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S24-2 Molt of the African penguin, *Spheniscus demersus*, in relation to its breeding season and food availability

R.J.M. CRAWFORD[1], M. HEMMING[2], J. KEMPER[2,3], N.T.W. KLAGES[4], R.M. RANDALL[5], L.G. UNDERHILL[2], A.D. VENTER[6], V.L. WARD[6], A.C. WOLFAARDT[6]

1. Marine and Coastal Management, Private Bay X2, Rogge Bay 8012, South Africa; crawford@mcm.wcape.gov.za
2. University of Cape Town, Rondebosch 7701, South Africa
3. c/o Ministry of Fisheries and Marine Resources, PO Box 394, Lüderitz, Namibia
4. University of Port Elizabeth, PO Box 1600, Port Elizabeth 6000, South Africa
5. South African National Parks, PO Box 176, Sedgefield 6573, South Africa
6. Western Cape Nature Conservation Board, Private Bag X100, Vlaeberg 8018, South Africa

Abstract In South Africa, most adult African penguins molt between September and January; at Namibia's Mercury Island, most molt in April and May. Throughout their range most immature birds molt between November and January. The season of breeding varies between colonies but at each takes place when food is likely to be most abundant nearby. The main molt of adults occurs when food is least available near colonies. Birds that stop breeding earlier than usual may undertake an early molt.

Key words Molt timing, Breeding timing, Food availability, African penguin

1 Introduction

African penguins (*Spheniscus demersus*) molt annually. Molt takes ca. 21 days from arrival at a breeding locality, after a pre-molt fattening-up period, to departure after replacing plumage. Birds undertake periods of fattening of ca. 34 days before and ca. 41 days after molt (Randall and Randall, 1981), so that the overall time allotted to molt, including pre- and post- molt gains in condition, is about 96 days per annum. The annual cycle of African penguins has been described for St. Croix Island at Eastern Cape, and Robben Island at Western Cape, South Africa (Randall and Randall, 1981; Crawford et al., 1995a). The cycle at Robben Island lags behind that at St. Croix by about one month. Breeding and molt at Mercury Island, Namibia, occur several months later than at Robben Island (Crawford et al., 1995b). In this paper we collate published and unpublished information on the period of molt of African Penguins at seven localities and assess how molt and breeding are related to the availability of food.

At Robben Island in 1994/1995, it was noted that the molt of adults was less synchronized than normal. This was attributed to the stopping of breeding and early commencement of molt in birds oiled by the foundering of the *Apollo Sea* in 1994 (Underhill and Crawford, 1999). In 2000, large numbers of penguins were again oiled at Robben Island, following the foundering of the *Treasure*. The date of molt in banded birds known to have been both oiled and unaffected was monitored to investigate further the likelihood that oiled birds molted earlier than normal. Results are reported.

2 Materials and methods

Counts of African penguins in the feather-shedding phase of molt were made at Mercury Island (25°43'S, 14°50'E) from July 1996–July 2001 (Kemper et al., 2001, 2002), at Lambert's Bay (32°05'S, 18°18'E) from September 1997–June 2002, at Dassen Island (33°25'S, 18°05'E) from November 1994–June 2002, at Robben Island (33°48'S, 18°22'E) from October 1988–June 2002 (Underhill and Crawford, 1999), at Dyer Island (34°41'S, 19°25'E) from September 1999–June 2002, at St. Croix Island (33°48'S, 25°46'E) from July 1979–June 1981 (Randall, 1983; Randall et al., 1986) and at Bird Island (33°50'S, 26°17'E) from June 1992–May 1997. At Bird Island, counts were of adult birds only; at all other localities birds in both immature and adult plumage were counted. Methods of counting were as described by Underhill and Crawford (1999).

Counts were made at weekly intervals at Dassen Island and bi-weekly at other localities. Gaps in data were filled by interpolation. In African penguins, the feather-shedding phase of molt lasts on average 12.7 days, so that counts at intervals of two weeks would be of different birds. The sum of such counts over a year thus provide an estimate of population size per colony (Randall et al., 1986). Counts at intervals of one week provide two such estimates. A procedure similar to that described by Underhill and Crawford (1999) was used to calculate numbers of birds molting in each month for which observations were made.

At Robben Island, band numbers were recorded

weekly for penguins in the feather-shedding phase between October 2000 and January 2001 (Hemming, 2001). For each week, the ratio of oiled to unoiled birds was calculated. Information on the phenology of breeding of African Penguins, and on the availability of prey near colonies, was obtained from literature. The average monthly catch of the sardine (*Sardinops sagax*) off South Africa's Eastern Cape during 1989–2001 was calculated from records maintained at Marine and Coastal Management.

3 Results

At Mercury Island, the proportion of adults molting was greatest in April and May. At South African colonies, it was greatest from September to January, with a tendency to start earliest at Bird Island and latest at Dassen and Robben islands (Fig. 1a, b). At all six localities monitored, most immature birds molted between October and January, molt being about one month earlier at Lambert's Bay and Dyer Island than at the other localities (Fig. 1c,d).

From October until the first week of December 2000, the number of oiled and cleaned birds molting at Robben Island was more than twice, and up to nine times, the number unaffected. In the second and fifth weeks of December 2000, numbers of oiled and unaffected birds in molt were approximately equal. In other weeks in that month and throughout January 2001, most banded birds that were molting had not been oiled (Fig. 2).

On Eastern Cape, the average annual catch of sardines is low in January, increases to a peak in May, remains high in June, and then falls into a trough in September. Reasonable catches are made in November and December (Fig. 1b).

4 Discussion

Off Namibia, sardine and anchovy (*Engraulis capensis*), two of the main prey species of African penguins (Shelton et al., 1984), usually occur north of penguin breeding localities. However, both may spawn off central Namibia, sometimes as far south as Mercury Island, the first mainly from October to December and the latter from November to April. Spawning occurs inshore (King, 1977). Another prey species, the pelagic goby (*Sufflogobius bibarbatus*), is also present in high densities near Mercury Island, where it spawns inshore from July to February, peaking in November and December. In February 1980, pelagic gobies comprised 73% of food eaten by African penguins

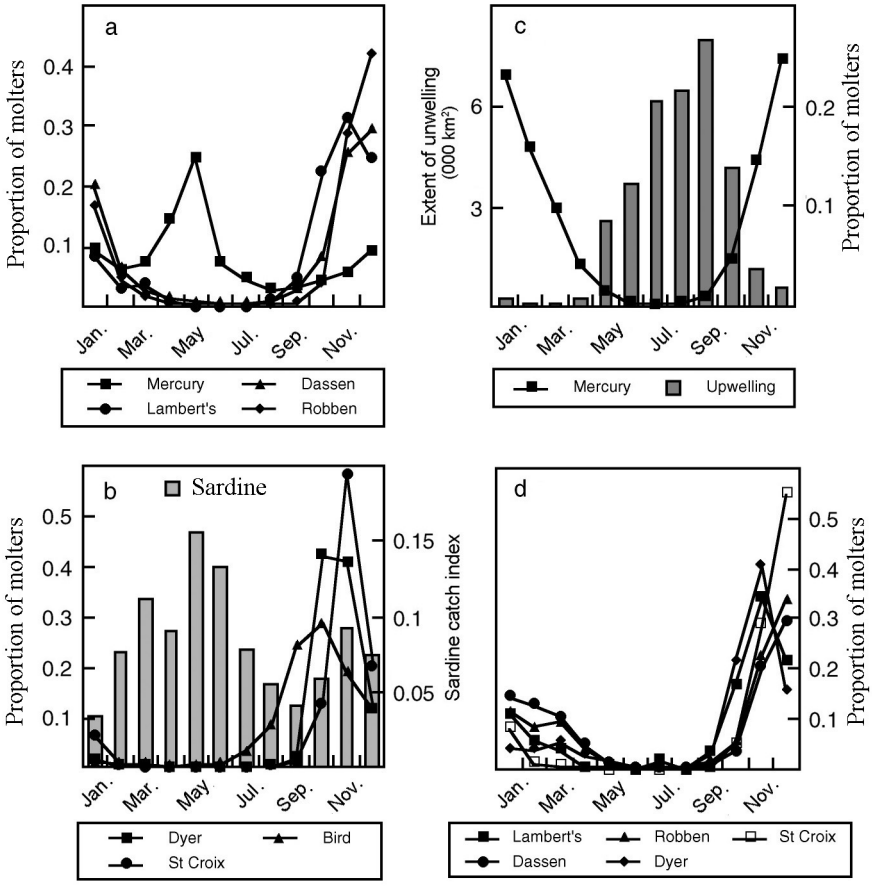

Fig. 1 Proportions of African penguins molting each month: a, adults at Mercury, Dassen and Robben islands and Lambert's Bay, west South African coast; b, adults at Dyer, St Croix and Bird islands, south South African coast; c, immature birds at Mercury Island; and d, immature birds at five South African colonies

The average monthly catch of sardine off Eastern Cape during 1989–2001 is shown in b, and the seasonal extent of intense Benguela upwelling in the vicinity of Mercury Island in c, estimated by Hagen et al. (2001).

at Mercury Island (Crawford et al., 1985).

Most penguin breeding at Mercury Island takes place between August and March, peaking between October and January (Crawford et al., 1995b; Kemper, unpublished information). At adjacent Ichaboe Island, most chicks have hatched by November (Shelton et al., 1984), so that chick rearing and fledging periods coincide with spawning anchovy, sardine and pelagic goby nearby. The main molt in adults then takes place in April and May when anchovy and sardine are locally scarce.

In South Africa, young sardine and anchovy congregate inshore along the west coast from March until September. They then migrate south to their spawning grounds over the Agulhas Bank, where they arrive from August onwards. Old sardine also are available along the west coast from March to September. Sardine of intermediate age are abundant on the western Agulhas Bank from January to April, after which some migrate past the Eastern Cape to KwaZulu-Natal for winter (Crawford, 1980). Unlike the situation in Namibia, most spawning over the Agulhas Bank takes place between 30 to 130 km offshore, and mainly from September to February in both fish (Armstrong and Thomas, 1989).

At South Africa's Western Cape, African penguins breed mainly from February to September (Crawford et al., 1995a) when young anchovy and sardine and older Sardine are most abundant in the area. At St Croix Island off Eastern Cape, the main breeding season is from January to July (Randall and Randall, 1981). Sardine is abundant off Eastern Cape from March to June (Fig. 1), the period when chicks from first-laid clutches are being reared and departing to sea (Randall and Randall, 1981). Most penguins in South Africa molt during the spawning period for sardine and anchovy, when these fish are generally farther offshore and beyond the usual foraging range of breeding penguins. Off western South Africa, the foraging range of penguins feeding chicks is estimated to be 11–15 km; off Eastern Cape, however, breeding birds may forage up to 40 km from their colonies (Heath and Randall, 1989; Wilson et al., 1989).

Molting in adults at Lambert's Bay peaks earlier than at Dassen and Robben islands, matching the southward movement of young anchovy and sardine to spawning grounds on the Agulhas Bank through winter and spring. Adults molting at Dyer and St Croix islands also peak ahead of those at Dassen and Robben islands. In spring, maturing anchovy join spawning shoals over the Agulhas Bank, and on the south coast may not be available regularly in waters near penguin breeding colonies inshore. At Bird Island, the easternmost breeding colony of African penguins, numbers of adults molting increase markedly from September, after sardine on the south coast have moved to KwaZulu-Natal or commenced spawning.

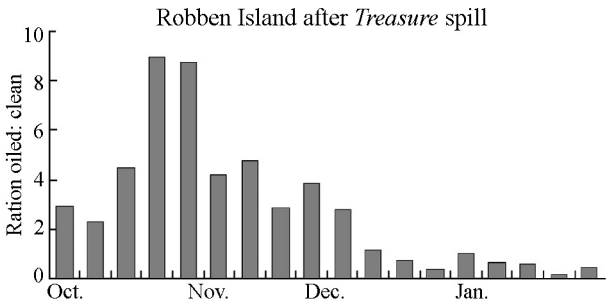

Fig. 2 The ratio of oil-affected banded penguins in molt at Robben Island to those unaffected for each week during October 2000–January 2001 (Data from Hemming, 2001).

As observed by Randall and Randall (1981), it appears that availability of fish in the vicinity of breeding colonies determines the main breeding season of African penguins and that this, in turn, determines when adults molt. Birds are able to forage farther afield on feeding trips undertaken before and after molt than when breeding. After terminating breeding in 2000, two African penguins from Dassen and Robben islands spent lengthy periods at feeding grounds well beyond the normal foraging ranges of penguins when breeding at these islands (http://www.uct.ac.za/depts/stats/adu/oilspill/ sapmap.htm).

In South Africa, immature and adult African penguins molt at more or less the same time. At Mercury Island in Namibia, immature penguins do not molt at the same time as adults. Rather, they and immature birds at Ichaboe (26°17'S, 15°46'E), Halifax (26°38'S, 15°05'E) and Possession (27°01'S, 15°12'E) islands (Kemper et al., 2002), molt at much the same time as immatures in South African colonies. It is the exception to the rule that African penguins molt when food is least abundant near breeding colonies. Immature penguins at Mercury Island molt when the seasonal surface waters there reach minimum temperatures of <13°C (Fig. 1c). Hagen et al. (2001) assume that this water provides an index of intense Benguela upwelling. However, in a review of other information, Shannon (1985) suggests that upwelling around Mercury Island peaks between October and December. From May to September, when the extent of cold surface water near Mercury Island is greatest, immature penguins may move north to feed on sardine and anchovy, which are then abundant at about 23°S.

The generally earlier molt in oil-affected adults at Robben Island in 2000/2001 (Fig. 2) suggests that rehabilitated birds stop breeding and enter molt before unaffected birds. Ability to alter the onset of molt will enable penguins shifting to other colonies with different breeding times to adjust their annual cycle to that of the new colony (Underhill and Crawford, 1999). Established breeders invariably return to former breeding localities to locate their mates (Randall, 1983), but those breeding for the first time may move elsewhere (Whittington, 2002). This provides a mechanism for African penguins to respond to long-term changes in the distribution of their prey (Crawford, 1998).

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