

SHORT NOTE

Differences in morphometric characters between little penguins (*Eudyptula minor*) in Oamaru and on Tiritiri Matangi Island

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Little penguins (*Eudyptula minor*) range around the coasts of New Zealand and southern Australia (Marchant & Higgins 1990). Kinsky & Falla (1976) divided this species into 6 subspecies in terms of morphometric features. Later, several studies suggested that there are 2 major clades within the little penguin by comparing the sequences of mitochondrial gene regions (Banks *et al.* 2002, 2008; Peucker *et al.* 2009). One clade ranges across Australia and Otago, while the other clade is restricted to the North Island, Cook Strait, Chatham Islands and Banks Peninsula (Banks *et al.* 2002; 2008). At Oamaru in north Otago, these 2 clades appear to occur sympatrically (Banks *et al.* 2008). Miyazaki & Nakagawa (2015) found geographical variation in acoustic parameters and behaviour between the little penguins in Oamaru

and those on Tiritiri Matangi Island suggesting differences between the 2 clades. However, there is no information on crossbreeding or patterns of assortative mating between birds in the 2 regions (Miyazaki & Nakagawa 2015). Females can discriminate between local and foreign male calls and they might use acoustic cues for mate choice (Miyazaki & Nakagawa 2015). In this study, I quantified differences in bill length, bill depth, flipper size and foot size of little penguins between these 2 regions. Although there are some morphometric data for some of the different subspecies (reviewed by Williams 1995), these data were collected by different people using different instruments. Here, I compared birds in 2 different breeding areas using the same set of measurements by a single person with a large enough sample size to generate meaningful conclusions.

The study was conducted on Tiritiri Matangi Island (36°36' S, 174°53' E) during the breeding season (May-June) in 1999 and in Oamaru (45°07'S, 170°58' E) during the breeding season (May-June)

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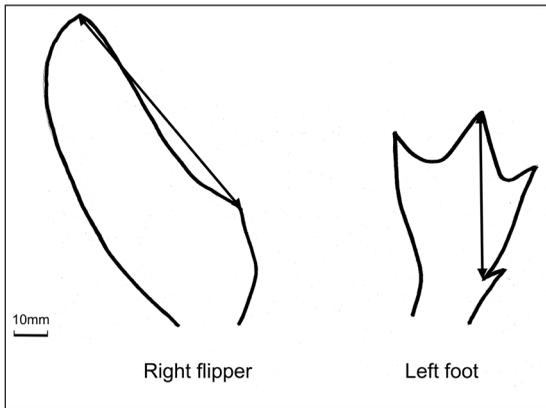


Fig. 1. Measurement of flipper size and foot size in the little penguin. Measurement follow methods in Miyazaki and Waas (2003). Flipper length (mm) was defined as the distance between the vestige of the second digit and the tip of the outstretched flipper. Foot length (mm) was defined as the distance between the tip of the claw of the third digit and the base of the first digit.

in 2000. I sampled 200 birds (40 nesting pairs from Tiritiri Matangi Island and 60 nesting pairs from Oamaru) and measured 4 body size parameters: (1) bill length, (2) bill depth, (3) flipper size, and (4) foot size. Bill length and bill depth were measured with digital calipers to 0.1 mm (following Klomp & Wooller 1988). Flipper size and foot size were measured by first tracing the outspread appendage on paper and later measuring length with a ruler to the nearest 1 mm (Fig. 1). Flipper and foot sizes were measured by following Miyazaki & Waas (2003). Flipper size was estimated by measuring the distance from the vestige of the second digit to the tip of the outstretched flipper. Foot size was estimated by measuring the distance between the tip of the claw of the third digit and the base of the first digit. I studied only breeding pairs in nest burrows and nest boxes. I used Gales' formula (Gales 1988) for birds on Tiritiri Matangi Island (following Miyazaki & Waas 2003) and Hocken's formula (developed for Otago birds by Hocken & Russell 2002) for birds in Oamaru for determining the sex from bill measurements.

Body-size parameters of birds in Oamaru and on Tiritiri Matangi Island are shown in Table 1. To compare the morphometric data between the 2 populations, *t*-tests were used. Little penguins show sexual dimorphism and males are slightly larger than females (Richdale 1940; Reilly & Balmford 1975; Jones 1978). Thus, I compared variables only within the same sex. Oamaru males had longer bills ($t = 8.90$, $df = 98$, $P < 0.0001$) and deeper bills ($t = 6.34$, $df = 98$, $P < 0.0001$) than males on Tiritiri

Matangi Island (Table 1). Furthermore, males in Oamaru had longer flippers ($t = 5.60$, $df = 71$, $P < 0.0001$) and larger feet ($t = 5.87$, $df = 71$, $P < 0.0001$) than on Tiritiri Matangi Island (Table 1). In females, there were significant differences in the 4 body-size parameters between these 2 regions (bill length, $t = 8.23$, $df = 98$, $P < 0.0001$; bill depth, $t = 2.43$, $df = 98$, $P = 0.017$; flipper size, $t = 4.91$, $df = 60$, $P < 0.0001$; foot size, $t = 4.05$, $df = 60$, $P < 0.0001$).

Miyazaki & Nakagawa (2015) showed geographical differences in acoustic signals of male little penguins between Oamaru and Tiritiri Matangi Island. In this study, I found statistically significant differences in 4 morphological parameters between birds from these 2 regions. Thus, body-size parameters can be an indicator of the differences in birds from the 2 geographical locations as well as their acoustic signals.

Sato *et al.* (2010) compared the relationship between morphological characters such as body mass, flipper size and behaviours at sea among 7 species of penguins. They suggested that morphological characters might be related to differences among species in swimming speed and stroke frequency. However, flipper size and diving behaviour within a single species have not been investigated. Further research is needed to determine if flipper size can affect diving behavior in little penguins.

Williams (1995) reviewed morphometric data for 3 measures (flipper length, bill length and bill depth) for 2 different subspecies (*E. m. minor* and *E. m. novaehollandiae*) in little penguins. Although these data were obtained by different researchers using different measurements, the data suggested that Australian birds tend to be larger. My results may support the scenario of 2 major clades in little penguins as proposed by Banks *et al.* (2002; 2008). Nevertheless, my results also are consistent with the 6 subspecies scenario of Kinsky & Falla (1976) because there are differences in morphometric parameters between the 2 subspecies (*E. m. iredalei* on Tiritiri Matangi Island and *E. m. minor* in Oamaru). As no data is currently available on 4 of the other 6 subspecies, future work is required to evaluate little penguin taxonomy in terms of these morphometric characters.

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Table 1. Morphometric measurements (mm, mean \pm sd [*n*]), of male and female little penguins in Oamaru and on Tiritiri Matangi Island.

Morphological characteristics	Male		Female	
	Oamaru	Tiritiri Matangi	Oamaru	Tiritiri Matangi
Bill length	39.39 \pm 1.65 (60)	36.57 \pm 1.38 (40)	36.98 \pm 1.76 (60)	34.21 \pm 1.45 (40)
Bill depth	15.76 \pm 0.90 (60)	14.70 \pm 0.64 (40)	13.46 \pm 0.98 (60)	13.01 \pm 0.77 (40)
Flipper size	84.97 \pm 4.48 (33)	79.55 \pm 3.78 (40)	80.91 \pm 3.74 (22)	76.15 \pm 3.59 (40)
Foot size	56.21 \pm 2.37 (33)	52.85 \pm 2.49 (40)	53.23 \pm 2.14 (22)	50.50 \pm 2.73 (40)

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