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.

INTRODUCTION


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 waterproof 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, Garretson & 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 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. Activities were assigned to the categories: feed, locomotion, preen, rest, and wing movement.

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 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.
behaviour as follows: 48.15% rest, 12.59% preen, bird observation sessions, individuals partitioned out statistical analyses. However, based on 6 harnessed birds (Table 1; two-sided t-tests, p > 0.05).

There were an insufficient number of behavioural observations 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, 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.

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).

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...
Halcyon cinnamomina indicated a retention span of that individuals successfully migrated with harnesses due to the onset of migration, use of the same reduction in handling time during transmitter attach-
provided insight on retention qualities of different radio transmitters used. Additional studies will likely that will degrade following the expected lifespan of the resulted in a retention time of 4-9 months (Powell et al. 
and showed no adverse effect of the attachment method 
premature loss of transmitters with use of adhesives 
techniques. For example, previous shorebird telemetry 
potential problems associated with other attachment 
studies have reported short retention times and/or 
presentment of radio transmitters to shorebirds of all sizes. 
and abdominally implanted transmitters on survival and 

ACKNOWLEDGEMENTS
We thank Heidi Packard and Michael Taft, who helped in the collection of field data and Dan Harmon who assisted in all aspects of the captive study. Design and modifications to the harness were greatly improved with the help of Dylan Kesler. Funding and logistical support was generously provided by USGS Forest and Rangeland Ecosystem Science Center; U.S. Fish and Wildlife Service; Oregon Department of Fish and Wildlife; and the University of Nevada, Reno.

REFERENCES


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.

<table>
<thead>
<tr>
<th>Behavior (mean % ± SE)</th>
<th>Birds (n)</th>
<th>Total observations (n)</th>
<th>% Rest</th>
<th>% Preen</th>
<th>% Forage</th>
<th>% Locomotion</th>
<th>% Wing movement</th>
<th>Flock cohesiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>4</td>
<td>800</td>
<td>68.50 ± 3.53</td>
<td>8.80 ± 4.49</td>
<td>40.25 ± 2.94</td>
<td>82.00 ± 10.50</td>
<td>6.00 ± 1.40</td>
<td>4.60 ± 0.43</td>
</tr>
<tr>
<td>Harness group</td>
<td>5</td>
<td>1000</td>
<td>63.80 ± 11.93</td>
<td>4.75 ± 4.43</td>
<td>28.80 ± 4.62</td>
<td>95.40 ± 8.32</td>
<td>4.60 ± 0.75</td>
<td>4.48 ± 0.29</td>
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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.


