FLIPPER BANDS ON PENGUINS: WHY NEWER IS NOT ALWAYS BETTER

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Introduction

Flipper bands have been invaluable devices to individually mark African Penguins *Spheniscus demersus* for many years in southern Africa. The first bands, made from soft aluminium, were fitted to penguins in 1947 but proved to be unsuitable for long-term studies because the rapid wear of the material made the engraved lettering illegible (Morant 1979). The subsequent attempts to make flipper bands last longer, first by choosing thicker aluminium plating, and then monel, a nickel-copper alloy, also gave unsatisfactory results until stainless steel was introduced in the early 1970s. The change to a sturdier material was accompanied by a re-design of the shape and dimensions of the band to accommodate the swelling of the flipper during moult (Jarvis 1970, Cooper & Morant 1981). This model, with some inconspicuous but very important modifications, is still in use today. More than 40 000 African Penguins have been ringed to date with this model (Underhill & Oatley 1994). Recent recoveries from birds which have carried their bands for well over 20 years (Whittington *et al.* in press) have shown that the stainless steel rings of this type have the capacity to outlast the maximum life expectancy of the species. Until about 1994, the South African Bird Ringing Unit (SAFRING), which orders the bands from its present supplier Lambournes, Birmingham, U.K., and issues them to accredited bird ringers in southern Africa, has received no feedback from ringers indicating that both the design and the method of application were unsatisfactory (Underhill *et al.* 1994).

At about the same time we became alarmed when we discovered increasing numbers of African Penguins coming ashore at Bird Island, Algoa Bay (33°15'S, 26°17'E) with partially-opened rings and damage to the surrounding skin. It did not escape us that this problem concerned only certain ring series, prompting us to investigate how their properties differed from other bands for which we had no indication that band loss and/or injury in the axilla of the birds occurred.

Materials and methods

Flipper bands from several series, distinguishable by their prefix and manufactured over a period of some 20 years by two different firms, were investigated. As ringers may hold stock for considerable periods of time before all is used up, bands were not necessarily applied to birds in strict numerical and chronological order. P-bands were the earliest stainless steel models and were used from 1972 to the mid 1970s. Banding with Z and T prefix models was done from the late 1970s to early 1980s. These three models were manufactured by a Cape Town engineering firm. Most V-bands were used in the mid 1980s. S-bands were introduced in the late 1980s and, now with a five-digit number, are still in use. These two models were made by Lambournes in England.

Bands were weighed and their dimensions (thickness of the sheet material, width of the metal strip, external short and long axes of the ovate shape of the band when closed correctly with free ends abutting) were measured with Vernier calipers. The second and third measurement allowed calculation of the frontal cross-sectional area of the band. This served as a measure of its drag potential when fitted to a penguin flipper. The force necessary to open a closed band was determined by holding the band in a vice at the blunt end of the ovate shape (the leading edge of the band when correctly fitted) and pulling at the long free end, which was connected to a spring balance. A band was considered open when the gap had widened for more than 8 mm (the thickness of a penguin flipper at the axilla), allowing the band to slip off the flipper. We also rated the depth and position of the engraved inscription, whether it facilitated reading the band information with binoculars from a distance of several metres as experienced in the field.

Results

The heaviest band had nearly twice the mass, in air, of the lightest band (Table 1), contributing 0,31 g and 0,60 g respectively to the average body mass of an adult African Penguin (2 836 g, Maclean 1993). A similar magnitude in variation was measured for the thickness of the sheet material from which the bands were manufactured (Table 1).

We have no information regarding the grades of stainless steel for which the bands were produced, except for the early P, Z (and T – not investigated by us) series, which consisted of 316 grade (16-18 % chrome, 10-14 % nickel) (Cooper & Morant 1981).

Table 1. African Penguin flipper band mass in relation to penguin body mass, band thickness and force needed to open the band.

Band series	Band mass g	% of bird mass	Thickness mm	Force N
P4677	14,8	0,52	1,9	245
P9258	17,0	0,60	1,9	245
V0145	12,4	0,44	1,6	235
V2422	12,2	0,43	1,6	235
Z1944	16,5	0,58	1,8	422
Z1945	16,5	0,58	1,8	422
S12070	8,8	0,31	1,0	59
S12073	8,8	0,31	1,0	59
S17069	8,8	0,31	1,0	59
S17371	8,8	0,31	1,0	59
S18517	8,8	0,31	1,0	59
S23860	9,4	0,33	1,0	59

We measured major differences in the forces needed to open a closed band: the two Z-bands each required 422 Newton (a reading of 43 kg on the spring balance) to pull the two abutting ends apart, whereas as little as 59 N (6 kg) sufficed for bands from the series S12, S17, S18, and S23 (Table 1). Contrary to the information given in Underhill *et al.* (1994), we found no difference in the rigidity of the steel of the latest batch, represented by S23860, and the earlier S-bands.

The total frontal cross-sectional area (FCA_{total}) of a swimming penguin fitted with a band is given by:

$$FCA_{total} = FCA + (B \times A) - (FLT \times B)$$

where:

FCA = frontal cross-sectional area of a swimming penguin without a band – 14 040 mm^2 (Wilson *et al.* 1986).

B = band width, *i.e.* width of the metal strip from which the band is shaped.

A = short axis of ovate shape of the band when closed correctly with free ends abutting.

FLT = mean flipper thickness at position where the band is fitted – 8 mm.

The flipper bands investigated in this study comprised between 0,57 and 0,92 % of FCA_{total} (Table 2).

The long axis of a closed band, which accommodates the width of the flipper, was not modified substantially over the years from series to series until 1994 when it was increased to 40 mm (Table 2).

A flipper band should be fitted such that the gap (the two abutting ends) is on the outside so as to minimize chafing under the axilla of the bird. In this context, the prefix and number of the P and V series bands were engraved on the wrong side, effectively preventing reading of the band without handling of the bird. However, the information was deeply engraved, facilitating legibility. All S-series bands, while engraved correctly with the numbering facing outwards and the return infor-

Table 2. African Penguin flipper band dimensions, frontal cross-sectional area of band when fitted to a bird (FCA_{band}) and percent contribution of the band to the total frontal cross-sectional area of a swimming banded bird (FCA_{total}).

Band series	Short axis mm	Long axis mm	Band width mm	FCA_{band} mm^2	% of FCA_{total}
P4677	21,5	34,0	14,0	129,0	0,92
P9258	20,0	34,0	12,7	94,0	0,67
V0145	20,2	34,0	12,0	80,4	0,58
V2422	20,2	34,5	12,0	80,4	0,58
Z1944	18,0	35,0	14,0	108,0	0,77
Z1945	18,0	35,0	14,0	108,0	0,77
S12070	17,0	36,5	13,2	88,4	0,63
S12073	17,2	36,5	13,2	89,4	0,64
S17069	17,2	36,5	13,2	89,4	0,64
S17371	17,2	36,5	13,2	89,4	0,64
S18517	18,3	36,0	13,2	95,2	0,68
S23860	17,0	40,0	13,2	88,4	0,63

mation on the proximal side, were also not satisfactory. The information (prefix and number) was positioned not closely enough to the gap, so that the last digit is often covered by body feathers and cannot be ascertained without provoking the bird to lift the flipper. While not as good as the older bands, the depth of the inscription of the S-series bands fulfilled the minimum requirements of legibility, *i.e.* they were readable from 10 m with binoculars under optimal light conditions.

Discussion

The recognition of individual penguins, ideally at a distance, is a pre-requisite of many types of biological studies. It is especially useful for the estimation of survival probabilities in wild populations where not each and every member of a cohort can be marked by other means. The quality of data gathered in such a way is critically dependant on two factors: bands should not disadvantage birds, such as retarding swimming speed, reducing diving depth, foraging range and number of prey encountered, and thus contribute to mortality. Secondly, there should be no band loss. This would bias calculations of survival rates from band recoveries and resightings or, generally speaking, mean loss of the individual from the marked sample with all its consequences.

The present study has provided substantial evidence that, at times, both of the above-mentioned two central tenets of a banding study have been violated for African Penguins marked during the last 20 years. In our opinion, S-bands are much too weak and are also unnecessarily large, causing them to be lost, lead to injury while half-open and facilitate entanglement in kelp and fishing lines. By comparison, the older V-series bands, with less drag potential, a four-times higher resistance to band loss and carefully prepared edges, are far less likely to be lost or to disadvantage the bearer. At the other extreme, Z-bands appear overly heavy and rigid. These differences between bands have important implications for long-term studies of the population dynamics of this endangered species, such as our own one in Algoa Bay, the last stronghold of the species (Crawford *et al.* in press).

For instance, we may wrongly conclude that penguins banded (mostly with V-bands) during the mid 1980s may have had higher survival probabilities than penguins of the 1990s, which were marked with S-bands that are prone to open through a comparatively modest external force acting on the band, such as entanglement in nesting material. Given that V-bands were evaluated in our investigation as the best models used so far in southern Africa, the recent modification of the length of the metal strip by adding a few millimetres of material to allow for overlap (Underhill *et al.* 1994; see also Table 2) appears as a step in the wrong direction towards better marking devices.

Our concern is not directed at the use of flipper bands *per se*. We do not share the opinion expressed in Fraser and Trivelpiece (1994) and by Culik *et al.* (1993) that flipper bands for penguins should be abandoned altogether. Apart from the methodical critique voiced by Underhill *et al.* (1994) about the statistical treatment of the experimental data by Culik *et al.* (1993), we have serious doubts that bands with a drag potential of $FCA_{band} = 80$ mm^2, such as the V-bands, can cause a 24 % increase in energy needed to propel the bird through the water. However, we feel compelled to conclude from our results that the present stock of flipper bands held at SAFRING does not fulfill the minimum specifications for a good band. Until improved bands become available again all banding of African Penguins should be suspended.

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REFERENCES

COOPER, J. & MORANT, P.D. 1981. The design of stainless steel flipper bands for penguins. *Ostrich* 52: 119-123.

CRAWFORD, R.J.M., WILLIAMS, A.J., HOFMEYER, J., KLAGES, N.T.W., DYER, B.M. & CHESSELET, Y. 1995. Trends in African Penguin *Spheniscus demersus* populations in the 20th century. *S. Afr. J. Mar. Sci.* 16: 101-118.

CULIK, B.M., WILSON, R.P. & BANNASCH, R. 1993. Flipper bands on penguins: what is the cost of a life-long commitment? *Mar. Ecol. Progr. Ser.* 98: 209-214.

FRASER, W.R. & TRIVELPIECE, W.Z. 1994. Workshop on researcher-seabird interactions. Washington: Polar Oceans Research Group. 57 pp.

JARVIS, M.J.F. 1970. A problem of banding penguins. *Ostrich* 41: 120-121.

MACLEAN, G.L. 1993. Robert's birds of southern Africa. Cape Town: John Voelcker Bird Book Fund. 848 pp.

UNDERHILL, L.G., THORNTON, M., CRAWFORD, R.J.M., DYER, B.M., UPFOLD, L., WILLIAMS, A.J., GILDENHUYS, A. & BAUMANN, L. 1994. Jackass Penguins, flipper bands and the *Apollo Sea* incident. Coastal Oil Spills: Effect on penguin communities and rehabilitation procedures: Proceedings of a symposium held at Tygerberg Nature Reserve, 7-8 November 1994. Cape Nature Conservation, Cape Town. 52 pp.

UNDERHILL, L.G. & OATLEY, T.B. 1994. The South African Bird Ringing Unit: 21 years of service and research. *S. A. J. Sci.* 90: 61-64.

WILSON, R.P., GRANT, W.S. & DUFFY, D.C. 1986. Recording devices on free-ranging marine animals: does measurement affect foraging performance? *Ecology* 67: 1091-1093.

WHITTINGTON, P.A., DYER, B.M. & KLAGES, N.T.W. 1996. Longevity of Jackass Penguins on islands off South Africa. *Marine Ornithology* in press.