

A STUDY OF THE GENTOO PENGUIN

Pygoscelis papua

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ABSTRACT

Gentoo Penguins were studied for 3 months at four separate colonies on Macquarie Island. No external characters were found for sexing and ageing adult birds, but first-year birds could be distinguished by plumage. Breeding success varied between colonies from an estimated 0.36 to 1.14 chicks per pair. Chicks joined creches by 5 weeks of age, and they were fully feathered by 11 weeks, when the mean weight was 5.4 kg. An unusual temporary partial retention of body feathers by moulting adults was observed, and a weight loss of 3.3% per day during moult was similar to that of other penguin species.

INTRODUCTION

The Gentoo Penguin (*Pygoscelis papua*) has been studied little in comparison with its congeners, the Adelie (*P. adeliae*) and the Chinstrap (*P. antarctica*).

On Macquarie Island the Gentoo nests all round the coast to 70 m above sea level, on gentle slopes or flattened areas covered with tussock grass (*Poa foliosa*) and Macquarie Island cabbage (*Stilbocarpa polaris*), or occasionally on rocky open areas. It builds well-formed widely spaced grass nests. Nesting areas are well separated from three other penguin species breeding on the island. The Gentoo does not use exactly the same site in successive seasons. It is present all year, and breeding usually begins in September but is not tightly synchronised (Falla 1937, Gwynn 1953).

This study was stimulated by a 6-day visit to Macquarie Island by PNR with the Australian National Antarctic Research Expedition (ANARE) in November 1977. Between 20 November 1978 and 14 February 1979 we established a marked population, looked for external characters suitable for sexing and ageing live birds, estimated breeding success, recorded the growth rate of chicks, described moult in both chicks and adults, and tried to get information on diet. When we arrived, larger chicks had already formed creches near the nesting areas. Some eggs were still being incubated but few if any were laid after that time.

METHODS

Four study areas where Gentoos were known to have bred for at least 10 years were chosen close to the Antarctic Division station. Birds were handled at two of them but in the other two we restricted

ourselves to regular observations only. The stage of breeding was noted at other colonies round the island.

At the study areas, preliminary counts of nests and eggs by members of the ANARE wintering party showed that breeding began in September. After our arrival we continued the counts but in greater detail. Because of the timid nature of the Gentoos and the risk of predation, considerable care was necessary in the nesting areas. Nestlings could be taken from and returned to the nest without the parent leaving, but if nests were left exposed, we covered the contents with nesting material.

All birds were caught for measuring and marking with a long-handled net or by a running tackle when in the creches or on the beach. No attempt was made to handle adults at the nest. A portable corral of stakes and string held up to 100 birds, but wire netting proved unsatisfactory because the birds could scramble over it.

Funnel-shaped bags of heavy-weight cloth-backed vinyl were most satisfactory for restraining the birds. The open narrow end allowed the bill to protrude and avoided breathing stress, noticeable with closed vinyl bags.

Bills were measured as shown by Warham (1975), and details were recorded of weight, flipper and tail length, colour of bill, feet, and underflipper, length of the strip of orange on the culmen, distension of cloaca and development of brood patch. Spotting on the head was photographed. Flipper length was measured with the rule pressed firmly into the axilla and the flipper flattened but not stretched. Chicks were weighed and plumage development noted throughout, and their bills were measured after they joined the creche. Four marked chicks were measured twice weekly.

Chicks with feathered flippers and birds of unknown age were banded on the flipper with bands supplied by the Australian Bird-banding Scheme, Division of Wildlife Research, CSIRO. Birds were dye marked with Rhodamine B in alcohol or Bendix purple meteorological ink, and this enabled us to follow four nestlings through to fledging.

To determine the rate of weight loss and progress of adult moult, 25 birds were kept penned, and their moult and weight were recorded on capture and thereafter on every third day.

A stomach pump (Emison 1968), a gastrotomy operation and freshly dead specimens were all tried for the collection of stomach contents.

RESULTS

Banding and morphology of adult Gentoos

In total 413 Gentoos were banded, of which 161 were chicks. This includes 62 banded by G. W. Johnstone in February 1978. Breeding birds were regularly found resting or later moulting with colonies away from their nesting area.

Adult measurements are listed in Table 1. There was a tendency towards a bimodal distribution of bill depths but not of bill lengths (Fig. 1). The sample of weights included both breeding and non-breeding birds but few, if any, approached the heavier weights recorded during moult. The inclusion of 56 birds weighed on 2 January 1979, when moult was first recorded, increased the mean weight by only 100 g.

We found a gradation of bill colour from orange to salmon pink, not sexual dimorphism in bill colour, as suggested by Despin (1972). Variation in colour was also apparent on the feet and underflipper. In addition, two specimens with salmon-pink bills were examined: one had active testes and the other had active ovaries.

A strip of orange on the black culmen was first noted on some birds by G. W. Johnstone (pers. comm.). We found the mean bill depth of birds with this orange strip significantly greater than that for all birds ($p < 0.01$). On some retrapped birds the length of the strip had either increased or decreased, perhaps because the ends were often indistinct. A spot of colour was also noted on a newly feathered chick but this had disappeared after 10 days.

Gentooes showed variable amounts of head spotting but, apart from identifying one-year-old birds, which had few spots and lacked the white orbital ring of the adult, this character was not useful for sexing or ageing. Because most incubation had finished, sex or breeding status could not be determined by distension of the female cloaca (Serventy 1956) or by the presence of a brood patch.

TABLE 1 — Measurements of live Gentoo Penguins of unknown age and sex. Measurements in mm

	Mean	s. d.	Range	n
Weight (kg) 22/11 - 19/12/78	5.7	0.61	4.2 - 7.2	97
Bill depth	18.3	1.6	15.3 - 22.2	156
Bill length	56.3	3.3	48.3 - 63.8	136
Bill width	10.0	0.8	8.6 - 11.5	16
Tail length	143	6.2	130 - 153	12
Flipper length	230	0.8	210 - 240	19
Length of orange on culmen	17.3	9.7	3 - 38	43

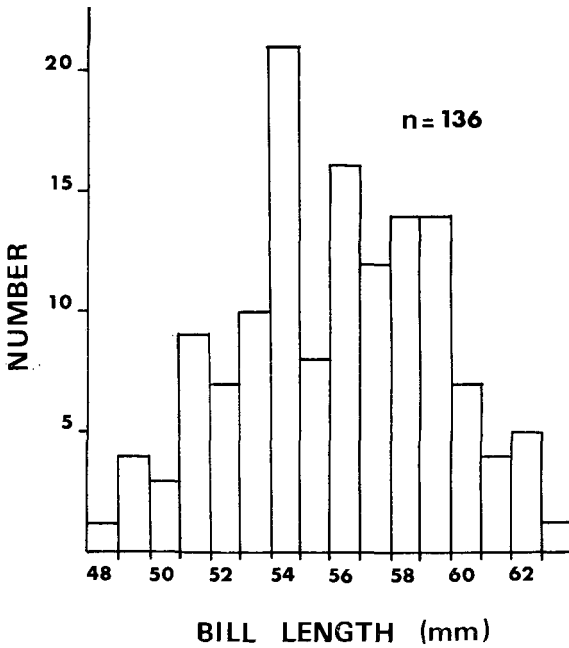
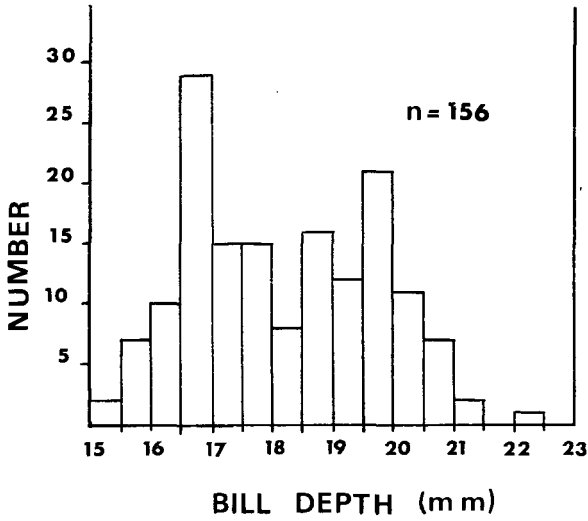


FIGURE 1 — Histograms of Gentoo bill depths and bill lengths measured in this study.

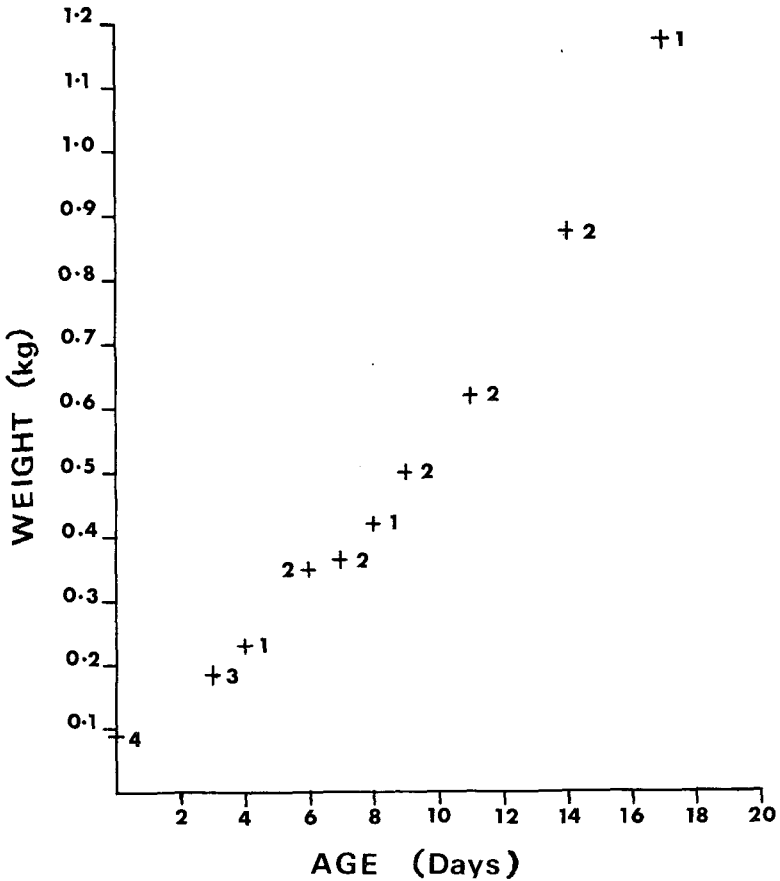


FIGURE 2 — The early growth of Gentoo chicks from hatching to 17 days (sample size is indicated by figures).

Breeding success

Breeding was well advanced when we arrived and we were unable to obtain an accurate estimate of breeding success but some indication was possible using earlier counts of nests and eggs and our subsequent counts.

The two study areas where birds were handled produced 0.90 and 0.93 chicks per pair; and the other two areas, 0.36 and 1.14 chicks per pair. Normal clutch size was assumed to have been two eggs per nest (Gwynn 1953). All eggs or nestlings still present when we arrived were unsuccessful, apart from the four largest nestlings, which were almost to creching stage.

Chick growth and plumage development

Because most late nests failed, our information on chick growth is based on the weights of only 20 nestlings. Nine were weighed once, three twice, four 3 times and four through to fledging. Only five were of known age. Figure 2 shows the early weight increases of these chicks and their estimated ages. The growth of four chicks through to fledging is shown in Figure 3.

The mean weight of 145 fully fledged chicks was 5.4 kg (s.d. 0.54, range 3.7-6.7 kg). The bill size of 65 fully feathered chicks lay within the range of adult measurements but most were below mean adult size.

The protoptyle down was replaced by the mesoptyle down at the end of the first week. The following plumage development of chicks and the ages and mean weights at which the various stages

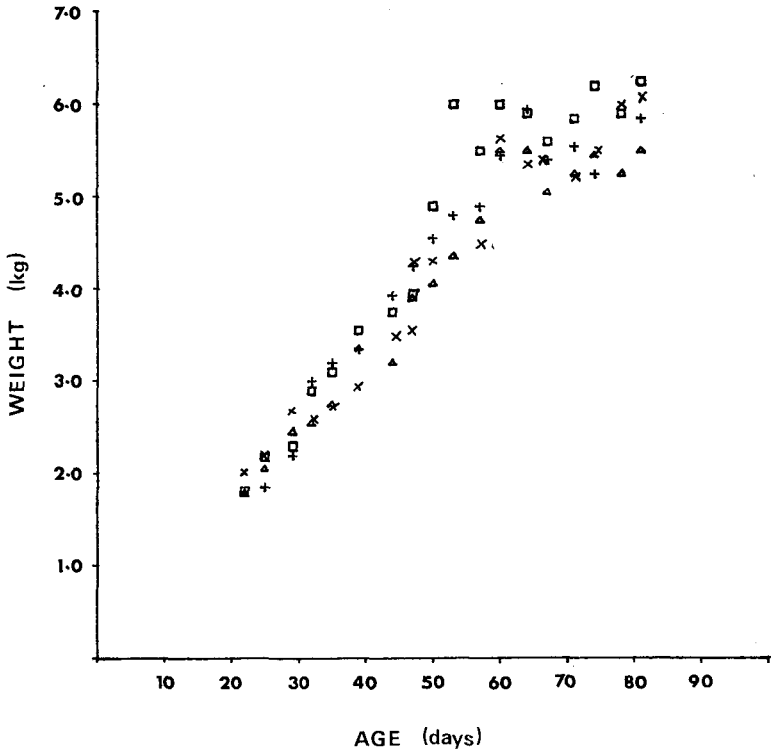


FIGURE 3 — Growth of four Gentoo Penguin chicks from 20 to 80 days. each chick represented by a different symbol.

occurred was determined from the four marked chicks and other observations. The stages of feathering, estimated age at the start of each stage, and the mean weight were as follows:

1. 18-29 days: Start of growth of rectrices
32-35 days: Appearance of white head-spotting
39 days: Feathering of tail coverts
During this period the mean weight was 3.3 kg (range 2.8 - 4.2, n = 11).
2. 47 days: Feathering of underflipper and thinning of down over supraorbital band. Mean weight 3.9 kg (range 3.4 - 4.9, n = 8.)
3. 47-53 days: Feathering of frons and thighs. Mean weight 4.4 kg (range 4.0 - 5.1, n = 8)
4. 53-57 days: Feathering of upperflipper; head mostly clear; underflipper mostly fully feathered. Mean weight 4.7 kg (range 4.3 - 5.5, n = 8)
5. 50-60 days: Head, throat and chin clear; start of feathering on centre of back; upperflipper half-feathered. Mean weight 5.1 kg (range 4.0 - 6.1, n = 12)
6. 60-67 days: Start of feathering on breast or abdomen; back half to fully feathered; upperflipper one half to two-thirds feathered. Mean weight 5.5 kg (range 4.7 - 6.3, n = 13)
7. 63-71 days: Feathering round neck; some patches of down remaining on breast and/or abdomen and upperflipper. Mean weight 5.4 kg (range 4.7 - 6.5, n = 7)
8. 71-74 days: Fully feathered

First-year plumage was distinguishable from the adult by the grey rather than black throat, few or no white orbital feathers and few spots on the head.

The four marked chicks spent less and less time at the nest, until they joined the creches when about 32 days old (the youngest was 25 days). Initially, small creches were scattered throughout the breeding area but these merged, and eventually all chicks migrated to the beach. At this time the four marked chicks, the youngest in the creche, were between 44 and 53 days old. Chicks from one study area with two nesting sites 300 m apart joined to form one creche when they moved to the beach.

Two chicks still downy on the breast entered the water when escaping from us but they were not proficient swimmers. Normally chicks began swimming within a week after becoming fully feathered, and by the first week in January many went to sea during the day and returned to their natal creche during the afternoon. Dye-marked chicks were first observed with other creches at the beginning of

February. From the middle of January the four marked chicks were hard to find, and the youngest was seen at another creche 2 km south when it was about 100 days old.

Moult

Birds nearing moult were heavy, clumsy, and tobogganed rather than ran. The first moulting bird was seen on 2 January 1979. On 10 January we caught, marked and released three beginning to moult, hoping to observe them without further handling. All soon disappeared and two were seen 4 days later, 0.5 and 1.5 km distant. Other birds in full moult swam away when disturbed though most stayed ashore.

There was some variation in the sequence and duration of moult of the 25 captive Gentoos. We defined the beginning of moult as the time when feathers started to lift and stand out from the body before being shed. Birds were released before they had completely lost all old feathers and when the rectrices were about 0.5 cm long. Eleven were released after 15 days of moult, 12 after 18 days, one after 21 days and one when only half moulted. All were in good condition.

The sequence of adult moult was as follows:

- | | | |
|-------------|-------------|---|
| Pre-moult: | 6 days: | Up to 40% weight increase; feathers dull and brown |
| | 3 days: | Loss of some tail feathers; flippers swollen and bleeding readily |
| Moult: | 0 days: | Body feathers lifting; tail lost |
| | 0-3 days: | New feathers on thighs, upper and under tail-coverts |
| | 3-9 days: | Partial loss of feathers from the breast, abdomen and from below the mantle to the tail; remaining old feathers concealing the new ones underneath. Feathers lost in complete patches from head, chin and flippers and re-Narrow band of new feathers encircling body at upper breast and mantle. |
| | 9-14 days: | New plumage increasing, leaving only partial layer of old body feathers (see Fig. 4) |
| | 15-21 days: | Sheathed tail growing approx. 1 cm every 3 days. Final gradual loss of remaining old feathers, giving a mottled appearance on dorsal surface. |
| Post-moult: | | All birds, including one-year-olds, in typical adult plumage with black throat, white band across crown, white orbital ring and variable amounts of head spotting. |



FIGURE 4 — Gentoo Penguins showing different stages of moult. The bird second from left is beginning to moult and losing some of its body feathers. The bird on the right is further advanced, having some of the old feathers still on its back.

The 24 birds that almost completed moult lost, on average, 3.3% of body weight per day (s.d. 0.33). For a weight loss of X to Y in n days, the "compound interest" % weight loss per day is $(100/n) \ln (X/Y)$. Peak weights of the birds ranged from 6 to 9 kg. so although weight loss in grams per day was variable it was very nearly constant when compared as a percentage of body weight. Figure 5 shows mean weight loss of birds during moult. One bird, 4.2 kg when released, had gained 1 kg when recaptured 3 days later.

Moulting birds stood pecking distance apart in the pen, and also in the wild, where they gathered on the lee side of rocks and hummocks on beaches or in fringing tussock grass. They did not maintain this distance at other times. They drank from a natural pool in the pen. Allopreening was not seen.

When released, some birds joined groups of creching chicks and pre-moulting and moulting birds. Others, including the one half-way through moult, immediately entered the water. All appeared to swim normally. Five of the released birds were later seen on other beaches, one 24 days later, 3 km from where it had been released, with moult complete but still without visible tail feathers.

Diet

Our attempts to obtain stomach contents produced little result. No recognisable items were collected by stomach pump. Palpation of the stomach after laparotomy indicated it to be empty except for pebbles, and gastrotomy was not proceeded with. Pebbles were also found in stomachs of dead birds, but little else. Squid beaks were collected when regurgitated by one adult and one chick.

DISCUSSION

Sexing and ageing

Bill depth and length have been successfully used to sex other penguin species (Downes *et al.* 1959, Kinsky 1960, Reilly & Balmford 1975, Boswell & McIvor 1975, Warham 1975) and may be useful for the Gentoo with further data from birds sexed during egg-laying. No other character such as body size (Falla 1937, Stonehouse 1970) or bill colour (Despin 1972) was of use in sexing Gentoos.

Apart from distinguishing first-year birds, we were unable to determine the age or breeding status of others. The strip of orange on the culmen may be a sign of maturity because it occurred only over the higher range of bill depths. We have not found any other reference to this character.

A faint orange colour on the underflipper of both adults and chicks appeared to be caused by deposits of orange fat showing through the skin. Towards the end of moult, when fat deposits dwindled, this colour became very faint. It does not seem to be a breeding character, as suggested by Murphy (1936), nor is it equivalent to the pink flushing displayed by some penguins when cooling after exercise.

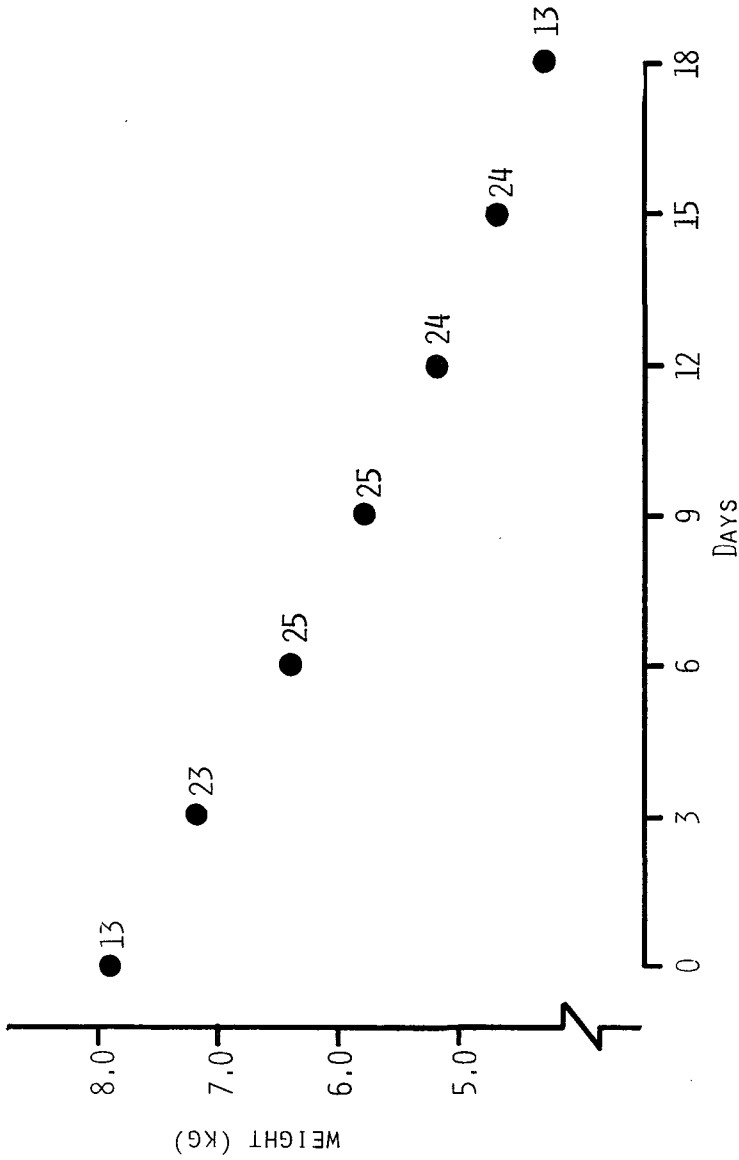


FIGURE 5 — Mean weight loss of adult Gentoos during moult. (Sample size is indicated by figures).

Chick growth and development

Weights of the four marked chicks increased steadily until they were about 55 days old. From that time the weights fluctuated, perhaps because the time of weighing varied from the time of feeding. Despite this, the mean weight of fully fledged chicks of 5.4 kg was significantly greater than that found by Bagshawe (1938) ($p < 0.05$). The average weight in Bagshawe's sample of 34 birds was 4.5 kg (s.d. 0.5, range 2.9 - 5.4).

We found less variation in the degree of whiteness on the throat and round the eye of immature birds than Bagshawe (1938), and the eye fillets extended from eye to eye rather than having an intervening band of "pepper and salt" like the Heard Island birds (Downes *et al.* 1959).

The four marked chicks began creching at about 4 weeks (25 - 32 days) compared with 35 days on Marion Island (Van Zinderen Bakker 1971) and up to 42 days on Heard Island (Downes *et al.* 1959). From the time they joined the creches chicks could defend themselves from skuas.

Moult

We have found no detailed description of moult of the Gentoo in the literature. Murphy (1936) claimed the tail was moulted last but mentioned that others disagreed. We always found the loss of the tail to indicate impending moult, and post-moult adults could be distinguished from newly fledged young because they had no tail. The rectrices were last to grow. Van Zinderen Bakker (1971) stated that the head and neck were the last parts to moult and made no mention of the temporary partial retention of feathers which we

TABLE 2 — Comparative weight loss by six species of penguin during moult

Species	Per cent loss/day	Sample size	Initial weight (kg)	Number of days	Reference
Emperor	2.80	4	ca 34	12?	LeMaho <i>et al.</i> (1976) p. 917
Gentoo	3.34	24	6-9	15-18	This study
Macaroni	2.75	10?	5.9	35	Williams <i>et al.</i> (1977) Fig. 1
Blackfooted	3.03	1	3.11	20	Cooper (1978) Fig. 2
Rockhopper	3.24	9?	3.6	25	Williams <i>et al.</i> (1977) Fig. 1
Little	3.78-3.19	Many	1.5-1.8	7-20	Hodgson (1975) 4.3, Table 4.31, 4.32

observed. Indeed, partial moult such as this does not appear to have been previously recorded for any penguins. Roberts (1940) claimed that the mandibular plates were shed during moult but we did not see any evidence of this either in the pen or on the beaches.

Stonehouse (1968) stated that moulting penguins rode high like ducks if they accidentally entered the water and Bagshawe (1938) noted three swimming in shallow water close to the shore. On a number of occasions we observed moulting Gentoos swimming. They swam underwater and were observed "porpoising" but most were quickly lost to sight. Usually they retreated to the water to escape. The temporary partial retention of body feathers may provide some insulation until the new feathers grow, allowing at least short periods in the water.

Comparative figures for the weight loss by six species of penguin during moult are shown in Table 2. The % weight loss per day for each of these species is surprisingly similar despite the differences in size and duration of moult.

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