A LEG-BAND FOR MOUNTING GEOLOCATOR TAGS ON PENGUINS

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SUMMARY

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We present a design for a simple, inexpensive leg band for mounting GLS tags on penguins. It causes a low level of injury and can be made from materials and tools that are readily available. We provide information on captive and field trials and outline deployment strategies that improve recovery rates. This device should facilitate further studies of penguin winter movements using geolocation.

Keywords: animal ethics, band, geolocator, penguin

INTRODUCTION

In the past decade, a marked increase in the use of geolocator, or global location sensor (GLS), tags has revolutionised our understanding of the winter movements and distribution of flying seabirds (e.g. Catry *et al*. 2011, Egevang *et al*. 2010, Frederiksen *et al*. 2012, McFarlane Tranquilla *et al.* 2011, Schaffer *et al.* 2006). The devices are typically attached to seabirds using plastic leg bands (Fox 2010), but this approach is unsuitable for penguins. Their tarsi are short, fleshy, covered by soft scales and swell with blood during moult, making them prone to abrasion and lesions when fitted with hard, sharp-edged plastic bands (Ballard *et al*. 2010, Dunn *et al*. 2011). GLS tags have been fitted to penguins with flipper bands (D. Oehler, in litt.), but these may also cause injuries and reduce survival rates (Jackson & Wilson 2002, Gauthier-Clerc *et al.* 2004). Both institutions and journals increasingly demand that animals used in scientific study are treated ethically. Concerns about the adverse effects of GLS tags on penguins may have impeded studies of their winter movements to date.

The winter movements of Macaroni Penguins *Eudyptes chrysolophus* from the sub-Antarctic Kerguelen Islands were studied using smoothed plastic leg rings (Bost *et al*. 2009), which were recovered the following year without any sign of injury (C-A. Bost, pers. comm.). This study and those that followed it (Thiebot *et al*. 2011, 2012, 2013) show that appropriately designed leg bands can be used to equip penguins with GLS tags, causing little harm. However, the details of their method are not yet published, which restricts the wider use of the method. Here, we present a design for a simple, inexpensive leg band for mounting GLS tags on penguins that causes minimal injury and can be made from materials and tools that are readily available from hardware stores. We provide information on captive and field trials, and outline deployment strategies that improve recovery rates. The ultimate aim of our paper is to facilitate further studies of penguin winter movements using geolocation.

METHODS

The materials required to make the bands are

- A length of 5 mm width dual-core electrical cable. This is flat-sided, round-edged cable with two inner electrical wires running through it (neutral and live only; no ground) that is commonly used for table lamps and laptop power adaptors;
- 140 mm × 3.56 mm black cable ties, ideally with stainless steel barbs—penguins may remove cable ties with weaker plastic barbs (A. Raya Rey, pers. comm.). Cable ties of different size could be used: 202 mm × 4.6 mm weather-resistant black cable ties were used for Humboldt and Adélie Penguin trials (see below);
- 92 mm × 2.9 mm (or 100 mm × 2.5 mm) black cable ties (barbs as above);
- a roll of self-amalgamating tape;
- cyanoacrylate glue (optional);
- GLS tags.

The tools required are

- wire strippers
- wire cutters
- a cable-tie tool
- a small file.

The steps to make and fit the bands are:

1. Strip the outer sheath off the dual-core cable and cut it into lengths appropriate for the study species. Stripping involves using the wire strippers to pull the sheath off the two wires running within it to form an intact tube, rather than cutting the sheath longitudinally and peeling it off the wires. The length will require some experimentation in the field or on captive birds of the same species to obtain the correct fit. For Rockhopper *E. chrysocome* and *E. moseleyi*, lengths of approximately 75 mm were used; for Adélie *Pygoscelis adeliae*, 80 mm; for Humboldt *Spheniscus humoldti* and Macaroni penguins, 85 mm. As tarsus size varies among individuals of the same species, it is best to cut a selection of lengths beforehand and store them separately in bags, labelled by length, to save time in the field.

2. If using BAS Mk19/Lotek Mk 3 loggers, file down the sharp points of the lugs on their sides to ensure these will not dig into the penguins' legs (i.e. the tips of the triangular epoxy protrusions designed to hold the cable tie, not the gold contacts used to connect the device to the interface box). Wrap a thin strip of self-amalgamating tape around the waist of the GLS tag for the small cable tie to bite on (Fox 2010).

3. Thread the large cable tie through the dual-core cable sheath and wrap it around the penguin's leg on the tibio-fibula above its joint with the tarsus (Fig 1). Use the cable tie tool to tighten it up until it starts to press against the end of the cable sheath, then snip off the excess tail of the cable tie. This forms a teardrop-shaped band around the leg (Fig. 1). Check the fit: it should spin freely on the leg, but not slip over the joint when you rotate the pointed end of the teardrop to the back of the leg and press down. If it does not fit properly, cut it off and try again with a different length of cable sheath.

Fig. 1. Photographs of the components required to make the band (left), a completed band (top right) and a band fitted to a wild Southern Rockhopper Penguin on Beauchêne Island, Falkland Islands, that was subsequently released and then recovered unharmed nine months later (bottom right).

4. Attach the GLS to the band with the smaller cable tie. Orient it so that the head of the small cable tie points up into the feathers, rather than down into the foot, to reduce the risk of injury. Position it so that the GLS sits over the point of the teardrop, where the tail of the big cable tie enters its head. This ensures that the small cable tie is tucked into the point of the teardrop so that it does not rub on the leg and that the GLS tag sits flat along the head of the large cable tie (Fig. 1). The gold contacts and light sensor must face outwards to minimise interference with detection of light, temperature and immersion (Fox 2010).

5. Tighten and snip off the tail of the small cable tie. File down any sharp points on the cut ends of the two cable ties. If you have to use cable ties with plastic barbs, a drop of cyanoacrylate glue in the head of each cable tie reduces the risk of band loss (K.E. Erikstad, pers. comm.)

CAPTIVE TRIALS

Captive trials of the band design with GLS tags mounted on them were conducted so that equipped birds could be monitored daily by qualified veterinarians, ensuring that any adverse effects could be recognised and remedied immediately. Initial trials were conducted on five Macaroni Penguins at Twycross Zoo in the UK in August 2009. The sheath material was Tygon tubing of the type used for aquarium air lines, and fitted with BAS Mk18H /Lotek Mk4 GLS tags. This sheath material is soft but has high traction, which caused, within a week, such chafing that the trial was discontinued. Further trials using electrical dual-core cable sheath were then conducted on eight Northern Rockhopper Penguins at Edinburgh Zoo from 4 November 2010 to 4 February 2011. Birds wore these bands during the entire period with no findings of clinical significance, according to the zoo's veterinarian. Captive trials of this band design with BAS Mk5/15 GLS attached were also conducted on 10 Humboldt Penguins at Tokyo Sea Life Park in Japan from 28 April to 1 September, 2010. The birds wore these bands during the entire period with no signs of injury or irregular behaviour. On the strength of these findings, both the British Antarctic Survey Animal Ethics Review Panel and Falkland Environmental Committee gave permission for deployments to proceed on wild Macaroni and Southern Rockhopper penguins, while the Japanese Ministry of Environment gave permission for deployments on wild Adélie Penguins.

FIELD TRIALS: CRESTED PENGUINS

BAS Mk18H/Lotek Mk4 GLS tags were deployed on 40 Macaroni Penguins on Bird Island, South Georgia (54°01′S, 38°03′W), and 41 Southern Rockhopper Penguins on both Steeple Jason Island (51°01′S, 61°23′W) and Beauchêne Island (52°92′S, 59°21′W), Falkland Islands. Deployments were timed to coincide with the moult period (March 2011): in *Eudyptes* penguins, both members of the pair attend their nest site at this time, there are no nest contents to disturb and the legs are swollen, which minimises the risk of bands being fitted too tightly. At the two Falkland Island colonies, birds were equipped in a discrete and well-marked corner of a subcolony that was GPS-referenced and photographed to facilitate relocation during the recovery visit. Birds were marked pair-by-pair to ensure a 50:50 sex ratio. Macaroni Penguins on Bird Island were marked at long-term study nests, a procedure that again maximised the likelihood of birds being relocated the following year. Deployment of 41 GLS tags on each of the Falkland colonies took a single afternoon.

Recoveries were targeted during the arrival period (November 2011), again because both members of the pair are present at the nest at this time, there are no nest contents to disturb and the duration of the deployments are minimised. As manpower was available permanently on Bird Island and intermittently through the season on Steeple Jason Islands, recoveries were made during regular visits to the colony during the arrival period and were also extended to the stages of incubation and brood guard. On Beauchêne Island all recoveries were made during a single afternoon visit supported by a yacht. Recovery rates of devices were high, at 103 (79%) across all populations, 32 (80%) for Macaroni Penguins, 32 (78%) for Rockhopper Penguins from Steeple Jason Island and 34 (83%) for those from Beauchêne Island. No birds were recovered with leg bands only and the GLS tag missing. The results from Beauchêne demonstrate that it is possible to conduct GLS studies during one-day visits for deployment and recovery if visits are timed appropriately, thus avoiding the complications of prolonged expeditions, which can be challenging on remote and uninhabited islands.

On Bird Island, all equipped Macaroni Penguins and 583 control birds were also marked with passive induced transponder (PIT) tags. An automated gateway on the sole pathway to the study colony detected all marked birds present in a given year (Green *et al*. 2006). These data revealed that all birds equipped with GLS tags that returned to the colony were recaptured. The return rate of control birds was 89%, a rate that was not significantly different from that of equipped birds (binary ANOVA, $F = 3.32$, $P > 0.05$). No independent data on survival were available for Southern Rockhopper Penguins at our Falkland Island study sites, but their recovery rates are comparable to the return or survival rates for unequipped *Eudyptes* penguins (see Dehnhard *et al.* 2013 for a review). This indicated that the rates of elevated mortality, band loss and incomplete recapture were low. Four birds recovered on Beauchêne Island had sores on their tarsi where the bands had been fitted too tightly, but the remainder of the recovered birds at all sites showed no or only superficial signs of abrasion in the form of a slight reddening of the skin and sloughing of scales under the band. The Beauchêne Island deployments occurred first, and the problems were hence due to inexperience in fitting the bands correctly, which was rectified in subsequent deployments.

FIELD TRIALS: ADÉLIE PENGUINS

GLS tags were deployed on 20 Adélie Penguins (5 received BAS Mk5 tags, 5 BAS Mk15, and 10 Lotek LAT 2500) at Hukuro Cove colony, Lützow-Holm Bay, East Antarctica (69°13′S 39°38′W) in January 2011, and 20 Adélie Penguins (all received Lotek LAT 2500 tags) at the same location in January 2012. GLS tags were first deployed on two birds that had recently experienced breeding failure in early January 2011. These two birds were marked with hair-dye and were recaptured after two weeks to check the status of the legs with a band. As there were no signs of abrasion, GLS tags were deployed on an additional 18 birds that were rearing chicks in late January. We caught 12 of 18 birds again one week later, and found small patches of reddening of skin under tags in three birds that wore slightly tighter tags. The GLS tags were removed from these three birds as a precaution. In total, 17 birds were left for winter deployments. In most but not all cases, Adélie Penguins depart the colony immediately after completion of chick rearing and moult on sea ice (Ainley 2002, Dunn *et al*. 2011), so deployments after moult, as for the *Eudyptes* penguins, are not usually practical. In the later part of the subsequent breeding period, late December 2011 and January 2012, 10 birds (59%) were recaptured. One of the 10 birds came back with the leg band only and the GLS missing. The relatively low recapture rates may have been due to the late arrival of fieldworkers at the study colony owing to logistical constraints. One additional bird was recaptured after two years in January 2013. GLS tags were again deployed on 20 birds in late January 2012, and were recovered from 15 birds (75%) in late December 2012 and in January 2013. In total, 26 out of 37 birds were recaptured (70%), with one bird having lost its GLS tag over the study period of two austral winters. All recovered birds showed feather wear underneath the tags. Five of the recovered birds showed sores on their tarsi, but the remainder showed no or superficial signs of abrasion similar to those described for the crested penguins and much less severe than those during GLS deployments with plastic rings on Adélie Penguins from Signy Island (M. Dunn, Pers. Comm.). The overall recovery rates of GLS birds was similar to or higher than other Adélie Penguin studies using plastic leg rings (68%: Ballard *et al*. 2010; 52%: Dunn *et al*. 2011).

CONCLUSIONS

The leg band design presented here produces a lower incidence and severity of leg abrasion than unmodified plastic bands, avoids the use of flipper bands, results in recovery rates in keeping with expected survival rates and produces low levels of device loss. Our trials indicate that the method is likely to be suitable for penguins of the genus *Eudyptes*, *Spheniscus* and *Pygoscelis*, but we recommend further field trials in other localities and environments, including comparisons of survival rates with unequipped controls where possible. We recommend captive trials for Little Penguins *Eudyptula minor* (where materials of smaller dimensions will be needed) and the two *Aptenodytes* penguin species (whose leg morphology differs from other penguin species) before committing to over-winter deployments. We encourage penguin researchers to report their recapture rates, device loss rates and incidence of injuries so that the optimal deployment methods and strategies can be developed for each species and environment.

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