SIZE VARIATION IN THE SNOW PETREL *Pagodroma nivea*[1]

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ABSTRACT

A colony of breeding Snow Petrels (*Pagodroma nivea*) in the Mühlig-Hofmann Mountains, Queen Maud Land, on the Antarctic continent was visited in January-February 1985. The birds were nesting under large boulders on the north-faced, ice-free hillside of Svarthamaren (71°53'S, 5°10'E), about 200 km from the open sea. The colony was roughly estimated to contain 500 pairs (Mehlum *et al.* 1985). Hatching took place in mid-January.

The Snow Petrels at Svarthamaren were on average significantly smaller than those breeding elsewhere in the Antarctic. The irregular geographical distribution of breeding birds of varying size does not immediately provide any support for a subspecific division of the species into one large and one small form, leaving the systematic and evolutionary status of the species unclear. It remains to be established whether inland breeding selects for relatively small birds.

INTRODUCTION

As stated by Cowan (1981), it has long been known that Snow Petrels vary greatly in size. Bonaparte (1856) described two subspecies, a larger one (*Pagodroma nivea major*) and a smaller one (*P. n. minor*). This view was followed by Prevost (1969) and Isenmann (1970). The latter pointed out that the large form is characterised by a great variability in size, whereas the small form shows little variability. Isenmann (1970) argued that the two forms were geographically imperfectly isolated and showed some genetic mixing. The distribution of the large form was mainly on Adelieland and adjacent regions, while the small form is thought to breed elsewhere. Cowan (1981), however, claimed that variability in size does not correlate with geographical distribution and questioned the existence of two subspecies. Croxall (1982) suggested that "the true status of the so-called large and small forms of the species can best be resolved by comparing birds of known sex and status." According to him, the sexual dimorphism in weight in the Snow Petrel is among the greatest found in the Procellariiformes and might be a result of natural selection in favour of an extension of the sound frequency of vocalisations.

Recently, Jouventin & Viot (1985) reanalysed the previously known data, together with some fresh information, and concluded that a separation into two subspecies is probably valid. They proposed the idea that during the Quaternary glaciations no refugia existed for the species on the Antarctic

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continent. When the climate last ameliorated the continent was invaded by birds from two refugia, "a low latitude one inhabited by small birds *Pagodroma nivea nivea,* and one in higher latitudes characterized by large birds *P. n. major*. Reproductive isolation broke down, and a hybridization zone was created." In this paper we present data which show that the Snow Petrels breeding in the Mühlig-Hofmann Mountains are among the smallest hitherto described.

METHODS AND MATERIAL

Altogether 35 incubating birds were caught on their nests during the period 17-26 January 1985 for biometrical measurements. Of these, 10 were killed and were sexed after autopsy.

All birds were weighed and measured. Wing length: maximal length of flattened wing measured on a ruler fitted with a zero-stop. Bill length: distance from bill tip to the start of feathering. Bill-nares: distance from bill tip to the nares. Bill + skull length: distance from bill tip to the hindmost point of the head, on the occiput. A slide caliper was used for making the last measurements. Fat content was estimated by weighing all visible subcutaneous and intestinal fat.

RESULTS

The biometric data from all birds captured at Svarthamaren are shown in Table 1. Only 10 of the birds were sexed. The males were on the average larger than the females, but, probably due to the small sample size, the differences in body weight and wing length were statistically insignificant,

TABLE 1 — Measurements of the petrels from Svarthamaren, Mühlig-Hofmann Mountains in Queen Maud Land. Weight and visible fat in grams; other measurements in millimetres, mean ± SD (range in parenthesis)

	Males	Females	Unsexed	Total
N	5	5	25	35
Weight	258.2±19.54 (237–278)	229.8±32.76 (200–283)	258.5±36.10 (212–343)	254.3±34.56 (200–343)
Wing	258.3±3.87 (253–263.5)	253.3±5.26 (245–258)	255.9±6.56 (246–267)	255.9±6.10 (245–267)
Bill length	20.0±0.37 (19.4–20.4)	18.8±0.38 (18.4–19.4)	19.9±0.96 (18.0–21.7)	19.8±0.92 (18.0–21.7)
Bill-nares	16.5±0.68 (15.8–17.5)	15.5±0.46 (15.0–16.0)	14.1±0.88 (12.3–15.6)	14.6±1.21 (12.3–17.5)
Bill + skull length	68.0±1.15 (66.6–69.5)	65.4±0.92 (64.2–66.6)	67.8±1.81 (64.3–71.2)	67.5±1.83 (64.2–71.2)
Visible fat	9.2±3.7 (5.3–13.9)	4.0±0.97 (3.1–5.4)	-	-

whereas the bill and skull measurements showed significant sex differences ($p < 0.025$, one-tailed t-test). It is also noteworthy that the males contained significantly more fat that the females ($p = 0.008$, Mann-Whitney U-test), although they were all captured on the same day (26 January).

DISCUSSION

Because of the marked sexual size dimorphism in the Snow Petrel, morphometric comparisons between different populations need to be made with care (cf. Croxall 1982). Thus, histograms for the birds measured at Svarthamaren (35 birds, of which only 10 were sexed) clearly indicate a two-topped distribution, probably due to sexual dimorphism (Fig. 1). The sexual dimorphism indexes (female/male x 100) of the individuals at Svarthamaren are within the extremes found for other localities: weight 89 (73-95), wing 98 (95-98) and bill length 94 (84-95) (data in parentheses taken from Croxall 1982, Tables 1 and 4).

Unexpectedly, we found that the males at Svarthamaren contained significantly more subcutaneous and intestinal fat than the females, although all birds were caught on their nests on the same day. This pattern might indicate sexual differences in energetic investment, for example, in incubation effort. However, the data given by Brown (1966) for the division of labour between the sexes during the incubation period do not indicate that the females on average spend more time on the nest than the males. The only reasonable explanation we can provide for the low fat content in the female is egg production.

Based on a comparison of wing length data for 21 localities spread around the Antarctic continent, Jouventin & Viot (1985) suggested a cline with a peak at the Balleny Islands, which seem to be inhabited by a homogeneous population of the large form *Pagodroma n. major*. They considered that the proportion of this form in any colony decreases roughly with the distance away from the Balleny Islands, whereby Adelieland, Casey, South Orkneys, Cape Hunter, South Sandwich Islands and "undoubtedly other localities" represent a vast hybridisation zone between the large form *major* and the small form *minor*. However, when the available morphometric data for birds of known sex are compared, no clear size trend or consistent pattern appears, except that related to sexual dimorphism (Fig. 2, see map Fig. 3). Statistically significant size differences (wing length, body weight) are to be found even between adjacent breeding colonies, as for example between Adelieland and Cape Denison (two-tailed t-test; $p < 0.001$). Furthermore, the birds on Signy Island (Orkney Islands), almost on the diametrically opposite side of the Antarctic continent to the Balleny Islands, are also relatively large (Fig. 2), as are those on the South Sandwich Islands (Cowan 1983). This is especially interesting in view of the relatively small size of the birds at Svarthamaren, which is the nearest breeding locality surveyed to Signy Island. In fact, the birds at Svarthamaren are on average significantly smaller than those from all other colonies hitherto described (Table 2.)

Different colonies are certainly to some extent exposed to different selection pressures. Thus, birds breeding far inland, but still entirely

dependent on marine food, are presumably constrained by factors of a different nature and strength than those breeding close to the open sea. It would be interesting to know whether the small size of birds at Svarthamaren is a characteristic of inland colonies. Some Snow Petrel colonies on Queen Maud Land are more than 300 km inland from the

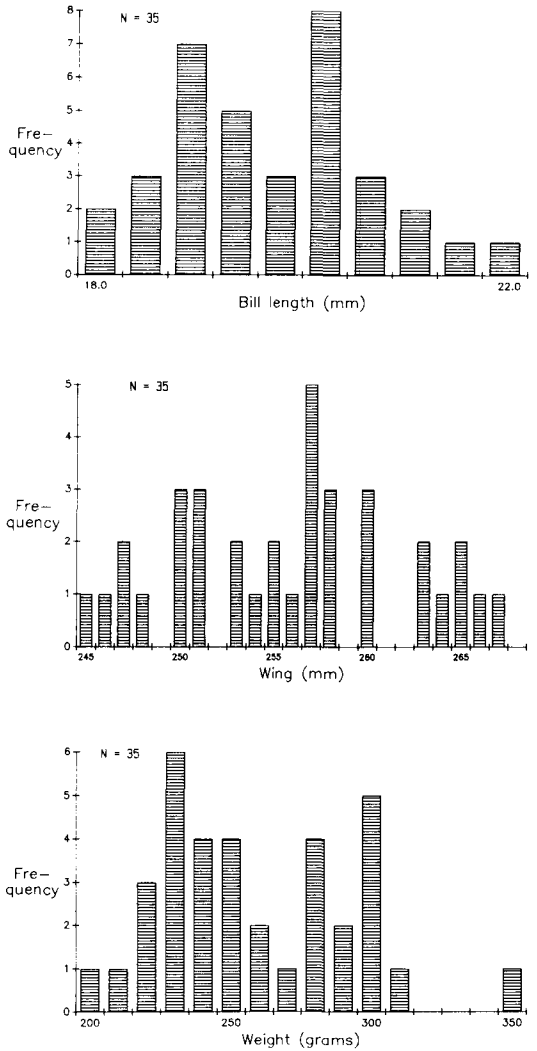

FIGURE 1 — Histograms of the bill length, wing length and body weight data of Snow Petrels from Svarthamaren, Queen Maud Land

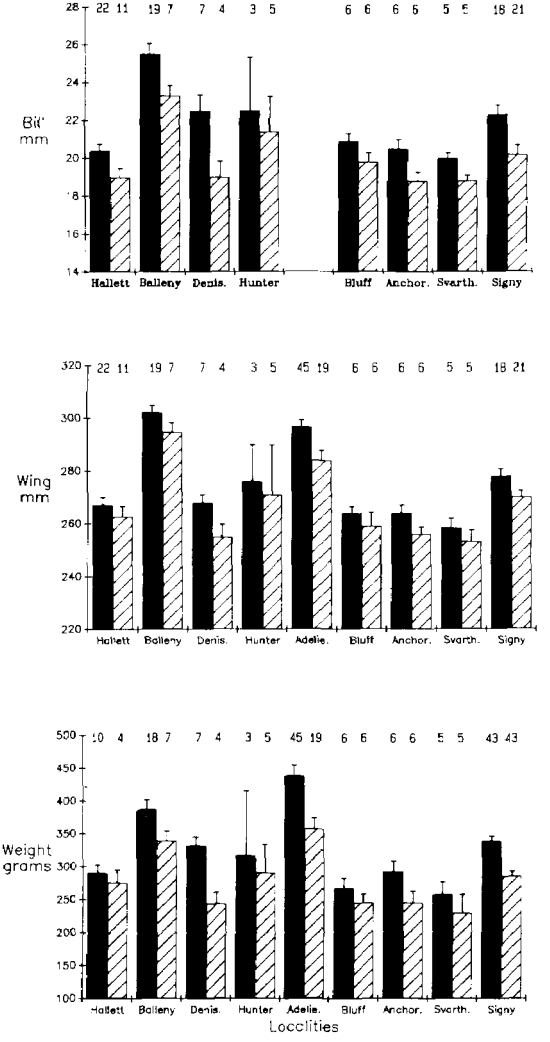

FIGURE 2 — Biometric data (means+2SE) for Snow Petrels of known sex from different breeding localities (data from the Balleny Islands, and bill and wing data from Cape Hallett refer to specimens held at National Museum in Wellington, New Zealand; the other data are taken from Croxall 1982, Jouventin & Viot 1985, and present study; the weight data for Signy Island refer to sample no. 3 in Croxall 1982, Table 2). Full names of the localities are: Cape Hallett, Balleny Islands, Cape Denison, Cape Hunter, Adelieland, Bluff Island, Anchorage Island, Svarthamaren, Signy Island (South Orkney Islands). Numbers on top of the histograms indicate sample size. Black columns = males, hatched columns = females

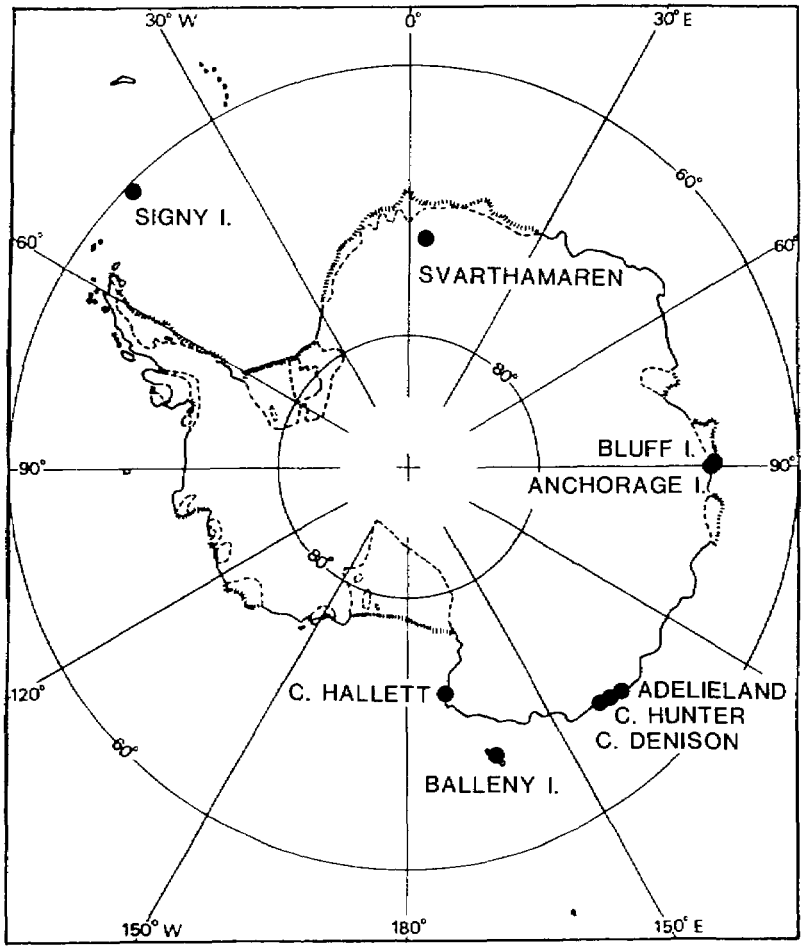

FIGURE 3 — Localities throughout Antarctica at which Snow Petrels of known sex have been measured

coast (Vestfjella, Sømme 1977), but unfortunately the size of these birds is still unknown.

In conclusion, more data for birds of known sex are needed before the systematic and evolutionary status of the Snow Petrel, and thus the validity of the two forms *P. n. major* and *P. n. minor*, can be settled. The existence of statistically significant size differences between birds from breeding colonies lying relatively close to one another, as for example Svarthamaren and Signy Island, indicate a fairly low gene flow.

TABLE 2 — Snow Petrels from Svarthamaren, Queen Maud Land (5 ♂, 5 ♀) were on the average smaller than those from other localities (one-tailed t-test; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns = not significant $p > 0.05$). Data from Balleny Islands, and wing and bill data from Cape Hallett refer to specimens held at National Museum in Wellington, New Zealand; the others are taken from Croxall (1982) and Jouventin & Viot (1985)

	Weight		Wing		Bill length	
	♂	♀	♂	♀	♂	♀
Cape Hallett (10♂ 4♀)	**	*	-	-	-	-
Balleny Islands (18-19♂ 7♀)	***	***	***	***	***	***
Cape Denison (7♂ 4♀)	***	ns	***	ns	***	ns
Cape Hunter (3♂ 5♀)	ns	*	*	*	*	*
Adelieland (45♂ 19♀)	***	***	***	***	-	-
Bluff Island (6♂ 6♀)	ns	ns	**	ns	**	**
Anchorage Island (6♂ 6♀)	**	ns	*	ns	ns	ns
Signy Island (18♂ 21♀)	***	***	***	***	***	***

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SHORT NOTE

Red-billed Gulls feeding on ngaio at the Mokohinau Islands

During a visit to the islands of the Mokohinau group, Hauraki Gulf, from 26 November to 2 December 1987, I observed Red-billed Gulls *(Larus novaehollandiae)* hovering over, landing on and apparently feeding from ngaio *(Myoporum laetum)* bushes on Burgess and Atihau (Trig) Islands. Upon careful observation it became clear that the gulls were feeding on the unripe berries of the plant.

On most days, gulls were seen on ngaio bushes in the morning up to 09.00 and from late afternoon to about dusk. On Burgess, birds were seen to fly directly from the breeding colony (c.450 pairs) to the bushes, and after feeding, some at least returned directly to the colony. Most nests contained eggs or recently hatched chicks. The gulls congregated over, and on, the bushes in groups of up to 30 birds. Birds sometimes pulled berries off while still on the wing; otherwise they landed on the vegetation (usually making several abortive landings until they found supportive branches) before delving into the foliage for the berries. On occasion, on Burgess Island, several flocks of gulls were in sight foraging on different ngaio bushes at the same time.

Red-billed Gulls have previously been recorded feeding on the berries of taupata *(Coprosma repens)* and puka *(Meryta sinclairii)* (Oliver 1955) but although Sandager (1889) described them driving cicadas from ngaio bushes and feeding on them I know of no previous records of the berries being eaten.

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