OBSERVATIONS ON THE BREEDING BIOLOGY OF THE CHINSTRAP PENGUIN, *Pygoscelis antarctica*, AT ELEPHANT ISLAND, SOUTH SHETLAND ISLANDS

By J. W. H. Conroy, M. G. White, J. R. Furse *and* G. Bruce

Abstract. Breeding chinstrap penguins, *Pygoscelis antarctica*, made two foraging trips per pair per day during the early chick stage. This, and other observations on the breeding biology of the chinstrap penguins made by members of the Joint Services Expedition to Elephant Island (1970–71) are presented and compared with the data on chinstrap, Adélie (*P. adeliae*) and gentoo (*P. papua*) penguins from other breeding localities. Adaptive radiation to reduce competition for food is discussed, and it is suggested that the Adélie and chinstrap penguins may feed in different marine regions during the breeding season.

In the Atlantic quadrant of the Antarctic (Fig. 1), the chinstrap penguin occupies a latitudinal range between the Adélie and gentoo penguins. The three species breed sympatrically on the South Sandwich, South Orkney and South Shetland Islands, and along the north and west coasts of the Antarctic Peninsula south to Petermann Island (lat. 65°10′S., long. 64°10′W.) (Clarke, 1906; Gain, 1914; Wilkins, 1923; Araya and Aravena, 1965; Holdgate and others, 1968). The chinstrap penguin appears to be increasing in numbers and expanding its breeding range; this is thought to be caused, at least partially, by an increased food supply made available by the reduction in whale stocks (Sladen, 1964; Conroy, 1974). Although locally abundant, the chinstrap penguin has been little studied (Bagshawe, 1938; Sladen, 1955; Conroy and others, 1974).

During the 1970–71 Joint Services Expedition to Elephant Island (Burley, 1972), observations were made by two of the authors (J.R.F. and G.B.) at a breeding colony of chinstrap penguins. This paper presents the data and discusses some of their implications, including the possibility that the Adélie, chinstrap and gentoo penguins may be adapted to feed primarily in different areas or take different prey species.

Field Observations

Study population

Observations were carried out at most of the chinstrap penguin colonies on Elephant Island (Fig. 2). About 120,000 pairs breed on the island. Two other species, the gentoo penguin, with about 2,600 pairs, and macaroni penguin (*Eudyptes chrysolophus*) with about 1,150 pairs, also breed on the island, while seven Adélie penguins and one moulting king penguin (*Aptenodytes patagonica*) were recorded by Furse and Bruce (1971) as vagrants.

Observations were made between late December and early January at one colony midway along the south coast of the island (Fig. 2). This colony, about 100 m. from the sea, extended up a narrow lateral moraine ridge from about 20 to 100 m. above sea-level. Counts here in December gave estimates of 5,000 occupied nests and 1,000 non-breeding birds.

The breeding season

Chinstrap penguin hatching was concentrated in the latter half of December. Since the incubation period of the species is between 35 and 40 days (Bagshawe, 1938; Sladen, 1958; Conroy and others, 1974), this would suggest that laying had begun in the second week in November. The earliest hatching date was 15 December and the first chick appeared in the study colony on 16 December. In the study colony, the majority of the eggs had hatched by 27 December and few remained by 1 January.

General observations on the daily behaviour of chinstrap penguins

Throughout the period of the expedition (5 December–26 March) there was a noticeable return of chinstrap penguins from the sea each evening and a corresponding morning departure from the colony. At night there was little movement between the sea and the colony, where there was relatively little activity. Throughout December into February most nests were occupied by

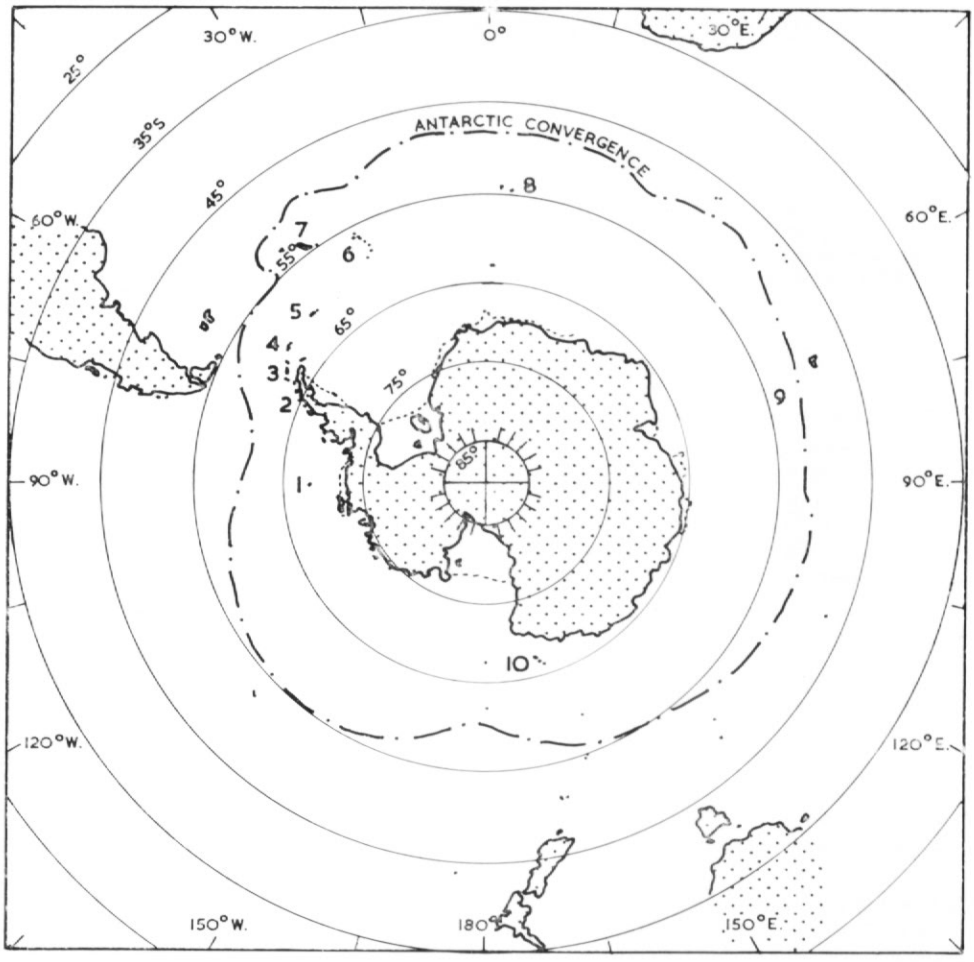

Fig. 1. The known breeding distribution of the chinstrap penguin. 1. Peter I Øy (Holgersen, 1951). 2. Antarctic Peninsula (Gain, 1914). 3. South Shetland Islands (Bennett, 1925). 4. Elephant Island (Furse and Bruce, 1971). 5. South Orkney Islands (Clarke, 1906). 6. South Sandwich Islands (Holdgate, 1963). 7. South Georgia (Stonehouse, 1967). 8. Bouvetøya (Holdgate and others, 1968). 9. Heard Island; status uncertain (Downes and others, 1959; personal communication from G. M. Budd). 10. Balleny Islands (Dawson and others, 1965).

a pair of birds at night. After early February the situation was confused by the presence of non-breeding moulting adults in the colony. The majority of pairs still appeared to roost at the nest, whether moulting or still attending chicks.

At night, presumed non-breeding, and later presumed failed breeding birds were frequently observed roosting ashore around the fringes of the colonies, on the beaches below them and on the more distant coastal areas. Evening gatherings on icebergs were also noted.

The movement of birds between the colonies and the sea appeared as a constant procession, but the results of observations made around the New Year and described below showed this not to be so. There was no indication that the routine at this time differed from that during the rest of December and early January, the latter part of the incubation period and guard periods (Conroy, 1972). Around mid-February, when some birds were moulting, many chicks were still being fed regularly at the nest but they were attended only at night, often by a single parent.

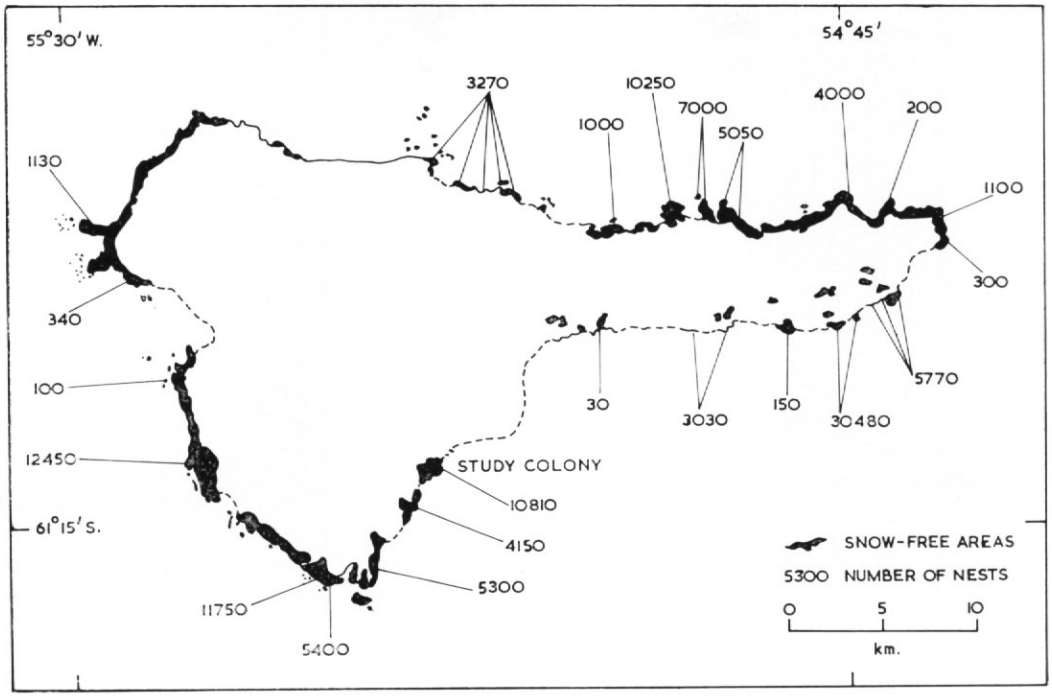

Fig. 2. The breeding distribution and sizes of the chinstrap penguin colonies on Elephant Island (from unpublished ornithological report in the files of the British Antarctic Survey).

24 hr. count on 31 December/1 January

A count of the chinstrap penguins travelling between the study colony and the sea was made during a 24 hr. period. A tent was pitched between the colony and the sea, at one side of the only access to the penguin colony, which was constricted between a rock ridge and glacier crevasses. All penguins passing to and from the tent were counted and the total recorded at half hour intervals.

The results of these counts are shown in Fig. 3, while Fig. 4 shows the net movements of penguins at the colony. During the 24 hr. period, 11,578 birds were counted travelling to the sea from the colony, while 10,845 were counted on the opposite journey. The two figures are equal to within 7 per cent. The morning and evening movements are clear, and the mid-day traffic indicated that many pairs were changing over around this time. Both figures show the pattern of forenoon and afternoon trips foraging at sea.

Observations of marked individuals at nests, 31 December/2 January (Fig. 5)

At 21.00 hr. on 31 December, seven nests occupied by both birds were selected at random and marked by numbered flags. The adult penguins were individually marked with white paint. A number of visits were made to these nests during the following 2 days, including a continuous watch over the mid-day period on the day following the traffic count. The observations are summarized in Fig. 5 and confirm that birds were changing over on the nest at this time.

Even when one bird remained away over night (nest 30), the pair still fitted in two foraging trips on the following day. The mid-day observations at nest 79 were particularly interesting in that one bird returned to the nest from the forenoon foraging trip and then itself returned to the sea. This behaviour invalidates estimates of the duration of foraging trips inferred from occasional observations at individual nests.

During a 21 hr. watch on five nests, eight changeovers were observed; this and examination

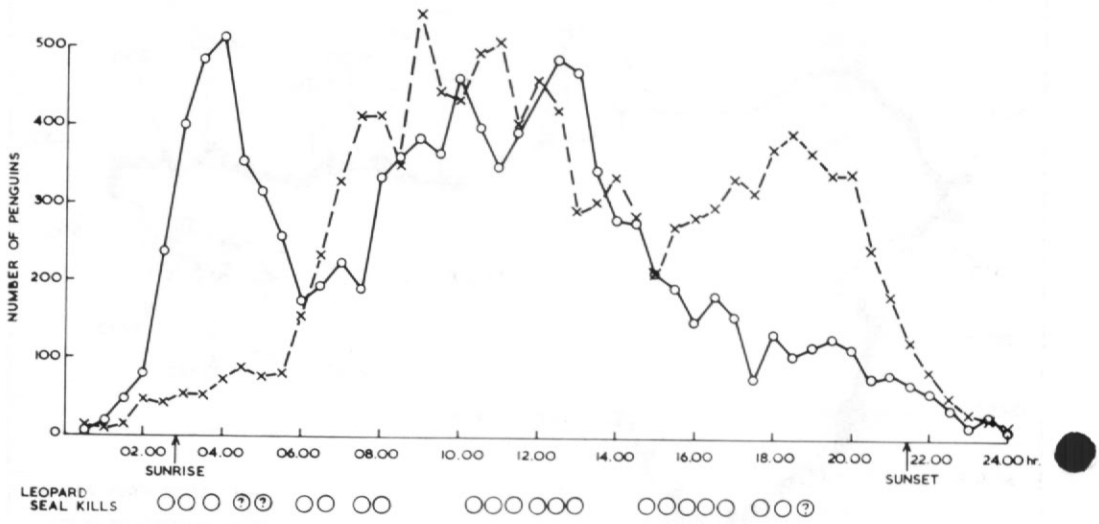

Fig. 3. The half-hourly counts of chinstrap penguins to and from the study colony during the 24 hr. continual watch period; also the timing of observed (○) and suspected (⍰) kills made by leopard seals.
x————x Penguins moving from the beach to the colony.
o————o Penguins moving from the colony to the beach.

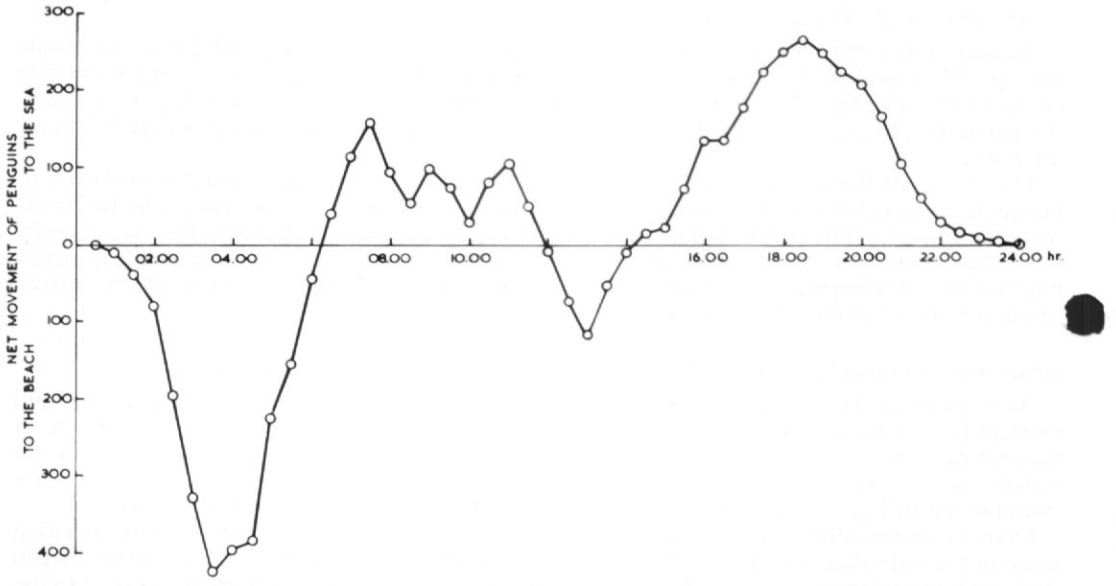

Fig. 4. The net movement of chinstrap penguins at the study colony during the 24 hr. continual watch period.

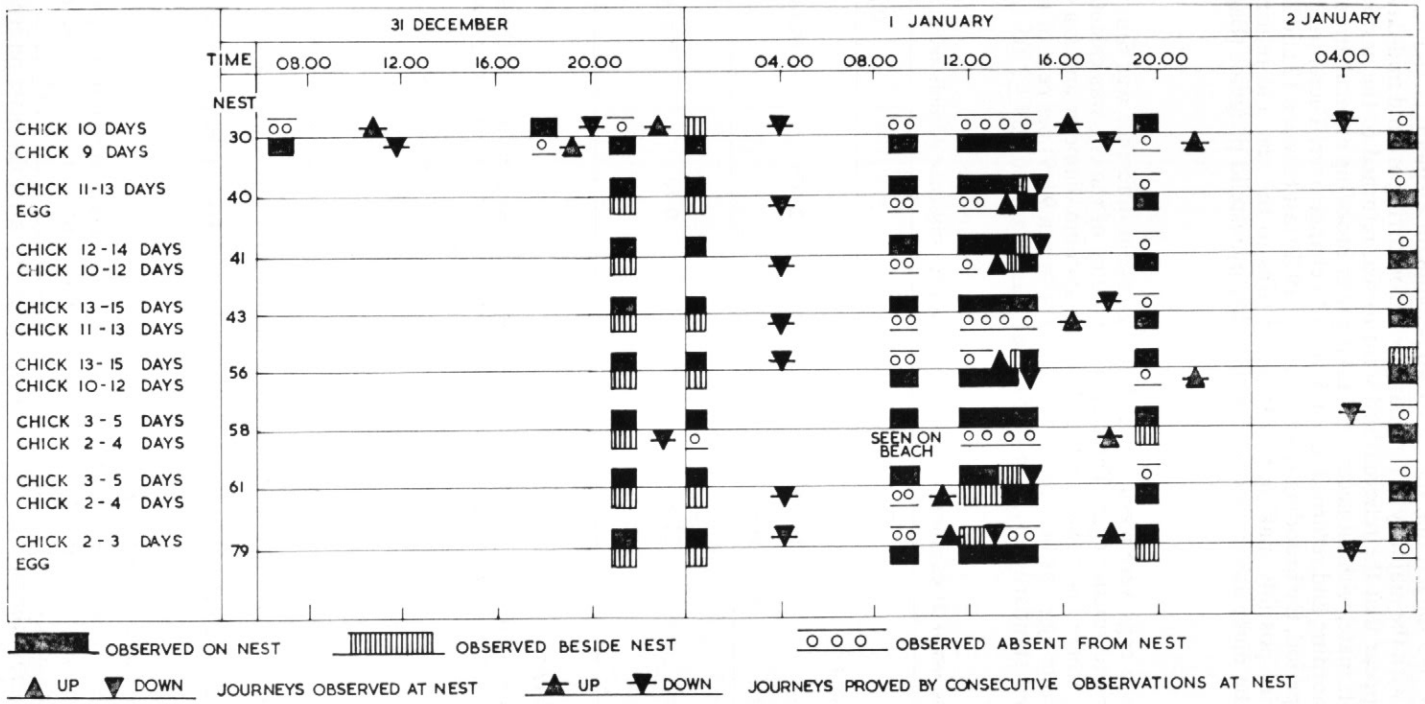

Fig. 5. The behaviour of the chinstrap penguin at eight marked nests between 31 December and 2 January. This figure lists nest contents, age of chicks and how adult birds were identified.

of the data in Figs. 3–5 suggest that the chinstrap penguin on Elephant Island has a 12 or 24 hr. brooding period, with the majority of the changeovers occurring around mid-day or during the night. It would appear that the relieved bird went to sea, returned to the nest in the evening, stayed alongside its mate, without necessarily taking over brooding or incubation, went back to sea again in the morning and returned around noon to change over. Therefore, during at least part of the guard period, the brooding spans (Conroy, 1972) last between 12 and 24 hr., with the non-incubating bird possibly making two foraging trips to the sea, and returning ashore at night. Spending the night ashore is common in other pygoscelid penguins (Bagshawe, 1938; Yeates, 1971).

Egg sizes

21 clutches of two eggs were measured and no significant difference was found between the sizes of the larger and smaller eggs (Table I). The volume of the egg was calculated from the formula $v = ld^2k$, where l is maximum length, d is maximum diameter and k a constant. The volume of the smaller egg was between 87·0 and 99·4 (mean 94·9) per cent of the larger egg. The mean size and standard deviation of 51 eggs was: length $67 \cdot 39 \pm 3 \cdot 05$ mm., diameter $51 \cdot 96 \pm 2 \cdot 09$ mm.

TABLE I. THE DIMENSIONS OF 21 CLUTCHES OF TWO EGGS FROM THE CHINSTRAP PENGUIN ON ELEPHANT ISLAND

	$\bar{x}$	*s.d.*	"*t*"	*Difference*
Egg length (mm.)				
Large egg	66·95	2·82	2·075	Not significant
Small egg	66·45	2·67		
Egg width (mm.)				
Large egg	52·81	2·34	0·86	Not significant
Small egg	52·20	2·83		

Growth rates of chicks

Fig. 6 shows the weight gains of the chinstrap penguin chicks measured in the study area. In all cases the two chinstrap penguin chicks in each brood showed very similar growth rates. This appears to be caused by the elder chick gaining very little weight before the second chick hatches. General observations around the island throughout the breeding period confirmed that in nearly all cases both chicks developed at about the same rate.

Three-egg clutches

A few three-egg clutches were found but rarely were all of the eggs successfully incubated. The main causes of failure were either one of the eggs being kicked out of the nest by the sitting bird or faulty incubation, the sitting bird having difficulty in covering three eggs with the brood patch.

Three broods of three chicks were found; in each case all chicks in the brood were of a similar size.

Observations on food and feeding habits

On 1 January observations were made on chick feeding. They were normally fed near their nest and the adult usually responded to the soliciting of the chick, although in some cases there was no apparent initiative from the chick. Most chicks were fed by the newly returned adult but, on at least one occasion, the sitting bird fed the chick shortly after the mate returned but before the mate took over brooding.

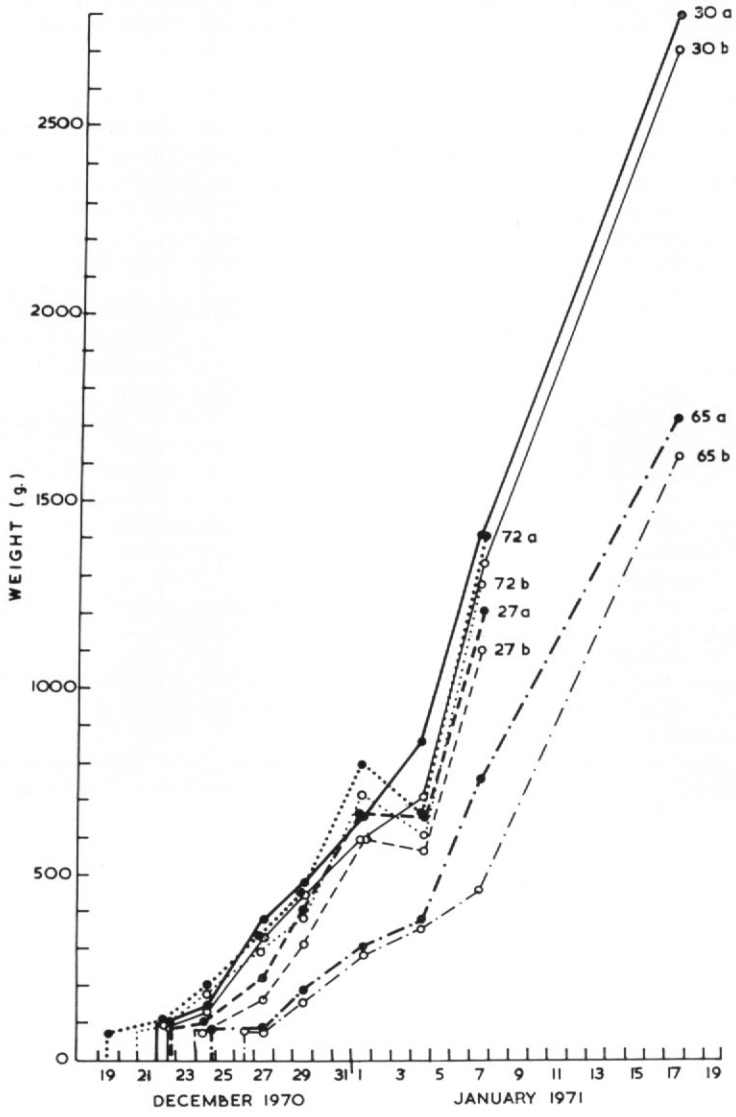

Fig. 6. The growth rates of four pairs of chinstrap penguin chicks, with information on the age at which they reached 1,000 g.

Nest number		*Date of hatching*	*Approximate age at 1,000 g.*
72	. . . ● . . .	19 Dec.	17½ days
	. . . ○ . . .	20/21 Dec.	16½ days
30	——● ——	21/22 Dec.	14 days
	——○——	22 Dec.	14½ days
27	– – –● – – –	22 Dec.	15 days
	– – –○ – – –	23/24 Dec.	14 days
65	– . –● – . –	24 Dec.	16½ days
	– . –○ – . –	26 Dec.	17 days

Waste food in the colonies was almost entirely Crustacea. 12 samples of krill were collected from the foreshore and later identified as *Euphausia crystallorophias*. John (1936) suggested this was the predominant neritic species of krill found around the Antarctic continent.

24 hr. watch on leopard seal predation

Leopard seals (*Hydrurga leptonyx*) were observed in ones and twos around the island from 8 December until 4 March but not thereafter. Because the expedition moved across the island, it was not possible to obtain accurate counts at any one place throughout the season, but there was some evidence of a small increase (from one or two to three or four) around the study colony from mid December into January, dropping again (to one or two) at the beginning of February. This increase during the second half of December could be connected with the peak of chinstrap penguin hatching.

We thought that the timing of the leopard seal presence might be determined by the frequency with which chinstrap penguins travelled to and from the sea, so offering the seal potential food.

On 28 December, a 24 hr. watch was kept on leopard seal predation near the study colony. 19 kills were observed and a further four suspected. It was estimated that on this day there were three, possibly four, leopard seals present. The times of the kills are shown in Fig. 3.

The seals took penguins close to the shoreline. In each of the actual catches observed, the seal lay in wait behind an underwater passage between rocks and took the penguins as they passed. It appeared that they seldom hunted for more than 5 min. before making a catch and the penguin was then carried about 100 m. offshore, flayed and eaten before the seal returned to the shore area. An interval of about 15 min. was observed between consecutive kills by one seal.

Several individual seals were observed making about four kills then hauling out to sleep. From 3 hr. before sunset until shortly before sunrise, no hunting activity was observed. At least two seals were hauled out for the night from well before sunset, at which time the return movements of the penguins was at its height.

A chinstrap penguin colony of 10,000 birds will provide about 40,000 targets per day crossing the waters edge, whereas an Adélie penguin colony of the same size will offer only 10,000 targets, because the duration of the foraging trips is different.

The kill rate noted on 28 December, if sustained, would account for about 10 per cent of the adult breeding population at the study colony on Elephant Island over 50 days (the approximate duration of the incubation and guard periods). However, this percentage is probably less because the seals could also have been killing birds from the adjacent penguin colonies.

A 5 per cent annual cropping rate by leopard seals has been recorded from the Adélie penguin colony at Cape Crozier (Penney and Lowry, 1967). Although the percentage of chinstrap penguins killed from the study colony on Elephant Island is double that for the Adélie penguin for Cape Crozier, the populations differ greatly: Elephant Island 10,000 breeding birds, Cape Crozier 300,000. A more meaningful comparison is between the number of penguins killed per hour of observation. These are more similar, Elephant Island 0·79 penguins per hour, Cape Crozier 0·61 per hour in 1964–65 and between 0·37 and 1·0 per hour in 1969–70 (Penney and Lowry, 1967; Muller-Schwarze and Muller-Schwarze, 1970).

Discussion

Growth rate of chicks

The weight gains recorded during the first 30 days for the chinstrap penguin at Elephant Island and for the Adélie penguin elsewhere (Sladen, 1958) are similar. Thus, during the first month after hatching the chinstrap penguin appears to gain little advantage from the more frequent changeovers at the nest. However, the older chinstrap penguin chicks increase in weight more rapidly than the Adélie penguin (Conroy and others, 1974). It can be inferred that during this initial month the chinstrap penguin chick meals are smaller than those of the Adélie penguin or less efficiently assimilated. If the metabolism of the adults and chicks is adapted to frequent small feeds, reliable local food supply is necessary.

Foraging range of chinstrap penguins

Field observations show that, at least during the early chick stage, chinstrap penguins on Elephant Island were foraging on trips lasting not more than 12 hr., and during the period from December until February most returned ashore every night. After mid-February there is some indication that these foraging trips may be longer with the absence of both parents from some of the nests.

Although quantitative results are available for only 1 day at one colony, the marked pattern of daily routine suggests that it is a regular feature. Observations at other breeding localities are needed to discover whether this daily behavioural pattern varies over the species' range and also if it continues during the whole of the breeding cycle.

Comparison between the pygoscelid penguins

The gentoo penguin feeds mainly on small fish and is known to forage to 250 m. depth (Conroy and Twelves, 1972), and so it does not compete for food with the Adélie and chinstrap penguins which feed predominantly on crustaceans. Whereas the chinstrap penguin appears to make short foraging trips, the Adélie penguin makes much longer ones, lasting several days during the incubation period (Sladen, 1958; Taylor, 1962; Stonehouse, 1963; Penney, 1968).

The significance of the difference in the lengths of the Adélie and chinstrap penguins' foraging trips is not clear but it may be evidence of niche separation between the chinstrap and Adélie penguin which could be in direct competition for planktonic crustaceans at sea. It can be argued that the short duration of the chinstrap penguin's foraging trip restricts its feeding range whilst breeding to near-shore waters, whereas the longer foraging trip of the Adélie penguin enables it to exploit resources farther offshore. This offers an opportunity for these sympatric species to avoid exploiting the same plankton stocks. A preliminary study at the South Orkney Islands (White and Conroy, 1975) adds weight to the hypothesis of niche separation as it was shown that these two species were both feeding on the same organism, *Euphausia superba*, but that they were taking significantly different size classes of the prey population. How this relates to the duration of the foraging trip and plankton distribution is not clear, although horizontal separation on the feeding grounds would be of adaptive advantage.

The breeding seasons of the three species also differ. The early breeding Adélie penguin (Sladen, 1958) and the comparatively late breeding chinstrap penguin (Conroy and others, 1974) have synchronous egg-laying, whereas the gentoo penguin breeding season is not so synchronous. This feature of the life history of the crustacean-feeding Adélie and chinstrap penguin suggests the species are avoiding competition by having different breeding seasons. Complete separation of breeding seasons has not been achieved because of the short length of the summer but it has been maximized by secondary adaptations such as accelerated chick growth at the end of the season by the chinstrap penguin and the longer incubation and brooding spans (i.e. length of time a bird sits on the nest before relief) of the Adélie penguin. The latter enables this species to have earlier access to the breeding grounds since it will be able to travel farther over sea ice to feeding areas. Only later in the season after the sea ice has almost completely broken out can the chinstrap penguin with its shorter incubation spans gain access to the near-shore plankton stocks and so begin nest-building and egg-laying.

Therefore, Adélie and chinstrap penguins can breed in similar areas and exploit the same food because they have evolved a partial separation in their breeding seasons by spatial and temporal mechanisms. The Adélie penguin breeds earlier, has longer incubation spans and hence foraging trips, which allows this species to travel farther, allowing it, if necessary, to cross fast ice to reach open water and food. The chinstrap penguin breeds about 3 weeks later, has a shorter incubation span and so must exploit the closer inshore feeding grounds. It is not known whether the Adélie penguin continues to forage at distant feeding grounds once the sea ice has broken out, or whether they ever feed closer inshore, spending more time hunting than the chinstrap penguin. The differences in prey size observed elsewhere suggest exploitation of different resource components, but the accelerated growth by the chinstrap penguin chicks once the Adélie penguins have dispersed at the end of their breeding season may be indicative of reduced competition for food.

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