Long-term attachment of transmitting and recording devices to penguins and other seabirds

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Transmitters or recorders attached to seabirds have greatly enhanced our understanding of seabird ecology (Kooyman and Kooyman 1995). Initially, such devices were large and cumbersome, but with advances in solid state technology, units have become increasingly smaller, can be deployed for long periods, and are more reliable (Wilson and Culik 1992). Because the operating life of devices typically spans many months, it is desirable to have a simple method for attaching devices to free-living animals that is effective for long periods with minimal impacts on the carriers (Fraser and Trivelpiece 1994).

Wilson and Wilson (1989) described the use of waterproof tape as a useful way to attach devices to penguins. They reported that units can remained attached for several days. We present a method for attaching devices to penquins that will allow the devices to remain securely attached for weeks to months at a time.

Study area and methods

Field work was carried out between December 1991 and November 1996 at the following locations: Ardley Island (62°13′S, 58°55′W), Antarctica; Possession Island (46°25′S, 51°40′E), Crozet Archipelago; Dassen Island (32°25′S, 18°05′E), South Africa; and Peninsula Valdes (42°04′S, 63°37′E), Punta Loberia (44°35′S, 65°24′E), San Julian (49°16′S, 67°43′E), and Cabo Virgenes (52°22′S, 68°24′E), Argentina. Devices were attached to the lower backs of penguins (birds with dry plumage) using 1 of 4 different methods.

Method 1. Units were attached according to instructions given in Wilson and Wilson (1989) in which Tesa tape (No. 4651; Beiersdorf AG, Hamburg, Germany) was used. We looped a strip of tape under a few feathers, adhesive surface facing up. We then placed the device on the feathers above the tape and wrapped the tape around the device. We used 4 strips of tape/device: 1 placed at the leading end of the device and 3 spaced evenly down its length. The complete attachment procedure took about 1 minute/bird (Fig. 1). We attached devices to 66 breeding penguins: 18 Adélie penguins (Pygoscelis adeliae), 17 chinstrap penguins (Pygoscelis *antarctica*), and 14 gentoo penguins (Pygoscelis papua) breeding at Ardley Island; 10 African penguins (*Spheniscus demersus*) breeding at Dassen Island; and 7 king penguins (Aptenodytes patagonicus) breeding at Possession Island. The devices weighed 200 g (max dimensions 140 x 58 x 28 mm; Wilson et al. 1993) and in the case of the Pygoscelis penguins, were hydrodynamically shaped according to suggestions in Bannasch et al. (1994).

Method 2. Units were attached using a slightly modified version of the first method. Holding penguins immobile, we lifted between our fingers a line of feathers on the lower back, with the line running at right angles to the main axis of the body. The line

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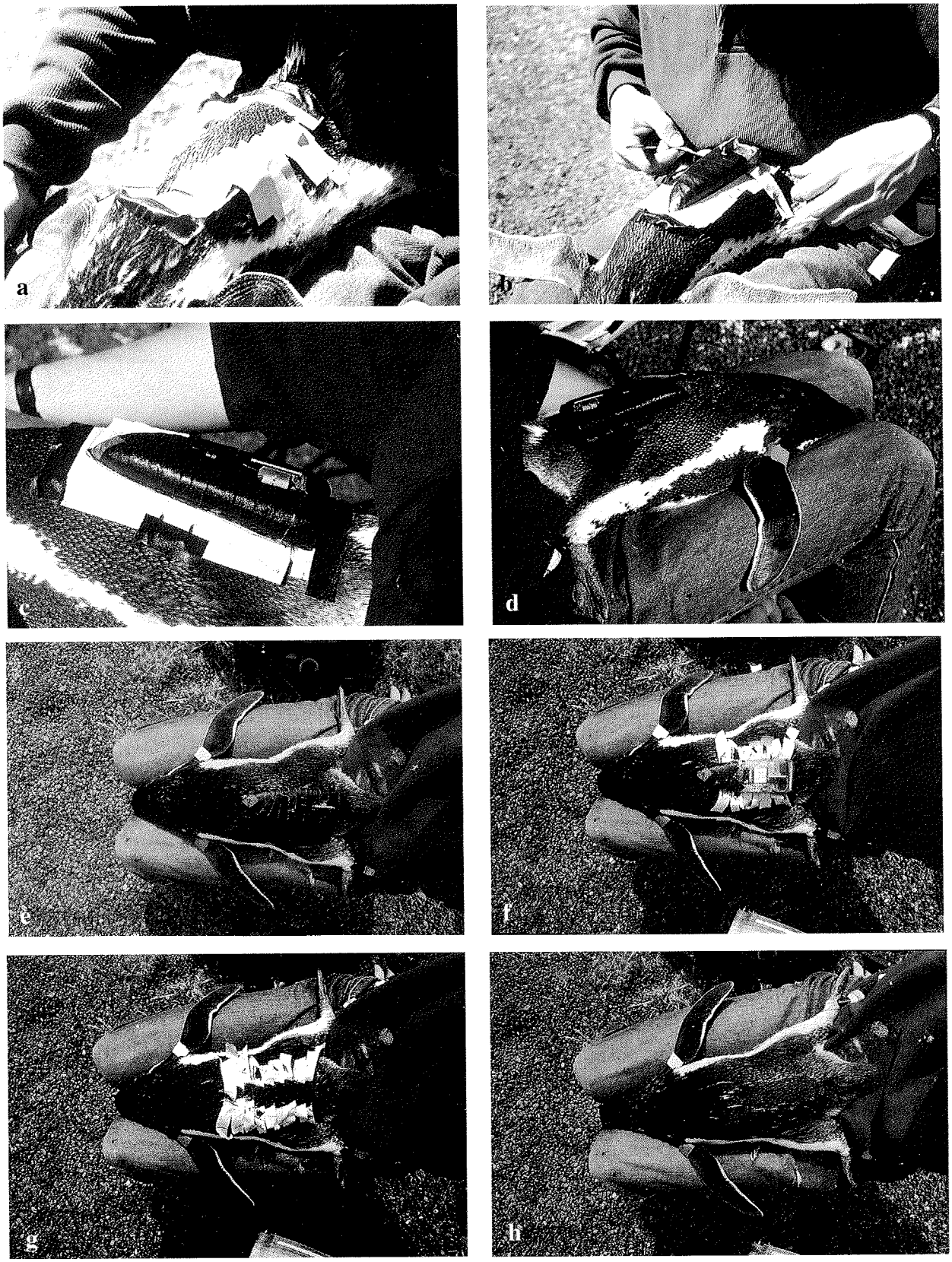


Fig. 1. A device weighing 200 g is attached (steps a–d) and detached (steps e–h) from a penguin

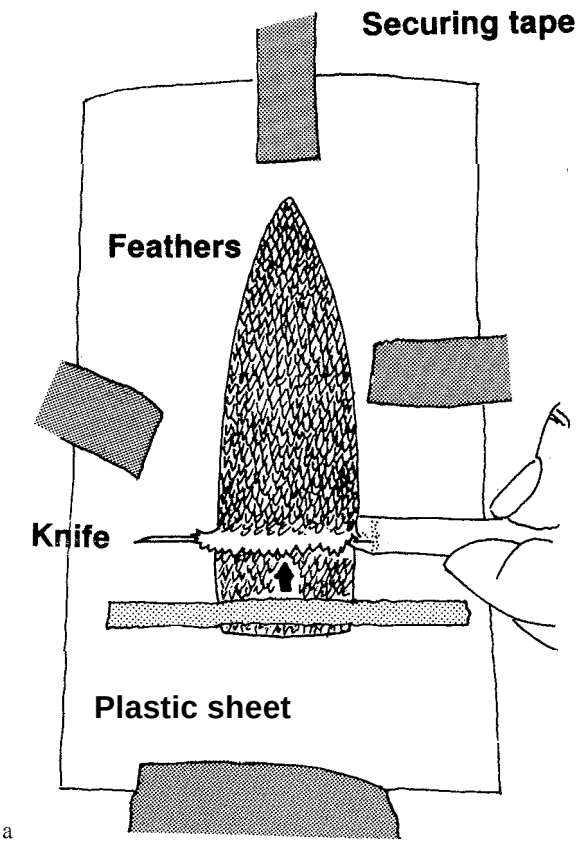
of feathers was lifted at a position corresponding to the most anterior projected position for the device to be attached. We cut a strip of tape the same length as the width of the device plus a few centimeters and slid the tape under the line of feathers, adhesive surface facing up. We then lowered the feathers and pressed down onto the tape. This process was repeated posterior to the first line and continued until multiple (generally 8), partially overlapping strips of tape were in place. We then placed the device on the bird and wound the tape around the device, starting at the most anterior position and working posteriorly, alternately using tape from the left and right sides. We covered the upper taped surface of the device with a thin layer of 2-component epoxy glue (Loctite fast epoxy; Loctite GmbH, Arabellastraße 17, D-81925 Munchen, Germany). This method was used to attach devices to 63 king penguins breeding at Possession Island.

Method 3. Into a thin sheet of plastic (approx 15 x 20 x 1 mm), we cut a hole the exact size of the base of the devices to be attached. We fixed the sheet to the lower back of the birds, using 4 short tape strips (Fig. 1, Fig. 2a). The hole in the sheet corresponded with the desired attachment position of the device (Fig. 2a) and insured that only those feathers directly underneath the device were used for attachment. We then used a knife blade to lift a line of feathers through the hole, with the line running at right angles to the main axis of the body (Fig. 2a). We slid a strip of Tesa tape (adhesive side facing up) underneath the lifted feathers, lowered the feathers onto the tape, and pressed down. The length of the tape was cut to the width of the section of the sheet hole to be covered plus a few centimeters. The width of the tape was selected so that when slid under the feathers, the tape was completely covered by feathers. If the tape tended to lift where it ran over the plastic sheet, we turned the ends over so that it stuck to the plastic and thus maintained its position. We repeated the process of sliding strips of tape under the feathers the length of the hole in the plastic sheet until there was a sheet of tape to the left and right of the hole made of overlapping strips of tape and a surface of apparently untouched feathers protruded through the hole in the plastic sheet (Fig. 2b). We then applied 2-component epoxy glue (Loctite) to the underside of the device and worked it well into the interstices of the feathers protruding through the hole. We placed the device on the feathers and starting anteriorly, lifted the tape strips from the plastic sheet and pulled them taut before sticking them, alternately left and right, to the device (Fig. 2c). We then removed the plastic sheet by lifting it over the device. Finally, we covered the upper taped surface of the device with a thin layer of epoxy glue. The complete attachment procedure took 10–20 minutes/bird. We fitted 17 postmolt Magellanic penguins (*Spheniscus magellanicus*) with devices using this method just before they went to sea for the winter migration. Devices weighed 55 g with maximum dimensions of 135 x 25 x 20 mm. In addition, we fitted 5 incubating Magellanic penguins with hydrodynamically shaped devices (42 g, max dimensions 125 x 38 x 25 mm) for foraging trips at sea.

Method 4. We attached devices as in method 3 except we used a 2-component, rubber-based glue designed for repairing inflatable dingies (Deutsche Schlauchbootfabrik, Eschershausen, Germany). This glue had to be touch-dry on both surfaces before it stuck effectively. The upper taped surface of the device was covered with epoxy glue. The complete attachment procedure took 10–30 minutes/bird depending on ambient temperature. Nine king penguins breeding at Possession Island were fitted with devices 125 x 38 x 25 mm in this manner. These birds were equipped in March 1995, just before the austral winter, when king penguins tending chicks undertake foraging trips 1–6 months long (Cherel et al. 1987, Weimerskirch et al. 1992). At Ardley Island, 20 Adélie penguins and 10 gentoo penguins were equipped with identical devices in October 1995 just before the egg laying and incubating period. In addition, 13 postmolt gentoo penguins at Ardley Island were equipped with these devices in May 1996 just before the austral winter, when the birds leave their breeding sites for several months. Finally, 34 incubating Magellanic penguins were fitted with hydrodynamically shaped devices (11 birds with devices weighing 42 g, max dimensions 125 x 38 x 25 mm, and 23 birds with devices weighing 130 g, max dimensions 140 x 63 x 20 mm) using this method. Birds were preparing to go to sea on foraging trips of 1–26 days.

Results

All Pygoscelid penguins fitted with devices using attachment method 1 returned to their breeding sites having retained their devices for a mean wearing period of 2.0 days (SD = 0.7, n = 49, range = 1–4). The mean length of time that units were worn by African penguins was 1.9 days (SD = 0.9, n = 10). The maximum length of time that a device was worn was 4 days, after which it became loose. None of the birds appeared to have suffered from having worn the devices; they continued to breed and feed chicks as did adjacent unequipped conspecifics. All 7 of the king penguins fitted with devices using this



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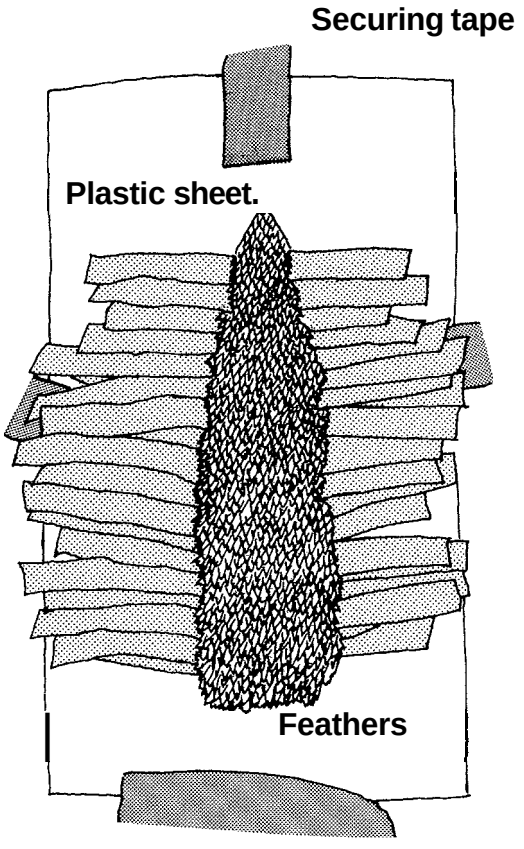

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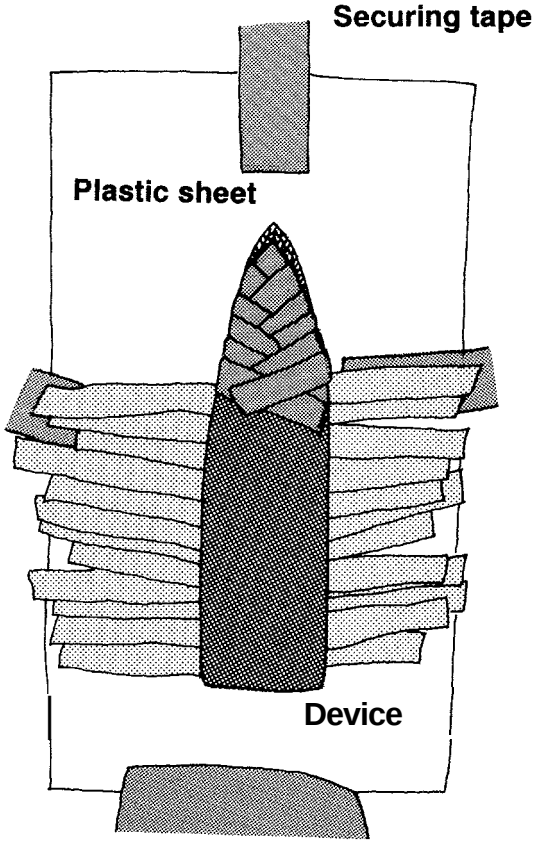

Fig. 2. Schematic diagram demonstrating the attachment of an external device to a penguin. (a) The plastic sheet is fixed in place with 4 strips of tape. A line of feathers is lifted with a knife, and a strip of tape is slid underneath, (b) More strips of tape are slid underneath the feathers in a comparable manner until the plastic sheet is covered left and right the full length of the device (note in this figure a final length of tape is still needed at the anterior tip of the device). (c) The device to be attached is placed on the feather layer and the tape wrapped around it starting at the most anterior point and working back, alternately left and right (see text).

methodology returned to their breeding colonies in good condition. However, 1 individual returned with a device after a foraging trip of 14 days. This particular device had not been attached well. Other birds returned after having been at sea for 18–34 days (Table 1).

All king penguins fitted with devices attached using method 2 returned to their breeding colonies in apparently good condition. All birds (n = 63) returned with their devices in place, most of which were firmly attached. These birds spent 5–9 days at sea. The tape on devices attached to birds that had spent the longest time at sea was beginning to wear where it ran between the bottom and the side of the devices.

The 5 incubating Magellanic penguins fitted with devices using attachment method 3 were recovered after wearing periods of 32–41 days. All units were firmly attached, and the birds were all apparently in good condition. We had to cut the distal section of many feathers to remove the devices. None of the devices attached using method 3 on Magellanic penguins during winter migration were recovered; although 2 birds were seen at the colony with devices after a period of 170 days. On a visit to the colony 10 days later to try to recover these devices, we found that 4 of the birds that had been wearing devices had lost them. The form of the base of the devices was evident on the back of each of these penguins because the feathers had broken or been bitten off near the middle of the shaft leaving a device-sized hole in the feather layer.

Thirty of the 34 incubating Magellanic penguins fitted with devices using attachment method 4 were recovered in apparently good condition after intervals of 14–58 days. All units were still firmly attached, and none of the feathers had to be cut to remove the units. In 3 cases birds apparently had bitten at the feathers anterior to the device, partially destroying the quill tips. All 20 of the Adélie penguins and 10 of the gentoo penguins equipped with devices prior to egg laying were recovered in good condition after periods ranging from 42 to 60 days. Since being equipped, all birds had been involved with egg laying, and all individuals were brooding ≥1 healthy chick at the time the units were recovered. Six of the 13 gentoo penguins that had been equipped with devices for the winter were recovered at Ardley Island as they started to breed in good condition after periods between 148–155 days. Failure to locate the remaining 7 birds was considered to be due to the fact that gentoo Penguins do not always molt at their breeding site and the birds that we equipped were not known to be breeders at Ardley Island. Six of the 9 king penguins equipped with units for the winter were recovered after 42–150 days. Three of the birds equipped with devices lost their chicks and were not subsequently seen at the colony. This is not necessarily attributable to the devices because returns of non-equipped birds at that time were greatly reduced and late. Sample birds were in good condition with devices firmly attached after the maximum wearing period. We did not have to cut feathers to remove units.

Table 1. Deployment of recording devices attached to penguins between December 1991–November 1996 at Ardley Island, Antarctica; Possession Island, Crozet Archipelago; Dassen Island, South Africa; and Peninsula Valdez, Punta Loberia, San Julian, and Cabo Virgenes, Argentina.

n	Penguin species	Mass of device (g)	Attachment method	Deployment (days)	No. of birds recovered or resighted
18	Adélie	200	1	1–4	18
17	Chinstrap	200	1	1–4	17
14	Gentoo	200	1	1–4	14
10	African	200	1	2	9
7	King	200	1	18–34	7
63	King	55	2	5–19	63
17	Magellan	55	3	170	4
5	Magellan	42	3	32–41	5
9	King	55	4	42–150	6
20	Adélie	42	4	49–64	20
10	Gentoo	42	4	49–64	10
11	Magellan	42	4	14–45	8
23	Magellan	130	4	14–58	22
13	Gentoo	42	4	148–155	6

Discussion

Wilson and Wilson (1989) advocated the use of Tesa tape to attach devices to free-living penguins because it provided a secure, light-weight attachment mechanism that was unobtrusive and not damaging to feathers. However, our results show that Tesa tape cannot be used reliably to attach large devices to penguins for periods of >1 week unless the attachment method suggested by Wilson and Wilson (1989) is modified. Wilson and Wilson (1989) noted that extremely small devices (3 g) attached using this methodology remained in place on Adelie penguins for ≥70 days. The differ-

ence in attachment success between their results and ours probably lies in the mass of the package. We suggest that for hydrodynamically shaped devices ≤50 g, wrapping the tape around the device in 4 strips as in method 1 is adequate if birds are departing for foraging trips of ≥3 days. The handling time for attachment is minimal, so stress to animals is minimized. In addition, the tape can be removed completely without damage to the feathers when the device is recovered.

When penguins will be absent from the nest for several days to 3 weeks, method 2 is effective. Although it takes longer, which causes more stress to the birds, feathers are not damaged by this attachment procedure.

Use of epoxy glue, as detailed in method 3, is not ideal. It penetrates almost to the base of the feather shaft, thus damaging the feathers and altering their normal function. In addition, this glue becomes brittle so that the feather shafts eventually break, and the whole device can be lost after long periods of wear. This is a particular problem when birds spend extensive periods on land, where they are often bending forward, exerting pressure on the inflexible glue joint. Not only is the device lost in this way; it is damaging to the birds' insulation.

We began using the 2-component rubber glue in an attempt to find an attachment system which would be flexible rather than brittle. This glue adheres well to feathers even if they are not de-waxed, and it does not penetrate down the feather shaft as far as the epoxy does. Furthermore, removal of the device does not necessitate cutting the feathers to the extent necessary with epoxy glue. A potential disadvantage of this glue is that it may require 20 minutes to dry before a device can be attached. The manufacturers of the rubber glue specify that full strength of the glue is achieved in 24 hours (compared to 6 hrs for the epoxy glue). Therefore, it is essential that initially the bond between the feathers and the device be maintained by the Tesa tape.

Attachment methods 3 and 4 cannot be used indefinitely for all species. Magellanic penguins apparently bite and break their feathers to remove units. Thus, long-term attachment (over months) in this species remains problematic.

There are many methods advocated for attaching external devices to free-living animals, including harnesses (Morris and Black 1980), hose clamps (Lishman and Croxall 1983), sutures (Perry 1981), and glue (Loughlin et al. 1987). The less invasive the method, the more it is to be recommended. We believe that the use of tape, properly applied as described in method 2, is a nearly ideal solution for birds to be fitted with devices for short periods. Where longer attachment periods are necessary, the use of tape with a 2-component, rubber-based glue is recommended.

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