

Sex determination and natal philopatry of Southern Buller's Mollymawks (*Diomedea bulleri bulleri*)

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ABSTRACT

Natal philopatry of 859 Southern Buller's Mollymawks (*Diomedea bulleri bulleri*) banded as chicks on North East Island, The Snares (48°02'S, 166°36'E), during August 1972 was investigated during 1977 to 1998. Eighty-six birds were recaptured as breeders; 57 of these were recorded within 100 m of their natal nest area and 29 dispersed over distances ranging from 100 m to 2430 m. The gender of 32 birds was determined by measurements of minimum bill depth and tarsus width, or by their behaviour. Of 17 males, 15 were found breeding within 100 m of their natal site and the remaining two birds dispersed 100 - 200 m. Of the 15 females, five were breeding within 100 m of their natal site and the remainder had dispersed 100 - 1640 m.

KEYWORDS: Procellariiformes, *Diomedea bulleri bulleri*, measurements, natal dispersal, The Snares

INTRODUCTION

Natal philopatry, the tendency for animals to return to breed near their birth place, is well developed in colonial nesting seabirds (Warham 1990). In general, seabirds are long-lived and have delayed breeding, so long-term studies are required to obtain quantitative data about philopatry. However, while a strong degree of philopatry has been demonstrated by long-term banding studies of, for example, breeding populations of Sooty Shearwater (*Puffinus griseus*) and Common Diving Petrel (*Pelecanoides urinatrix*) on Whero Island (Richdale 1963, 1965), Short-tailed Shearwater (*Puffinus tenuirostris*) on Fisher Island (Wooller *et al.* 1990), and Laysan Albatross (*Diomedea immutabilis*) on Midway Island (Fisher & Fisher 1969, Fisher 1976), there are reports of birds breeding at colonies other than their natal site. For example, Brooke (1978) found that some Manx Shearwaters (*Puffinus puffinus*) from Skokholm Island, particularly females, settled to breed on nearby Skomer Island. Similarly, Short-tailed Shearwaters from Fisher Island shifted to breed on islands nearby (Serventy & Curry 1984). Once breeding, however, all species of seabirds show considerable site tenacity (Warham 1990).

Southern Buller's Mollymawks (*Diomedea bulleri bulleri*) breed from December to September in colonies only at the Solander Islands (46°34'S 166°52'E) and The Snares (48°02'S, 166°36'E), off southern New Zealand. The species has

been studied at The Snares for many years (Richdale 1949, Warham & Richdale 1973, Warham & Bennington 1983, Sagar & Warham 1998) and banding studies show that the species exhibits considerable mate and breeding site fidelity. Despite the long time period over which studies have occurred on The Snares, chicks have been banded only in more recent years (1972, 1985, and annually since 1992). Even less banding of chicks has occurred on the Solander Islands, with 186 banded in 1985 (Cooper *et al.* 1986). The objectives of this paper are to determine the philopatry of the chicks banded in 1972 on The Snares, and to examine whether gender-related dispersal occurred.

METHODS

At The Snares, 859 well-grown pulli were banded during August 1972 at a large number of colonies distributed over much of North East Island, the main island of the group. The locations where these birds were banded were plotted to within 100 m on a large-scale map of North East Island, although band numbers used at an intensively studied colony were listed separately. Subsequently, some of these birds were recaptured on North East Island during visits in 1977 and 1983-1986. Our study of the Southern Buller's Mollymawk population on The Snares began in 1992 and each year until 1998 we made a visit to North East Island during March, the egg stage of this mollymawk. Two visits during March were also made (1992 and 1997) to Broughton Island, which lies 300 m south of North East Island. Five visits have been made to Solander Island, two in 1996 and three in 1997. On all of the visits to The Snares and Solander Island searches were made for banded birds. Information recorded about each banded bird found was band number, location, and whether it was incubating.

In this paper we use the terminology proposed by Greenwood (1980) and Greenwood & Harvey (1982). Natal philopatry refers to the return of the mollymawks to breed at the colony of their birth. Natal dispersal is defined as movement from the place of birth (natal) to the site of breeding.

Male albatrosses tend to be larger than females and have heavier (relatively deeper) bills (Warham 1990). However, before our study was undertaken there was no means of reliably determining the sex of Southern Buller's Mollymawks from measurements. Therefore, bill and tarsus measurements (mm) were made of pairs of birds of known sex breeding in an intensively studied colony to calculate a discriminant function (df) for distinguishing males and females. In this colony, gender was assigned on the basis of behaviour (for example, the male was assumed to undertake the first long incubation shift following laying) or by the presence of a partner of known sex (as determined by the behaviour described above). This discriminant function was then applied to bill and tarsus measurements recorded from 28 birds originally banded as chicks in 1972 to estimate the gender of these birds. Insufficient measurements were taken of birds recaptured before this discriminant function was calculated.

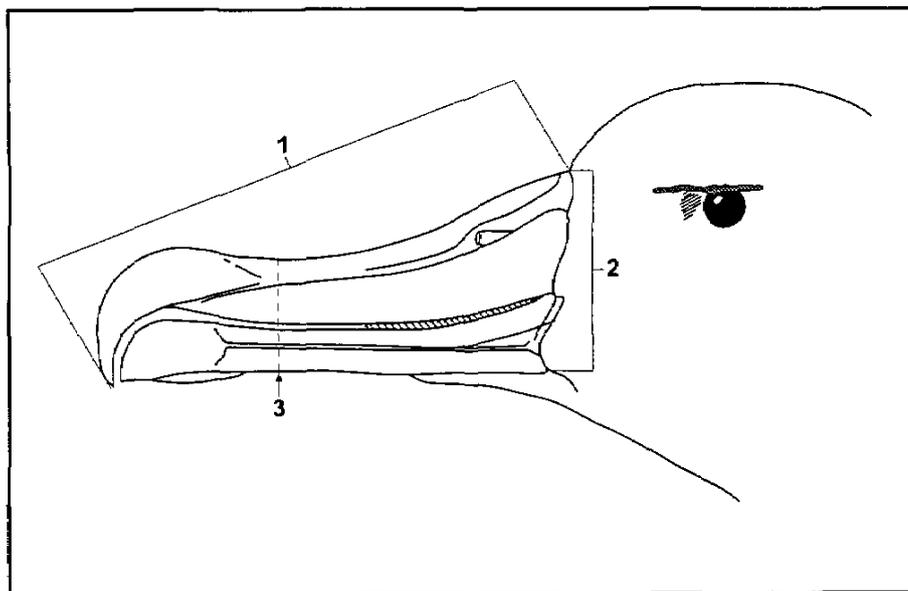


FIGURE 1 – Profile of albatross bill showing locations where measurements were taken. 1 = bill length; 2 = bill width and maximum bill depth; 3 = minimum bill depth.

Bill length was measured as the straight line along the dorsal surface, from the edge of the feathers at the base of the culmen to the most distant part of the curve of the nail (hook); bill width was taken at the edge of the feathers at the base of the culmen; maximum bill depth was taken at the edge of the feathers at the base of the culmen; minimum bill depth was taken at the proximal edge of the interramicorn (Figure 1); tarsus width was measured at the distal end of the tarsometatarsus. All measurements were made to the nearest 0.1 mm using vernier calipers. The discriminant function equation used on these measurements was derived, using the df analysis procedures implemented in SYSTAT version 6.0 (Wilkinson 1988) from bill and tarsus measurements of a sample of pairs of adults, where the gender of at least one bird of each of these pairs had been determined independently by behaviour (see above).

RESULTS & DISCUSSION

Sex determination

Measurements from known pairs, and birds where their sex was assumed from behaviour, demonstrated significant differences in bill length, bill width, maximum bill depth, minimum bill depth and tarsus width (Table 1). Using discriminant function (df) analysis, minimum bill depth and tarsus width measurements could be used to distinguish male and female Southern Buller's Mollymawks using the following equation:

$$df = 1.556 \times \text{tarsus width} + 0.981 \times \text{minimum bill depth} - 50.648$$

TABLE 1 – Mean length, width, maximum depth and minimum depth of the bill, and tarsus width (\pm s.e.) of 35 male and 33 female Southern Buller's Mollymawks breeding on North East Island, The Snares. All measurements are in mm.

	Male	Female	P (t-test)
Bill length	120.9 (\pm 0.579)	118.4 (\pm 0.627)	<0.01
Bill width	27.7 (\pm 0.149)	28.13 (\pm 0.143)	<0.001
Maximum bill depth	45.6 (\pm 0.255)	44.4 (\pm 0.265)	<0.01
Minimum bill depth	24.8 (\pm 0.11)	22.9 (\pm 0.121)	<0.001
Tarsus width	18.1 (\pm 0.069)	17.0 (\pm 0.073)	<0.001

The mean value of the *df* of a sample of birds containing an equal number of males and females is zero. Negative values of *df* indicate females and positive values males. Using this equation alone 97% of mollymawks could theoretically be correctly classified (Figure 2). When measurements from both partners are known, the likelihood of correctly sexing a bird is 99%.

Philopatry

Of the 859 Southern Buller's Mollymawks banded as chicks on North East Island during August 1972, 103 were recaptured during the period 1977 to 1998, all on North East Island; none was found on Broughton Island or Solander Island. None of the 186 chicks banded on the Solander Islands has been recaptured at The Snares, nor have any Snares birds been recaptured on Solander Islands. Of the 103 birds recaptured on North East Island, 17 were either not associated with a nest or breeding was not confirmed. All of these 17 birds were recaptured during the period 1977 to 1986, when they were 5 to 14 years old, and so may be considered as pre-breeders (Sagar, Molloy & Stahl unpub. data). Because immature birds may visit colonies where they do not later breed (Fisher & Fisher 1969, Harris 1972, Rabouam *et al.* 1998) these birds were not considered in subsequent analyses of philopatry.

Of the 86 birds which were recaptured while they were incubating, 57 (66%) were occupying a nest within 100 m of their natal nest. The distances moved by the remaining 29 birds ranged from 100 m to 2430 m (median = 520 m; Figure 3 shows the movements of the 15 birds which moved farthest). The median distance moved provides a better description of dispersal distance than mean distance because dispersal distances are skewed towards the point of origin (Greenwood & Harvey 1982). The maximum possible distance that could be moved on North East Island is about 3000 m.

It is often assumed that population density is a major cause of dispersal (Greenwood & Harvey 1982). However, in Wandering Albatrosses (*D. exulans*) on Possession Island, dispersal from the natal colonies was most pronounced in less dense colonies, with birds raised in a dense colony being more likely to breed in the same colony (Weimerskirch & Jouventin 1987). On North East Island, the

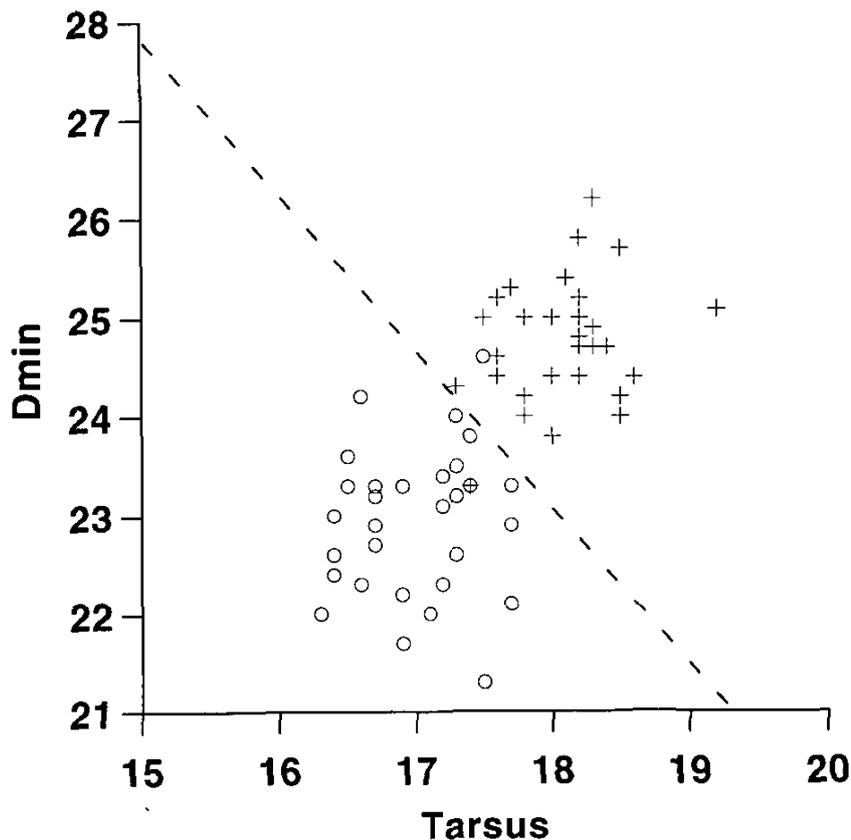


FIGURE 2 – Minimum bill depth and tarsus width (mm) for 33 male and 35 female Southern Buller's Mollymawks breeding at The Snares. The line is the calculated discriminant function. +, male; o, female.

densest concentrations of breeding mollymawks are on the west coast (Sagar *et al.* 1994). However, in our study the search effort for banded birds was not the same in all areas of North East Island, with colonies on the east coast, where 68 of 309 (22.0%) chicks banded have been recaptured, receiving more attention than those on the west coast, where 35 of 550 (6.3%) chicks have been recaptured. Consequently, the apparent predominance of natal dispersal from west to east coast colonies (Figure 3) may be an artifact of search effort.

Gender-based dispersal

Of the 86 birds recaptured incubating, 32 were sexed reliably from bill and tarsus measurements (28 birds, Figure 4) or behaviour (4 birds). The sex of the remaining birds was not determined, either because insufficient measurements were taken or the discriminant function calculated from the measurements was considered too close to the cutoff value, and so did not provide a reliable indication of gender. The sexed sample of birds comprised 17 males and 15 females. Males showed a greater natal philopatry with 88% breeding within 100 m of where they were banded as chicks, whereas only 33% of females did so (χ^2 with Yates' correction = 8.043, d.f. = 1, $P < 0.005$). The two males which bred farther from their

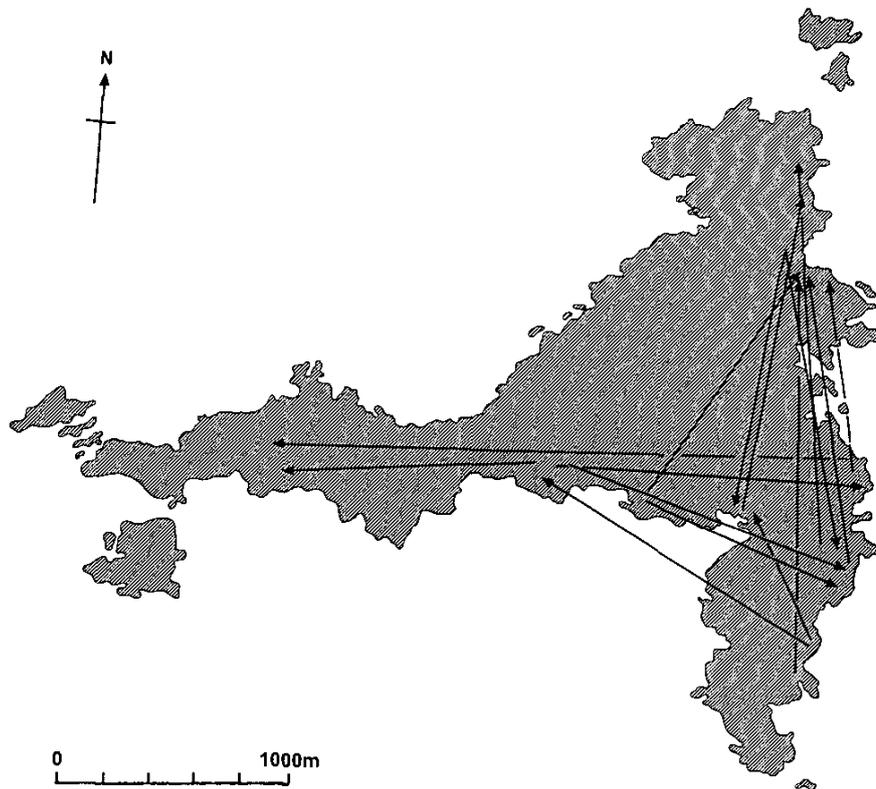


FIGURE 3 – North East Island, The Snares, showing approximate distance between natal nest site and breeding nest site as an adult for 15 Southern Buller's Mollymawks. Tail of the arrow indicates the approximate location of the natal nest; head of the arrow indicates approximate area of the nest site occupied as an adult. Only distances >500 m are shown, see text for shorter distances moved.

natal area did so within 200 m. However, the corresponding ten adult females ranged from 100 m to 1640 m (median = 500 m).

Sex differences in natal dispersal have been recorded in a wide range of philopatric bird species, with dispersal usually more extensive among females (Greenwood & Harvey 1982). Evidence for this among seabirds comes from a study (Brooke 1978) of Manx Shearwaters where some birds, particularly females, bred in a different colony to that where they were fledged. Likewise, in two studies of Cory's Shearwater (*Calonectris diomedea diomedea*) males bred near where they had been reared more often than did females, and females changed subcolony more often than did males (Thibault 1993, Rabouam *et al.* 1998). By comparison, in an intensive study over many years of Laysan Albatrosses on Midway Island, Fisher (1976) found that both sexes make an attempt to breed near their natal nest. In this study Fisher (1976) found that males settled a mean distance of 15 m and females a mean distance of 26 m from their natal nests. The difference in distance was attributed to males establishing territories and thus choosing their location, while females depended upon finding an unpaired male on a territory. By dispersing greater distances, females are able to exercise a greater choice of breeding area and of mate (Greenwood & Harvey 1982).

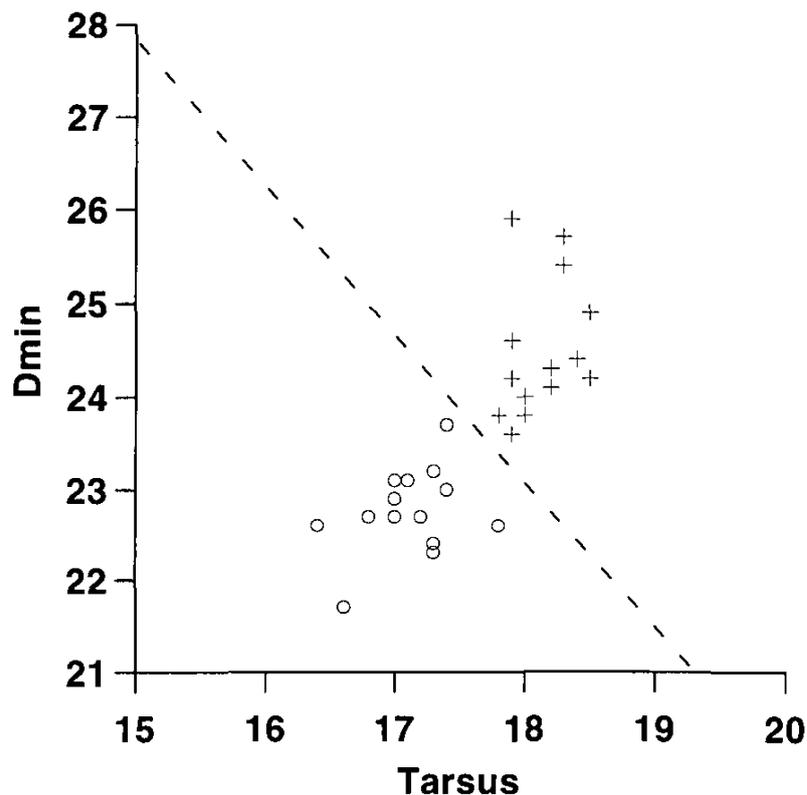


FIGURE 4 – Minimum bill depth and tarsus width (mm) measurements for 28 breeding Southern Buller's Mollymawks banded as chicks on North East Island, The Snares, August 1972. The line is the calculated discriminant function (see Figure 2) separating males and females. +, assumed male; o, assumed female.

Gender-related natal dispersal of seabirds has implications for studies of population dynamics. In the case of Southern Buller's Mollymawks, calculations of overall survival to breeding age of cohorts banded as chicks will be underestimates if subsequent searches are limited to natal colonies and those immediately adjacent. With the assumption that the sex ratio is even at age of first breeding, it will be important to identify the gender of all birds recaptured as breeders and any imbalance in sex ratio must be taken into account for survival estimates to be realistic.

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