COUNTS OF MOULTING AND BREEDING JACKASS PENGUINS *SPHENISCUS DEMERSUS*: A COMPARISON AT ROBBEN ISLAND, 1988-1993

R.J.M. CRAWFORD & H.G.v.D. BOONSTRA

Sea Fisheries Research Institute, Private Bag X2, Roggebaai 8012, South Africa

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SUMMARY

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Over a five-year period counts of active nest sites of Jackass or African Penguins *Spheniscus demersus* at Robben Island, southwestern Cape Province, South Africa, in May, at the middle of the breeding season, were significantly related to estimates of numbers of adult penguins obtained from counts of birds in the feather-shedding phase of moult. Nest counts made earlier or later in the breeding season were not as well related to the moult count, because of abandonment of nests probably as a result of heat stress, late initiation of breeding arising from a scarcity of food, and early termination of breeding. The number of moulting adults over a 12-month period was largely determined by a few counts conducted around the early December peak in moult. The number of moulting adults was higher than maximum counts of nests by a factor of between 2.5 and 3.7 (mean 3.2). This was in agreement with a factor used in a previous study to adjust nest counts to obtain an estimate of the overall population of Jackass Penguins.

INTRODUCTION

Various methods exist for counting penguins (Randall *et al.* 1986). Off southern Africa, methods that have been applied to the Jackass or African Penguin *Spheniscus demersus* include counts from aerial photographs (Rand 1963), ground counts of chicks, subadults, adults, breeding pairs or nests (Berry *et al.* 1974, Shelton *et al.* 1984), ground counts of moulting birds (Randall *et al.* 1986), measurements of area utilized by breeding birds (Crawford *et al.* in press) and calculations of numbers in a colony from measurements of colony area and density of birds in subareas of the colony (Ross 1971). Recent assessments of trends in the population of Jackass Penguins have been based on two methods: counts of moulting birds and of active nest sites (Crawford *et al.* 1990).

Counts of moulting penguins (adults and juveniles) have been used to estimate the overall population. Jackass Penguins moult annually with a mean interval between moults of almost exactly one year (Randall & Randall 1981). During their moult, Jackass Penguins shed their feathers over a mean period of 12.7 d (Randall 1983). Therefore, counts of moulting birds made at 14-d intervals and summed over a year should estimate, slightly conservatively, numbers of Jackass Penguins at a colony (Randall *et al.* 1986). Because adults have been recorded moulting only at localities at which they breed (Randall 1983), such an estimate is thought to be especially robust for adult birds (Randall *et al.* 1986).

Counts of active nests provide a measure of the breeding population. Not all mature Jackass Penguins necessarily breed in a particular year

(Crawford *et al.* in press). Therefore, the measure is distinct from the estimate of total population derived from counts of moulting birds.

If the objective of counting is to determine trends in the overall population of Jackass Penguins, counts of moulting birds, conducted properly, appear the best method at present. The major drawback of this method is that it is necessary to undertake counts every second week, or at a rate of about 26 counts per year (Randall *et al.* 1986). For accessible or permanently manned breeding localities this is feasible, but it makes considerable demands on time. However, for remote localities it has often proved impractical to visit the colony even once annually (Shelton *et al.* 1984). For adult Jackass Penguins, a well-defined peak in moulting means that a reasonable estimate of numbers may be obtained by counting during the main moult period only (Randall *et al.* 1986), so that it may prove possible to reduce the number of counts. This presupposes that the main moult period is known. There is accumulating evidence that this period varies around the southern African coast (e.g. Crawford *et al.* in press). Clearly, it will need to be ascertained for each breeding locality.

Counts of nest sites have drawbacks in determining trends in both the overall population and the breeding population. The most important of these are that there may be interannual differences in the proportion of mature birds breeding, and that counts may be conducted during a period of absenteeism of breeders (Randall *et al.* 1986). However, for localities that are seldom visited, counts of nests may still provide the most reliable indication of population trends. To investigate this possibility, counts of moulting adults and of active nest sites were made at Robben Island (33°48'S, 18°22'E), southwestern Cape Province, South Africa, between 1987 and 1993. Robben Island was recolonized by Jackass Penguins in 1983 and the colony subsequently has grown to more than 2000 breeding pairs in 1992 (Crawford *et al.* in press).

At many colonies of Jackass Penguins, counts of penguins moulting in a year are not available. Therefore, estimates of overall numbers of penguins have been obtained by adjusting counts of nests to account for non-breeders (Crawford *et al.* 1991). Comparisons of counts of moulting birds and nests at Robben Island permit assessment of the procedure previously used in this adjustment.

At Robben Island, breeding by Jackass Penguins extends throughout the year. However, few nest sites are occupied in November and December. The number of active nests increases from January and peaks around May. Breeding remains at a high level until July to September, after which it tails off. Most adult Jackass Penguins moult between November and January, with a peak in December (Crawford *et al.* in press).

METHODS

Active nest sites were counted in February, March, May and August of each year between 1988 and 1993, except in 1988 when a count was conducted in mid April instead of March, and in 1992 in late September instead of August. Methods used to count nest sites of Jackass Penguins have been described by Shelton *et al.* (1982, 1984). Sites were defined as active if they were defended by adult birds, or contained live eggs or chicks. When chicks formed crèches, the number of chicks in a crèche was divided by two to estimate the number of nests represented. Resulting halves were taken to represent complete nests; for example, crèches of six and five chicks would both be regarded as representing three nests. Jackass Penguins may fledge two chicks from each brood, although at Robben Island the mean annual number of chicks in fledging plumage seen at nests varied between 1.36 and 1.53 between 1986 and 1991 (Crawford *et al.* in press).

Counts were made of penguins in adult plumage in the feather-shedding stage of moult at approximately two-week intervals between

October 1988 and June 1993. A total of 112 counts was made.

Most penguins shedding feathers were encountered in groups on the shoreline that also included birds not shedding feathers. Binoculars and a telescope were used to ascertain whether penguins were shedding feathers, including those losing their last old feathers around the head and flippers (Cooper 1978). Feather-shedding birds in large groups of penguins (> *c.* 50 individuals) were counted twice. If there was a substantial difference in the two counts, a third count was undertaken. The mean of the two closest counts was adopted. Numbers of penguins shedding feathers in the breeding area were also counted.

Annual indices of numbers of adults moulting were obtained by lumping all counts made between July and June. In all, 18 counts were made between October 1988 and June 1989, 25 between July 1989 and June 1990, 24 between July 1990 and June 1991, 25 between July 1991 and June 1992, and 20 between July 1992 and June 1993. Numbers of moulting adults in 1988/89 were adjusted upwards to account for the period prior to initiation of counts in October 1988. Information from 1989/90 was used to estimate the proportion of adults that moulted between 1 July and 20 October, when the first count of moulting birds was conducted in 1988.

Counts of moulting adults were assumed to represent the potential breeding populations. They were correlated with counts of active nest sites obtained in February, March, May and August of the immediately preceding breeding season, as well as with the maximum count of nests in that season. In the correlations, the nest counts for April 1988 and September 1992 were used as the March and August estimates for the respective years.

The 12-month count of moulting adults was correlated with the moult count made during the first week in December, with the sum of this count and the immediately preceding and following counts, and with the sum of the early December count and the two prior and subsequent counts.

Lastly, the 12-month moult count was compared with the maximum nest count of the preceding breeding season.

RESULTS

The greatest nest count was obtained in May in all years, except in 1989 when the August count was marginally higher (Fig. 1). The greatest number of moulting adults was consistently recorded in the first week of December.

Counts of moulting adults were positively related to counts of nest sites in all comparisons made (Table 1). There was a high level of significance between the moult count and the May and maximum nest counts.

The moult count in the first week of December was significantly related to the 12-month moult count at the 2% level. The correlation coefficient increased as more counts were added, and the significance level improved to 1% when three and five counts straddling the peak moult count in early December were used. However, the 12-month count is not independent of the individual counts used to derive it. Therefore, the significance levels are not strictly applicable.

The 12-month moult count was greater than the maximum nest count in the preceding breeding season by a factor that ranged between 2.46 and 3.68 (n=5, mean = 3.24).

DISCUSSION

Although positive relationships were obtained between the 12-month count of moulting adult Jackass Penguins and nest counts, the only significant relationships were with the count of nests in May and maximum count of nests in the

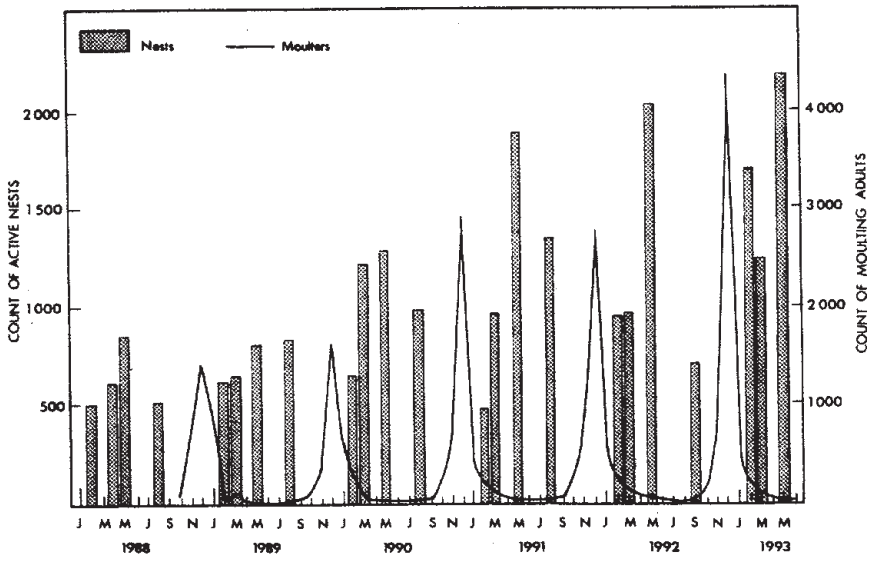

Figure 1

Counts at Robben Island of numbers of active nests of Jackass Penguins and numbers of adults moulting, January 1988 - June 1993.

TABLE 1

RESULTS OF CORRELATIONS OF COUNTS OF MOULTING JACKASS PENGUINS IN ADULT PLUMAGE OVER A 12-MONTH PERIOD (JULY-JUNE) WITH COUNTS OF ACTIVE NEST SITES PRECEDING THE PEAK MOULT IN DECEMBER, AND WITH COUNTS OF MOULTING ADULTS OVER A SHORTER PERIOD AT ROBBEN ISLAND. NUMBERS OF OBSERVATIONS (*n*), CORRELATION COEFFICIENTS (*r*) AND PROBABILITIES (*P*) ARE INDICATED

Nest count	*n*	*r*	*P*
February	5	0.75	>0.10
March	5	0.66	>0.10
May	5	0.93	<0.02
August	5	0.22	>0.10
Maximum count	5	0.93	<0.02
Moult count			
First count in December	5	0.95	<0.02
First count in December and two adjacent	5	0.97	<0.01
First count in December and four adjacent	5	0.98	<0.01

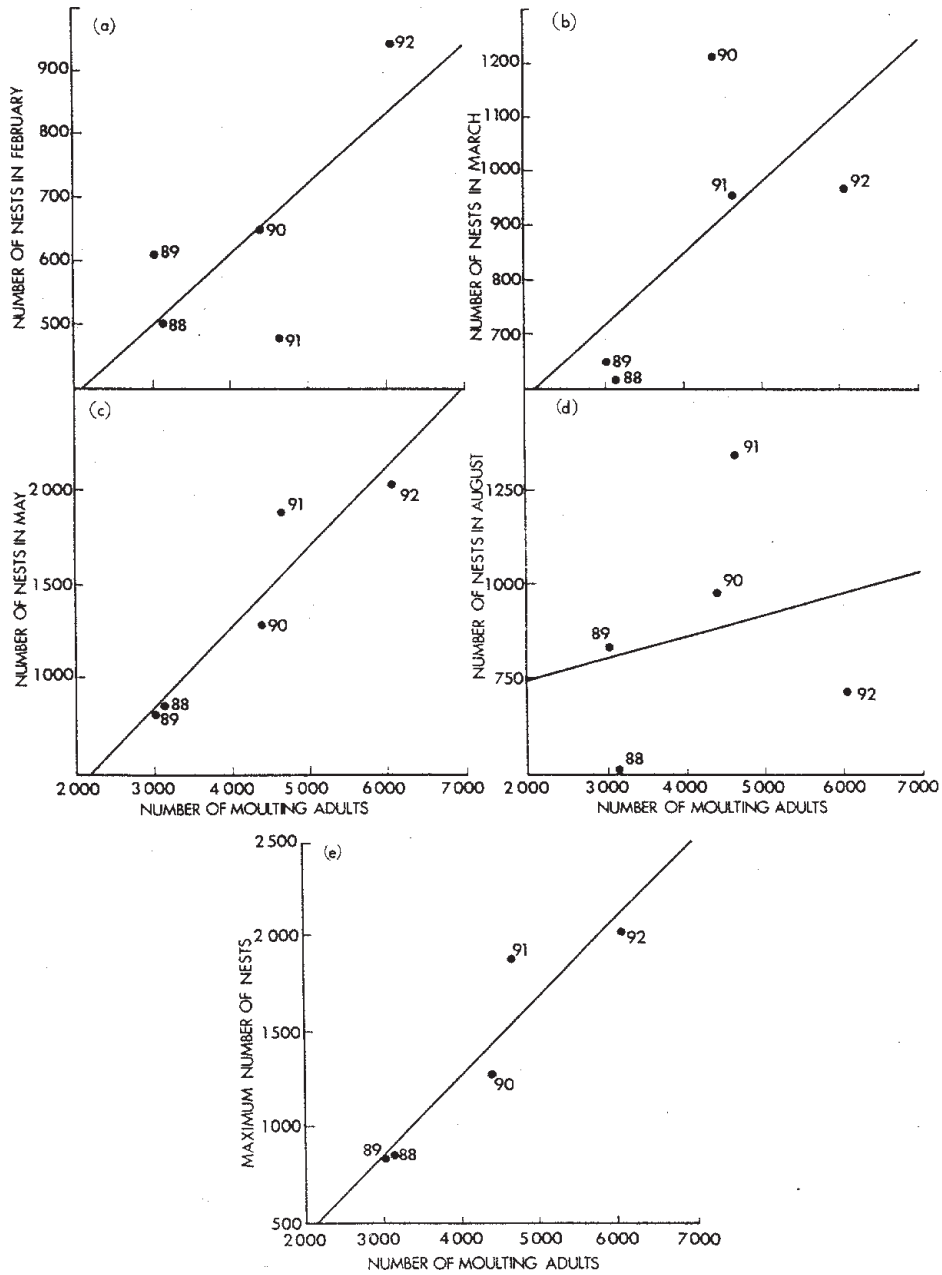

Figure 2

Relationships at Robben Island between the 12-month (July-June) total number of adult Jackass Penguins in the feather-shedding phase of moult and numbers of nests preceding the peak moult in December for: (a) February, (b) March, (c) May, (d) August and (e) maximum nest count. Data points are shown for each year treated (1988-1992) and the regression lines are shown.

year (Fig. 2c, e). At Robben Island, the number of active nests increases steadily after January, as more birds move in to breed, to attain a peak in May (Crawford *et al.* in press).

There was a reasonably close relationship between the moult count and the February nest count, except for 1991 (Fig. 2a). Few penguins were breeding in February 1991, probably as a result of a scarcity of food at that time (Crawford *et al.* in press). Anchovy *Engraulis capensis* was the main prey of penguins at Robben Island over the period of the study (Crawford *et al.* in press), but the biomass of the species was low from autumn 1989 until autumn 1991 following formation of poor year-classes in 1989 and 1990 (Hampton 1992). From autumn 1991, a stronger 1991 anchovy year-class (Anon. 1993) became available as food for penguins, and many additional penguins commenced breeding between March and May (Fig. 1). Deferred initiation of breeding may have resulted in nest counts conducted early in the season underestimating the strength of the breeding population.

The count of nests in March 1990 was close to the maximum obtained in that year, suggesting that, unlike the situation in other years (Crawford *et al.* in press), most birds initiated breeding relatively early in the season. By contrast, the March nest count of 1992 is lower than expected from the 12-month moult count (Fig. 2b). Towards the end of February 1992, 145 occupied nests were abandoned by penguins, probably as a result of heat stress (Crawford *et al.* in press). If these nests are added to the count for March 1992, a considerably better fit between the March counts and the 12-month moult counts results ($r = 0.80$). As well as deferred breeding, desertions of this nature have the potential to depress nest counts, particularly in the early, warmer months of the nesting season.

Nest counts conducted in May and maximum nest counts, four of the latter made in May (Fig. 1), show a good relationship with the 12-month moult count (Fig. 2c, e). This suggests that nest counts conducted towards the middle of the breeding season are a good indicator of population size at Robben Island.

The counts in August, towards the end of the breeding season, have the poorest fit with the 12-month moult counts (Fig. 2d). The 1992 count is probably too low as a result of its having been conducted at the end of September, when more birds are likely to have terminated breeding than one month earlier. However, the overall poor fit for August suggests substantial variability in the date at which penguins stop breeding at Robben Island.

The good relationships at Robben Island between moult counts made around the peak adult moult period and the totalled 12-month moult counts (Table 1) suggest that, if the time of the moult peak can be ascertained accurately, a reasonable index of the size of the adult population may be obtained by conducting just a few counts of moulting adults centred around the peak moult period. This results from the synchrony of the adult moult (Randall *et al.* 1986). Our results suggest that a nest count conducted at the middle of the breeding season (May at Robben Island) will also provide a reliable index of trends in numbers of adults. If both methods are applied, valuable information should result regarding interannual variations in the proportions of Jackass Penguins attempting breeding, a factor likely to be important in influencing population trends (Crawford *et al.* in press), but about which much has yet to be learned.

The factor used by Crawford *et al.* (1991) to adjust nest counts to obtain an estimate of the population of Jackass Penguins in adult plumage was 3.53. This was based on a comparison during the late 1970s for the area between Saldanha and Dassen Island of an estimate from moult counts of numbers of penguins in adult plumage and a count

of breeding pairs. This factor falls within the range observed at Robben Island, but it is above the mean of 3.24. Crawford *et al.* (1991) estimated the world population of Jackass Penguins in the mid 1980s to be 163 000 individuals (excluding chicks). If the factor of 3.24 is used instead of 3.53, the estimate of overall numbers decreases to 153 000.

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