

AN INTERPRETATION OF THE AGE STRUCTURE AND BREEDING STATUS OF AN ADELIE PENGUIN POPULATION

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INTRODUCTION

The size and complexity of Adelie Penguin rookeries along with the modified behaviour of individuals banded and studied in subsequent years has shown that long term study of a marked population may not provide reliable data on population dynamics.

Banding and close observation during seven summers caused the breeding population in six colonies at Cape Hallett to decrease by more than 90%. Several factors contributed:

- (a) higher prefledgling mortality resulting from nest checking;
- (b) daily disturbance associated with study prevented young birds returning to their natal colonies to breed;
- (c) adults with previously good breeding records abandoned the study colonies for nesting sites free from interference and
- (d) proportionately fewer of those adults that did return to the study colonies bred. Standard and recognized treatment of recoveries from these colonies gave an adult mortality rate of 48% per annum which fallaciously implies that the Adelie is a rapidly declining species.

In such cases where *prima facie* interpretation of data give improbable values other studies, although primarily concerned with different topics, may provide more meaningful parameters on certain aspects of population. If the collation and fusion of data from diverse projects provides a basis to which acceptable concepts may be appended and if the resulting population structure shows all features essential for equilibrium; then a working model for conservationists exists until such time when many facets of the population may be determined more precisely.

In this discussion three concepts are accepted as fundamentally true:

- (a) Adelie populations are stable and evidence suggests, even slowly expanding. They may fluctuate but there is no measurable imbalance between recruitment and mortality (Reid 1962, Taylor 1962).
- (b) Chicks return to breed at their natal rookery (Sladen et al. 1966, Reid et al, 1967).
- (c) After the first year of life the mortality rate is more or less constant although it is probably slightly higher for birds in their second and third years than for older birds.

ESTIMATES OF MORTALITY

Cape Hallett is the summer home for some 140,000-150,000 Adelie penguins. The breeding population varies between 56,000-62,000 pairs. These nest in several hundred colonies situated on shingle mounds and ridges scattered throughout the 100 acre spit.

During the four summers 1958-59 to 1961-62 inclusive over 4,800 adults (mostly breeding pairs) were banded on 83 colonies. In addition, 510 chicks were banded on ten of these colonies.

Disturbance, and in some cases destruction, of banded colonies resulting from station activities (vehicle movements, maintenance and construction work, etc.) made follow-up studies at many of these meaningless.

By 1962-63 only nine of the 83 colonies were in areas of the rookery still unaltered or undisturbed by human interference. Recoveries that summer of adults banded on these colonies in 1961-62 showed that 86% returned to the rookery and of these 97% were on their traditional colony. As the bands used on these birds were more durable than those used on the six long term study colonies and there was no evidence of band loss (worn or abraded upper flipper feathers, or bands still intact but gaping) this recovery percentage is a direct measure of survival during the preceding twelve months. Furthermore, counts in these and other undisturbed colonies during six years gave a similar number of breeding birds each summer with 4,190 pairs in 1960 and 4,170 pairs in 1965. This suggests, and is accepted for this discussion, that the mean mortality rate during the six years was in the order of 14% per annum.

Recoveries of adults and chicks banded on ten colonies in 1959 and 1960 provides data on *relative* survival. Both age classes were subjected to the same interference on return to the rookery in subsequent years and both were banded with less durable bands than were birds on the nine undisturbed colonies. Therefore a true recovery rate is not possible. However, the difference in percentage of recoveries permits a calculation of juvenile mortality from the adult mortality rate. Recoveries show from equal numbers banded that for every ten adults recorded four to six years after banding only six bird banded as chicks are known to be alive after the same number of years. With adult mortality placed at 14% per annum some 67% of the chicks alive at four weeks must die before the age of four years. If for convenience (although perhaps not strictly true) the adult mortality rate is applied from the second year on, when birds are full grown although not sexually mature, then the difference in survival between those banded as adults and those banded as chicks is accounted for if 48% of chicks die during their first year.

With over 5,000 penguins banded and after seven years of study it is possible to say only that *about* 48% of chicks may die in their first year (between the ages of one and twelve months) and thereafter the adult mortality is *probably* 14% per annum. Although these mortality estimates agree closely with Richdale's (1957) figures for yellow-eyed penguins (i.e. 52% in the first year, thereafter 13%

p.a.) their validity depends on whether, when correlated with data on clutch size, hatching success, breeding age, proportion of non-breeders, etc., they show the population to be at least stable.

POPULATION DATA

Clutch size. Of 213 breeding females of unknown age, 184 (86.4%) laid two eggs and 29 laid one egg giving a mean clutch of 1.86 eggs per breeding pair (Reid, 1965). Four-year-olds lay one egg, therefore the same is assumed for three-year-old females. Five-year-olds are equally likely to be incubating one or two eggs (Reid et al. 1967) and the mean clutch for 64 females known to be six or more years was 1.92 eggs.

Chick survival, to the age of four weeks ("creche" stage, Sladen 1958). ...Counts during three seasons showed a 38% combined loss of eggs and chicks before the latter reach the age of four weeks. In 1959 a sample of 236 breeding pairs had 281 chicks alive at four weeks (1.19 chicks/pair); the following year 1,070 breeding pairs had 1,466 chicks (1.37 chicks/pair); and in 1962 a sample of 949 breeding pairs had 845 (0.89 chicks/pair) survive their first month. These data suggest a mean annual productivity of 1.15 chicks per breeding pair (Reid 1964 and unpub) to the age of four weeks.

Percentage of each Age Class at the Rookery. If a constant mortality rate is assumed from the second year on then the number of birds recovered in younger age classes provides an estimate of the percentage of these age groups that return to the rookery. Limited data from Hallett (Reid et al. 1967) suggests approximately 5-10% of two-year-olds, 25-30% of three-year olds, 80-85% of four-year-olds and all birds five years or older tend to return to the breeding grounds.

Percentage of each Age Class Breeding: A preliminary statement on results from Cape Crozier (Sladen et al. 1966) mentions a small number of three-year-olds bred. As a working estimate this is taken at about 10% of those returning to the rookery. The youngest breeders recorded at Hallet were four years and 25% of those in this age class were incubating. Recoveries suggest that some 80-90% of five-year-olds, 85-95% of six-year-olds and 90-95% of older birds at the rookery breed (Reid, et al, 1967 and unpub.).

POPULATION STRUCTURE AND EQUILIBRIUM

By incorporating all counts, calculations and estimates it can be shown (Table 1) that the age structure and breeding status derived for an Adelie penguin population in an "average" year will ensure stability. This table shows the population will be maintained if each breeding female produces about 1.83 eggs while actual counts give a mean clutch of 1.86 eggs. Furthermore, it indicates some 22% of the population at a rookery will not breed. This agrees closely with a 20% estimate based on field counts (Eklund 1961).

Furthermore, although the two species have quite different ecologies, the productivity and survival known or inferred for the

Table 1

The Adelie Penguin

Table showing Age Composition and Breeding Status of a Population
(Deduced from several studies carried out at Cape Hallett)

| Age | Mortality Percent | Number Alive | Percent Ashore | Number Ashore | Percent Ashore Breeding | Number Breeding | Mean Clutch Size | Eggs Laid |
|--------|----------------------|-----------------|-------------------|------------------|-------------------------------|--------------------|------------------------|---------------|
| Eggs | 38 | 10,000 | | | | | | |
| Chicks | 48 | 6,200 | | | | | | |
| | -c68 | | | | | | | |
| 1 yr. | 14 | 3,224 | | | | | | |
| 2 " | " | 2,772 | 5-10 | 208 | 0 | | | |
| 3 " | " | 2,384 | 25-30 | 655 | 10 | 65 | 1.0 | 65 |
| 4 " | " | 2,050 | 80-85 | 1,691 | 25 | 422 | 1.0 | 422 |
| 5 " | " | 1,763 | 100 | 1,763 | 80-90 | 1,498 | 1.5 | 2,247 |
| 6 " | " | 1,516 | " | 1,516 | 85-95 | 1,364 | 1.92 | 2,619 |
| 7 " | " | 1,303 | " | 1,303 | 90-95 | 1,205 | | 2,314 |
| 8 " | " | 1,120 | " | 1,120 | " | 1,036 | | 1,989 |
| 9 " | " | 963 | " | 963 | " | 890 | | 1,709 |
| 10 " | " | 828 | " | 828 | " | 766 | | 1,471 |
| 11 " | " | 712 | " | 712 | " | 658 | | 1,263 |
| 12 " | " | 612 | " | 612 | " | 566 | | 1,087 |
| 13 " | " | 526 | " | 526 | " | 486 | | 933 |
| 14 " | " | 452 | " | 452 | " | 418 | | 803 |
| 15 " | " | 388 | " | 388 | " | 359 | | 689 |
| 16 " | " | 333 | " | 333 | " | 308 | | 591 |
| 17 " | " | 286 | " | 286 | " | 264 | | 507 |
| 18 " | " | 245 | " | 245 | " | 226 | | 434 |
| 19 " | " | 210 | " | 210 | " | 194 | | 372 |
| 20 " | " | 180 | " | 180 | " | 166 | | 319 |
| | | | | <u>13,991</u> | | <u>10,891</u> | | <u>19,834</u> |

1. Average clutch size required to maintain population may be obtained by

$$(a) \frac{\text{Total Eggs Laid}}{\text{Total Number Breeding}} = \frac{19,834}{10,891} = 1.82 \text{ Eggs/Pair.}$$

$$(b) \frac{\text{Number Eggs at Start}}{\frac{1}{2} \text{ Total Number Breeding}} = \frac{10,000}{5,445} = 1.84 \text{ Eggs/Pair.}$$

2. An estimate of the breeders in the rookery population may be made, i.e.

$$\frac{\text{Total Number Breeding}}{\text{Total Number Ashore}} = \frac{10,891}{13,991} = \text{c78\% of population breed.}$$

Adelie penguin closely parallels those obtained from extensive studies by Richdale (1957) of the larger Yellow-eyed Penguin (*Megadyptes antipodes*).

- (a) The mean clutch for Yellow-eyed Penguins and also for Adelie Penguins aged six or more years contains 1.92 eggs.
- (b) 15.4% of eggs laid by Yellow-eyed Penguins survive to breed and calculations suggest approximately 15.7% of Adelie eggs survive to breed. (This percentage is derived by adding 14% of the breeding three- and four-year-olds to the number of breeding five-year-old birds).
- (c) 52% of Yellow-eyed Penguins die during their first year and thereafter the mortality rate is shown to be 13% per annum. Calculations place the Adelie mortality rate at 48% in the first year and then at about 14% per annum.
- (d) From Richdale's data it seems that about 93.5% of adult Yellow-eyed Penguins breed. Records from Hallett show 90-95% of "established" Adelies breed.
- (e) Calculations imply that about 5% of yearling Adelie Penguins will live another 19 years. Some Yellow-eyed Penguins are known to be at least 19 years old and Richdale's data show approximately 7% of yearlings should survive to their 20th year.

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