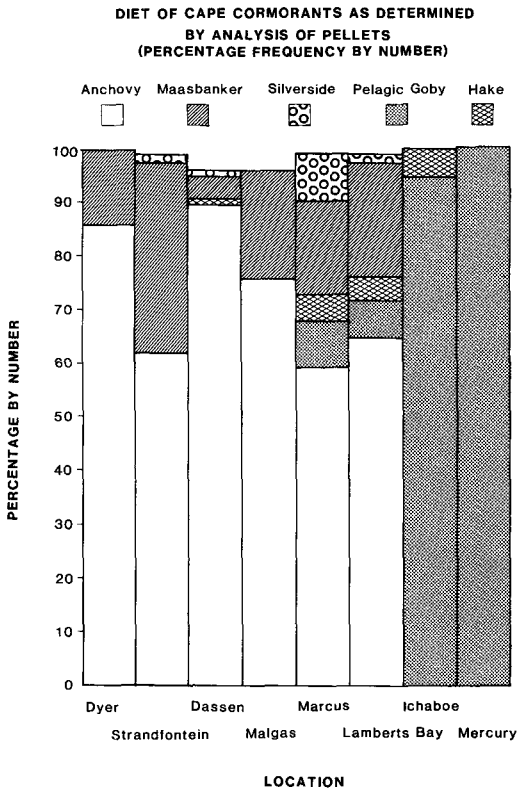

FIGURE 3. Regional variation, based on relative numerical abundance, of Cape Cormorant diets in Namibia and South Africa.

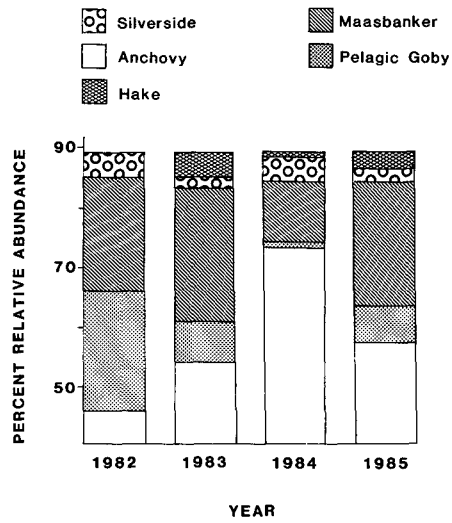

FIGURE 5. Interannual variation of major prey species in pellets of Cape Cormorant at Marcus Island 1982 to 1985.

by frequency of occurrence. At Ichaboe and Mercury islands, off central Namibia, anchovy were almost entirely absent. Pelagic goby accounted for 10% of the otoliths found in pellets from Marcus and Bird islands, and for almost all otoliths found in pellets from Ichaboe and Mercury islands. Hake accounted for up to 6% of prey items in pellets at islands between Dassen and Ichaboe, and a silverside (*Atherina breviceps*) accounted for up to 9% of prey items between Dyer Island and Lambert's Bay.

In Saldanha Bay, pellets collected from January through August were highly variable in species composition (anchovy relative abundance, $\bar{x}$ = 58.5%; SD = 14.4%; Fig. 4), with pelagic goby, anchovy, maasbanker, and hake numerically most abundant during different

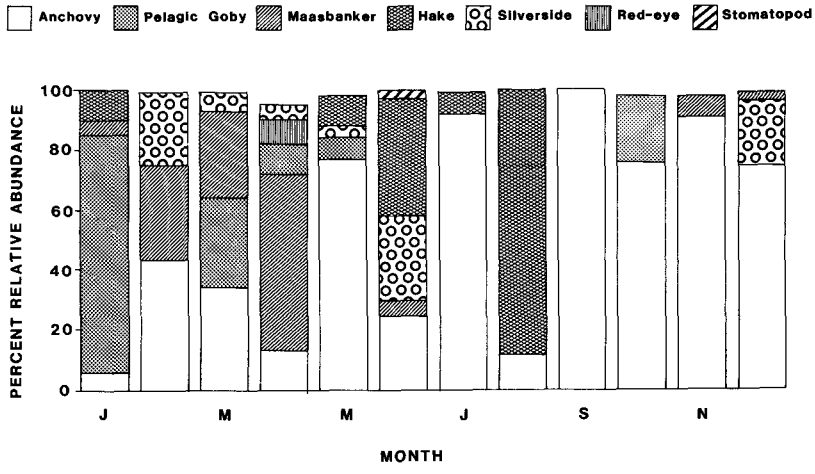

FIGURE 4. Seasonal variation of major prey species in pellets from Marcus and Malagas Islands, Saldanha Bay: 1982 to 1985.

months. From September through December, anchovy otoliths were most abundant, accounting for more than 78% of the identifiable prey remains in pellets.

There was comparatively little interannual variation in the numerical abundance of the major prey items in pellets collected at Marcus Island during 1982 to 1985 (anchovy relative abundance, $\bar{x} = 76.3\%$; SD = 3.4%; Fig. 5). Anchovy otoliths accounted for 56 to 83% of all prey remains and maasbanker, 10 to 22%. Pelagic goby showed the most variability, accounting for 1 to 20% of all prey remains.

DISCUSSION

The abundance of anchovy in Cape Cormorant diets was highly variable between colonies, and between days and months, but less variable between years. This suggests that for Cape Cormorants the Benguela upwelling is more predictable between years than it is within years or between areas.

Cape Cormorants feed almost exclusively on pelagic fish (cf. this study, Rand 1960, Crawford and Shelton 1981) and the high between-day variability in pellet composition may arise because the birds feed primarily in large flocks (Duffy, unpubl.). Such flocks must feed on large fish schools, so all birds within a flock are likely to contain the same prey, because they have obtained their daily food ration from only one or a few schools. In contrast, African Penguins (*Spheniscus demersus*) exploit the same prey species as do Cape Cormorants, but have a low variability in diet composition (Wilson 1985b). African Penguins forage in small groups (Siegfried et al. 1975, Wilson et al. 1986) on small schools (Wilson 1985a) and are more likely to encounter prey in proportion to their relative abundance in the environment. However, daily examination of Cape Cormorant diet, particularly when considered together with data on penguin diet, may yield valuable insights into the short-term schooling behavior of pelagic fish.

Sampling over short periods or inferring the Cape Cormorant's diet from samples at a single colony may be misleading. We suggest that the large variances in the diet of the Cape Cormorant necessitate an intensive and extensive sampling program before prey abundance data can be useful for assessing fish population dynamics within years, but that assessments between years require fewer samples.

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APPENDIX

Collecting localities and dates for pellets of Cape Cormorants.

1. Dyer Island (34°41′S, 19°25′E), Cape Province, on 18 November 1981; 23 February, 18 November 1984; 4 February, 10 November 1985 (202 pellets; 5,091 identifiable otoliths).
2. Strandfontein sewage works (34°05′S, 18°31′E), Cape Town, on 16 February, 20 March, 24 September, 3 October, 30 November, 17 December 1984 (130 pellets; 5,132 identifiable otoliths).
3. Dassen Island (33°26′S, 18°05′E), Cape Province, on 1 March, 24 July 1984; 20 August 1985 (58 pellets; 389 identifiable otoliths).
4. Marcus Island (33°03′S, 17°58′E), Saldanha Bay, Cape Province, on 14 March 1982; 12 and 14 April 1983; 29 February, 16 and 26 July, 26 October to 2 November, 6 November, 21 December 1984; 13 to 15 January, 12 to 13 February, 27 April, 17 May, 29 June, 24 August 1985 (277 pellets; 4,064 identifiable otoliths).
5. Malagas Island (33°03′S, 17°56′E), Saldanha Bay, on 9 March 1982; 16 June, 27 September, 21 November 1983 (44 pellets; 168 identifiable otoliths).
6. Bird Island (32°05′S, 18°24′E), Lambert's Bay, on 4 July 1982; 14 June, 19 July, 19 August, 28 September, 19 October, 17, 18, 19, 21, 23, 24, 25, 26, 27, 28, and 29 November 1983 (286 pellets; 4,665 identifiable otoliths).
7. Ichaboe Island (26°17′S, 14°56′E), Namibia, on 19 February 1982; 15, 16, and 18 March, 3 October 1983 (101 pellets; 8,876 identifiable otoliths).
8. Mercury Island (25°43′S, 14°50′E), Namibia, on 6 February 1982 (10 pellets; 1,103 identifiable otoliths).