

BODY DIMENSIONS OF WEDGE-TAILED SHEARWATER *Puffinus pacificus* FLEDGLINGS AT HERON ISLAND, GREAT BARRIER REEF, AND THE IMPORTANCE OF TIMING TO BREEDING

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Body weights and dimensions were recorded for 70 fledglings at Heron Island, on the southern Great Barrier Reef. Results show that the length of the longest primary feather and tarsus were significantly different between habitats, with the Fringe showing highest and Buildings area showing lowest means. This outcome probably resulted from most nestlings measured in the Buildings area being the progeny of early breeders. Variability in the breeding cycle may have confounded the analyses of body weight and of dimensions. When data were grouped according to the timing of laying, early breeders showed significantly lower hatching and breeding success. Both these results are useful for detecting inter-annual differences at this locality or for comparisons with colonies located elsewhere.

INTRODUCTION

Body weights and dimensions are useful in ecological studies by providing information to age birds, and to detect differential rates of offspring development between habitats. Typical growth in procellariiform chicks such as the Wedge-tailed Shearwater *Puffinus pacificus* is slow, with a long and flexible fledging period, large fat reserves, and a maximum pre-fledging weight above that of the adult weight (Pettit *et al.* 1984). As the nestling ages, feeding intervals become longer and more irregular, which presents some difficulty when attempting to analyse body weight data (Pettit *et al.* 1984; Fry *et al.* 1986).

However, Pettit *et al.* (1984) note a lack of studies comparing intraspecific growth rates at various localities. Their results showed variation in growth parameters between consecutive breeding seasons at a single locality, and between localities. Differences were attributed to fluctuations in food supply. Ricklefs *et al.* (1975) also suggest that young seabird growth rates are susceptible to regional, seasonal and annual variability in food supply.

This paper quantifies the body weights and dimensions of Wedge-tailed Shearwater *Puffinus pacificus* chicks at Heron Island within a single

season, to detect any influences of habitat on nestling development, and to provide the baseline for inter-annual or regional comparisons.

STUDY AREA AND METHODS

Heron Island (151°55'E, 23°27'S) is the third-largest island of the Capricorn Group in the southern Great Barrier Reef. The central area of the island is comprised of *Pisonia grandis* forest (in the *Pisonia* area) while in the north a fringing habitat with *Argusia* and *Casuarina* species exists (the Fringe area). The western sector of the island has been largely cleared and accommodates a tourist resort and university research station (the Building area). A narrow strip in the south (the Southern Fringe area) presents a habitat of fringing species as described above, however, density resembles that of forest. Although Hill *et al.* (1989) give a detailed breakdown of eight habitats of the island, time constraints in this study only permitted a designation of four habitats, i.e. *Pisonia*, Fringe, Southern Fringe and Buildings areas. However, only four fledglings were found in the Southern Fringe habitat and these have been included in the Fringe habitat for improved statistical power. The three habitats in this study then are Fringe, *Pisonia* and Buildings.

As part of a larger monitoring programme, 74 fledglings from the three habitats were banded and weighed with a 2 kg Pesola spring balance to ± 10 g, during April 1994. The length of each individual's primary feather was measured to ± 0.1 cm using a stopped ruler while the length of each individual's tarsus was measured to ± 0.1 mm with a set of callipers. A return sampling period to record body weights and dimensions

had been planned for May 1994, however, only 14 of the banded fledglings remained on the island upon return. Measurements taken during the May visit were not used due to the small sample size.

Non-parametric Kruskal-Wallis tests were used to evaluate the means of body weights and dimensions in differing habitats, for those measurements taken in April only, that is, soon after commencement of fledging. *A posteriori* non-parametric Tukey-type multiple comparisons for unequal sample sizes were used to detect where significant differences lay.

Where the time of laying was known (i.e. in 54 fledglings) the data were separated into two categories in order to understand the importance of the timing of breeding in relation to developmental parameters. Early breeders were those birds which had laid an egg prior to the sampling period in December 1993 (n = 28). Burrows where eggs were found for the first time after the initial mid-December sampling were categorized as housing late breeders (n = 26). These groups were then re-analysed by the Mann Whitney nonparametric test with respect to developmental parameters of early and late layers.

In addition, as an index to the importance of early breeding, chi-square analyses were used to evaluate hatching success, fledglings produced per chick, and overall reproductive success between early and late breeders aggregated across habitats. Since these are not independent parameters, Bonferroni's correction was used to maintain the overall alpha level at 0.05, setting the significance level at $p = 0.017$.

RESULTS

Table 1 shows the mean growth parameters recorded. Analysis of the data shows that significant differences occur between the body weights of fledglings in the various habitats ($H = 16.37$, $df = 2$, $p < 0.001$), in the length of the primary feather between habitats ($H = 21.63$, $df = 2$, $p < 0.001$) and in the tarsus length between habitats ($H = 21.04$, $df = 2$, $p < 0.001$). Post-hoc evaluations failed to detect a difference between habitats in body weight but showed that the feather lengths were significantly different between the Fringe and Buildings habitats ($Q = 2.92$, $df = 2$, $p < 0.05$) and also between the Fringe and Buildings habitats for tarsus length ($Q = 2.91$, $df = 2$, $p < 0.05$). Fledglings measured in the Fringe area had lower mean primary feather and lower mean tarsus lengths, while those from the Buildings habitat had the highest means for both developmental measurements.

Developmental stage of all individual fledglings appeared to be highly variable, with body weight ranging between 110 and 520 g, primary feather length between 11.2 and 22.9 cm and tarsus length between 49.5 and 59.2 mm.

TABLE 1
Developmental stages of fledglings with habitat.

Habitat	N	Body weight	Wing	Tarsus
		(g) mean (range)	(cm) mean (range)	(mm) mean (range)
<i>Pisonia</i>	24	445.4 (310–580)	17.3 (12.7–22.1)	54.7 (50.3–57.7)
Fringe	28	406.4 (270–500)	16.1 (11.2–21.1)	53.8 (51.0–58.5)
Buildings	22	394.1 (110–510)	17.9 (12.0–22.9)	55.1 (49.5–59.2)
Overall	74	415.4 (110–580)	17.0 (11.2–22.9)	54.5 (49.5–59.2)

Results for the differences in developmental parameters taken between early and late layers showed that birds which laid before 18 December had offspring with significantly greater body weights ($U' = 435.5$, $df = 28,26$; $p < 0.0005$), significantly greater primary feather lengths ($U' = 571$, $df = 28,26$; $p < 0.0005$) and significantly greater tarsus lengths ($U' = 481$, $df = 28,26$; $p < 0.0005$) compared with later layers.

The timing of breeding and its effect on reproductive success was analysed. Hatching success was significantly lower for early breeders than for late breeders ($\chi^2 = 23.44$, $df = 2$, $p < 0.005$). Breeding success was similarly significantly lower for early breeders ($\chi^2 = 20.14$, $df = 2$, $p < 0.005$). However, no significant difference in the fledglings produced per chick was found between early and late breeders ($\chi^2 = 1.74$, $df = 2$, $p > 0.25$).

DISCUSSION

Although significant differences in developmental parameters were found, perusal of the data showed a greater proportion of early breeders were examined in the *Pisonia* and Buildings habitats. Early breeders accounted for nine out of 14 and 10 out of 15 in these two respective habitats. In the Fringe habitat only nine out of 22 were early breeders which probably accounts for the significant differences found between Fringe and Buildings habitats. Thus, the preferred habitat for promoting growth rates could not be confirmed, and the second finding of greater developmental measurements for early-laid offspring, regardless of habitat, suggests no habitat is preferred for raising young. The large ranges of measurements found support the suggestion by Byrd *et al.* (1983) that the fledging period is the most variable in terms of timing and duration.

Of particular interest, however, is the significant difference found in hatching and breeding success between early and late breeders. Much of the research to date suggests that in synchronous breeding species, early breeders have access to the best sites, gain the greatest value from food availability, or have some advantage with respect to weather conditions (Perrins 1966; Perrins 1970; Hornung *et al.* 1976; Ollasen *et al.* 1988). Since Wedge-tailed Shearwaters are thought to be synchronous breeders (Amerson *et al.* 1976), it was expected that early breeders would show higher reproductive success.

In this season and locality, early breeders did not appear to gain any fitness benefits, and later breeding was the most successful. Since breeding success usually increases with experience (Mills 1973; Potts *et al.* 1980; Ollasen *et al.* 1988) experienced breeders may have delayed laying at Heron Island during 1993/94, although it is also possible that the species may not in fact breed synchronously (Carter *et al.* 1996).

The higher breeding and hatching success found with later breeders may be due to some critical period in chick development being dependent on prey availability, if high food abundance occurred later in the season. The timing of laying was found to differ between sympatric tern species, possibly allowing prey to develop to a greater size (Smith 1993). Alternatively, success may be due to the susceptibility of burrows to collapse under varying levels of substrate moisture (Carter 1994).

Chicks of early breeders which did successfully raise offspring showed advanced developmental parameters compared with chicks of later breeders. Any increased risk of mortality at the early stage of the season in some years may be offset by decreased intra-specific competition, advantaging those which do survive.

The current study was conducted over a single season, with only one complete dataset pertaining to body weight and dimensions. However, such initial results are useful as a baseline for inter-annual comparisons with future studies at Heron Island, or with colonies at other Australian localities. The results derived from this study highlight the developmental variability within the colony and within the season, and possible variability in the effect of early breeding between years.

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