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Differential Digestion Rates of Prey by White-chinned Petrels (*Procellaria aequinoctialis*)

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We investigated the gastric digestion rates in the White-chinned Petrel (*Procellaria aequinoctialis*), which is a generalist feeder (Croxall and Prince 1980, Croxall et al. 1984, A. Berruti pers. comm., S. Jackson unpubl. data). The natural diet of White-chinned Petrels includes the three prey types used in the experiments: light-fish (*Mauroliscus muelleri*), squid (*Loligo reynaudi*), and antarctic krill (*Euphausia superba*) (A. Berruti pers. comm., S. Jackson unpubl. data).

Seven fledgling White-chinned Petrels were removed from their burrows on subantarctic Marion Island (46°52'S, 37°51'E) and kept in separate wire-mesh cages (40 × 40 × 60 cm) for 12 days before the start of the experiment. We maintained the birds at approximately constant mass on diets of equal proportions of light-fish, squid mantle flesh and heads, and antarctic krill. We noted the total numbers of squid beaks fed to the birds throughout their period of captivity.

For the experiment, we fed each bird a mixed meal comprising 40 g each of light-fish (approximately 40 individuals), squid (1 head and several pieces of mantle), and krill (approximately 60 individuals). All the food had been frozen, but was thawed slowly and handled with care during feeding to avoid tissue damage that could have affected the rate at which food was digested.

We stomach-pumped individual birds 15 min and

1, 2, 4, 7, 12, and 24 h after feeding, using a water-offloading technique (Wilson 1984). We then killed the birds and dissected their oesophagi, stomachs, and gizzards. The samples were drained and weighed. We counted identifiable food objects separately, noting the apparent state of digestion. We counted all cephalopod beaks recovered and noted their state of wear. We also counted otoliths and krill eye lenses.

The mass of all food types recovered after 15 min increased by less than 5%, presumably due to the water added during stomach pumping, or to initial water absorption by the prey. We compensated with a correction factor (C) such that $C = I/F'$, where I = initial mass of a food type and F' = mass of that food type recovered after 15 min. We assumed that the mass gain of each food type was proportionally the same for the birds stomach-pumped after different time intervals. We expressed the mass of food recovered as a percentage of the mass initially fed to the bird after each time interval.

White-chinned Petrels digested light-fish more rapidly than they digested either squid or krill: no traces of fish remained in the stomach after 12 h (Fig. 1). The results of similar experiments on Jackass Penguins (*Spheniscus demersus*; Wilson et al. 1985) are included for comparison (Fig. 2). We could not count individual fish in White-chinned Petrel stomachs after 4 h (Fig. 3). Initial digestion of krill was slower

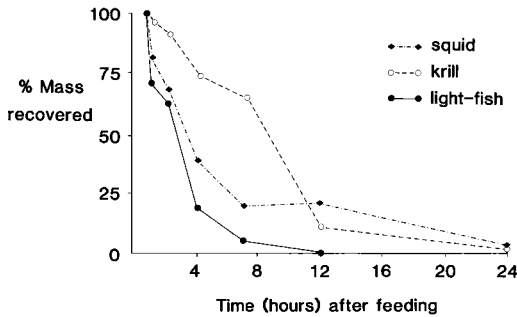


Fig. 1. Percentage of the mass of different foods recovered from White-chinned Petrels at increasing intervals after feeding.

than that of the other food types. After 12 h, however, proportionally more squid remained (Fig. 1). Pieces of squid appeared unchanged after 4 h, but their mass decreased by more than 50%. The number of krill could still be determined after 24 h by counting the loose eyes present in the stomach.

We distinguished three discrete states of wear in the cephalopod beaks: "fresh," with the brittle "wings" (Clarke 1962) intact; "intermediate," with the rostrum sharp but with broken or abraded wings; and "worn," when all surfaces of the beak were smooth and rounded. A mean of 87% of all the *Loligo* sp. beaks recovered from the 7 White-chinned Petrels after 3 weeks of captivity were fresh (range = 62.5–100%). All the birds contained worn beaks of other cephalopod species that must have been ingested before capture.

Short-term adaptations to specialized diets may affect the digestive efficiencies of different individuals of the same species (Partridge and Green 1985). However, interspecific differences in the prey digestion rates of seabird species with different diets have not been documented.

Although White-chinned Petrels show a general

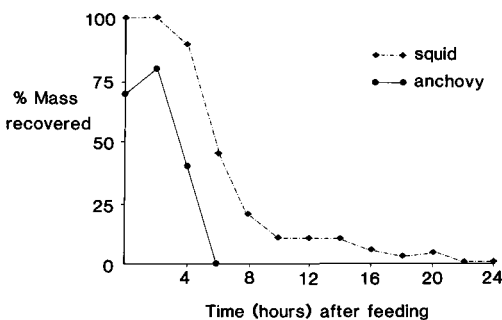


Fig. 2. Percentage of the mass of different foods recovered from Jackass Penguins at increasing intervals after feeding (after Wilson et al. 1985).

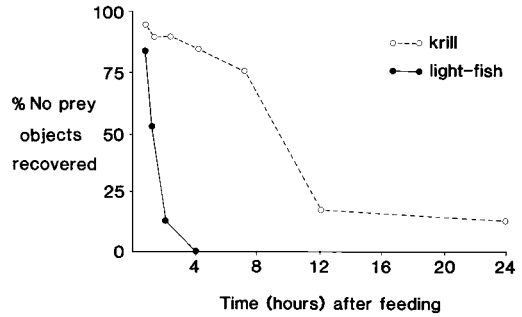


Fig. 3. Percentage of individual objects of different foods recovered from White-chinned Petrels at increasing intervals after feeding (counts of light-fish after 1 h = number of brain cases; counts of krill after 6 h = number of pairs of eyes).

pattern similar to that observed in Jackass Penguins, differences in the digestion rates of fish and squid occur. Total passage time of squid through the stomach was similar in both birds, but squid lost mass faster in the White-chinned Petrel. After 4 h, squid remains in White-chinned Petrel stomachs were less than 50% of the mass of those in Jackass Penguin stomachs (Wilson et al. 1985). Initial digestion of light-fish by White-chinned Petrels also may be faster than digestion of anchovy (*Engraulis capensis*) by Jackass Penguins, but the evacuation time of all anchovy remains from the stomachs of the penguins was shorter than that of light-fish from White-chinned Petrel stomachs.

The rate of mass loss by squid remains in the stomachs of both White-chinned Petrels and Jackass Penguins decreased after 8 h (Figs. 1 and 2). This possibly was due to the presence of resistant collagen fibers in squid mantle (Gosline and DeMont 1985). Tissue structure of prey may affect the rate at which items are digested, independently of adaptations in the birds to specialized or generalized diets.

The initially slow digestion of krill by White-chinned Petrels probably is due to the chitinous crustacean exoskeleton, which retards penetration by the digestive juices. This effect may be reduced in the wild, where damage to prey during capture may provide sites for entry of enzymes.

The persistence of squid and crustacean soft remains in seabird stomachs may result in overestimation of the relative importance of such food types in seabird diets, as does the persistence of squid hard parts (Furness et al. 1984). Otoliths are digested rapidly in seabird stomachs (Duffy and Laurenson 1983). Consequently, the importance of fish in seabird diets may be underestimated.

Differential digestion rates may be due both to the nature of the prey and to differences in the digestive systems of the predators as a result of dietary specializations. Whatever the causes of differential

digestion in seabirds, allowances must be made for unequal retention times of both hard and soft prey remains in seabird stomachs to avoid biases in diet studies.

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Infanticide by a Male Parent and by a New Female Mate in Colonial Egrets

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Infanticide by avian conspecifics is observed most often in the context of sibling competition, i.e. siblicide (see Mock 1984, 1985; Fujioka 1985a, b). In several mammals, instances of infanticide with mate takeover have been documented (Sugiyama 1965; see Hrdy 1979 for a review). Infanticide in a similar context, including egg destruction, has been reported in some group-living birds (e.g. Vehrencamp 1977, Trail et al. 1981, Mumme et al. 1983, Stacey and Edwards 1983). Recently, infanticide by a female was suggested for the polyandrous Northern Jacana (*Jacana spinosa*; Stephens 1982). Apparently, "adaptive" parental infanticide is rare among birds, excluding parental nest abandonment. Here I present observations of two unusual social interactions in monogamous colonial herons: egg destruction by a male parent of the Cattle Egret (*Bubulcus ibis*) and infanticide by a new female mate of the Little Egret (*Egretta garzetta*). Because a breeding cycle lasts about three months (pers. obs.), these egrets generally breed once in a season.

The study was done at a mixed-species heronry in Mie Prefecture, Japan (34°50'N, 135°35'E), 50 km southwest of Nagoya. Further description of the study area can be found in Fujioka and Yamagishi (1981).

One to 11 nests were observed simultaneously from a blind built on a scaffolding 5.1 m high. In 1982, 12 Little Egret nests and 10 Cattle Egret nests were observed every 1-9 days from 9 May to 6 September, for a total of 90 days or 1,056 h (>3,789 nest-hours). Five of the 12 Little Egret pairs and all 10 Cattle Egret pairs reared 2-5 chicks. Adult egrets were distinguished individually by idiosyncracies in their lores, legs, and so on. Adult gender was determined from observations of courtship displays, egg-laying, or repeated copulation positions (see Blaker 1969a, b).

Egg destruction by a male that deserted his mate.—On 20 May 1982 a Cattle Egret female (F2a) laid an egg at 0821, when I first noticed that she had a fractured bone in her left leg. Her mate (M2) attempted to copulate with her repeatedly, but she was unable to support the mounted male. At 1032 and 1448, M2 copulated with her while she was forced to lie prone on a twig. That night, M2 slept on the nest, and F2a nearby.

Early the next morning, M2 stayed on the nest while F2a left, presumably to forage. At 1654, M2 also departed, leaving the egg unprotected. Normally, parents do not leave the nest for more than 7 h even if their mate remains, and they never leave the