Application of a modified harness design for attachment of radio transmitters to shorebirds

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Radio transmitter attachment methodology is important to the design of radio telemetry studies. In 1998, we attached 5 transmitters to a captive population of Western Sandpipers (*Calidris mauri*) and 7 transmitters to wild Killdeer (*Charadrius vociferus*) using a modified version of the Rappole and Tipton (1991) figure-8 leg-loop harness. Captive birds fitted with harnesses did not exhibit quantifiable differences in behavior relative to control birds. Based on initial success in using the leg-loop harnesses, we used harnesses to attach transmitters in the wild to 30 Killdeer and 49 Dunlin (*Calidris alpina*) during the winters of 1998-1999 and 1999-2000. This was part of a study on movements of wintering shorebirds in the Willamette Valley of Oregon, USA. Wild birds showed no adverse effects of the harnesses. Thus, the described harness is a practical method for attachment of transmitters to shorebirds. Advantages of this harness method include a reduction in handling time at capture, elimination of the need to clip feathers for attachment, and increased transmitter retention time.

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INTRODUCTION

Radio telemetry is an important tool in studies of shorebird biology. Recent applications of the technique include studies of migratory patterns (Iverson *et al.* 1996, Johnson *et al.* 1997), within-season movements (Warnock *et al.* 1995; Warnock & Takekawa 1996; Knopf & Rupert 1996; Farmer & Parent 1997; Haig *et al.* 1998; Powers 1998; Plissner *et al.*, 2000), foraging ecology (Whittingham 1996), mating tactics (Colwell & Oring 1988), and general ecology (Wood 1986, Cresswell & Summers 1988, Gill *et al.* 1991, Warnock & Oring 1996). Further, a growing recognition of the importance and need for multiple scale landscape studies in ecological research and conservation biology will undoubtedly lead to an increased utilization of radio and satellite telemetry in the future (Haig *et al.* 1998).

An important consideration in any telemetry study is the method used for attachment of transmitters to the study organism. Primary concerns include potential effects of the attachment method on the behaviour of the organism and transmitter retention time (Rappole & Tipton 1991, Warnock & Warnock 1993). Currently, the most common attachment method in shorebird radio telemetry studies involves direct application of the transmitter to the birds' plumage with a glue or water-proof epoxy adhesive (Raim 1978, Warnock & Warnock 1993, Knopf & Rupert 1996). In many cases, this technique is adequate; however there are a number of potentially troublesome issues. Transmitter retention times are highly variable depending on the study species, moult schedule, experience of the researcher, behaviour of the bird, and environmental conditions. Handling time required to process birds is dependent on curing time of adhesives and is greatly influenced by ambient temperatures. In addition, procedures with adhesives sometimes involve clipping an area of feathers at the point of attachment. The thermoregulatory implications of such actions are potentially problematic, particularly during times of cold weather and precipitation.

In some cases, it is possible to mount a transmitter on a U.S. Fish and Wildlife Service metal identification band, which are subsequently attached to the leg of the study subject (Plissner *et al.*, 2000; Haig & Oring, unpub. data). This technique appears to be well suited for larger, long-legged species such as the recurvirostrids and some scolopacids; however issues of leg length and transmitter size prevent application of this method to a broad range of shorebirds. In addition, attachment of transmitters to leg bands does not provide a mechanism for eventual 'shedding' of the transmitter.

The attachment of transmitters with harnesses has been used extensively in studies of waterfowl (Conroy *et al.* 1989, Orthmeyer & Ball 1990), songbirds (Sykes *et al.* 1990, Rappole & Tipton 1991, Neudorf & Pitcher 1997, Powell *et al.* 1998), and other avian groups (Godfrey 1970; Hooge 1991; D. Kesler, personal communication). Unfortunately, harness designs often are intrusive with attachment points at the wings, neck, or bill. Hence, a number of studies have documented adverse effects of harness attachments (Ward & Flint 1995, Dzus & Clark 1996, Garrettson & Rohwer 1998). In contrast, recent application of a leg-loop design for songbirds has proven highly successful (Rappole & Tipton 1991, Neudorf & Pitcher 1997, Powell *et al.* 1998).

In this paper, we present results on the development and use of a figure-eight leg-loop harness for the attachment of transmitters to captive and wild shorebirds. This method offers a solution to potentially problematic issues associated with other transmitter attachment techniques.

METHODS

In the fall of 1998, we used a modified version of the Rappole & Tipton (1991) harness design to attach 1-gram mock transmitters to a population of Western Sandpipers *Calidris mauri* held in a captive facility at the University of Nevada-Reno. Transmitters were crafted with modelling clay to match specifications of those used in field studies of Western Sandpipers (Warnock & Warnock 1993, Warnock & Takekawa 1996; Holohil Sytems, Ltd., Canada). All birds also were marked with a unique combination of 1-2 colour bands to allow individual identification. Transmitters were harnessed to five individuals. A control group of four individuals was not harnessed. All harnessed birds were weighed immediately following attachment of the transmitter package, after 10 days, and again at the conclusion of the study. Birds also were checked on a daily basis for obvious signs of discomfort or stress. Over the course of the 20-day study period we conducted behavioural observations on all individuals on eight different days. On days of observation, all captive birds were randomly ordered and each individual was observed for a five minute time period. Activities were then recorded every ten seconds and assigned to the categories: feed, locomotion, preen, rest, and wing movement. In addition, we recorded the number of birds within two feet (0.61 m) of the focal bird every 60 seconds in order to assess flock cohesiveness. Two-sided t-tests were used to analyze behavioural data.

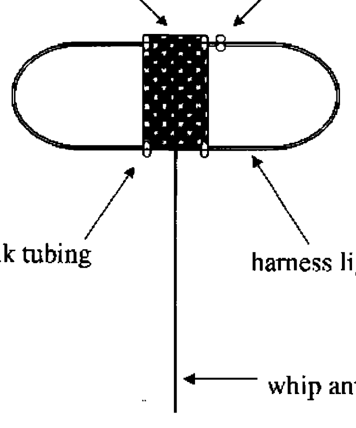

Figure 1. Attachment of a figure-eight leg-loop harness to a radio transmitter.

In the spring of 1999, we attached 13 transmitters (2.5 gram, Holohil Systems Ltd., Canada; model PD-2) to a wild population of Killdeer *Charadrius vociferus* during the course of a study on winter shorebird movements and wetland connectivity in the Willamette Valley of Oregon. All birds were captured using leg-noose traps (G. Page, personal communication) and banded with unique color band combinations. Of the 13 transmitters deployed, seven were attached with harnesses and six with the epoxy method of Warnock & Warnock (1993; Titan Corporation, Lynwood, Washington, USA). Birds were tracked daily using radio-trucks and aerial telemetry for the duration that they remained in the study area (mean = 10.8 days). Visual observations of study birds were recorded when possible. Observations consisted of recording activity of the radio-tagged individual every 15 seconds over a ten-minute period. The process was then repeated for a randomly selected control individual in the same flock. Behaviors were assigned to the categories feed, locomotion, preen, rest, and wing movement.

Following initial results of the captive and field study, we also used harnesses to attach transmitters to 23 Killdeer and 59 Dunlin *Calidris alpina* during the winter of 1999-2000 as part of ongoing shorebird studies in the Willamette Valley of Oregon, USA.

DESCRIPTION OF HARNESS AND ATTACHMENT

The harness used in this study was a modification of the leg loop figure-eight harness described by Rappole & Tipton (1991; Figure 1). It consisted of two loops that slide over each leg of the bird, allowing the transmitter to rest over the lower back/synsacrum area above the uropygial gland. Time required for harness attachment was approximately 2-5 minutes, depending on the experience of the researcher. Modifications to the original design included use of heat-shrink hollow tubing set at the front and rear end of the transmitter at time of construction (Holohil Systems Ltd.). The harness material was threaded through the tubing, eliminating the need to glue or tie the harness to the transmitter. Tubing added only 0.1 g weight and 4.5 mm length to the original transmitter dimensions. In addition, an earring backing was used to fasten the harness to the bird. Free ends of the harness material were threaded through the eyelets of the backing and then the eyelets crimped when the harness was of proper length. As a result, the harness was fit for each individual bird and there was no need to tie potentially troublesome knots. The earring backing added 0.09g weight to the transmitter package.

The harness ligature should be a non-abrasive material with a diameter 1 mm or greater in order to prevent irritation (Rappole & Tipton 1991). In our trials, we used a 2 mm diameter silk cord. The harness ligature must be of a diameter equal to or less than that of the transmitter tubing and earring backing.

Attachment procedure: see Figure 2.

1. Prior to a bird's capture, string a 30 cm length of ligature through the front and rear tubing of the transmitter. Thread each end of the ligature through the earring backing and crimp one

eyelet. This results in two loops of material on either side of the transmitter (Figure 1).

2. With bird in hand, slip the left leg of the bird through the left harness loop. Manoeuvre the loop up the leg as far as possible, such that the ligature rests against the bird's body. The loop must be situated above the tibia/femur attachment point, otherwise the legs will be immobilized when the harness is pulled taut.
3. Holding the left leg loop in place, lay the transmitter across the birds' back with the transmitter resting over the lower back/ synsacrum, proximal to the uropygial gland.
4. Slide the remaining leg loop over the free leg of the bird, as previously described.
5. With the transmitter in place, slowly pull the free end of the ligature through the eyelet of the earring backing until the harness is taut. The transmitter should have 2-3 mm of play and the ligature should be tight enough that the leg loops cannot slip down beyond the tibia/femur joint. As an example, Killdeer harness ligature after proper fitting was 16.5 cm in length and each leg loop measured approximately 2.95 cm from the edge of the transmitter to the end of the stretched loop. With the harness properly aligned, crimp the eyelet of the earring backing with pliers and trim off excess ligature. The earring backing should rest against the transmitter so it does not contact the birds' body and cause irritation. A drop of quick drying superglue at one end of the front and rear transmitter tubes will prevent the transmitter from sliding on the birds' back.
6. Feathers pinned underneath the ligature and/or transmitter on the birds' back should be carefully freed so that they lay over the transmitter. This will allow the bird to preen the transmitter into the plumage, reduce transmitter visibility, prevent alteration of thermoregulatory processes, and reduce the aerodynamic drag of the transmitter (Caccamise and Hedin 1985).
7. Following harness attachment, place the bird in a holding box (covered laundry basket) for 1-5 minutes in order to check for immediate signs of immobilization or discomfort.

RESULTS

Captive Western Sandpipers were observed for 20 days and showed no signs of discomfort or abrasion where the harness and transmitter contacted the bird. However, all birds with harnesses preened out a 5 mm swath of feathers in the distal region of the tibia. All harnessed birds gained weight during the study (mean = 1.58 grams, SE = 0.33), presumably to compensate for the added weight of the transmitter. We neglected however, to weigh control birds as a comparison. Analyses of over 1,800 behavioural observations collected in 360 minutes of observation time did not suggest significant differences in behaviours between harnessed and control birds (Table 1; two-sided t-tests, $p > 0.05$).

There were an insufficient number of behavioural observation sessions of wild Killdeer ($n = 13$) to carry out statistical analyses. However, based on 6 harnessed bird observation sessions, individuals partitioned behaviour as follows: 48.15% rest, 12.59% preen,

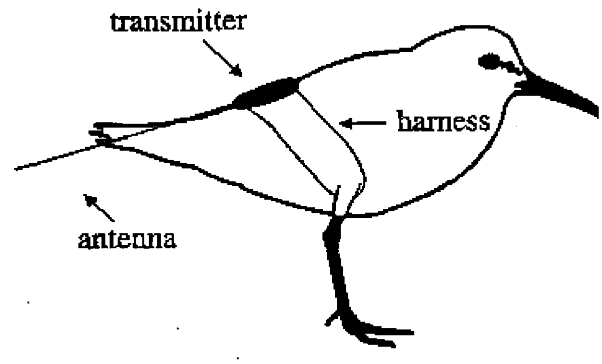

Figure 2. Proper alignment of figure-eight leg-loop harness and transmitter on shorebird.

22.96% forage, 16.30% locomotion. In seven observation sessions of control birds, we observed the following behaviours: 71.05% rest, 13.16% preen, 11.58% forage, 3.68% locomotion, 0.53% wing movement. Additional resightings of radio-tagged birds ($n = 37$) did not indicate differences in behaviour among harnessed birds, epoxy birds, or birds without transmitters attached. In one case, the harness was not properly secured (earring backing not crimped) and within 24 hours following release the bird shed the transmitter. Within two weeks of capture, all radio-tagged birds, except for one harnessed individual, migrated out of the study area. These movements coincided with the departure of large numbers of winter resident Killdeer. The harnessed bird that remained was a male that we observed copulating numerous times following harness attachment and was presumed to be nesting in the area.

During the course of the winter of 1999-2000 there were 18 direct visual sightings of 12 different Killdeer with harness packages. Additionally, we recorded four sightings of four different Dunlin with transmitter harnesses. In all cases birds were observed with other conspecifics and did not exhibit any behaviours indicative of discomfort or stress. Activities observed included foraging, walking, flying, and preening. Furthermore, we collected extensive numbers of locations of radio-marked birds. Over the course of ten weeks we recorded 493 locations of 20 marked Killdeer and 294 locations of 29 marked Dunlin. Harness packages did not appear to inhibit flight capabilities of study subjects as marked Dunlin were detected making non-stop flights of up to 48.3 km.

DISCUSSION

Findings indicate that our modified harness attachment did not significantly alter the behaviour of study subjects and is a viable method of transmitter attachment for shorebird studies. The issue of feather loss in the captive Western Sandpipers is a concern. It is noteworthy; however, that birds preened out feathers on their tibia, not an area contacted by the harness. It is possible that initial inexperience of the researcher resulted in attachment of harnesses too tightly or altered arrangement of feathers such that birds were irritated. Another potential explanation is that feather loss was a by-product of the captive setting whereby birds had more time for comfort movements and tended to fall into fixed-action patterns. In addition, all captive birds

Table 1. Behavioural observations of captive Western Sandpipers. Activity categories expressed as proportion of each behavior observed, with flock cohesiveness measured as mean # of individuals within 2 feet of focal birds.

	Birds (*n*)	Total observ-ations (*n*)	Behavior (mean % ± SE) % Rest	% Preen	% Forage	% Locomotion	% Wing movement	Flock cohesiveness
Control group	4	800	68.50 ± 3.53	8.80 ± 4.49	40.25 ± 2.94	82.00 ± 10.50	6.00 ± 1.40	4.60 ± 0.43
Harness group	5	1000	63.80 ± 11.93	4.75 ± 4.43	28.80 ± 4.62	95.40 ± 8.32	4.60 ± 0.75	4.48 ± 0.29

preened heavily immediately after their facility was cleaned. This extra stimulus may have heightened awareness of birds to the presence of the harness. Finally, early removal of harnesses prevented an evaluation of whether birds replaced lost feathers following initial stages of harness wear.

Use of the harness method eliminates a number of potential problems associated with other attachment techniques. For example, previous shorebird telemetry studies have reported short retention times and/or premature loss of transmitters with use of adhesives (Rappole & Tipton 1991; Whittingham 1996; Powers 1998; S. Haig, unpublished data). This is a serious concern given the time and resources required to conduct radio telemetry studies. While we were not able to quantify retention time of our transmitter harnesses due to the onset of migration, use of the same harness material and design on a tropical kingfisher *Halcyon cinnamomina* indicated a retention span of well over four months (D. Kesler & S. Haig, unpublished data). Further, studies of a migratory songbird reported that individuals successfully migrated with harnesses and showed no adverse effect of the attachment method after 21 months (Powell *et al.* 1998). Previous studies found that use of a 5-kg test braided Dacron line resulted in a retention time of 4-9 months (Powell *et al.* 1998). Ideally, there is the need for a ligature material that will degrade following the expected lifespan of the radio transmitters used. Additional studies will likely provide insight on retention qualities of different harness materials.

Other benefits of the harness technique include a reduction in handling time during transmitter attachment and elimination of the need to clip feathers. Attachment of our leg-loop harness required 2-5 minutes. In contrast, the curing time of the commonly used bird epoxy (Titan Corporation) ranges from 4-15 minutes and was highly dependent on ambient temperature (Warnock & Warnock 1993; P. Sanzenbacher, personal observation). Furthermore, Warnock & Takekawa (1996) reported an increased mortality of radio-tagged birds associated with increased handling time. These are potentially important issues, particularly if researchers need to process multiple individuals at a time or during adverse weather conditions.

In summary, our findings indicate that the harness method reported is a viable technique for the attachment of radio transmitters to shorebirds of all sizes. These harnesses will not alter behaviour but will provide a safe, long-lasting, and simple method of transmitter attachment. As the use of radio-telemetry in avian studies progresses there is the need for further studies of the effects of different attachment techniques on all aspects of behavior including flight capabilities and breeding activities.

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