PENGUIN BANDING: TIME FOR REAPPRAISAL?

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SUMMARY

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This paper reviews the history of penguin banding from 1908, when L. Gain first applied tarsus bands to Antarctic penguins. Though later workers also used tarsus bands, W.J.L. Sladen's method of applying metal flipper bands, first used in 1947, is now in general practice. Several thousand flipper bands are currently applied every year in national and international programmes. However, their use raises many problems and misgivings among researchers: metal flipper bands are perceived to inflict damage, fall off at unpredictable rates, and reduce viability of their wearers. A 1993 workshop of avian biologists concluded that, in studies requiring permanent identification, flipper bands remain the most effective technique available; however, significant design improvements may be possible. This review points the need for field research on plastic alternatives, which conceptually offer many advantages over traditional metal bands.

INTRODUCTION

This paper arose from a Workshop on Alternative Penguin Marking Techniques, held on 30 July 1996 at British Antarctic Survey, Cambridge, UK (Fraser & Patterson 1997). The chairman, Dr W.R. Fraser, invited me to outline the history of penguin banding. Staying on to hear some of the other papers, I found myself involved in discussions on the longest-lasting metals for flipper bands, the most reliable method of closure, tissue damage inflicted by bands that for one reason or another had been misapplied, the statistical uncertainties introduced by bands of unreliable performance, and the need for a workshop to improve the design of metal flipper bands.

I contributed further to the history of banding by pointing out these were the identical topics that an earlier generation of banders, including myself, were discussing in very similar terms in workshops 40 years previously. Clearly, though many thousands of bands have been applied since those times, the technology of penguin flipper banding has advanced little, and its problems have remained unsolved. My role now is to question why that is so, and to suggest ways of achieving progress, better discrimination and greater certainty in research programmes that involve penguin banding.

DEVELOPMENT OF PENGUIN BANDING

Bird banding, with the object of identifying birds either as individuals or as members of particular groups or communities, is just coming up to its 100th anniversary (Spencer 1985). From 1899 Christien Mortensen of Viborg (Denmark) used tarsal bands in large-scale banding studies of migrant waterfowl, and German biologists a few years later used similar bands for population studies.

At that time the main business of biologists on Antarctic expeditions was to collect specimens for anatomical and taxonomic studies. First to break away from this tradition was Louis Gain, biologist of Charcot's Deuxiéme Expedition Antarctique Français, 1908–1910. A naturalist interested in bird behaviour, in December 1908 and the month following Gain applied 90 coloured celluloid rings, described as of the kind used for marking poultry, to tarsi of both adult and juvenile Gentoo Penguins *Pygoscelis papua* at Port Lockroy, Antarctic Peninsula. He hoped simply to determine whether adults or juveniles returned to the colonies to breed. Ten months later he recovered five banded adults on the same colony, but no juveniles. Birds bearing his celluloid bands were still found up to three years later, by whalers who were taking them for food (Gain 1914).

Murray Levick, who studied breeding behaviour of Adélie Penguins *P. adeliae* at Cape Adare, marked individuals only with red paint (Levick 1914). Thomas Bagshawe (1939), studying breeding behaviour of Chinstrap Penguins *P. antarctica* and Gentoo Penguins at Waterboat Point, Antarctic Peninsula, used only paint as a marker: so did Brian Roberts (1940), studying Gentoo Penguins on South Georgia. Respectively a surgeon, a geologist and a geographer, these were *ad hoc* ornithologists. Only Roberts is likely to have known of banding, and he clearly saw no need for long-term marking in a study that could last only one season.

Lancelot Richdale's long-term study on the breeding behaviour and population dynamics of Yellow-eyed Penguins *Megadyptes antipodes* demanded more permanent methods of marking. Working in Otago, New Zealand, from 1936 to 1954, Richdale used soft aluminium tarsus bands of two gauges, which he cut and stamped individually by hand. He expected them to last little more than two or three years, on penguin whose lifetimes he expected to last five or six times longer. For permanent marking he punched distinctive patterns of holes into the webs of the feet. Thus Richdale's bands, though individually numbered, were primarily indicators of birds that were marked more permanently, though less obviously, by another method.

FLIPPER BANDING

In banding the tarsus Richdale followed what others had done. The first Antarctic biologist to use flipper bands was William

Sladen, a medical officer and a dedicated ornithologist and bander. His early studies in 1947–1949 at Hope Bay, Antarctic Peninsula, resulted in the first properly-organized Antarctic banding programme, using addressed bands (Sladen 1952). From this developed the major 12-year study at Cape Crozier, starting in 1961/62, for which he and his team are best known (Sladen *et al.* 1968).

Sladen also used web punching, mainly to distinguish cohorts of chicks and check the efficiency of bands applied to young birds. By a curious inversion of Richdale's method, he and his group first scanned the feet of young birds for punched holes, then checked the flippers to see if a band remained (Ainley *et al.* 1985) – a simple means of assessing band losses. Sladen also experimented with a range of band materials including aluminium alloys, monel and plastic, and tested different methods of closing or fastening the bands. He pioneered the methods that were used by virtually every other researcher in the many penguin population studies that developed during the 1950s, 1960s and 1970s.

Sladen's work marked a high point in penguin band development. Since his time many studies involving flipper banding have appeared in the literature, and banding, often on a substantial scale, appears to have become an essential component of virtually every penguin study. This is not surprising. Most penguin workers for most purposes still require markers that are readily seen and read, cheap, and quickly applied. Flipper bands meet all these requirements. They can be mass-produced, to high specifications of uniformity, from metal strip of reliable composition, at prices that represent a minute component of the total budget for a long-term project. Banding a hundred, a thousand or ten thousand penguins may represent a useful goal or stage in a study that is readily achieved at little cost. It is hard work, and recovering significant numbers of bands is often harder work still.

COUNTER-INDICATIONS

However, metal flipper bands have for long been subject to scrutiny and found wanting. Checking the effects of several of their techniques, including banding, Sladen's team found that birds which had been banded, including young ones returning for the first time, remained 'leery' of operators, though banded birds that they subsequently visited at the nest tended to be less aggressive toward them than naive birds. The bands themselves caused 'some' mortality: birds banded as chicks and re-banded on return to the colony between four and seven years later suffered a 28% higher mortality during the first year after re-banding than in subsequent years: this was assumed to be due to ' . . . complications arising when the wing swells during moult and the band constricts blood flow' – an early acknowledgement of the major hazard imposed by a rigid, closely-fitting metal band on a penguin's flipper.

More recently, serious criticisms of their effectiveness are summarized in a recent report by Fraser & Trivelpiece (1994), from a workshop on interactions between seabirds and their researchers held at Monticello, USA, in 1993 (see also Sallaberry & Valencia 1985, Culik *et al.* 1993, and for a contrary view, Hindell *et al*. 1996) . Individual short papers in the report include damning indictments of the use of standard flipper bands. Valencia & Sallaberry (p. 31) wrote of 'protruding fasteners that produced severe wounds on the breast'. Bannasch (p. 28) speculated on how flipper bands impede swimming, and Culik reported that bands impose an unacceptable 24% drag. Trivelpiece & Trivelpiece (p. 19) comment on double-banding experiments that confirm the ill-effects of single banding, and the likelihood that silver-coloured bands may attract predators.

A consensus statement (pp. 2–5) developed by seven senior penguin ornithologists, among a peer group of experienced field workers (practically all of whom were present at the Third International Penguin Conference in Cape Town), identified two main areas of concern over the use of metal flipper bands. The first involves application. Applying bands properly is a highly skilled task that cannot be left (as it may easily be left) to the unskilled. Flipper bands incorrectly applied may – to say the least – defeat their objective by wounding, maiming or killing penguins. Even correctly applied, they tend to fall off: in well over 40 years of mass-banding we have yet to design a closure that begins to approach 100% reliability.

The second area of concern, band-induced effects on behaviour and mortality, is less easily remedied. Band design has been improved, says the report, though it does not say how. Yet recent studies of four species have documented significant levels of band loss, and several have indicated significant band-induced mortality, particularly of fledglings and young birds. There are further indications that bands increase energy costs of swimming by inducing drag.

The minutes of the 1996 Cambridge workshop (Fraser & Patterson 1997) contain evidence both of entirely satisfactory banding programmes (see also Hindell *et al*. 1996), and also of studies, for example of King Penguins *Aptenodytes patagonicus* on Iles Crozet, in which banded birds have higher rates of mortality, breed later and experience diminished reproductive success. A recent report by Klages & Spencer (1996) draws attention to inconsistencies in performance of different series of bands use on African Penguins *Spheniscus demersus*, due to small but important variations in composition, and concludes that, until improved bands become available, all banding of African Penguins should be suspended.

So despite their improvements, metal flipper bands in current general use continue to inflict damage on their wearers, to fall off at unpredictable and inconvenient rates, to induce their own kinds of mortality, and to hamper the birds at sea. These factors bring quite unacceptable levels of uncertainty to population studies, which are among the main objectives of banding.

The experts at Monticello commented that in studies where permanent identification is required, '. . . flipper bands may still be the most effective, least disruptive, and/or economic technique currently available for marking penguins'. 'Nevertheless', they add, 'it would seem prudent and essential to rapidly develop alternative methods for permanent identification of penguins that do not have the drawbacks inherent in the use of flipper bands.' The alternative they explored was implanted transponders. However, transponders are invisible; being fitted internally, they do not fulfill one important advantage of flipper bands – instantaneous visual identification, with equipment no more complex than a pair of binoculars. For most practical purposes, a bird wearing one requires an identifying tag to indicate the transponder's presence – indeed something remarkably like a flipper band.

BAND IMPROVEMENT

I prefer a further alternative proffered by the Monticello Workshop – that of improving flipper bands. 'Significant design improvements may still be possible', they suggest, 'provided recommendations are subjected to thorough testing for drag and other effects'. Bands continue to be useful as visual markers, and are likely to continue in use even if transponders and other alternatives become commonplace. The possibility of improving design is well worth considering.

In mass metal-banding we are using a technique that, now almost fifty years old, has hardly been improved since its inception. Sladen's original soft aluminium bands would no longer be applied today. However, comparing the improved hard-metal version of the mid-1950s with those currently available, I see very little improvement, except perhaps in quality and finish. The problems are still the same – damage-inducing weight against firmness, hardness against liability to crack, difficulty of fitting, difficulty of manipulating butt-joints that are never quite right, and the over-riding problem of providing for engorgement and swelling of the flipper during moult. These are all problems arising from use of hard metals. Sooner or later we must conclude that metal is no longer the right material to use for penguin flipper bands.

It seems to me quite astonishing that, with so many thousands of metal bands of mixed and dubious quality applied to penguins in international research every year, so little progress has been made toward designing and producing more reliable standard bands, in a more suitable material. Before fitting more bands – even with skill and care – to our cherished study birds, should we not try to improve the bands in ways that (a) reduce their chances of maiming, killing or hampering their wearers, and (b) ensure that they no longer fall off, to invalidate the calculations that are so important a feature of our research?

USE OF PLASTICS

What are the alternatives? In the five decades since metal flipper bands were first used there has been a virtual revolution in materials – an influx of plastics that have replaced metals in almost every application. Plastics are by no means unknown to avian biologists, who apply them in studies where identification is required, for example as tarsal bands for parrots, and neck-collars and tarsal bands for swans, geese and other large wildfowl (e.g. Ogilvie 1972, Wells 1995). The preferred material appears to be 'Darvic', available in thin laminated sheets, which bends readily in hot water and on which indelible numbers can be made to appear in contrasting colour by scraping away the surface layer. Darvic and similar materials have already been used to make temporary bands for penguins in zoos. It is unlikely, however, to be the best material for long-term marking in the field: there is every reason for testing alternatives.

In this, as in so many other facets of penguin banding, Sladen's group has already led the way. They tried plastics 30 years ago and found one – Teflon – that was good for at least four years (Penney & Sladen 1966) and possibly for much longer. Since then hundreds more kinds of plastics have appeared. It would be surprising indeed if there were not at least one plastic in current production that could provide a strong, flexible, moulded, readily-bonded, non-eroding penguin flipper band, completely reliable for at least 20 years under field conditions.

Commercial manufacturers, heavily committed to producing metal bands, tend to be dismissive of plastic bands. We cannot rely on them to undertake the research and field testing that will be required to make their current products obsolete. Developing plastic bands will take time and involve expense. However, the expense of mass banding is not inconsiderable on today's reduced budgets, and the rewards of a new kind of band could be great.

Sophisticated plastic bands could carry more information and offer more research opportunities than standard metal bands, as credit-cards carry more than visiting cards, and laser printers offer more alternatives than pencils. They could be colour-coded, bear a clear, indelible number, and if necessary a bar code and imprinted magnetic messages. They could be tuned to precise operational needs. Though individually more costly, such tailor-made bands would be more reliable, and less likely to fall off. Doubling their certainty of staying on reduces by half the number needed, reducing costs and field effort. They would still have all the virtues of traditional flipper bands. If such developments are under way, I see no sign of them. Neither, it seems did the experts at Monticello.

I suggest that, having reached the fiftieth anniversary of metal flipper bands, penguin biologists should make every effort to discontinue their use, and develop alternatives with greater flexibility in more appropriate materials.

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NOTE ADDED IN PROOF

The challenge contained in this paper has been taken up by Dr. Peter Barham, H.H. Wills Laboratory, University of Bristol, Bristol BS8 1TL, UK. See: BARHAM, P. 1999. Design of plastic flipper bands for penguins. *Penguin Conserv.* 12: 4–10.