

MOLT IN THE ADELIE PENGUIN

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RICHDALE (1957: 175-176) and Murphy (1936: 402-403) had to rely on the fragmentary accounts of early Antarctic explorers and biologists for information on the molt of Adelie Penguins (*Pygoscelis adeliae*). They had encountered molting birds on land and in the pack-ice during February and March at the close of the breeding season and noted that the birds did not enter the water or feed during the molt (Clarke, 1906; Wilson, 1907; Gain, 1914). On the basis of his own observations and a review of the literature, Sladen (1958: 65) concluded that the majority of Adelie Penguins molt while on ice floes in the pack and that the number which molt on land in different areas varies from year to year according to prevailing ice conditions. Taylor (1962: 196-198) found that about one-third of the birds which molted in the vicinity of his study rookery at Cape Royds (the most southerly Adelie Penguin rookery) were local breeders and the rest, non-breeders.

Wilson (1907: 54-58) simply stated that the length of molt was two weeks and Gain (1914: 31) gave 20 days. Cendron (1953) studied the complete molt on three birds and these took 9, 15, and 17 days to replace their old plumage. Taylor (1962: 196-198) noted the duration of molt as being about two weeks, after which the birds departed to sea.

Clarke (1906: 162) found that birds which had recently completed the molt (in April) weighed about 30 per cent less than those at the beginning of the breeding season (in October). Cendron (1953) weighed 25 Adelie Penguins at the beginning of molt and 12 at the end and obtained an average weight loss of 40 per cent.

My observations on molting birds were made at Wilkes Station, Antarctica (66° 15' S lat., 110° 32' E long.), at the end of the 1958-59 and 1959-60 breeding seasons and represent part of an intensive study of Adelie Penguin behavior during a two-year period at the same location (Penney, in press).

METHODS

In the study rookery containing approximately 2,700 breeding birds, molting was observed systematically in 248 adults and 59 juveniles. (Adults are at least two years old and are characterized by a black chin before the observed molt; juveniles, hatched the previous season, have a white chin.) Molting birds under study were flipper-banded (Sladen and Penney, 1960) as were about 1,000 other birds being studied for territorial and social behavior. The total number of birds molting in the area of the rookery was about one-fifth the estimated total breeding population. The majority of the molting Adelie Penguins were banded at the end of the

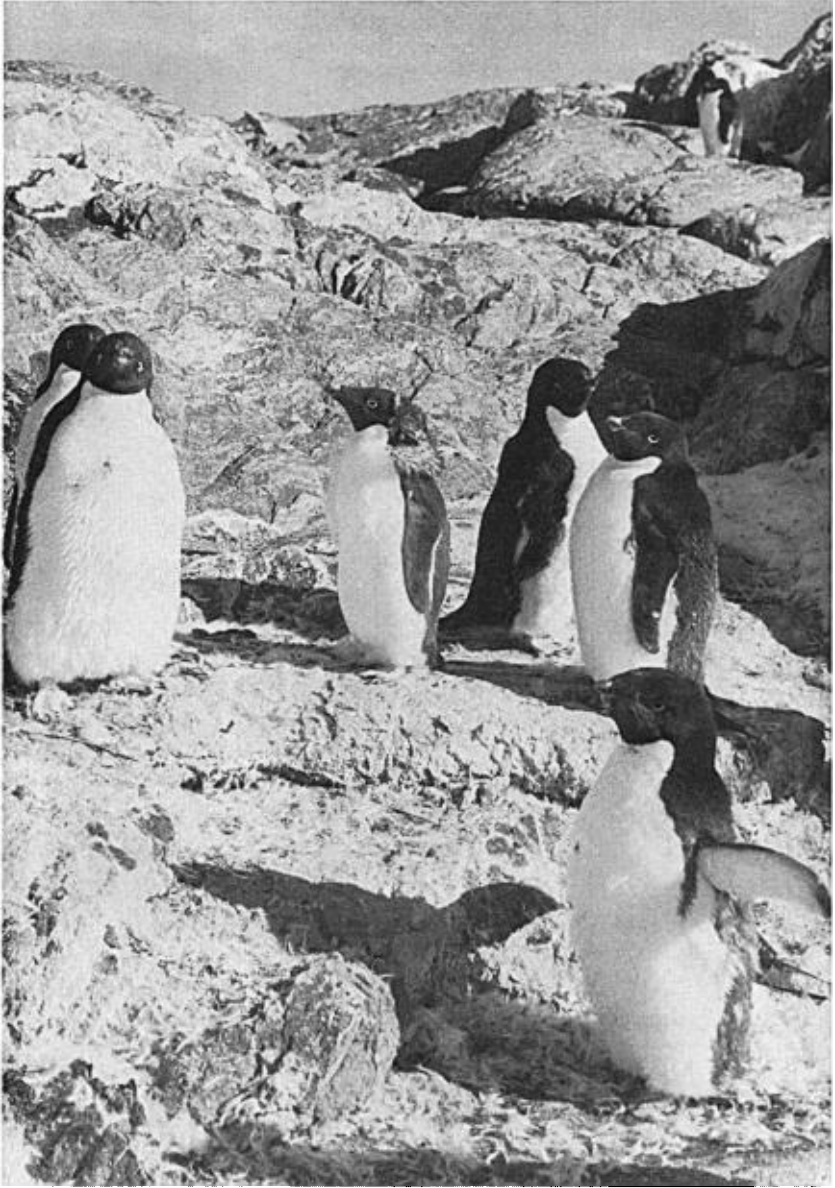


Figure 1. Six Adelie Penguins in foreground showing various stages of molt. From left to right the birds are classified as in pre-molt stage II, pre-molt stage III, molt (stage 4), molt (stage 1), pre-molt stage III, and molt (stage 1). Note the accumulation of old feathers on the rocky surface.



Figure 2. Adelie Penguin in pre-molt stage I showing typical posture and obvious heaviness necessary for the ensuing molt sequence.

1958-59 season by catching them individually or herding groups into a corral for banding and weighing. Some of those studied in 1959-60 had been banded in the preceding breeding season.

To determine weight loss during the fast accompanying the molt, 234 weighings were made on adults and 66 on juveniles. For weighing, a bird was suspended by a leather thong attached to its tarsus or, more efficiently, was weighed while in a tapered bag which had a catching hoop. Measurements were taken to the nearest quarter pound (113 g) with a spring scale.

After banding, the birds were observed daily to note the progress in molt and the birds' behavior. Band numbers were read with 6 × binoculars or 20 × scope. A few adults and juveniles were confined during molt to obtain more detailed notes on plumage changes and weight losses.

OBSERVATIONS

There are several intensive studies dealing with the general life history and behavior of the Adelie Penguin (Sladen, 1958; Sapin-Jaloustre, 1960; Taylor, 1962; Penney, in press). Summarizing briefly, the Adelie Penguin is a circumpolar species confined to an area south of 60° South latitude. The winter months of March into October are spent in the pack-ice feeding grounds. In mid-October and early November adult breeders move south to rookeries on the rocky shores and islands around the Antarctic continent. After courtship, nest building, and egg laying the females depart to sea to feed. The males remain behind for the first two weeks of incubation which is later shared in decreasing temporal shifts by both sexes until the eggs hatch (mid-December) after an average of 36 days of incubation. Following a three-week guard stage, when one parent stays with the one or two chicks, and a somewhat longer creche stage, dispersal of both adults and young of the year begins in early February. The molting season overlaps with the dispersal stage of the breeding cycle.

Plumage and associated changes.—In the terminology of Humphrey and Parkes (1959: 15–17), the molts of Adelie Penguins include a first prebasic molt of juveniles (in which the birds change from their juvenal to first basic plumage) and complete, second and subsequent prebasic molts of adults. After the first prebasic molt the plumage is described as definitive rather than adult.

Richdale (1957: 160) considered the period of penguin molt to extend from the time the bird first remains ashore until it departs to sea after having replaced its old plumage. This period in the Adelie Penguin can be conveniently divided into three pre-molt stages, four molt stages, and one post-molt stage (see Figure 1), all of which can be easily recognized in the field. Since penguins lack pterylae the feather loss is described by topography rather than by feather tracts.

Pre-molt stage I (Figure 2) begins when the birds come ashore. The birds have heavy sub-cutaneous fat deposits, their excreta is bile-stained (a reflection of fasting), and they act lethargically. Such birds seek out areas on permanent snow slopes sheltered from the wind, nearly always joining other birds in molt condition. Their dry contour plumage has a dull cast and the dark feathers on the back and rump are brown tipped. Juveniles often have missing rectrices.

TABLE 1
DURATION OF THE PRE-MOLT, MOLT, AND
POST-MOLT STAGES OF CONFINED ADELIE PENGUINS

Stages	Adults		Juveniles	
	Mean and range (in days)	N ¹	Mean and range (in days)	N ¹
Pre-molt				
I	1.6 (1-2)	3	1.2 (1-2)	4
II	1.6 (1-2)	10	1.2 (1-2)	9
III	1.9 (1-3)	10	2.1 (2-3)	7
Molt				
I	4.7 (2-8)	9	1.9 (1-2)	7
II	2.4 (1-3.5)	9	2.0 (1-3)	6
III	2.9 (2-5)	9	3.0 (1-4)	5
IV	4.9 (3-9)	9	4.8 (4-6)	5
Post-molt	2.5 (2-3)	9	3.6 (3-4)	5

¹ The variable number of birds is a result of differences in the stages of birds when they first came ashore (pre-molt I or II) and accidental losses.

A noticeable swelling of the flippers marks pre-molt stage II, yet the contour feathers of the body remain in their normal position. As the flippers swell their scale-like feathers lose their natural sheen as they are pushed apart by new growth from below. A few juveniles are in pre-molt stage II when they leave the sea to molt.

In pre-molt stage III the flippers swell to double their normal dorso-ventral thickness resulting in a very snug fit of flipper bands. All of the body feathers stand out, exaggerating the sizes of the birds. There is an increase in the vascularity of the skin to the extent that bleeding easily occurs if a bird's flipper strikes a hard object.

The dropping of old feathers follows a predictable course related to preening and abrasion from normal movements. Any birds handled during the four molt stages shed feathers profusely. Recognizable molt stages are: (I) no new plumage is visible, but odd, loose feathers protrude and drop from the central spinal and sternal areas; (II) one-quarter of the new plumage is visible on the posterior sternal region; (III) one-half of the new plumage is visible, including the sternal region, lores, chin, rump, scapular area, tail, and the anterior border and distal portions of the flippers; and (IV) three-quarters of the new plumage is visible with old feathers remaining in tufts on the foreneck, crown, and sides of neck and legs.

In the post-molt stage the birds appear much different. They are very thin; the keel of the sternum is obvious beneath the white breast on birds which are very light in weight. The new dark feathers of the head, chin, and dorsal surfaces are blue-tipped and the tails are stubby. On

TABLE 2
TOTAL DAYS ASHORE FOR MOLTING ADELIE PENGUINS

<i>Class</i>	<i>Mean</i>	<i>Range</i>	<i>N</i>
Confined adults	22.4	18-27	14
Confined juveniles	19.8	19-21	5
Free adults	19.8	15-25	45
Free juveniles	18.6	15-21	12

rare occasions a bird departed to sea with a few tufts of old feathers still in the process of being pushed off. All birds depart the rookery before their rectrices have grown one inch beyond the posterior contour feathers of the rump and belly.

As determined on captive adults and juveniles, the time taken to pass through these stages is quite variable (Table 1). The total time from arrival to departure for confined and free birds of both age groups was close to three weeks (Table 2); on the 45 free adults the standard deviation was 2.3 days. Juveniles generally complete this sequence one to two days faster than adults, the molt stages being much briefer (Table 1). The longer molt period (Table 2) for confined birds could be due to the artificiality of confinement even though the juveniles, released in the post-molt stage, did not depart to sea until 24 hours after release. I also tended to select birds for confinement which had just entered the rookery, and, in the case of free birds, I might have missed their arrival time by up to one day.

Dates of molting in relation to breeding status and age.—In the 1959-60 season a few pre-molt juveniles came from the sea in late January and early February (Figure 3). They completed their molt before all of the non-molting adults (mostly parents having returned to feed their chicks) and the young of the year had departed the rookery. Adults began coming ashore for molt in the first week of February and their numbers increased daily to a peak in the first week of March.

The first adults ashore completed the molt and departed the rookery by the time the total molting population reached its peak. Thus, the total number of adults molting in the rookery approximated 500 or nearly one-fifth the estimated total breeding population of 2,700. Similar proportions of molting to breeding populations were observed in other rookeries in the Wilkes vicinity in both the 1958-59 and 1959-60 seasons. Juveniles composed an estimated 10 per cent of the molting population during the 1959-60 season. In the 1958-59 season the entire molting population in the study rookery reached a peak of 343 on 5 March. The last molting birds observed in each of the two seasons were on 1 and 3 April, respectively.

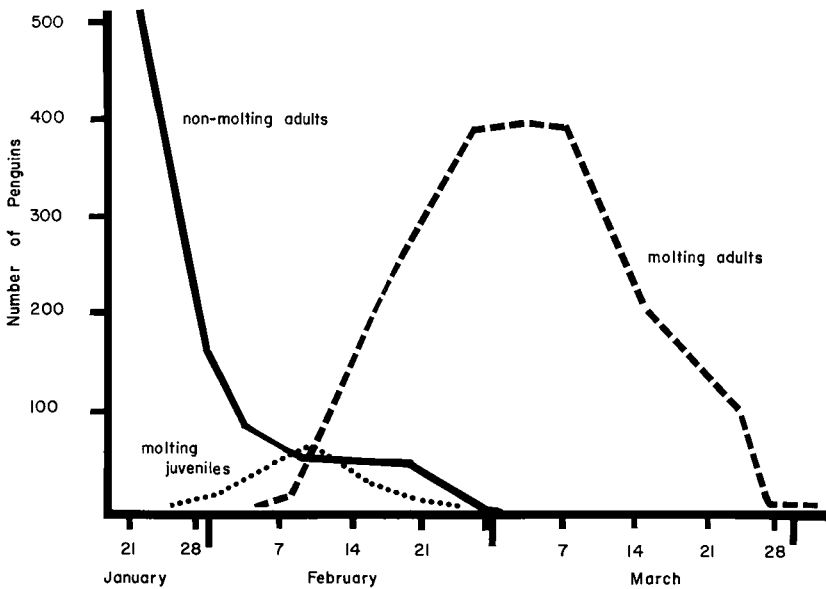


Figure 3. Populations of non-molting adults, molting juveniles, and molting adults in the study rookery at the close of the 1959-60 breeding season.

Breeding status and sex.—In the 1959-60 season there were 1,081 banded Adelie Penguins present in the study rookery. Nearly all were breeding adults; the rest, if not breeding, were known to have persistently occupied individual territories within the rookery. The estimated total breeding population for the same season was 2,700 birds. Only 33 (3.0 per cent) of the 1,081 banded birds returned to the rookery at the end of the season to molt. (The remaining banded birds presumably molted on ice floes in the pack.) From these figures it follows that about 16 per cent ($.03 \times 2,700/500$) of the estimated total adult molting population consisted of locally breeding birds. This figure is only one-half that found by Taylor (1962: 196-198) at Cape Royds. The other molting birds could have been breeding birds from other rookeries or young, non-breeding adults. The latter seems more probable since no banded birds from the study rookery were found with molting birds in nearby rookeries—the closest being three-quarter mile distant. It is also of interest to note that Adelie Penguins that had been banded as molting birds in 1958-59 and that returned and laid eggs in the study rookery during 1959-60 were at least 20 per cent less successful at rearing chicks to the creche stage than were birds from a random sample of breeders in the same rookery (Penney, in press).

TABLE 3
WEIGHTS OF ADELIE PENGUINS DURING THE BREEDING
SEASON AND IN THE PRE-MOLT STAGES¹

<i>Class</i>	<i>Mean (in pounds)</i>	<i>Range (in pounds)</i>	<i>N</i>
Adults early in season (6 November) ²	10.9	8.5-14	57
Adults with chicks (29 January-3 February)	9.9	8-12	51
Adults without chicks (3 February)	9.8	8.25-11	25
Pre-molting adults (stages I and II)	14.9	12.25-18	74
Pre-molting juveniles (stages I and II)	13.2	10.25-14.25	38

¹ Birds weighed to the nearest one-quarter pound (113 g).

² From a random sample of birds in a colony which was fenced in, seven days after the arrival of the first resident. The sex distribution in the sample probably favors males.

Of the 33 Adelie Penguins observed to molt after their 1959-60 breeding activities, 8 were known to have lost their eggs or chicks before the latter were three weeks of age. The average date at which these unsuccessful breeders began their molt was 1 March (range, 25 February to 6 March). The 25 birds known to have raised chicks successfully into the creche stage of the breeding cycle (Sladen, 1958; Penney, in press) began their molt on the average date of 3 March (17 February to 10 March). One-half of the presumed non-breeding adults on the other hand had begun their molt by 19 February (Figure 3). Statements regarding the relative dates of molt of birds of different breeding status and age must carefully differentiate between unsuccessful breeders and non-breeders.

Of the 33 molting adults which were known to have bred in the rookery during 1959-60, 21 were judged as males on the basis of their breeding behavior (Penney, in press). This preponderance of males in the molting population was also noted in the recoveries from 174 Adelie Penguins which had been banded during the molting season of 1958-59. Of 71 recoveries (41 per cent), 47 (66 per cent) were judged as males and 21 (30 per cent) as females. Observations on the remaining 3 birds were insufficient to judge the sex adequately on the basis of behavior.

Weight loss.—The weights of Adelie Penguins taken at various times during breeding (Table 3) show that birds in pre-molt stages I and II weigh more than those early in the breeding season prior to the long fasting routine which occurs during courtship, egg laying, and incubation (Sladen, 1958; Penney, in press).

TABLE 4
WEIGHT LOSS DURING THE PERIOD ASHORE FOR MOLTING ADELIE PENGUINS¹

Class	Weight at pre-molt stages I and II		Weight at post-molt stage		Mean per cent
	Mean and range (in pounds)	N	Mean and range (in pounds)	N	
Confined adults	15.0 (13.5-16.75)	13	7.0 (5.25-9)	13	53.3
Confined juveniles	12.3 (11.75-13.25)	5	6.2 (4.75-7)	5	50.4
Free adults	14.7 (12.25-18)	61	8.1 (6-9.5)	57	44.8
Free juveniles	12.2 (10.25-14.75)	33	6.8 (5.75-7.75)	12	44.5

¹ Birds weighed to the nearest one-quarter pound (113 g).

Weight loss during the molt is approximately one-third of a pound (150 g) per day. The total loss for free adults and juveniles is about 45 per cent (Table 4); for captive birds it is higher and probably exaggerated by confinement and handling.

Behavior.—Adelie Penguins, entering the rookery to begin their fasts associated with the molt, sometimes remain standing near the beaches for a day or so. A few individuals enter colonies during pre-molt stages I and II and collect nesting stones. Early-molting juveniles sometimes spend their entire molt period in the vicinity of the colonies, near groups of creche chicks and birds in the definitive plumage which are occupying nesting territories late in the season. Most molting birds seek out areas in the rookery on the sides of hills away from prevailing winds. Several of these areas show an accumulation of many old feathers and bile-stained ice and snow indicating that they are repeatedly chosen for their shelter.

Immobility is the significant behavioral feature of birds during their fast, especially during the period when there is feather loss. Once situated in a sheltered area there is little movement of individuals except when they are disturbed during observations or by an unusually persistent change in wind direction. Such sedentary behavior is undoubtedly related to thermoregulation. Molting Adelie Penguins are very alert to disturbance and can be described as "bad-tempered." Juveniles are generally more shy than adults and sometimes utter threat vocalizations and move away when the separating distance from an observer is 180 feet. When groups are disturbed, distances between individual birds are often reduced to about 18 inches and raucous pecking between neighbors results.

Displays normally associated with breeding behavior (Penney, in press) are rare during molt. The "ecstatic" and "loud mutual" displays are seen, but these are nearly always related to the observer and probable disturbance. Also of rare occurrence are the three threat displays (the "direct stare," "alternate stare," and the "bill-to-axilla" display) which are given either toward an observer or another bird.

Next to sleeping, the major activity is preening. Snow is eaten and sometimes bile-stained feathers, presumably consumed with the snow, are found in the excreta.

Toward the end of molt stage IV and in the post-molt stage there is an increase in the mobility of individuals. They leave the sheltered areas and collect in groups along the beaches. Three birds were observed to pause in vacated breeding colonies and collect some nesting stones. Individuals about to depart the rookery wander up and down the beaches for two or three days. Preening is accentuated as the birds prepare for return to the aquatic habitat. Shortly before departure to sea, call notes are repeatedly given and the flippers are exercised. This appears to attract other birds which have finished their molts and departure is usually a group activity.

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SUMMARY

The annual molt of the Adelle Penguin was studied at the end of two breeding seasons in a small rookery. Adult and juvenile birds carrying heavy sub-cutaneous fat deposits come ashore and remain until they completely shed their old plumage. In this time, eight stages are recognized on the basis of behavior and plumage. On captive birds three pre-molt stages averaged 5.1 days in duration while the four molt and one post-molt stages averaged 14.9 and 2.5 days, respectively. Juveniles usually completed the whole sequence one to two days faster than adults. Free-ranging adults and juveniles spent an average time ashore of 19.8 and 18.6 days, respectively.

Adelle Penguins in pre-molt condition weigh more than they ever do during the preceding breeding season. Mean weight loss during the molting fast was 45 per cent for free adults and juveniles and up to 53 per cent on captive birds.

A few juveniles molted in late January. The majority of Adelie Penguins molt on floating ice floes in the pack-ice and not on land. Adults which came ashore to molt beginning in early February, reached peak numbers the first week of March. All birds had departed by 3 April in the two seasons. The population of molting adults equalled about one-fifth of the local breeding population. Of these, only 16 per cent were local breeders, mostly males. Most of the birds molting in the rookery are presumed to be young non-breeding adults.

Except for extensive preening, molting Adelie Penguins are very inactive after having sought out areas sheltered from prevailing winds.

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