SEXING GREY-FACED PETRELS BY DISCRIMINANT ANALYSIS OF MEASUREMENTS

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ABSTRACT

Discriminant function analysis was used to calculate classification formulae for predicting the sex of 98 adult Grey-faced Petrels *(Pterodroma macroptera gouldi)* at the start of incubation. Body weight, bill length, bill width, and bill depth all showed statistically significant sexual dimorphism. A classification formula based solely on bill measurements is impractical for sexing Grey-faced Petrels because of 37% error. The combination of body weight and bill depth in the formula proved useful, correctly classifying 92% of birds. This method provides a simple and reliable way of sexing Grey-faced Petrels in the field just after laying. Cloacal examination also allows definitive sexing at this time.

INTRODUCTION

Identification of sex is often necessary for ecological and behavioural studies of seabirds but can be difficult because many species lack obvious sexual dimorphism.

Morphometric characteristics are frequently used for sexing seabirds (Warham 1975, Scolaro *et al.* 1983, Schnell *et al.* 1985, Gales 1988, Schreiber & Schreiber 1988). Body weight and bill size differ enough between the sexes of many procellariiform birds to allow reasonably accurate sexing (Croxall 1982). Imber (1971) demonstrated sexual dimorphism in the Grey-faced Petrel *(Pterodroma macroptera gouldi)*. He sexed pairs by comparing partners' weights, filoplume count, and culmen length. The partner with the higher score in at least two of the three measurements was assumed to be the male.

Petrels lay a large egg for their size (Rahn *et al.* 1975), for which the female cloaca dilates to allow its passage. From the obvious dilation, one can tell the female from the male by eye after egg laying (Serventy 1956). Thus, this method is applicable only to females that have recently laid eggs and to their known mates (Serventy 1956, Boersma & Davies 1987).

The aim of this study was to calculate formulae which could be used to predict the sex of Grey-faced Petrels in the field without having to compare mates.

METHODS

We analysed measurements taken by RMJ from 98 adult Grey-faced Petrels on Whale Island (Motuhora) (37°52'S, 176° 58'E) in the Bay of Plenty between 12 June and 14 September 1987.

Petrels found in a nesting burrow during the day were removed through an observation hole that had been dug into the nest before the birds had reoccupied it at the start of egg laying. We sealed this opening with a plastic bag filled with soil.

The birds were weighed with a 1 kg Pesola scale accurate to ± 5 g. Bills were measured with vernier callipers accurate to ± 0.1 mm. Bill length measures the length of exposed culmen (Baldwin *et al.* 1931, Imber 1971).

Bill depth was measured from the anterior-most feather on the dorsal surface of the culmen to the fusion of the mandibular rami; bill width was measured below the gape at the anterior-most feather on the border between the dorsal and ventral rhamphotheca plates of the mandible (Baumel 1979).

The birds were sexed by a superficial examination of the cloaca within two days after the egg had been laid (Serventy 1956), females being identified by swelling and transverse distension of the cloaca. At least one partner of each pair was colour banded (green for males, black for females).

The data was analysed by discriminant function analysis (DFA) on the BMDP computer software package (Dixon 1981). The discriminant function calculated by DFA weights morphometric characters according to their discriminatory power. It is used to predict the sex of petrels. The assumption of DFA that the variance covariance matrices of the two sexes are equal was confirmed for this data using Box's M test ($F = 0.64$; d.f = 1, 38212; $P = 0.59$).

RESULTS

Table 1 shows the means, standard deviations, and ranges in measurements of birds sexed by cloacal examination. Although there is much overlap, all characters are significantly different between sexes, the males being larger.

The sex of a Grey-faced Petrel is predicted from the following classification formula when weight is excluded and only bill measurements are used in the analysis:

$$D = -18.11 + (0.88BD)$$

where D is the discriminant score and BD is the bill depth. If the score is postive, the petrel is a male; if it is negative, a female. This is equivalent to saying that the sex is a male if the bill depth is greater than 20.58 mm.

To test the accuracy of this classification function we calculated the discriminant score for the 98 known-sex birds and compared the predicted sex with the actual sex. The formula provided little discrimination for classifying the known sex sample (Fig 1.). It classified only 35 of of the 56 males (63%) correctly and 27 out of the 42 females (65%) correctly.

When weight was included with bill measurements the analysis produced this classification formula:

$$D = -41.4 + (0.03\ W) + (1.11\ BD)$$

where D is the discriminant score, W is the bird's weight, and BD is the bill depth.

This formula provided greater accuracy, correctly classifying 52 out of the 56 males (93%) and 38 out of the 42 females (91%) (Fig. 2).

Note that this classification formula was derived from weights taken straight after laying and at the start of incubation. It may not be appropriate at other stages of the breeding cycle because of the significant loss of weight by incubating birds.

TABLE 1 — Weights (g) and bill measurements (mm) of Grey-faced Petrels

Character	Sex	*n*	Mean	Range	s.d.	*t*-statistic
Weight	F	45	505	385-650	61	10.36*
	M	56	641	460-820	69	
Bill depth	F	42	20.2	18.4-22.5	1.04	4.14*
	M	56	21.0	19.4-23.5	0.90	
Bill length	F	42	36.7	34.3-39.5	1.25	2.00*
	M	56	37.2	34.0-39.3	1.25	
Bill width	F	42	12.4	10.7-14.5	0.85	2.26*
	M	56	12.8	10.7-14.7	0.84	

*indicates $P < 0.05$

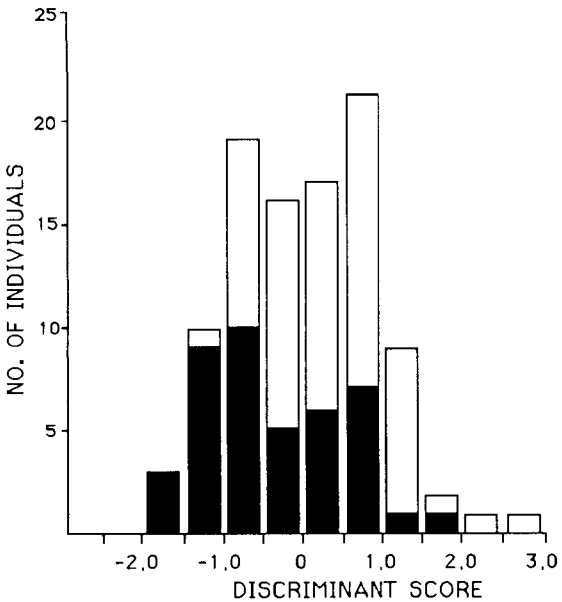

FIGURE 1 — Discriminant scores of known-sex male (light) and female (dark) Grey-faced Petrels, calculated from bill measurements only

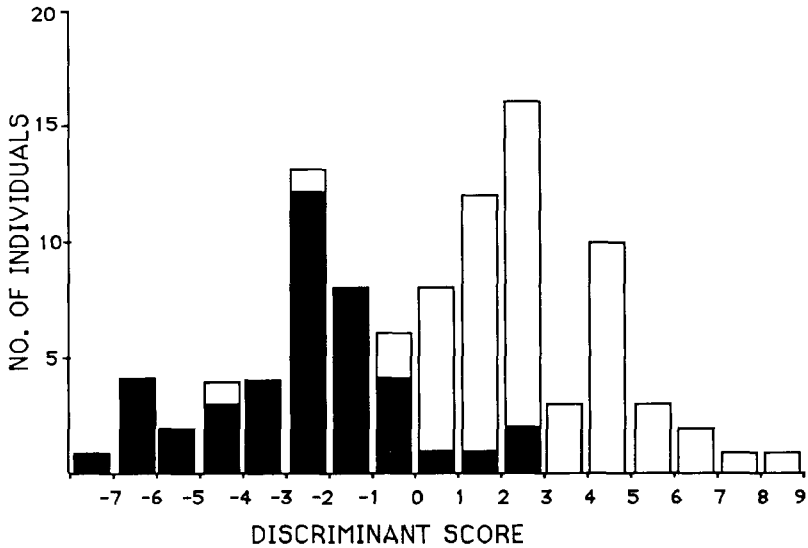

FIGURE 2 — Discriminant scores of 98 known-sex male (light) and female (dark) Grey-faced Petrels, calculated from bill measurements and body weight

DISCUSSION

Imber (1971) found separation in the same direction as this study between sexes in body weight, bill length, and bill width. Discrimination between sexes of the Grey-faced Petrel is possible on the basis of this separation.

A Grey-faced Petrel's weight varies greatly, especially during the incubation period when it fasts and loses a great deal of weight (Imber 1976). A classification formula without weight as a parameter would thus give accurate sexing in the field throughout the breeding cycle. Despite significant differences between sexes, the combined bill measurements had too little discriminatory power, giving 37% error, and so the formula based solely on bill measurements was impractical for sexing Grey-faced Petrels.

Adding other characters, for example, wing, tarsus, and middle-toe length (Scolaro 1987, Schreiber & Schreiber 1988) may increase the accuracy of a classification formula based solely on morphometric measurements. The use of filoplume counts for discriminating between sexes is limited because an accurate count takes too long (Imber 1971).

Including post-laying body weight in the formula greatly increases the the accuracy of sexing. Body weight has a high discriminating power, and when combined with bill depth it gives a formula by which Grey-faced Petrels can be sexed with 92% certainty. This method does not rely on the presence of both partners for sexing, as in Imber (1971), who did. Highly reliable sexing at the start of incubation is possible in the field by measuring these two characters and applying them to the classification formula.

Although this method does allow accurate sexing, the inclusion of body weight restricts the application of this formula to the start of incubation, a period when cloacal examination already allows definitive sexing (Boersma & Davies 1987).

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