

## Cephalopod Beaks and Studies of Seabird Diets

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Cephalopod beaks and other hard prey remains are frequently used to study pelagic seabird diets, because intact prey are rarely found in collected birds (Baltz and Morejohn 1977, Brown et al. 1981). Beaks and fish otoliths can be used to identify the species consumed (Clarke 1962, Ross et al. 1979). Prey leaving hard remains in the stomach, however, can appear to be more important than more readily digested prey (Hartley 1948, Hyslop 1980). This paper reports a study of the retention times of such hard parts in a captive Shy Albatross (*Diomedea cauta*).

The albatross was captured on 1 December 1982 from a demersal trawler approximately 150 km northwest of Cape Point, South Africa (34°50'S, 16°40'E). Using the techniques of Frings and Frings (1959), we maintained the bird for 46 days at approximately its weight at capture of 3.9 kg by feeding it 200–300 g of pilchard (*Sardinops ocellata*) daily.

The cage was examined daily for regurgitations and feces containing hard prey remains such as squid beaks and fish otoliths. On 13 December we fed the bird 19 pairs of *Loligo reynaudi* beaks (i.e. upper and lower). After 16 January 1983, the bird began to lose weight, and we killed it on 21 January when it became too weak to be released. All remaining hard parts in the stomach and gizzard were identified to family.

During the 7 weeks of its captivity, we found no hard parts in regurgitations or feces, but after death 38 squid beaks were found in the stomach and gizzard. Nineteen were identified as *Loligo reynaudi* and were, therefore, the same ones we had fed to the bird, and the other 19 were from the family Ommastrephidae. All beaks found were relatively uneroded. We found no fish otoliths.

The *Loligo* beaks persisted in the stomach for 38 days. The Ommastrephid beaks must have been ingested before capture and so must have been present for at least 50 days. In contrast, no otoliths were present in the stomach, although the bird had been fed pilchard the previous day.

This suggests that there can be great differences in the residence times in seabird stomachs of the hard parts of two of the major prey types. Laysan Albatrosses (*D. immutabilis*) retained plastic telemetry transmitters in their stomachs for up to 40 days (Pettit et al. 1981), a similar time scale to our findings. Uspenski (1956) found that Thick-billed Murre (*Uria lomvia*) retained fish otoliths for no more than 24 h. Duffy and Laurenson (1983) found that Cape Cormorants (*Phalacrocorax capensis*) retained fish otoliths for only a day and severely eroded them.

Although digestion rates of squid beaks in nature remain unknown and could vary among different seabird species, our data tend to confirm Ashmole and Ashmole's (1967) suggestion that squid beaks can persist in seabird stomachs far longer than the hard parts of other types of prey. Consequently, the importance of squid could be severely overemphasized if squid beaks were used to reconstruct original meal volume and frequency of occurrence of different prey types. When not too eroded, squid beaks can often be used for the identification of species and sizes of squid taken by seabirds. Moreover, there is a strong possibility that smaller squid beaks are digested completely (Imber 1973), which would overemphasize the importance of larger individuals.

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### Aerobatic Rolls by Ravens on Santa Cruz Island, California

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Common Ravens (*Corvus corax*) are skillful fliers known for their aerobatic maneuvers, particularly rolls (Dawson 1923, Goodwin 1976, Wilmore 1977, Coombs 1978). Santa Cruz Island, one of the eight Channel Islands off the shore of southern California, supports a large population of ravens that exhibit a high frequency of rolling. The significance of rolling, and raven aerobatics in general, is uncertain; such behavior has been attributed to courtship (Bent 1946, Angell 1978), play (Hoffmann 1927, Fagen 1981), or both (Dawson 1923, Wilmore 1977). Angell (1978) noted that rolls often coincided with vocal communication, and Dawson (1923) reported that aerobatics seemed more frequent when ravens were in groups. The purpose of this study was to describe rolling by ravens on Santa Cruz Island, to test some hypotheses about the significance of rolling, and to compare frequency of occurrence of this behavior among island and mainland ravens.

Santa Cruz Island (SCI), located 40 km south of Santa Barbara, Santa Barbara County, is about 25,000 ha in area and is characterized by rugged and precipitous topography. Data were collected during three seasons: fall (28 October to 21 November 1980), winter (17-26 January 1981), and spring (23-27 March 1981). Daily during these periods, I walked or drove along roads and observed ravens in flight. For each bird in view for more than 5 s, I described any aerobatic maneuver involving a roll (defined as rotation about the longitudinal axis) and, whenever possible, recorded the size of the group in which the raven occurred. Few ravens remained in view longer than 30 s; in order to help standardize observations, I recorded no further data on those that did. I classified wind speed each day according to four qualitative categories: none, light, moderate, and strong. From 1981 to 1983 I observed mainland ravens in flight in Arizona, California, Colorado, Nevada, Oregon, and Utah, noted the number of birds in view for 5-30 s, and recorded any rolls performed.

Rolls were performed during 205 of a total of 1,272 raven observations on SCI. Of 410 individual rolls observed, 95% were half-rolls, in which the bird folded its wings back at the wrist, rolled rapidly onto its

back for about 1 s, then reversed rotation and returned to an upright position, simultaneously extending its wings. Half-rolls were performed both to the left and to the right; rolls to the left, however, were more frequent ( $\chi^2 = 12.36$ ,  $df = 1$ ,  $P < 0.001$ ), totaling 60% of 321 half-rolls in which direction could be determined. I observed individual birds roll in both directions in sequence 19 times. Three percent of all rolls were full-rolls, which were performed in one steady motion, slower than a half-roll, with both wings mostly or fully extended. One percent of rolls were double-rolls and were performed as two continuous full-rolls. Twice I observed a raven perform an Immelmann turn in reverse; the bird rolled onto its back and then proceeded into a one-half inside-loop, which it concluded gliding upright in the opposite direction.

Ravens often followed one roll with another; 62% of rolls were performed in sequences of 2-11. The remainder were single rolls. During a sequence, ravens proceeded from one roll to the next with only a brief glide of 1-3 s between rolls. While performing half-rolls, the birds lost lift when inverted and regained it when righted, producing an undulating flight path. Ravens often called when beginning each roll in the sequence. I once observed a raven perform a sequence that included 6 half-rolls, 2 full-rolls, and 2 double-rolls.

Ravens in coastal southern California begin nesting in late March (Willett 1912); if aerobatic rolls are important in courtship, a higher frequency should be evident in spring. Roll frequencies, however, were similar ( $\chi^2 = 2.68$ ,  $df = 2$ ,  $P > 0.05$ ) among seasons (Table 1). Rolling may serve as a social display; if so, frequency should be higher when other ravens are close by. Roll frequency, however, was independent of the number of other ravens with which the rolling bird was associated ( $\chi^2 = 8.44$ ,  $df = 4$ ,  $P > 0.05$ ). I consider play the most likely cause of rolling by ravens on SCI: corvids have the most complex play known in birds (Ficken 1977), and ravens in particular are known for their spectacular aerobatic play (Fagen 1981). Ravens are inverted briefly during a half-roll, and inverted postures are a feature of raven