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SHORT NOTE

Incubation weight loss of Christmas shearwater eggs on Christmas Island, Pacific Ocean

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The Christmas shearwater *Puffinus nativitatis* is a procellariiform seabird of the tropical Pacific Ocean (Warham 1990). It lays a single egg in a shallow scrape in the ground (Fig. 1). In a recent report (Whittow & Naughton 1999), data were presented for the weight, volume, and dimensions of the eggs of Christmas shearwaters breeding on Laysan Island in the Northwestern Hawaiian Islands. Information was also provided on some of the characteristics of the eggshells: shell thickness, weight, pore density, and water-vapour conductance. The present note adds to our knowledge of Christmas shearwater eggs by recording measurements of the weight loss of the eggs during incubation, for Christmas shearwaters nesting on Christmas Island in the central Pacific Ocean. Eggs lose weight during incubation as water vapour diffuses out of the egg and is replaced by air, which forms the aircell at the blunt pole of the egg (Rahn & Ar 1974). The formation of an aircell is important because it allows the developing chick to begin to use its lungs after the egg has pipped.

Observations were made on Motu Tabu and Motu Upua islets in the lagoon of Christmas Island (2° 1'N, 157° 25'W, Fig. 2). The weight loss of unpipped eggs was determined by weighing the eggs at intervals of 45.9-72.6 h on an Ohaus field balance (Model 1010-10) at the nest site. Egg dimensions were measured with a dial micrometer calipers that could be read to 0.025 mm.

The mean daily weight loss of the eggs is shown in Table 1, together with their linear dimensions. The egg dimensions may be used to arrive at a figure for the mean weight of the freshly-laid egg (W), using Hoyt's (1979) formula: $W = K_w . LB^2$, where L = egg length, B = egg breadth, and K_w = a species-specific coefficient.

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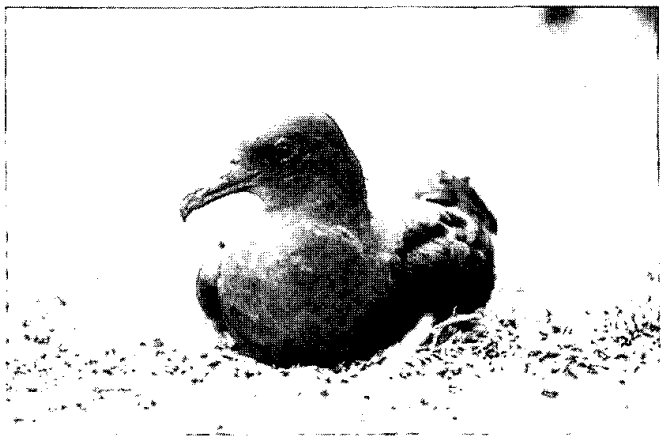

Fig. 1 Incubating Christmas shearwater *Pterodroma nativitatis* on Motu Upua, Christmas Island. Photo: G.C. Whittow.

Table 1 Dimensions (mm) and daily weight loss of the eggs of Christmas shearwaters (*Pterodroma nativitatis*) on Christmas Island. Means ± standard deviation; sample size in parentheses.

Egg length	57.5 ± 2.2 (28)
Egg breadth	39.6 ± 1.6 (28)
Daily weight loss of unpipped eggs (mg day^{-1})	128.8 ± 23.2 (25)

The coefficient K_w (0.551) was derived from the measured values of fresh-egg weight (W) and egg dimensions (LB^2) for the Christmas shearwater eggs collected on Laysan Island (Whittow & Naughton 1999). The fresh-egg weight so obtained is 49.6 g. Rahn & Whittow (1988) developed a number of predictive allometric equations for procellariiform eggs; 1 of them, based on the weight of the freshly-laid egg and its incubation period, predicts that an egg weighing 49.6 g

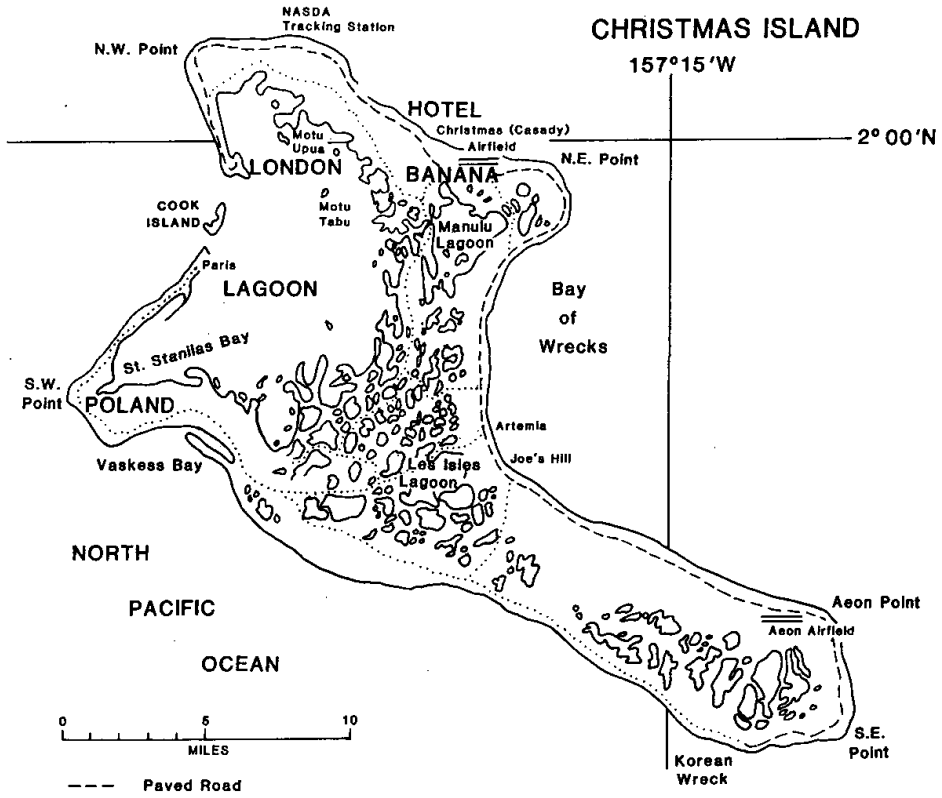

Fig. 2 Christmas Island showing Motu Tabu and Motu Upua. After Bailey (1977); reproduced with permission.

with an incubation period of 53 days (Naughton 1982), should lose weight at the rate of 140.3 mg day^{-1}. Thus, the measured weight loss of the eggs is 91.8% of the predicted value. This conforms with Whittow & Naughton's (1999) conclusion based on data obtained from Christmas shearwater eggs collected on Laysan Island, viz. that the measured values were within 10% of predictions.

One egg, not included in Table 1, was pipped (very small star fracture of the shell) on the 2nd occasion that it was weighed. The weight loss of this egg (148.7 mg day^{-1}) was higher than the average value for unpipped eggs (Table 1). When the egg was weighed on a 3rd occasion, it was more extensively pipped and the chick was vocalizing (cheeping) indicating that the chick had penetrated the aircell of the egg with its beak and that it was breathing aircell gas (Pettit & Whittow 1983). The weight loss of this egg under these conditions (344.0 mg day^{-1}) was substantially greater than the weight loss of unpipped eggs. Thus, the sequence of events during pipping (star-fracture of the shell, followed by penetration of the aircell and vocalizations), and the effect of pipping on the weight loss of the egg, are qualitatively similar in this 1 egg of the Christmas shearwater to pipping in wedge-tailed shearwater eggs (Pettit & Whittow 1983). Further measurements are needed to corroborate this.

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