ELECTRONIC APPENDIX

This is the Electronic Appendix to the article

Long-term effects of flipper bands on penguins

by

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Electronic appendices are refereed with the text; however, no attempt is made to impose a uniform editorial style on the electronic appendices.

Electronic Appendix A: Supplementary material

Methods

About 10 000 pairs of king penguins have access to the sea via the three paths. Two antennas are buried 3 m apart along each of these paths. Each active over an area of 3-5 m2, they supply energy to the miniature passive microwave transponder tag which is activated at a distance of 70 cm. The antennas are connected to a computer that logs the data. The sequence of signals emitted by the two antennas on each pathway indicates whether a bird is entering or leaving the colony.

One hundred adult king penguins were randomly caught outside the colony between 17 and 28 February 1998, as they departed to forage after being relieved by their partner. Once a transponder was implanted, its operation was verified using a hand-held reader (TIRIS). Half of the birds with transponders were randomly chosen to be fitted with a numbered band on the right flipper. The 23 g stainless steel bands measure 13 mm by 55 mm (Lambourne, Solihull, UK). The birds were also weighed, and bill and flipper lengths were measured as an index of body size. Body masses and sizes were not significantly different between the banded and unbanded birds (mean body mass ± SE: 10.83 ± 0.14 kg versus 10.82 ± 0.15 kg, $F_{1,98} = 0.002$, $p>0.05$; bill length: 122 ± 1 mm versus 123 ± 1 mm, $F_{1,98} = 0.82$, $p>0.05$; flipper length: 347 ± 1 mm versus 346 ± 2 mm, $F_{1,98} = 0.19$, $p>0.05$, respectively). The sex of the birds was determined by analysing the chronology at the beginning of the breeding cycle. At this time, males were ashore for one month, engaged in approximately 12 days of courtship and an 18-day incubation shift, whereas females averaged 9 days ashore until laying, followed by departure for an 18-day foraging trip at sea. Seventy birds were sexed according to this method. The gender composition of the banded and unbanded groups was not significantly different ($\chi^2_2 = 1.402$, $p=0.496$). The banded group was composed of 20 males, 12 females and 18 birds of unknown sex, while the unbanded group comprised

21 males, 16 females and 13 birds of unknown sex. To determine flipper band loss and to follow the breeding cycle chronology, a remote controlled video camera was placed on the most intensively used path (used by about 90% of the birds of the colony). The system remained active from September through December, recording data at 5x slower than real time during the daylight hours. The video recordings provided information on band loss and the plumage and body condition of individuals. The latter information allowed us to differentiate between stages of the breeding cycle (e.g., chick rearing, moulting or displaying). Binocular observations of the colony were made once a week to look for banded birds, complementing data of the video recordings. If the antennas detected a banded bird but the flipper band was not observed at the colony or on the videos, we assumed that the flipper band was lost. If a bird was seen with its flipper band but was not detected by the antennas, we deduced that the transponder was defective or lost. It was not possible to determine which birds, if any, lost both the flipper band and the transponder. Of the 50 banded birds, only one lost its flipper band in the four years and was removed from the analysis. This occurred during the first year of the study and the band was found in the colony. The transponders in two banded birds did not respond. In one case, the bird was observed visually but never detected electronically, which suggests it probably lost its transponder just after implantation. In the other case, the transponder was either lost or stopped working 10 months after implantation. In the survival analysis, these birds were given right-censored survival times, as they were not detected by the antennas and therefore were assumed to have left the study. Conclusions from analyses with and without these birds were identical.

We assumed that the month a bird was last detected by the antennas was the last month that the bird was alive. Birds surviving to the end of March 2003 were given right-censored survival times. A G-test of number of birds alive/disappeared at the end of the study indicated no difference in survival ($G = 2.3$, $df = 1$, $p = 0.16$). However, the use of the Cox proportional hazards model allowed us to determine the trajectory of the survival curves and where the major changes in survival occurred.

The breeding pattern over the four post-banding seasons of the banded and unbanded birds could be directly compared using the 27 banded and 32 unbanded birds that survived through the 2001 breeding season (e.g., until November 2002). The patterns were not the same ($G = 15.1$, $df = 4$, $p = 0.006$). With standardized residuals and an $\alpha = 0.05$, unbanded birds attempted to breed all four seasons while the banded birds were more likely to breed only once or twice in the four seasons. If we use only this subset of 59 birds in a pooled probability of breeding analysis, the pooled probability of breeding goes up to 0.75 but the conclusions presented in the text do not change. The groups did not follow the predicted common pattern ($G = 14.2$, $df = 4$, $p = 0.007$) and residual analysis showed that unbanded birds in the subset were more likely to breed all four years and banded birds in the subset were more likely to breed once or not at all.

In addition, two cohorts of ten-month old king penguin chicks were fitted with transponders while left unbanded (N=100 chicks in 1998 and N=200 chicks in 1999). Their survival was later assessed from the same automatic identification system used for adults.

Figure 3. Date of arrival at the colony for courtship the third year after banding (summer 2000/2001). Each point represents the cumulative number of birds.