BREEDING ECOLOGY OF THE ANTARCTIC PETREL *THALASSOICA ANTARCTICA* IN MÜHLIG-HOFMANNFJELLA, DRONNING MAUD LAND*

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Abstract: Possible adaptations to breeding in a thermally hostile environment far inland on the Antarctic Continent includes: shorter incubation, rapid growth rate of chicks, high metabolic rate and thermal insulation in newly hatched chicks compared to other procellariiform chicks. Moreover, the foraging frequency is lower, but the chick meal size higher, than for other procellariiform bird species of similar size.

1. Introduction

The Antarctic Petrel *Thalassoica antarctica* exclusively nests on the Antarctic Continent, and several of the ten breeding colonies known hitherto are situated far inland (Watson, 1975). The largest inland colony is located in Dronning Maud Land about 200 km south of the iceshelf edge, at an elevation of about 1600 m a.s.l. The colony, which was discovered by Soviet geologists in 1961 (Konovalov, 1962; Konovalov and Shulyatin, 1964), is situated on a northeast-facing slope on Svarthamaren (71°53'S, 5°10'E), one of the mountains in the Mühlig-Hofmannfjella.

This huge colony was reported by the Soviet geologists to be inhabited by about one million Antarctic Petrels. In this remote inland colony the ambient temperature is permanently below zero degrees, and often reaching values as low as −25°C during the breeding season. The Antarctic Petrels depend mainly on krill for food (Montague, 1984). The adult birds therefore have to fly at least 200 km to the open sea in order to collect food for themselves and their chicks.

During the austral summer of 1984/85 we visited the Svarthamaren colony of Antarctic Petrels, estimated the colony size and studied different aspects of the species' biology emphasizing adaptations for breeding in such a thermally hostile habitat (Mehlum *et al.*, 1985). The study was carried out during the period 11 January–15 February 1985.

Results from different aspects of the study are reported elsewhere (Bech *et al.*, 1988a, b; Mehlum *et al.*, 1987, 1988). In this paper some of the results are summarized.

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2. Breeding Habitat

The colony is located on a northeast-facing scree with a slope of 31–34.5 degrees. The two main sub-colonies have the shape of amphitheatres. The prevailing wind direction during the summertime is northwards along the mountain slopes. Strong katabatic winds often occurred during the nighttime. The topography reduces the wind speed along the slopes, so that the petrels normally are exposed to relatively low wind speed at the nests. In addition to the favourable wind conditions the birds are also favoured by other microclimatic conditions caused by the radiation regime at the nest places (MEHLUM et al., 1988). On calm, sunny days the ground temperature may exceed 20°C and the air temperature 1.5 m above the ground −5°C. Under such circumstances incubating petrels were influenced by the relative high temperatures close to the ground. These temperatures are undoubtedly within the thermoneutral zone of the adult petrel.

The number of breeding pairs was estimated by counting the number of nests with eggs or chicks in 96 squares (3 × 3 m) evenly distributed throughout the colony, and by multiplying the density of nests by the total area of the colony. The latter figure was obtained by use of photogrammetric techniques (MEHLUM et al., 1988). The total number of breeding pairs was estimated to 207000±8000 (mean±S.D.), and the mean density of nests 0.76 per square meter.

The only predator in the Antarctic Petrel colony at Svarthamaren was the South Polar Skua Catharacta maccormicki. About 50 pairs were breeding at the base of the petrel colony and preyed upon petrel eggs and chicks.

3. Breeding Biology, Metabolism and Thermal Properties

A summary of observed and expected values based on literature data of different breeding biology and physiological parameters is given in Table 1.

The study started a few days prior to the major hatching period. Therefore, we did not have the possibility of determining the length of the incubation period. Others have reported an incubation period of 40–45 days for this species (ORTON, 1968; J. A. VAN FRANEKER, personal communication). This is shorter than the expected value (55 days) based on the general allometric relationship between egg size and incubation period in procellariiforms (MEHLUM et al., 1987). The hatchling weight, 63 g, is slightly larger than the expected 59 g obtained by the general relationship between egg mass and hatchling weight in procellariiforms (GRANT et al., 1982).

In an environment with air temperatures below zero and the nest placed directly on the ground, the incubating parent must pay special attention to heating of the egg. Proper egg temperature in the Antarctic Petrel is obtained by placing the egg on top of the foot webs, and by covering the upper parts of the egg by the large feather-free brood patch on the belly. The brood patch as well as the foot web are rich in blood vessels. In this way the egg is almost completely surrounded by the parent's body surface. The newly hatched chick is brooded in a similar way.

Like other procellariiforms the chicks of the Antarctic Petrel are unable to maintain a high and stable body temperature at hatching, and are dependent on warming

Table 1.   Observed and expected values of different variables concerning breeding biology, and chick thermoregulation in the Antarctic Petrel Thalassoica antarctica.

Parameter		Observed	Expected	Obs/Exp×100%
Incubation period	(days)	40–45[1,2]	55[3]	73–82
Hatchling weight	(g)	63	59[4]	107
Growth rate (t_{10-90})	"	37	54[5]	69
Brooding period	"	11	~14[6]	—
Chick (1 day) BMR	(Wkg^{-1})	8.7	8.2[7]	106
Chick (11 days) BMR	"	7.4	6.7[7]	115
Chick (1 day) conduct.	(Wkg^{-1}°C^{-1})	0.616	0.708[8]	87
Chick (11 days) conduct.	"	0.480	0.457[8]	105
Foraging frequency	(meals/24 h)	0.5	0.8–4[9]	13–63
Chick meal size	(g)	150	63–75[10]	200–238

[1] J. A. VAN FRANEKER (personal communication).
[2] ORTON (1968).
[3] GRANT et al. (1982) (based on egg mass).
[4] CROXALL (1984) (based on adult body mass).
[5] RICKLEFS (1979).
[6] CRAMP and SIMMONS (1977) (Northern Fulmar *Fulmarus glacialis*).
[7] LASIEWSKI and DAWSON (1967) (based on adult body mass).
[8] ASCHOFF (1981) (based on adult body mass).
[9] FURNESS and TODD (1984) (Northern Fulmar, Great Britain).
[10] SIMONS and WHITTOW (1984) (Dark-rumped Petrel *Pterodroma phaeopygia*).

by the parent.   Thermal independence was obtained at an age of 11 days, and the chicks are left alone in the nest shortly thereafter (BECH et al., 1988a).   Reported brooding periods for the smaller species Snow Petrel *Pagodroma nivea* and Cape Pigeon *Daption capense* are 12 days (CROXALL, 1984), and for the Northern Fulmar *Fulmarus glacialis* two weeks (CRAMP and SIMMONS, 1977).

The thermoregulatory capacity of a chick is set by the metabolic rate (basal metabolic rate and metabolic capacity) and the thermal insulation of the plumage (BECH et al., 1988a).   The BMR of newly hatched Antarctic Petrel chicks was slightly higher than the expected value using a general formula of BMR versus body mass in adult birds (LASIEWSKI and DAWSON, 1967), whereas that of other procellariiform chicks is considerably below such expected values.   Thus the values of BMR reported in the literature of newly hatched chicks of six other procellariiform species were only 49.1–73.1% of the value expected for adult birds of similar mass.   The maximum metabolic capacity of newly hatched chicks was calculated to be 1.6×BMR, and at 11 days age this value has increased to 4.3×BMR.   So, at the end of the brooding period the chick is able to increase the metabolic rate considerably in response to cold exposure.   This increase is also reflected in elevated heart rate.

The growth rate of procellariiforms is generally slow compared to other birds. In the Antarctic Petrel we estimated the growth rate to be higher than in other procellariiforms (time for 10 to 90% growth being 37 days compared to an expected value of 54 days).   This growth rate, however, is similar to that found in other birds orders. We did not study the colony during the latter part of the chick-rearing period.   However, the nestling period is reported by others to be in the region of 42–47 days (ORTON,

1968; J. A. VAN FRANEKER, personal communication). The shortening of both incubation period and nestling period may be an adaptation, which make the species cope with the short summer on the Antarctic mainland.

The chicks were fed every 48 h, on average, but feeding frequency varied considerably. In a number of instances one parent fed the chick only a few hours after the other. The mean meal size delivered to a 200–300 g chick was 150 g. This value is more than twice the corresponding value for the similar-sized Dark-rumped Petrel *Pterodroma phaeopygia* (SIMONS and WHITTOW, 1984) in Hawaii. The large meal size is necessary in order to compensate for the low feeding frequency. The chicks can almost double their body weight after a meal. The capability of receiving such large meals may be an adaptation to cope with the parents' low feeding frequency. The amount of food brought to the whole colony was estimated to be 15 tonnes per day.

Metabolic rate of chicks was calculated by using weight loss during the last part of the inter-feeding intervals, assuming the weight loss to represent 45% fat, 10% protein and 45% water (BECH et al., 1988b). This results in a mean metabolic rate of 83.2 kJ kg^{-1} h^{-1}. Energy intake was estimated for chicks (mean weight 234 g) assuming they were fed every 48 hours with 150 g food. We also assumed the average energy content of the food (krill and squid) to be 4.6 kJ g^{-1} (CLARKE and PRINCE, 1980) and the assimilation efficiency to be 75%. The estimate of energy intake was 46.1 kJ kg^{-1} h^{-1}. The discrepancy between the two values must be due to the unique ability of procellariiforms to metabolize the food at sea during their foraging trips and convert it into the energy-rich stomach oil (WARHAM, 1977). Only 5–10% oil in the food is enough to make up for the discrepancy between estimated metabolic rate and energy content of assimilated food.

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