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## DIVING ABILITY OF BLUE PETRELS AND THIN-BILLED PRIONS<sup>1</sup>

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*Key words:* Blue Petrel; Thin-billed Prion; maximum diving depths; foraging behavior; *Halobaena caerulea*; *Pachyptila belcheri*.

Capillary depth recorders (Burger and Wilson 1988) are useful tools for studying the foraging ecology of seabirds, and have been used successfully on penguins, alcids, shags and gannets (Burger 1991, Wanless et al. 1991, Adams and Walter 1993, Croxall et al. 1993). Recent studies of Procellariiformes have revealed that diving petrels (*Pelecanoides georgicus* and *P. urinatrix*) are able to dive routinely down to 25–40 m (Prince and Jones 1992, Chastel 1994). Furthermore, investigations on albatrosses (Prince et al. 1994), and on the White-chinned Petrel *Procellaria aequinoctialis* (Huin 1994), have shown that these seabirds can reach a depth of several meters, giving a new insight on the foraging techniques of albatrosses and petrels, which are generally regarded as surface-seizers (Harper 1987, Prince and Morgan 1987).

The Blue Petrel *Halobaena caerulea* and the Thin-billed Prion *Pachyptila belcheri* are small burrow-nesting petrels (190 and 150 g, respectively). At Kerguelen Islands these two seabirds breed in very large numbers (up to 1 million pairs, Weimerskirch et al. 1989); the prions particularly are believed to have a significant impact on subantarctic resources (Ridoux 1994). During the chick-rearing period (50 days, Weimerskirch et al. 1994), both species alternate long and short foraging trips over pelagic and neritic waters (Weimerskirch et al. 1994) and prey mainly on small crustaceans (Harper 1972, Prince 1980, Ridoux 1994), principally by surface-seizing (Harper 1987, Prince and Morgan 1987).

This paper reports the first study on maximum dive depths attained by Blue Petrels and Thin-billed Prions, during the chick-rearing period at Kerguelen Islands.

### METHODS

Field work was carried out on Mayes Island, Kerguelen Archipelago (48°28 S, 69°57 E), between 17 January and 7 February 1993. Maximum depth recorders consisted of 12 cm lengths of plastic tubing (internal diameter, 0.8 mm.) lined with icing sugar and sealed at one end. Each tube weighed approximately 1 g (< 0.7%

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TABLE 1. Maximum diving depths and gauge deployment durations of Blue Petrels and Thin-billed Prions at Kerguelen Islands.

	Gauge deployment (days)	Initial tube length (mm) $L_s$	Length (mm) compressed $L_d$	Maximum depth (m)
Blue Petrel	7	97	69.5	4.0
	4	99.5	64.5	5.5
	9	106	71.5	4.9
	1	104.5	95.5	1.0*
	7	83	51.5	6.2*
	9	98	66	4.9
Thin-billed Prion	2	101	66.5	5.2
	1	101	58	7.5
	5	97	60	6.2
	4	96	65.5	4.7
	1	108.5	79	3.8

\* Maximum depths attained by the same individual.

of adult body mass) and was attached to the back feathers using waterproof adhesive tape. On recovered gauges the length of tube still covered with icing sugar was measured to the nearest 0.5 mm. Maximum dive depth was calculated by the equation:  $d_{max} = 10.08(L_s/L_d - 1)$  where  $d$  is depth (m),  $L_s$  is the initial length (mm) of undissolved indicator, and  $L_d$  its length on recovery (Burger and Wilson 1988).

In both species, the single chick is left alone in the burrow within a few hours after hatching (late December and early January for the Blue Petrel and the Thin-billed Prion, respectively; Weimerskirch et al. 1989) and thereafter fed regularly by both parents. To identify the parent and to recover the depth gauges, traps were installed at the entrance of 13 Blue Petrel and five Thin-billed Prion burrows during the course of the study. The trap was fitted with a swing-door that let the parent enter the burrow when coming from the sea to feed the chick, but trapped it when it tried to return to the sea. Birds were banded with monel rings for identification. During the course of the study, 19 Blue Petrel and 12 Thin-billed Prion depth gauges were attached to adult birds that returned to feed their chick. The traps were inspected every hour at night and the trapped adults were identified and released immediately after recovery of the capillary gauge.

## RESULTS

Eleven capillary tubes were successfully recovered from five individuals in each species (Table 1). The mean ( $\pm$  SD) maximum depths were  $4.4 \pm 1.8$  m (range: 1.0–6.2 m) and  $5.5 \pm 1.4$  m (range: 3.8–7.5 m) for the Blue Petrel and the Thin-billed Prion, respectively. In the Blue Petrel, the shallowest and the deepest dives were performed by the same bird. Maximum depths recorded and gauge deployment durations were not correlated for either species (Spearman rank correlation: Blue Petrel:  $r_s = 0.24$ ,  $n = 6$ ,  $P > 0.05$ ; Thin-billed Prion:  $r_s = 0.10$ ,  $n = 5$ ,  $P > 0.05$ ).

## DISCUSSION

Most Procellariiformes are unlikely to exhibit significant diving abilities, due either to low wing loading, high aspect ratios or unstreamlined tarsi (Warham 1977). Considering these morphological features, shearwaters, and particularly diving petrels (the southern ecological and morphological analogues of alcid, Thoresen 1969), should be the most proficient divers (Warham 1977). Anecdotal observations have revealed that Short-tailed Shearwaters, *Puffinus tenuirostris* (Skira 1979) and Sooty Shearwaters, *P. griseus* (Brown et al. 1981) could reach 10 m down; likewise, Flesh-footed (*P. carneipes*) and Fluttering Shearwaters (*P. gavia*) were recorded to depths of about 5 m and 2–3 m, respectively (Wood 1993). Two studies using maximum depth gauges have shown that the highly specialized diving petrels dove as deep as 48 m in the South Georgia Diving Petrel (Prince and Jones 1992) and 63 m in the Common Diving Petrel (Chastel 1994).

However, all Procellariiformes studied so far do dive, except the Wandering Albatross, *Diomedea exulans* (Prince et al. 1994). Black-browed (*Diomedea melanophris*) and Gray-headed Albatrosses (*Diomedea chrysostoma*) routinely dive to 3 m, whereas Light-mantled Sooty Albatrosses (*Phoebastria palpebrata*) on average attain 4.7 m, with a maximum depth of 12 m (Prince et al. 1994). Furthermore, the White-chinned Petrel has recently been shown to regularly dive to 6 m, with a maximum of 13 m (Huin 1994).

Blue Petrels and Thin-billed Prions are poorly suited for diving, having low wing loading (Warham 1977), and feeding mainly by surface seizing or dipping (Croxall and Prince 1980, Prince 1980, Harper 1987), although aerial plunging and surface diving have been reported in the Blue Petrel (Croxall and Prince 1980), more scarcely in the Thin-billed Prion (Harper 1987). The submersion duration in the Blue Petrel did not seem to exceed six seconds (Bierman and Voous 1950), suggesting shallow dives. Our results show that during the chick-rearing period, both species regularly dive to 5 m, and can attain a maximum depth of 7 m. These dives are shallower than those of diving petrels, and probably of shearwaters, but similar to those of albatrosses, consistent with their morphology.

Burger and Wilson (1988) pointed out that depths tended to be overestimated during shallow dives (39% overestimate at 5 m). Nevertheless, even if we take into account their corrections, Blue Petrels and Thin-billed Prions can still dive regularly to 3 m, and occasionally 5 m. Wanless et al. (1991) noticed that devices not recovered within 24 hours could also overestimate values. However, we found no correlation between gauge deployment time and maximum depth, suggesting that our results are reliable. Consequently, Blue Petrels and Thin-billed Prions forage not only on and near the sea surface, but also exploit a water column 5–7 m deep.

Studies using capillary tubes on Procellariiformes have shown that, by diving, these seabirds use more foraging techniques than previously supposed, probably allowing them to enlarge their dietary spectrum. Capillary gauges as maximum depth recorders, being simple and efficient, should be applied to other Procellariiformes particularly during diet studies.

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