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THE ROCKHOPPER PENGUIN, *EUDYPTES CHRYSOCOME*, AT MACQUARIE ISLAND

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ORNITHOLOGISTS and other biologists have found most of the sub-Antarctic islands of absorbing interest. They provide resting and breeding places for many colonies of birds and mammals and, by their isolation from the larger centers of civilization and the main marine transport routes, constitute part of a vast, natural wildlife sanctuary. Unique opportunities for scientific work present themselves here to naturalists interested in observing the life and habits of numerous species of flying birds, penguins, and seals which spend varying proportions of the year swimming in the surrounding ocean or flying over it in search of food.

The Australian National Antarctic Research Expeditions (ANARE) have established stations at two sub-Antarctic islands, namely Heard Island and Macquarie Island. The writer was a biologist with ANARE at the latter station and carried out field work there from 29 December 1959 to 12 March 1961.

Macquarie Island lies at latitude 54°30'S and longitude 159°E. It has been briefly described by the author (Warham, 1962) and in detail by Law and Burstall (1956). Here the large colonies of Rockhopper Penguins (*Eudyptes chrysocome*) are mainly found on the rocky west coast. Because these colonies adjoin and to some extent intermingle with those of the Royal Penguin (*Eudyptes chrysolophus schlegeli*) and because of their location amid talus debris, it is not possible to estimate the island's total Rockhopper population, but it must be of the order of some hundreds of thousands of birds. Most of the larger rookeries spill over into those of the Royal Penguins in this way, the latter occupying the more level and open areas between boulders, while the main body of Rockhoppers breeds higher up in niches and among tussock grass. Rockhoppers do not nest

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Rockhoppers and their chick. The female is on the left and the chick is 31 ± 1 days old.

at the edges of the inland rookeries of Royal Penguins; these are far higher than any Rockhopper colony on the island. On the east coast there are small colonies on most rocky points: a group at Garden Cove, about five minutes walk from the ANARE station, was used for the present study.

The Rockhopper stands about 30 cm high and has straw-colored and drooping superciliary crests. It is a penguin of the sub-Antarctic zone of surface water and breeds also at the Falkland Islands, at Tierra del Fuego, Tristan da Cunha and Gough Island, Marion Island, the Crozets, Kerguelen, Amsterdam Island and St. Paul Rocks, Heard Island, and at the Auckland and Campbell islands south of New Zealand (Murphy, 1936: 416). It is present at the breeding stations only during the spring, summer and autumn months, the precise wintering areas at sea being unknown, though presumably lying in the sub-Antarctic zone.

At Macquarie Island the species had not previously been studied in detail, but in 1949 A. M. Gwynn (1953) investigated egg laying and learned the length of the incubation period. In 1957, 75 pairs of adults were flipper-banded by M. P. Hines. Previous accounts of the species are those of Murphy (1936: 415-431), Falla (1937: 87-94), Hagen (1952: 12-35), and Elliott (1957: 554-556).

Rockhopper Penguins, like other members of their genus, are readily sexed by bill size. Males have larger and deeper bills than females. Falla's conjecture (1937: 87) that the sexing of birds collected at the island by the Australian Antarctic Expedition of 1912-1913 was mistaken, because some small-billed birds were labelled as males, is undoubtedly correct. Males are also heavier than females. Sixteen pairs weighed on 30 December 1960, gave averages of 2.7 kg for the males (range, 2.1-3.2) and 2.5 kg for the females (range, 2.0-3.2). Only one female was heavier than her mate. These differences would probably have been greater if weighings had been made later in the breeding cycle, for on 30 December breeding males have been ashore fasting for about 25 days and their weights must be below normal, whereas their mates have been going to sea daily and should be in better condition. Sexing was particularly easy when both members of a pair were together (Frontispiece) and was confirmed by behavior at copulation and by a display used only by males. Only one instance of reversed coition was noted (proved by subsequent dissection) and even here the birds had been correctly sexed on bill size and display. Examination of the cloaca as used by Richdale (1951: 88) was not necessary and would have been inadvisable owing to the risk of egg loss to Southern Skuas (*Catharacta skua*).

METHODS

Very few Rockhoppers have been banded at Macquarie Island as chicks, and the present account is not based on a community of known age structure. The data are the result of regular observations of about 30 pairs, most of which were flipper-banded in January, 1960, as breeding adults. A few were marked in early November the same year.

The bands were of aluminum and of a type developed by A. M. Gwynn from those used by W. J. L. Sladen at the Falkland Islands for other penguins. Each was stamped with a two-letter combination. These bands seemed quite satisfactory but the early ones, of soft metal, started to be lost through breakage after about three years' wear.

When re-sighting, the positions of each bird's feet were marked directly with a ball-point pen on a photograph of the rookery and the band letters added. These data were later transferred to a master photograph, and the writing on the duplicate erased with acetone. Once the penguins had settled down to breed, each next nest site was given an identifying letter on the photograph.

In winter, in the birds' absence, a blind was built overlooking the colony. This blind protected observers from bad weather during long watches and also protected the birds from undue disturbance. Tame though they are, penguins tend to behave abnormally if the observer is not concealed, a point emphasized by Richdale (1957: 44).

Visual records of behavior were supplemented by motion pictures, subsequent frame-by-frame analysis being made later in Australia.

BREEDING CATEGORIES AND IMMATURES

All penguin and petrel communities appear to include large numbers of birds that do not breed. The Rockhopper community is considered as being composed of the following categories:

- (a) Successful breeders, age unknown. These, which had mostly reared chicks during the previous season, usually re-mated with their previous partners and reoccupied their former nest sites.
- (b) Failed breeders, age unknown. Many of these were believed to be inexperienced birds, which, as Richdale found in *Megadyptes antipodes*, tended to lose their chicks or eggs through lack of attentiveness, and in whom the pair bond was weaker than in established breeders. Failed breeders also include older birds that lost their eggs or chicks through misfortunes of various kinds.
- (c) Non-breeders, birds in adult plumage with fully developed crests. These were either lone males or were pairs occupying nest sites or birds without nests which appeared from about 5 December onwards.
- (d) Immatures:
 - i. Yearlings. R. Carrick collected a very short-crested bird on 11 December 1957, known from its band to be a yearling; the many similar, rather small and subdued birds that come ashore about mid-December are believed to have been of the same age. Their bills and eyes were dull brown in color. It has been established by many ANARE biologists that yearling Royal Penguins return as dull-billed, short-crested birds at a year old and the probability is that similarly short-crested Rockhoppers are of the same age.

- ii. Probable two- and three-year-olds. Many birds had short but quite prominent crests which were bushy and not pendant. By analogy with *E. chrysolophus*, whose plumes are mostly fully developed at three years old, it seems likely that these Rockhoppers were two years of age.
- iii. Chicks. Born between 17 and 28 December, these left the island between about 24 February and 10 March and did not return until mid-December.

THE ANNUAL CYCLE

Successful breeders.—In 1960 and 1961 most of the males in this category arrived between 18 October and 1 November. They went straight to the nest sites which they had occupied the preceding March at the molt and were joined by their previous mates 0 to 14 days later. The eggs were laid from 7 to 18 November and, after one long incubation span by each sex, hatched between 17 and 25 December. The chicks ceased to be guarded between 6 and 16 January, huddled together in crèches, and left the island between about 24 February and 10 March. Concurrently their parents also went to sea to “feed up” in preparation for the annual molt. These birds returned from 23 March to 18 April to stand on their nests. Molting started about 2 to 8 April and finished about 19 April to 5 May. After a further 2 to 9 days ashore they departed for their winter at sea. Successful breeders are discussed in detail below.

Failed breeders.—In the study area containing 30 pairs, 7 failed to breed. One pair, OX and WT, laid two eggs in a nest profusely lined with grasses—the work mainly of the male—but soon allowed both to be lost. OX went to sea at once and the female WT followed two days later. Both reappeared three weeks afterwards and for about a fortnight were seen near or at their nest. Then WT was found with a new male at nest site Z. Shortly after this, OX appeared at his nest with a new unbanded female. OX and WT now wandered independently and stood in various nests in the absence of their rightful owners during the crèche stage of the chicks. The two birds did not rejoin. Indeed, WT was seen copulating with an unbanded male on 29 January while OX stood only a short distance away. Both WT and OX disappeared in early February and OX was not seen during the subsequent molt. He did, however, breed in the following year at a new nest. WT returned to molt at the same time as the successful breeders and did so with an unbanded male on site Z where she bred the next season.

Birds that lost their eggs after incubating them for some time left the colony for 0 to 14 days and then returned to stand in pairs at their nests. They showed an increasing tendency to wander and to take up new positions as these became vacant. Thus pair C, who lost their egg around 14 December, were both present daily to 11 January, i.e., right to the start of the crèche stage. At this time all failed breeders left the

colony but many returned intermittently in the evenings from mid-January until early March when chicks and parents departed. Pair AB, who failed to hatch their egg, continued incubation, rather erratically, for 14 more days. Even when the eggs disappeared the pair remained at their nest until the general daytime exodus of the breeders, which was complete by 16 January.

Non-breeders.—An unbanded pair at site Z, and a lone male, WB, were ashore from the start of the season until the end of the guard stage, apart from about 14 days when the breeding females were incubating. SB did not attract a mate until 21 December when a temporary attachment was formed with a newly arrived female VV. From then until 7 February, when he disappeared, this male had several temporary partners but he seemed unable to keep them. At this time, too, the pair bond of the birds at site Z started to weaken. They had been very active in display, but parted company on 7 January and were not identified again. WB returned to its chosen spot the following year, gained a mate and the pair produced an egg.

During the incubation and guard stages the aggressiveness of the nest holders prevented newcomers from gaining footholds in the colony. Only those birds like WB and the pair at Z, which arrived early, maintained their positions there. Few other non-breeders were ashore until 5 December, by which time incubation was well advanced. Now, long-crested birds that had not been seen before, started to occupy places vacated by failed breeders. This penetration increased until, with the absence of the successful breeders at sea by day, the newcomers wandered at will over the rookery. They acquired partners and stood on nest sites as though they were the rightful owners. The males harried the chicks, pecking them severely and driving them from place to place. These non-breeding birds began to molt in the last week of February and by the end of that month most had returned to sea.

Immatures.—The yearlings and medium-crested birds were first noted about 10 December. Their numbers gradually increased until, like the non-breeders, they were able to find positions inside the rookery. The yearlings were very silent and self-effacing, dominated by all other Rockhoppers except by the chicks, and these the yearlings sometimes attacked vigorously. Some of them formed liaisons with non-breeders, with other immatures and even with chicks, but such liaisons did not last long. About 16 January some of the yearlings started to molt and completely molted birds were present by 31 January. Thereafter, the numbers of all classes of immatures decreased until by the end of February very few remained. They did not reappear that season. Barrow, quoted by Murphy (1936: 431) states that at the Falkland Islands the one-year-olds

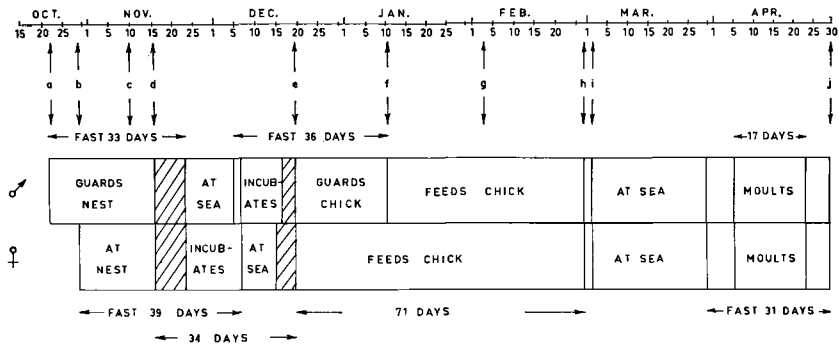


Figure 1. Diagrammatic cycle of successful breeders from arrival to molt.

arrive with the returning adults for the annual molt, but this did not occur at Macquarie Island.

THE CYCLE OF THE SUCCESSFUL BREEDERS

The full cycle of a representative pair is shown in Figure 1.

Return.—The first Rockhoppers to appear in the spring of 1960 and 1961 were males that had bred the previous season. After a short pause on the rocks to preen, these birds climbed to the nest sites where they had molted five and one-half months before. The first birds were seen both in 1960 and 1961 on 15 October. The season has apparently not changed in the last 50 years, for the 1911 party also saw their first birds on the same date (Falla, 1937: 94). This is interesting in view of Elliott's (1957: 556) suggestion that at Tristan da Cunha the species arrives about a fortnight later than formerly. In 1960 the first marked bird reached the Garden Cove colony on 18 October but the inflow was greatest from 21 to 24 October when 13 out of 23 marked males were first sighted.

There was some wandering about the rookery by the earlier males but, as soon as their numbers built up, each remained on its nest. Elliott's statement that the newly arrived males appear to have no attachment to any particular site does not accord with the present findings, nor with the behavior of other penguins of the genus.

The females returned from 24 October to 3 November, 0 to 14 days after their mates. The mean difference based on 23 records was 6.5 days. Most of these females immediately joined their mates, but some, of unknown origin, formed temporary attachments with males whose own mates were delayed, or perhaps never arrived. However, in all instances where the females had been marked previously, such substitute partners were ousted when the regular ones appeared.

Nest occupation to egg laying.—On the evening of 2 November the colony appeared to be full and on the following days the first copulations were noted, though coition may have started before this date. The interval between the arrival of the female and the laying of the second eggs was 17, 17, and 21 days in the only instances where both dates were known. Laying began on 8 November and was complete by 18 November. Most eggs were seen between 11 and 16 November. An egg at Raine's Point on 31 October must have been laid nearly a week sooner than the normal date at which first eggs are seen at Macquarie Island. Once the eggs were laid copulation ceased between the nesting pairs.

The first small egg was not incubated but either adult stood over it, the other bringing grasses or stones which were set on the edge of the nest. Mutual display was fairly frequent but the rookery was not very noisy during this period. Change-over on the egg occurred often, accompanied by the shoulders-hunched attitude. No bird was known at this time to feed and it is unlikely that any did so, for usually both birds were present during the daily check. On the morning of 12 November three nests were guarded by single birds but the missing partners all reappeared while the colony was under observation. Only one, a male, was wet. It had probably been bathing in a rock pool.

Incubation.—Incubation did not start until the second egg was laid. This large egg was given priority and was the first to be tucked into the incubation pouch following a change of guard. The incubation period was determined by Gwynn (1953: 2–6) who gives useful data on the length of time between chipping and hatching and of the effect of removing one or both eggs. Re-laying did not occur. He showed that the smaller egg was viable and that, if the big one was lost, the small one could take its place effectively. His three accurate determinations of the incubation period were 33, 34, and 34 days. Three further determinations, accurate to one day, made during the present study, were 34, 33.5, and 32.5 days. No three-egg clutches were seen in 1960, although such have been recorded, and they are common at Tristan da Cunha.

The start of incubation was marked by one bird squatting in the nest in the prone position. The eggs were rested on the upper parts of the webs and tucked into the deep incubation pouch which exists in both sexes. Although some males incubated sporadically in the early days, the females were more persistent, and by 20 November the first of the males left for the sea. The remainder disappeared gradually until by 26 November only females were incubating and all but two were alone. The period between the males' arrivals and their return to the sea was 25 to 39 days. For 19 records the mean was 33 days. Deviations from the mean were mostly due to differences in the dates of arrival.

The colony was now very quiet. Some females threatened the occasional non-breeders that entered the rookery, others were more receptive. Thus the lone male WB now moved about, preened the heads of several incubating females, and was sometimes preened by them. Attacks on sitting birds by non-breeding males were also seen; the response was the submissive attitude described below. The feces of the sitting birds were greenish or yellowish, indicating the absence of food in their stomachs. Many nestings failed in this period. Thus, on 29 November, the egg at nest V was found uncovered and the female VB, which had been incubating, was seen coming up from the rocks with her plumage wet; she had apparently gone to bathe, leaving her eggs unguarded and, by the following evening, both eggs and bird were missing.

The feeding period at sea for the males lasted from 9 to 17 days and averaged 12 days for 25 determinations. The first relief of a female was noted on 1 December, 5 days before the next male appeared. By 10 December all the females had been relieved and were back at sea. They had been ashore for 33 to 45 days, averaging 39 days (20 records) and had been incubating for 10 to 19 days, averaging 14.5 days (20 records).

The time elapsing between the male's arrival and his assumption of incubation varied. Some females seemed reluctant to relinquish their eggs. WA, whose mate arrived on 9 December, did not leave until the night of 12-13 December, although she changed guard soon after his arrival. When the males came in, a greeting ceremony with mutual trumpeting took place, and for some hours afterwards the newcomers were recognizable by the cleanliness of their plumage and feet.

The colony was again quiet while the males incubated. Strangers now got a severe drubbing if they came within pecking range and there were no assaults on sitting birds. The males' spells ranged from 8 to 16 days, averaging 10.5 days for 21 determinations and their nest reliefs occurred between 14 and 21 December.

During rainy periods the rookery became a quagmire. Eggs and adults became encrusted with mud but most of the eggs hatched and there was no obvious tendency in favor of drier sites.

Hatching.—The eggs hatched from 17 to 25 December. Each female was back before her egg started to chip; usually she was present two days before the hatch. Her stay at sea varied from 7 to 13 days and averaged 8.5 days from 21 determinations. During the hatch both adults remained on duty and there were fairly frequent changes on eggs or chicks, the shoulders-hunched attitude being struck at nest relief. The tiny chicks rested on the feet of the parents and were effectively blanketed by the thick feathers on either side of the incubation pouches.

Gwynn (1953: 3) showed that normally only one egg is hatched and

that, because the smaller egg was not covered until the bigger one was laid, the latter hatched first even when both were incubated. Often the small one was ejected from the nest before the big one started to chip. Both might hatch and some of the study pairs had two chicks. No pair reared more than one. A. Gourin, medical officer of the 1954 ANARE party, weighed a few chicks from hatching to the end of the guard stage: he found that the smaller chick died from two to five days after birth, its maximum weight being about 156 g. The weight at birth was about 75 g.

The guard stage.—From hatching until the time when neither parent remained with the chick a new routine was established. The males were always at their nests whenever the colony was inspected. This was done morning and evening, sometimes after dark, and on 28 December a continuous watch was made from 0300 to 2000 hours. No evidence was gained that any male left the rookery to feed, although one was seen to leave the nest for a short period when its mate was present, apparently to bathe.

The excreta of the males was white as contrasted with the pinkish mutings of birds that had been feeding. The males now brooded during the morning while their mates came ashore, perhaps as early as 0800 hours but mostly in the afternoon. By 1800 hours both were present, the females covering the young and the males standing nearby. The females were gone before dawn, leaving the males on guard. This routine began one to five days after the chick was first seen and was general by 25 December.

The end of the guard started about 6 January when a chick was first seen to leave its nest; by then several others were too big to be brooded. By 16 January the guard stage was over and neither parent was present during the morning inspections. The length of the males' periods on guard varied from 21 to 30 days and averaged 26 days (21 determinations). The total length of the males' second fasts ashore, varied from 31–40 days and averaged 36 days (21 determinations).

The crèche stage.—The chicks left their nests when from 19 to 23 days old, apparently of their own volition, sought the company of other chicks, and huddled together in small crèches. On entering the crèches they weighed 825 to 1,070 g, averaging 907 g (4 records by A. Gourin), and had not started to "shed down." This is a much shorter guard period than obtains with some other penguins; e.g., in *Megadyptes* it is from 35 to 53 days (Richdale, 1957: 40). Pettingill (1960: 216) gives two records suggesting that, at the Falkland Islands, crèching in the Rockhopper starts at 13 days of age, all his 9 chicks being in huddles by 16 days from hatching. This is appreciably shorter than at Macquarie Island,



Figure 2. Adult about to feed fully feathered chick.

but Pettingill did not know the dates of hatching and merely estimated his chicks to be six days old at the start of his observations.

From one to three days after the chicks vacated their nests the parents began to spend the day at sea. This allowed the non-breeders and molting immatures then ashore to take up positions in the colony, where they formed temporary attachments and defended the places where they stood as if they had been present since the start of the season. Male parents, on returning, usually ousted such intruders without difficulty but some females were unable to do this. They were attacked and perhaps even prevented from feeding their chicks (see also discussion under bowing display below).

Feeding of the young was now done in the late afternoon, in the evening, or after dark (Figure 2). Inspections were mostly made in the evenings and no sustained watches were undertaken. However, numerous sightings of chicks being fed by banded adults proved that both parents were feeding, that some chicks got meals from both on the same day, and that the same parent might feed its chick on successive days. Each chick received about two visits every three days. There was no evidence that the parents kept together at sea and they were seldom seen together at the nest. If one appeared while the other was present, the normal ceremony, with loud trumpeting, signalled the event.

At first the crèched chicks were not venturesome. In heavy rain or sleet, or if spray was blown into the colony, the young penguins turned their backs to the weather and huddled together often with one flipper across the back of a neighbor. Others clustered beneath rocks. The huddles were often broken up by aggressive non-breeders but some of these preened the chicks.

Many chicks supplicated from non-breeders, whose reactions varied: some vigorously pecked the young ones away; some bent down as if bewildered by the chicks' impatient tappings against their bills; some throbbled and even opened their beaks as if to feed the suppliant, but despite close observation none was ever seen to do so. No chicks were observed begging from short- or medium-crested Rockhoppers nor did they display as Sladen describes in the chick of the Adélie Penguin (*Pygoscelis adélieae*).

As the chicks grew they begged from strangers less often. They became more independent and began to stand on their nests if these were vacant. They were now less tolerant and fought one another mildly, tilting their heads to one side in threat, pecking and using their flippers. Some also helped their parents to evict intruding chicks. The composition of the crèches varied from hour to hour as their members moved around, and as the birds became stronger the crèches gradually dispersed. If frightened, they quickly huddled together again and they were always more timid than the old birds.

On arriving at the nest, their plumage sleek and wet from the water, parents usually first adopted the shoulders-hunched posture, then bowed and finally trumpeted loudly forward or perhaps vertically. Some males gave the male display. One or more chicks, peeping loudly and waving their flippers, then left the crèche and approached the parent. If several appeared the adult brusquely pecked off all the young except its own. The latter begged by wobbling its head and by pecking at the sides of the adult's bill and at its belly and flanks. Some were so eager that they tried to insert their bills into those of the parents as these bowed into the nest. Some parents, mostly females, needed little inducement before they disgorged. They might even open their beaks to enclose those of the chicks when they were not begging—as they did during the nestling's early days before it was strong enough to supplicate properly. Others needed persistent stimulation before they disgorged, when they often delivered small meals. Occasionally a penguin appeared not to recognize its young one and pecked it. The latter, accustomed to assaults from the non-breeders, continued to beg until its importunity eventually gained it a meal.

The chicks' "see-up" calls, which, unlike those of the Adélie (Sladen,

1958: 36), did not seem to alter appreciably from birth to departure, ceased only when food was actually being passed. The bill remained inside that of the parent for four to six seconds and a series of meals was delivered. Thus the male at nest M gave 19 meals between 1615 and 1624 hours on 23 January; the male at nest O gave 25 meals between 1720 and 1736 hours on 8 February; and the female, nest W, gave 10 meals between 1625 and 1643 on 15 February, despite interruptions from non-breeder WB and his current partner, both trumpeting whenever she fed her chick. On the other hand, the female, nest L, gave only 5 meals on 18 February despite the chick's continued supplications.

Food was spilled in feeding, so that chicks that had been fed and the parent responsible were often identifiable by the pink stains on their breasts or by food adhering to their gapes. The pinkish color of the food and feces at this stage apparently came from pigment in the crustacea on which the adults were feeding.

Pettingill (1960: 215) marked 10 family groups and saw two chicks fed by their own parents after crèching had begun. This appears to be the first indication that the chicks are not fed communally at this stage. Pettingill's conclusions were confirmed by experiments made at Macquarie Island where nine of the chicks were marked with colored collars shortly before the end of the guard stage. After they had entered the huddles these chicks were seen on 29 occasions to be fed by their own banded parents. None was ever seen to get a meal from strange penguins or to be fed anywhere but on or near the appropriate nest site. The so-called "guardians of the crèches" are, of course, merely the non-breeders already discussed. These seem to be concerned solely with guarding their own persons or those of their partners, and showed only a passing interest in the chicks. Many other unmarked chicks were fed by banded birds and again there were indications that these were the rightful parents. No banded bird was ever seen to feed more than two meters from its nest. This routine held right up to the last meals seen to be given, when many chicks had already gone to sea.

Pettingill was doubtful whether chicks that were large enough to leave the crèches were still fed by their parents. He reports seeing fully-grown young fed at great distances from their nests and noted at least one instance where an adult responded to begging regurgitation, then continued farther inland where it again fed a large chick. No such incidents were seen at Macquarie Island and, although chicks often begged from adults not their parents (but adults that sometimes opened their beaks and appeared to feed), no food really passed. Close observation was needed and, as Pettingill does not mention this behavior in non-breeders, it is possible that he was misled by their actions.

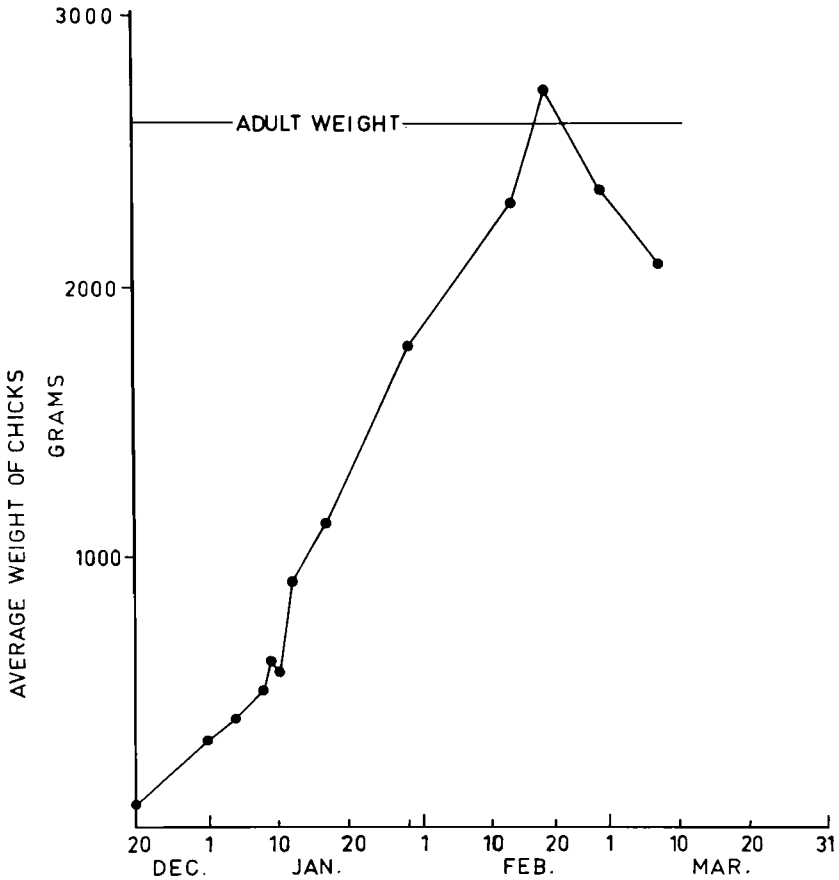


Figure 3. Average weights of Rockhopper chicks during 1956 (after K. Keith).

Sladen (1958: 60–61), who showed that the parents of the Adélie chicks fed their own young throughout, saw only two instances of parents feeding chicks other than their own. In both, the young were on nest sites and supplementary to the rightful chicks. With the King Penguin (*Aptenodytes patagonica*), which also feeds only its own chick (Stonehouse, 1960: 40–43), “mock-feeding” occurs between non-breeders, or adults without food, and chicks. Stonehouse notes that such behavior cannot easily be distinguished from true feeding.

Rockhopper chicks were not weighed in the study as they were easily frightened and might have been lost in deep holes between rocks, but Figure 3 shows the average growth curve made from weighings taken in 1956 by the ANARE biologist, K. Keith. The rapid growth to more than

adult weight, followed by a decline to fledging, should be noted. This decline may be partly due to the high energy demands accompanying feathering but, from direct observation, it seemed that the weight of food given during the last fortnight of the chicks' stay ashore declined. Even if there was no slackening of the parents' visits—and this cannot be gauged from the data obtained—there was certainly a curtailment in the time spent feeding the chicks. Furthermore, as already noted, the females were hindered from feeding by the non-breeding males still present.

After a series of meals many chicks still supplicated. The parents tried to escape; they climbed onto a rock to preen, the chick followed, the parent descended again to the nest, and so on. Many parents now pecked their young but seldom succeeded in subduing them. Some escaped by going back to sea. Usually the old birds did not stay long in the colony after feeding but some remained to stand on their nests preening themselves or their now satiated young.

On 29 January feathers were seen on the tips of one chick's flippers. By 6 February tail feathers were also visible on several birds. On 11 February some had shed all their down except for tufts on the mantle, the nape and at the bases of the flippers. By 18 February most had lost all their down apart from a little on their napes, crowns and the roots of the flippers, and faint superciliary stripes were visible. A few had stripes as distinct as in the yearling birds.

About this time the young Rockhoppers began violent flipper exercises. A few birds seemed to become demented, vibrating their flippers to and fro at high speed and, dancing across the rookery, collided with adult birds. Such chicks appeared to be unaware of the pecks they received and they employed the same flipper actions as used under water, the flippers often touching at the top of each stroke.

The chick's departure.—The first chicks left about 24 February, and near the larger colonies small mobs congregated on the rocks below the nesting areas. Few chicks were seen to set off. One marked chick left aged 71 ± 1 days old and others left at 67 ± 2 , 72 ± 1 , and 70 ± 1 days old.

A chick on the rocks on 6 March had to climb a line of boulders heavily embedded in kelp from which it was repeatedly washed backwards by the waves. Eventually the chick got through to the open sea but only a strong and healthy bird could have done this. Similar hazards face many of the young penguins as thick kelp beds encircle the island.

It was not discovered whether the young were deserted by their parents, but four banded birds visited their nests after their chicks had left. This suggests that there is no desertion period.

Discussion of the breeding cycle.—An interesting feature of the breed-

ing routine is the female's assumption of the first incubation shift. It might have been expected that after laying she would go to sea to "recuperate," this being the rule with Adélie, King, and Yellow-eyed penguins, and with many petrels. But the Rockhopper is not alone in this behavior, for Macaroni and Royal penguins behave similarly. Whatever other benefits this arrangement conveys, it seems that a system whereby the male can take charge of the chick up to the crèche stage is important. The male is far more vigorous in defense of the nest site than the female and is not intimidated by the non-breeding infiltrators. If the female were on duty during the guard stage it seems likely that many nestings would fail through interference.

Stonehouse (1960: 55) reproduces a graph showing the monthly variations in surface plankton in sub-Antarctic waters based on samplings made from the research vessel *Discovery* and drawn from Foxton (1956). This graph shows a peak of plankton in December, a fall in January, and a sharp rise to a high level extending throughout February into March. Foxton also emphasizes that at 160°E the plankton in January, 1938, and February, 1936, was typical of the summer months in other regions, with most of the organisms concentrated on the surface and with very high plankton counts in February. If similar variations in the foods taken by the Rockhopper Penguin apply at Macquarie Island—and there has been no comparable sampling there—then the division of labor between the sexes during the incubation and rearing stages may be correlated with such variations.

Hatching occurs when the plankton supply, as given by Foxton's graph, is almost at a minimum; the weight of food needed for the chick is also very small and it seems reasonable to expect a single parent to make good its fast and collect sufficient additional food to nourish the chick during the guard stage. From the time of hatching onwards, the plankton graph climbs steeply until, by the crèche stage, the food situation is excellent. Both adults are now feeding and adequate food should be available for them and for the rapidly growing chick now demanding big meals. Indeed, with several millions of penguins fishing local waters and coming ashore daily to tend their young, the food supply now must be approaching superabundance. When adults and chicks finally leave in early March the plankton curve is still at a high level and, though about to decline, remains high until mid-March. The chicks therefore go to sea while there is still plenty of food in local waters.

Most recent students of penguins have concluded that parents recognize each other and that chicks recognize their parents. Mated Rockhoppers can certainly identify each other at distances of several yards and, as has been shown, recognize their chicks after they have entered a crèche.

Richdale (1951: 229), thought that in *Megadyptes* adult birds rely on visual clues but that appearance and voice differences are involved in parent-chick, chick-parent recognition. Sladen (1958: 73) thought that visual means are most important with the Adélie, but Stonehouse (1960: 41) provides evidence suggesting that the King Penguin chick recognizes its parents by their calls. In the Rockhopper both visual and auditory clues appear to be used and it is perhaps significant that the writer was able to identify several of the study birds by peculiarities of voice, behavior, or posture. Presumably such differences are even more apparent to the birds' mates and neighbors. On the other hand, the chicks' voices seemed very uniform to human ears and the writer could not identify individuals by their voices. That auditory means are used is suggested by the way in which adults feed chicks on dark nights when appreciation of small differences of posture or appearance seems impossible.

The occupation of the colony by non-breeders during the crèche stage and the formation of temporary partnerships may have a bearing on pair formation. Although the ages of such birds were unknown, many must have been nearly mature so that their attachment to particular partners and to particular places could provide a basis for successful breeding in the following season. This might also be one reason why nest sites left unoccupied by previous tenants at the start of a season were promptly occupied by other pairs: these could be pairs formed when at the site as "second tenants" during the crèche period the year before.

DISPLAY AND POSTURING

Penguins of the genus *Eudyptes* have more displays than the pygoscelid penguins. Many of the behavior patterns described by Richdale for *Megadyptes* as "love-habits" (Richdale, 1951: 15-34) seem to have counterparts in the present species, but a direct comparison is difficult with the available descriptions.

Both Murphy (1936: 416) and Roberts (1940: 215) state that Rockhopper Penguins can erect the yellow superciliary plumes and do so during fear and rage. This ability was not noted on Macquarie Island. Some voluntary movement of the black occipital crests was evidently possible, though they were normally kept erect, but there seemed to be no muscular control of the drooping yellow tassels of the adult birds. Nor were the eyes capable of great changes as in the Adélie Penguin, although the irides do contract and dilate, perhaps according to emotion, as others have noted.

DISPLAYS OF A SEXUAL NATURE

Mutual preening.—This activity was seen between mated birds whenever they were together and it frequently followed more vigorous display.

The birds turned their heads to one side and nibbled each others' throats and necks with the tips of their bills. Between mated birds such actions seemed to have sexual significance but the same movements were also seen between most other categories of Rockhoppers in or out of the breeding season. Non-breeders that formed attachments always preened their partners and mutual preening followed when a bird allowed another of the opposite sex to join it for the first time. Chicks were preened by their parents and *vice versa* and this may have helped to curb excessive begging.

Stone-carrying.—The placing of stones around the nest had some practical value in reducing losses caused by eggs rolling down the slopes, but the formal manner in which stones, grasses, and earth were laid down suggested that such actions had a deeper significance. Much stone-carrying was done by the males in the laying period when their mates were on the nests. The females took the offerings from the edges of their nests and placed them to one flank with a quivering movement. Following a change of guard on the egg, many males hurried to and fro in search of stones or grass, sometimes tearing the latter from the tussocks, before they departed. Stone-carrying was seen whenever the birds were ashore, even during the molt.

Quivering.—A nesting bird bent down and, with bill slightly ajar, shook its head rapidly from side to side while pointing into the nest or moving its head from flank to flank. The flippers were not lifted and the movements were either conducted in silence or accompanied by deep repeated *kruk kruk* calls. The crests became blurred because of the head movements. The bill might be empty during quivering, but more often grasses and the like were simultaneously placed to one flank, the bird either sitting or standing. Both sexes quivered, sometimes in unison. Most displays were initiated by the males and then might lead to more intense activity or might follow mutual or trumpeting displays. Quivering was seen mainly at the nest but, during the molt, birds which shifted from their places and took up temporary positions elsewhere until the disturbance was over were seen to quiver and bow. WB, a male non-breeder in 1960, also quivered occasionally.

Bowing.—With its bill near its feet, the penguin uttered a succession of deep, throaty, throbbing notes while its body shook in time with the calls. The head was not shivered, as in the last action. Bowing display was used by both sexes and as solo or dual performances when both reached forward with their bills together (Figure 4). Many such displays faded out but others led to male display or mutual display and the latter always seemed to begin with bowing. When two birds were together the bowing and throbbing of the one usually triggered similar behavior in the other. This was why females were so easily distracted from feeding their

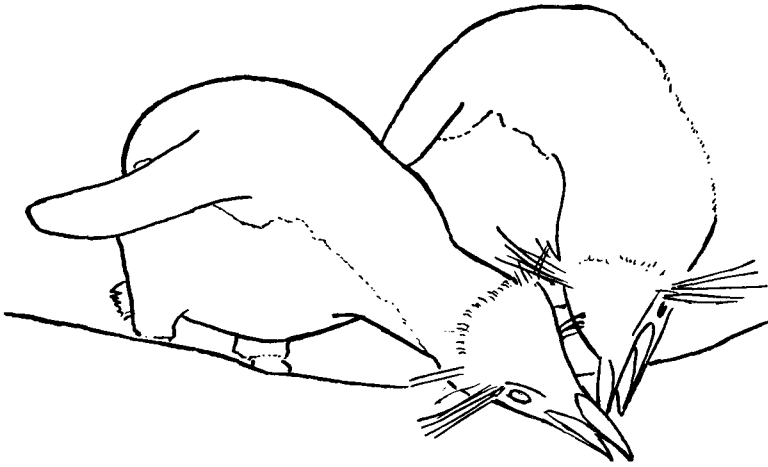


Figure 4. Bowing display.

young if neighbors bowed as the females bent down to disgorge. The latter then seemed unable to resist bowing in response; as some onlookers bowed whenever a female nearby bent down to feed, serious interference resulted.

One example from many will illustrate this. On 4 February 1961, a female returned to a rock overlooking her nest and made regurgitating movements towards the chick that emerged from a crèche. Two birds on an adjoining site, male OX and his partner, both non-breeders, showed great interest, cocking their heads to one side and throbbing towards the parent whenever she started to disgorge. She responded each time by display and never succeeded in delivering any food. Soon OX jumped up and drove her away, and when the chick switched its begging to OX, it was ignored. The female went back to sea shortly afterwards.

Shoulders-hunched attitude.—In the action the body was fairly upright but the head was tilted forward so that the bill pointed down. The shoulders were peculiarly hunched with a kink showing at the back of the neck. The flippers were held stiffly forward and downward at about 30° to the vertical with their inner surfaces parallel and facing each other (Figure 5).

This distinctive stance was used by a bird returning to its nest in the absence of its mate. When a few paces off, the penguin adopted this posture and, on reaching the nest, padded around with a quaint mincing gait, pivoting on its feet. Usually it held the shoulders-hunched posture for several seconds before breaking into loud trumpetings. At nest relief during incubation the bird relinquishing the egg moved off silently in this way. Its mate, similarly hunched, then stepped forward and took over.

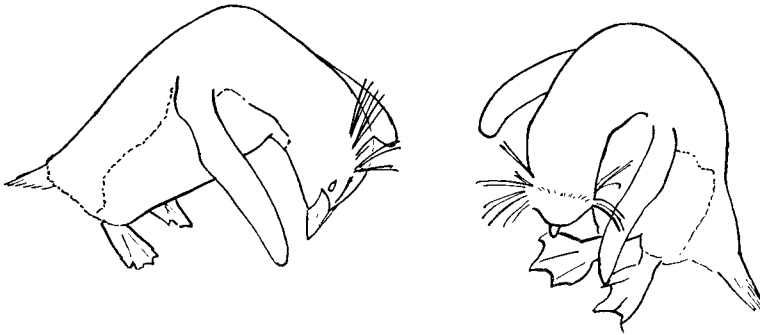


Figure 5. Aspects of the "shoulders-hunched" posture adopted on arrival at the nest.

The shoulders-hunched posture was also adopted by the male immediately after coition when he stood quite still before shaking his head and preening.

Trumpeting.—See Figure 6, Left. Typically, as a relieving bird approached its nest, both it and its mate broke into loud trumpeting with their opened bills reaching towards each other. Neighbors often joined in, directing their yells towards the newcomer. When the latter stepped into the nest the pair switched to vertical trumpeting or perhaps to the mutual display described below. In vertical trumpeting the beaks were pointed

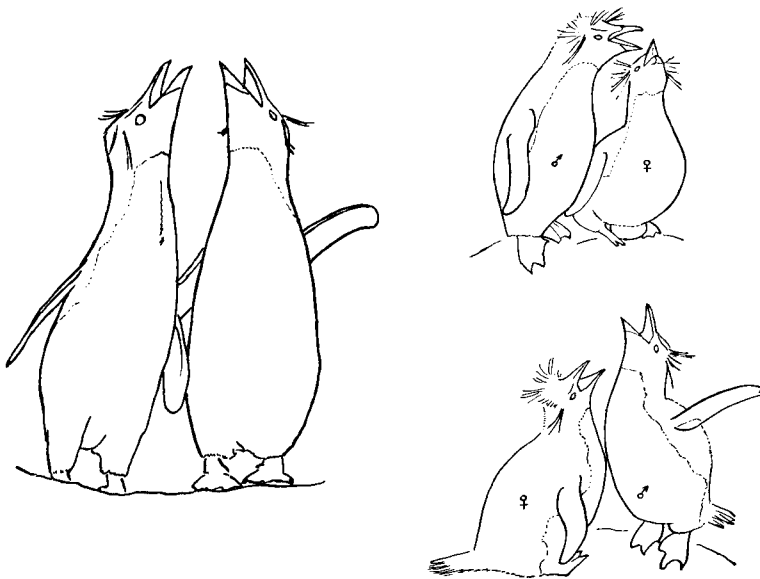


Figure 6. Left. Mutual trumpeting. Right. Mutual display.

to the sky, bills wide open, and the flippers rose and fell in time with the braying. The muscles of the chest rippled and swelled as the sounds poured forth. These were quite different from those used in mutual display, lacking the pulsating rhythm heard then, but being louder and delivered with tremendous "punch." Nor were the heads swayed or wobbled as in mutual display; they remained fairly still with the male reaching a little higher than his mate. Gradually the cries died down, the male probably changing to his special display with head wobbling, after which the whole performance subsided to throbs and silence. If the relieving bird had been off for some time this ceremony was usually repeated several times before both relaxed.

This distinctive display was rarely seen away from the nest. It occurred occasionally from the time of the females' return at the start of the season, but became more frequent during incubation. It was common in the guard stage when changes of duty took place daily.

The vertical form of this display is evidently akin to the "ecstatic" of Sladen and others, or to Richdale's "full trumpet." It appeared to be an important indication that the two birds recognized each other, and the one on the nest might bray when its mate was two yards away and had then not made a sound. The responses of pairs nearby may have been due to some infectious quality in the display but it certainly appeared that they too recognized the new arrival and greeted (or threatened) it themselves.

Trumpeting with bill forward or, less often, vertical was the normal action when single penguins returned to their nests during the crèche period; it followed the adoption of the shoulders-hunched attitude. The trumpeting was evidently the signal for the chick to leave the huddle in the expectation of a meal.

This display was twice used by immatures. A probable two-year-old displayed towards another immature and a one-year-old did so towards an adult, but was promptly driven off.

Male display.—This began with bowing, the bill being directed first at the feet and then suddenly swung back so that the crown was vertical and the beak pointed to the sky. The head was then rapidly shaken from side to side through an arc of about 30°. The flippers were sometimes held to the sides but more often were raised progressively as the display proceeded. They were not beaten in time with the calls as in trumpeting. As the head wobbled, loud, pulsating, raucous cries were given through the open bill. If the female was present she usually, but not invariably, responded with her special display, and mutual display resulted (see below).

Male display was common from the breeding males' arrival until their

departure after their first long fast. It was seen again following their return for the second incubation shift and while they guarded the chicks. Males that occupied sites but failed to find mates used the display a great deal, and it evidently had an advertising function.

Mutual display.—See Figure 6, Right. This activity began with the male bowing and throbbing and then swinging into the special action described in the previous paragraph. The female's response, if she responded at all, was to bow and perhaps to quiver. When the male swung up his head she rose to face him and, calling with her bill slightly open, she reached towards his head or neck. Her body heaved as she called but there were no violent muscle contractions, as in trumpeting. Nor was her head wobbled about as was that of her mate, her bill being kept more horizontal. Her flippers were seldom raised. Incubating females generally behaved similarly but most remained seated.

While the male's performance was often seen as a solo, that of the female was used only in response to male display or, occasionally, to a male's vertical trumpeting. Mutual display is figured by Falla (1937: 93), the male being the rear bird.

Coition.—The preliminaries to coition were similar to those in *Pygoscelis* (Roberts, 1940: 209) and *Eudyptula* (Warham, 1958b: 611) and are preceded by what Richdale terms the "arms act." The male crowded up to his mate, nibbled her nape with his bill, and flicked his flippers against her back. If receptive she then subsided and he mounted. She remained quiet, her head upraised, while with quick, jerky movements, he nibbled around her cheeks and crown. She might stretch her flippers on either side to touch the ground. His downturned flippers continued to drum her flanks as he trod with his feet, his tail swishing from side to side while he gradually edged backwards and depressed his tail so that the cloacas were opposed as she tilted her tail upward. Just before contact the female's cloaca was everted. The male now kept quite still during the climax, when his flippers propped him in place and the female's beak was turned into his neck. After about two seconds the male slid off and the female's cloaca was inverted. He remained motionless immediately after his descent, holding the shoulders-hunched attitude; she too kept quite still except for pulsations around the cloaca. Then both started to preen, shook their heads, and relaxed.

Most instances of apparently effective coition were seen between 2 and 5 November, and on 17 November it was noted that no matings had been seen for several days. Subsequent occasions, while often appearing complete, were doubtless ineffective and, where the participants were identified, they were failed breeders or non-breeders. Thus the birds of a pair at nest C that lost its eggs about 14 December were seen in

coition on 28 December. Copulation was not seen between birds with eggs or chicks and occurred only at the nest. Either sex solicited, the female by squatting or the male by beating his mate with a flipper, but after the peak period the males were the most active. Many fruitless attempts were seen when males solicited but the females failed to respond.

Birds VB (female) and WE lost their eggs about 7 December but were seen copulating seven days later, and on 28 December they did this three times. On each occasion the female was uppermost. These were the only instances of reversed coition seen and, although the sexes were clear from the male display used by WE, both were later collected. On dissection it was found that WE had only one testis, the left, which measured about 15.9×7.2 mm. The ovary of the female was slightly enlarged. These two birds are preserved as skins in the National Museum, Melbourne (No. 5652 male; No. 5653 female). Previous instances of reversed coition in penguins are given by Roberts (1940: 208) for the Gentoo (*Pygoscelis papua*) and by Falla (1937: 77) for the Adélie.

Coition or attempted coition was always between fully crested birds, except on 4 February 1961, when a short-crested Rockhopper was seen to pat an older bird ineffectively with its flippers in the usual invitation to mating.

DISPLAYS AND ACTIVITIES OF A THREATENING NATURE

Mild threat.—This was shown when one penguin reached towards another, turned its head to one side and bobbed it up and down. The flippers were often raised ready for use and a series of short cries was given. This was the response when a strange bird walked through the rookery or when a human entered. Birds or boots that came within range were pecked fiercely or struck with the flippers.

Severe threat.—This consisted of birds jabbing their opened bills towards each other and making harsh cries. Beaks sometimes became interlocked and one of the disputants might even be pulled off its nest.

Fighting.—The penguins grappled together until one had its rival by the nape and belabored it with a flipper. Very aggressive males clung to their opponents when they fled and followed them through the colony, oblivious to the pecks they both collected from angry birds into which they blundered.

In all threat activities the males were the more vigorous. Threats were directed at any moving object close to the bird involved. Their mates appeared to be exempt through individual recognition and the resulting trumpeting greeting. Much bickering took place between breeders in the pre-egg stage and shortly after laying, when both sexes were present and the colony was crowded. Later, with immatures and non-breeders

about, an hierarchical system was established in which the breeding males dominated all the others, the non-breeding males dominated the rest, short-crested birds dominated the yearlings, and the last dominated the chicks.

ATTITUDES SUGGESTING NERVOUSNESS

The slender walk.—When a Rockhopper had to move through a mob of penguins it employed a special attitude apparently intended to shield it from attack. The body was erect but the head was rather bowed, with the bill pointing down at about 45°, the feathers sleeked, and the flippers held forward as in the shoulders-hunched attitude. Such birds hurried through places where the throng was thick and paused where there was more space. They then lifted their heads and jerked them rapidly from side to side as if trying to get their bearings.

The slender walk suggested nervousness, as the birds seldom retaliated to pecking, but it did not protect them entirely from attack if they came too near to an occupied nest. When hemmed in by others, the travellers stretched as high as possible and pushed through in an effort to get out of the area without injury. They appeared to be concerned to keep their eyes out of beak range. The attitude was rather similar to the shoulders-hunched posture seen at nest relief, into which it merged when the nest was gained.

The submissive posture.—The sitting bird flattened onto the nest, drew in its head, and kept still while an attacker pecked it and beat it with a flipper. Such behavior was seldom seen and only as a reaction by incubating females to attack by strange males. Some attacks seemed to be due to a male's misidentification of his nest site. The posture had obvious value in that the eggs or chicks were protected by the female mantling over them; had she retaliated the eggs might well have been broken or the chick injured. Furthermore, the submission of her nape to the aggressor may have helped to inhibit pecking as it does in the Australian Gannet (*Sula serrator*) and other birds (Warham, 1958a: 349). Two instances may be detailed:

On 12 November 1960 an intruder entered the colony and, using the slender walk, approached nest R where a lone female was incubating. The newcomer began belaboring the female. She pulled in her head, flattened her body, and tucked her bill into the nest. The intruder gave the male display several times and then half-preened and half-pecked the female's head. She did not move. Soon another banded penguin appeared, wet from the sea. This was the correct male for nest R and he immediately dived at the intruder, ejected him, and then broke into loud trumpeting in which his mate joined.

On another occasion the submissive female was apparently on the wrong nest. Her attacker was joined by a female and both combined in mutual display. The squatting bird then got up and moved off, after which the new female sat down.

Wing shivering.—It is often thought that penguins are unaffected by the proximity of people. That this belief is wrong is suggested by the nervous way in which the Rockhoppers nearest the human observer shivered their flippers through a small amplitude, like an insect warming up its muscle engine in preparation for flight. Comparable behavior is seen in other penguins and in the Procellariiformes.

UNCLASSIFIED ATTITUDES AND ACTIONS

The head shake.—All penguins of the genus *Eudyptes* punctuate their activities with rapid side-to-side shakes of their heads so that these appear blurred. Anything adhering to the bill, such as nesting material, droplets of excretion from the nasal glands, etc., is shot to one side. Head-shaking in the Rockhopper invariably follows any period of activity, and R. Carrick has suggested that it serves as a “full-stop,” marking a return to rest.

The squeal.—Occasionally a sudden and penetrating cry, sustained for several seconds, was heard in the colonies. No movements accompanied the sound which seemed to be given through a closed bill. Rarely was the bird responsible identified, although the call was heard many times and at close quarters throughout the breeding season. The squeal may have arisen from fear because, while incubating, one bird cried out as a skua flew very low, others repeated the cry, and a strange hush fell over the colony. It was rather like a “dread” among terns. Similarly, a one-year-old was seen to squeal on sighting the approach of the owner of the nest upon which the younger bird was standing. A third instance was noted when one of a party of molted adults squealed several times as they teetered on the rocks, hesitating before plunging into the water.

Individual recognition may have been involved when on 8 February 1961 a male on its nest squealed loudly just before his mate reached him, then broke into the usual trumpets of greeting.

THE MOLT

After their chicks departed, the adults were at sea for about five weeks. They reappeared from 25 March onwards, much heavier than on leaving, weighing 3.2 to 4.1 kg, with an average of 3.5 kg from seven determinations. The normal weight of a mixed sample of both sexes was 2.6 kg. Some 7 to 10 days elapsed before the first feather fell, and the plumage was now dull brown, the birds getting very obese as the new feathers pushed out the old. Feathers fell first from the tail, and 14 to 22 days elapsed, with an average of 17 days from 28 records, before the last feather was shed. The penguins fasted throughout this period. The new plumage was blue-gray in color and the birds were very sleek. Their

weights now averaged about 2.3 kg from five determinations, a fall of some 1.2 kg to slightly below the normal figure.

Molting birds were subdued, but the shoulders-hunched attitude, the quiver, some trumpeting, mutual preening, and even stone-carrying and nest-making were occasionally seen. No attempts at coition were noted, as happens with *Eudyptula minor* (Warham, 1958b: 615) and *Eudyptes pachyrhynchus* (Richdale, 1941: 35, 39). During the two to nine days (average 5.5 days from 11 records) from the end of the molt to the birds' departures for the winter, some descended to bathe in rock pools. A few still in molt did the same.

In 1961 J. McNally found that 17 of 22 successful breeders molted on their nests. Of four successful pairs only one bird each reappeared. These either molted alone or formed attachments with neighbors. A lone female, VL, from nest P molted with male VN from R whose own mate failed to appear, and these two bred together in the 1961-62 season. Unsuccessful breeders also molted together, but again, with four pairs, only one bird was resighted.

The members of any pair seldom arrived together and unless both finished at the same time they returned to sea independently. The pair, nest Y, provided an extreme instance: the female molted at her nest with a new bird and left on 28 April 1961 two days before her proper mate reached the rookery to start molting on 5 May. He was the last bird on the colony that season.

The data are insufficient to determine whether failed breeders molt before successful ones. Four failed breeders finished a few days before most of the successful birds, two finished concurrently with them, and the mateless male WB also molted four days in advance of the successful breeders.

TENACITY TO SITE AND TO MATE

At least 13 pairs bred in the 1961-62 season with the same mates and at the same places as in the previous year. Six birds bred on their previous sites with new mates, their old partners not having reappeared. Five others had new mates and bred at new sites. These included two penguins that were mated in 1959-60, took new partners in the following year but reverted to their previous alliance in 1961-62. Another pair did not remate in 1961-62. Instead, each took a new partner and nested independently. Not less than 11 of the banded males bred at the same sites in 1959, 1960, and 1961. There are also four records of birds banded in 1957 by M. P. Hines that were breeding at the same nest-marker in the 1960-61 season and two records of birds that had shifted their nests a few yards. Pair XA and XI, banded together in April, 1957, molted

together in March, 1960, and reared a chick in 1960–61. Although their original nest-marker was missing they were evidently breeding very near to their site at banding four years before.

These records suggest that breeding Rockhopper Penguins continue to be reunited for successive seasons if both members of a pair reappear at the rookery and that they reoccupy the same nest sites as they previously held. When one bird fails to return, the survivor either acquires a new partner and breeds at its customary site or shifts to a new one. In the event of a pair failing to return, the nest is taken over by new birds and no blank spaces are left in the centers of the colonies. As shown above, while a male may acquire another partner at the start of a season, she is quickly discarded in favor of the old one when the latter returns.

ENEMIES AND MORTALITY

Detailed figures for breeding success were not obtained. Of the 30 pairs at the study colony, 28 laid eggs in 1960 and 22 produced chicks to the crèche stage. Causes of failure were: no eggs laid, or eggs lost before being seen, 2; egg incubated but infertile, 1; egg lost during female's first shift, 2; egg lost during male's first shift, 1; egg or chick lost at hatching, 1; chick died in guard stage, 1.

These findings support the impression gained at larger colonies that most losses occurred during egg-laying and incubation. While it was usual for the small egg to be ejected, some birds also ejected the large one. Most of such eggs were taken by skuas and by Wekas (*Gallirallus australis*). Rats were not known to be responsible for any losses.

During January and February occasional Rockhopper Penguins were found bearing gashes on their breasts. These were apparently victims of the fur seals (*Arctocephalus forsteri*) now recolonizing the island and most plentiful in these months.

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SUMMARY

1. A study of the Rockhopper Penguin (*Eudyptes chrysocome*) in 1960 and 1961 was based mainly on observations of banded breeders. The birds were sexed on bill differences and on behavior.
2. Breeding males were the first to return to the island after spending the winter at sea. They went to the places where they had previously

bred and molted and were joined about 6 days later by their previous mates.

3. After a week, during which both sexes changed over frequently on the eggs, the females took the first shift of about 14 days. The males then incubated for about 10 days and the females returned a few days before the hatch. The incubation period was 34 days.

4. The males did not return to sea when the females reappeared but brooded or guarded the chicks for about 26 days, after which the chicks deserted the nests and entered a crèche. During the guard stage only the females fed the young, returning each evening for this purpose.

5. In the crèche stage both parents went to sea by day and fed the chick in the afternoon or at night. They fed only their own young, near or at the nest site. Chicks left when about 70 days old and did not return to the island until the following season.

6. Non-breeders and failed breeders dominated the rookery during the crèche stage, the males interfering with females trying to feed their chicks.

7. Immatures molted in late January and most had left by the end of February. Breeding birds molted in mid-April after about 28 days at sea. They had then been ashore 31 days, 17 days of which were occupied in shedding the old feathers.

8. Rockhopper Penguins had many dramatic displays which are described. Males had a display not used by females and of value in sexing the birds.

9. Reversed coition was noted with one pair whose sexes were confirmed by dissection.

10. Rockhopper Penguins exhibited a strong tendency to return to their nest sites and mates from year to year. Several nested in 1960-61 at the same sites as those they occupied four years before.

LITERATURE CITED

- DOWNES, M. C., E. H. M. EALEY, and P. S. YOUNG. 1959. The birds of Heard Island. ANARE Reports, Ser. B., **1**: 135 pp.
- ELLIOTT, H. F. I. 1957. A contribution to the ornithology of the Tristan da Cunha group. *Ibis*, **99**: 545-586.
- FALLA, R. A. 1937. Birds. BANZAR Expedition Committee, Adelaide, Rept. Ser. B., **2**: 288 pp.
- FOXTON, P. 1956. The distribution of the standing crop of plankton in the southern Ocean. *Discovery Reports*, **28**: 191-236.
- GWYNN, A. M. 1953. The egg-laying and incubation periods of Rockhopper, Macaroni and Gentoo penguins. ANARE Reports, Ser. B., **1**: 29 pp.
- HAGEN, Y. 1952. Birds of Tristan da Cunha. Results of the Norwegian Sci. Exp. to Tristan da Cunha, 1937-1938. Vol. 20. Oslo.

- LAW, P. G., and T. BURSTALL. 1956. Macquarie Island. ANARE Interim Reports, **14**: 48 pp.
- MURPHY, R. C. 1936. Oceanic birds of South America. New York, Amer. Mus. Nat. Hist., 2 vols.
- PETTINGILL, O. S., JR. 1960. Crèche behavior and individual recognition in a colony of the Rockhopper Penguin. *Wilson Bull.*, **72**: 209-221.
- RICHDALE, L. E. 1941. The Erect-crested Penguin (*Eudyptes sclateri* Buller). *Emu*, **41**: 25-53.
- RICHDALE, L. E. 1950. Further notes on the Erect-crested Penguin. *Emu*, **49**: 153-166.
- RICHDALE, L. E. 1951. Sexual behavior in penguins. Lawrence, Kansas. Univ. of Kansas Press.
- RICHDALE, L. E. 1957. A population study of penguins. London. Oxford Univ. Press.
- ROBERTS, B. 1940. The breeding behaviour of penguins with special reference to *Pygoscelis papua* Forster. *Brit. Grahamland Exp. 1934-1937. Sci. Reports*, **1**: 195-254.
- SLADEN, W. J. L. 1958. The pygoscelid penguins. Falkland Islands Dependencies Survey Sci. Rept. No. **17**: 97 pp.
- STONEHOUSE, B. 1960. The King Penguin (*Aptenodytes patagonica*) of South Georgia. Falkland Islands Dependencies Survey Sci. Rept. No. **23**: 81 pp.
- WARHAM, J. 1958a. The nesting of the Australian Gannet. *Emu*, **58**: 339-369.
- WARHAM, J. 1958b. The nesting of the Little Penguin (*Eudyptula minor*). *Ibis*, **100**: 605-616.
- WARHAM, J. 1962. The biology of the Giant Petrel (*Macronectes giganteus*). *Auk*, **79**: 139-160.

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