Long-term attachment of GPS loggers with tape on Great Cormorant *Phalacrocorax carbo sinensis* proved unsuitable from tests on a captive bird

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Abstract
In preparation for a field study on wild birds, we conducted an experiment on captive Great Cormorants *Phalacrocorax carbo sinensis* to evaluate methods of attaching GPS loggers. Loggers (65 g) were attached to two injured cormorants in a bird rehabilitation centre. One logger was attached to the first bird with TESA tape and another logger to the second bird with a teflon harness. The taped logger was attached on the lower back, and subsequently on the upper back and the tail. This logger was removed within 10 (lower back), 4 (upper back) and 15 (tail) days by the cormorant biting off and pulling out the feathers to which it was attached. The logger deployed with the teflon harness on the second bird stayed on for 21 days, after which we removed it undamaged.

Introduction

With the increasing use of tracking devices for ecological research on birds, several different methods of attachment have been developed (e.g. Kenward 1985; Wilson *et al*. 1997; Tremblay *et al*. 2003; Mallory & Gilbert 2008). Two of the most commonly used techniques for seabirds are attachment by a harness (often made out of teflon) (e.g. Gyimesi *et al*. 2011), or with an adhesive tape (TESA is the most commonly used brand; e.g. Ropert-Coudert *et al*. 2006). Other methods to attach loggers to birds are the use of cable ties (e.g. Grémillet 1997), or a mix of tape and cable ties (e.g. Wanless *et al*. 1997), or a mix of tape and glue (e.g. Cook *et al*. 2010). Members of the *Phalacrocoracidae*, the family of cormorants, have also been deployed with different types of loggers in the past. Loggers deployed on species of shags and smaller species of cormorants have been attached with tape to the feathers on the back (Wanless *et al*. 1997; Cook *et al*. 2010) following the methodology described by Wilson *et al*. (1997). The methods used to deploy loggers on larger species such as Great *Phalacrocorax carbo* and Double-crested Cormorants *P. auritus* have been more diverse. Often devices were attached to the middle two or middle four tail feathers with a combination of tape and cable ties (Grémillet 1997; Grémillet *et al*. 1999) although attachment with tape on the back has also been used (Grémillet *et al*. 2006; Ropert-Coudert *et al*. 2006). In these studies tags stayed

on the birds for periods ranging from 1–9 days, but often loggers were not lost after that period but were deliberately removed by the researchers to allow data downloading. Less common is the use of a backpack harness for cormorants but it has been successfully used in tracking Double-crested Cormorants in the USA and those devices stayed on the birds for more than one year (King *et al*. 2000; Guillaumet *et al*. 2011).

We planned to use GPS loggers to study foraging behaviour of Great Cormorants *P. c. sinensis* in the south-western part of The Netherlands during the breeding season of 2012. As it was intended for the loggers to be attached to the birds throughout the chick-rearing stage (> 12 weeks) and with a small-scale sampling scheme, we used specially made loggers that weighed 65 g. We trialled four logger attachment methods to study the potential consequences of logger deployment on this species, determine the ideal harness size for Great Cormorants, and to test the duration of deployment per method.

Methods

Two captive Great Cormorants were deployed with exact replicas of specially designed GPS loggers of 65 g (manufactured by Madebytheo, Nijmegen, The Netherlands). This represented ~2.5% of the body weight of the birds, below the generally applied limits for tag size of 3% (e.g. Phillips *et al*. 2003; Vandenabeele *et al*. 2011). The shape of the loggers was optimised to minimise drag underwater following suggestions described by Bannasch *et al*. (1994). One bird had one of the loggers attached with TESA tape (No. 4651 Beiersdorf AG, Hamburg, Germany) to the small feathers on the lower back (Figure 1 - Photo 1). Later during the trials, we placed the logger higher on the back of the same

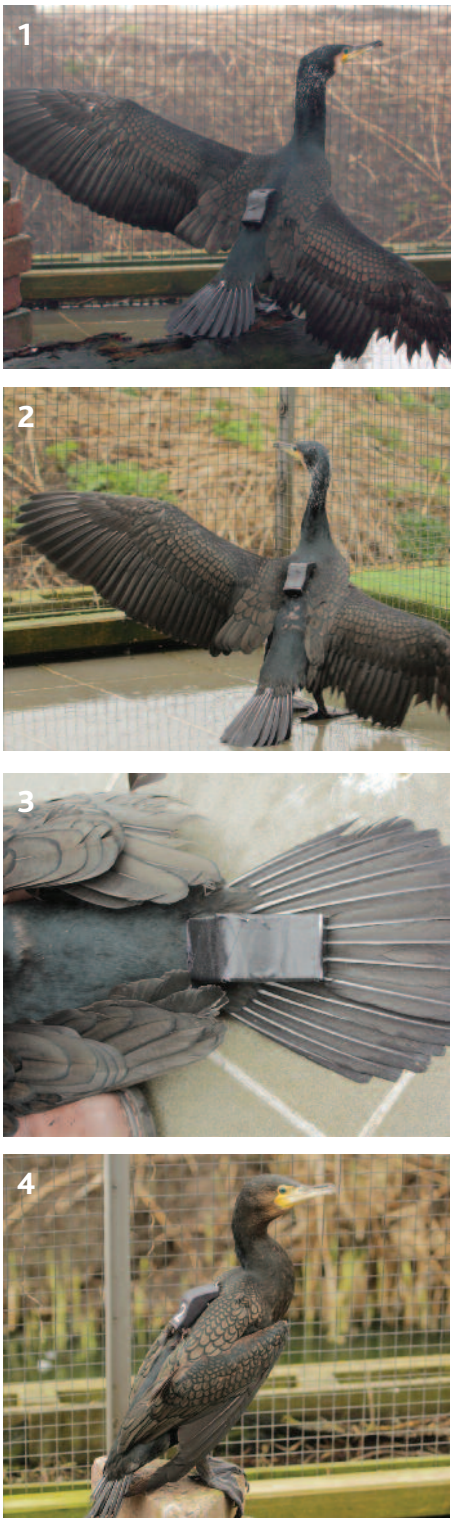

Figure 1. Four methods of logger attachment on captive Great Cormorants *Phalacrocorax carbo sinensis*. 1. Back attachment with tape. 2. Shoulder-height attachment with tape. 3. Tail attachment with tape. 4. Backpack with teflon adjustable harness. Bird Rehabilitation Centre 'De Bonte Piet', Midwoud, The Netherlands. February–April 2012. © Ruben Fijn.

bird, roughly between the shoulders (Figure 1 - Photo 2). The last position where the logger was deployed on this bird was on the upper part of the four middle tail feathers (Figure 1 - Photo 3). Attaching the loggers with tape was done following the method of Wilson *et al*. (1997), although due to the smaller tag size fewer strips could be applied (5 or 6 strips of tape, width 20 mm, weight ~4 g). These strips were looped under about 10–25 back feathers per strip and wrapped around the device. We did not apply glue in between the feathers and the logger (as recommended by Wilson *et al*. (1997)), because we intended to remove the logger after the trials without damaging the feathers too much.

The other logger was attached with a flexible backpack harness on the other bird. This harness was X-shaped with the joint of the 'X' placed in the middle of the breast (Figure 2, similar to the harness described by Kenward (1985)). Doing so, the logger was located on the back roughly at the height of the wings (Figure 1 - Photo 4). Several harnesses were prepared with different lengths of the arms of the 'X' (range 10–17 cm) to allow the best fit of the harness. The harness with the best fit for this specific cormorant had upper arms of 11 cm and lower arms of 12 cm. Both lower arms were individually connected to small plastic rings on the side of the loggers with split rings with a diameter of 9 mm (Figure 2). The two upper arms were joined in one split ring and then similarly connected to a small plastic ring on the top of the logger. Harnesses were made of a teflon outer lining with an synthetic elastic inner lining as successfully developed, tested and applied on Purple Herons *Ardea purpurea* (van der Winden *et al*. 2010) and Lesser Black-backed Gulls *Larus fuscus* (Gyimesi *et al*. 2011). So far, only in Greylag Goose *Anser anser* has this type of harness been lost prematurely, as this species proved able to find the weakest point of the harness (the sewn ends of the arms) and had a bill strong enough to nibble this open (Voslamber *et al*. 2010).

Figure 2. Attachment of the X-shaped elastic teflon harness (below) with a split ring to plastic loops on the side of the logger (above). © Ruben Fijn.

Figure 3. Underside of the logger after a Great Cormorant *Phalacrocorax carbo sinensis* bit the feathers to lose the logger (result of attachment number 1; Figure 1). Bird Rehabilitation Centre 'De Bonte Piet', Midwoud, The Netherlands. February–April 2012. © Ruben Fijn.

The behaviour of both cormorants was monitored visually through daily observations by the authors and staff of the Bird Rehabilitation Centre 'De Bonte Piet'. The birds took daily baths and short dives in a small canal of 4 x 0.8 m with a depth of 0.8 m. Birds were caught six times during the 7.5 week trial to check the tags and their attachment, and to remove the harness after the trial.

Results

Attaching the logger to the back of the first Great Cormorant with tape was quick (less than five minutes) and relatively simple. The feathers on the back were rather small and soft but still long enough to cover the whole width of the tape with ease. After deployment the bird did not show any interest in the logger and started drying its wings almost immediately. Fitting the harness to the second Great Cormorant took more time than the application with tape to the first bird but was still relatively quick (5–10 minutes). Harness fitting needs more preparation and skill to find the right fit for each individual bird. After deployment, this bird showed no interest in the logger but started preening the feathers on the breast, covering the harness bands and ordering the feathers around and over the bands. No changes in food intake were noted for either bird during the experiment. The rehabilitation centre regulated the food availability to three Common Roach *Rutilus rutilus* of ~20 cm per bird per day and both birds ate all food offered, before the start of the trial and throughout its duration. The birds did not need to dive or swim for their food, but took daily baths and dives before deployment (generally once a day for about 15 minutes, sometimes twice a day)

and this did not change during the trial, neither bird developing an aversion to swimming or diving as a consequence of the attachment of the loggers.

The cormorant with the logger taped to its lower back managed to remove it after 10 days by plucking feathers from the skin and biting through the feather shafts at the base of the logger, after which it fell off with the feathers still attached to the tape (Figure 2). After 7 days the logger was re-attached to the back of the same bird but now slightly higher (roughly between the shoulders) as it was thought that this would be less easy for the bird to reach. However, after 4 days the logger was again removed by the bird in a similar manner. Ten days later, we deployed the logger again with tape but now on the tail. This time it remained attached for 15 days but then the bird bit through two tail feathers and pulled out the other two feathers to get rid of the logger.

The cormorant with the logger attached with a backpack harness was not seen to try to bite the harness, which we removed after 21 days. Both logger and harness were unaffected and showed no signs of damage on removal. The plumage of this bird was in good condition, showing no signs of feather wear, and no skin abrasions or other injuries were found. The general condition of both birds seemed unaffected by the trials, although neither was weighed before and after the experiment.

Discussion

The use of tape to attach devices to seabirds has previously been shown to be an effective and quick technique (e.g. Wilson *et al*. 1997), even for longer-term tag deployments. However, this study shows that some combinations of tags and bird species are not suitable for long-term tape attachment. The Great Cormorant with the logger taped to the back and tail proved to be aggressive to the logger after a while and did not refrain from damaging its own plumage to get rid of the device. Individuals might vary in their tolerance of taped tags and their propensity to remove them, and a sample size of only one bird is small, but the finding that Great Cormorants can easily remove taped loggers is of use for future studies. This behaviour was suspected, but not confirmed, in earlier deployments of radio tags on the tails of Great Cormorants (M. van Eerden & S. van Rijn pers. comm.). To what extent our findings apply to wild Great Cormorants remains speculative, since captive birds are less active during the day, which could lead to increased preening (and biting) of feathers out of boredom. An increased chance of tag loss might also be related to the weight of the device. In this study, the logger used was towards the upper end of the weight range of the current generation of such devices and probably relatively heavy for the small, soft feathers on the back of the cormorant. This may have contributed significantly to its loss, either by mechanical force of the weight pulling out feathers or by promoting preening and plucking since heavier tags are likely to be more obvious and irritating to the bird. This limitation does not reduce the value of our findings, and should be borne in mind when considering other tag designs, their weights, and where and how to attach them.

We conclude that in short-term deployments of loggers on Great Cormorants, tape might be the preferred method as it has a short handling time, which minimises stress to animals and lasts only one moulting cycle at most. Attachment with tape to the thick and sturdy tail feathers would be the preferred position as it is the least likely that birds would be able to remove these feathers. Whether tail attachment of loggers of the size we used affects flight and swimming behaviour of Great Cormorants negatively was not tested quantitatively in this study. If longer periods of deployment are intended with large tags however, we suggest using a harness for Great Cormorants, as this study shows that this species can remove taped devices without difficulty[1]. However, detrimental effects of harnesses such as lesions of the skin and deep muscular exposure (Peniche *et al*. 2011) and nest desertion (Falk & Moller 1995) have been recorded for some species and long-term effects need to be taken into account before deployment. We tried to minimise these effects by using a flexible (elastic) harness as tested in previous long-term deployments in several heron species and gulls (e.g. van der Winden *et al*. 2010; Gyimesi *et al*. 2011). Such a harness can better adjust to the body size of the bird compared to the one-size sturdy harnesses used in the past, reducing the risk of skin abrasions and feather damage.

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[1] We successfully deployed GPS loggers on eleven Great Cormorants in May 2012 and were able to track birds for up to 82 days at a GPS sampling interval of 2 minutes. We used a backpack harness to deploy the loggers and results will be made available in future publications.

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