Testing radio transmitter attachment techniques on chicks of galliforms

Victoria Dreitz, University of Montana - Missoula
Lauri Baeten
Tracy Davis
Margaret Riordan

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Tools and Technology

Testing Radiotransmitter Attachment Techniques on Northern Bobwhite and Chukar Chicks

VICTORIA J. DREITZ,1,2 Colorado Division of Wildlife, 317 W Prospect Road, Fort Collins, CO 80526, USA
LAURIE A. BAETEN,3 Colorado Division of Wildlife, 317 W Prospect Road, Fort Collins, CO 80526, USA
TRACY DAVIS, Colorado Division of Wildlife, 317 W Prospect Road, Fort Collins, CO 80526, USA
MARGARET M. RIORDAN,2 Colorado Division of Wildlife, 317 W Prospect Road, Fort Collins, CO 80526, USA

ABSTRACT We compared 4 external radiotransmitter attachment techniques to determine the optimum attachment method on chicks of 2 galliform species. The attachment methods included tissue glue, silicone gel, suturing, and leg harness. The study was conducted in captivity with a 2-phase assessment: first with northern bobwhite (Colinus virginianus), and then chukar (Alectoris chukar) chicks. We applied each technique and assessed effects on growth rates, retention times, ease of attaching the transmitter, and effects on physical development. No apparent adverse impacts on chicks were observed for any of the attachment techniques. We found the leg-harness technique was most reliable in terms of retention time, required the least amount of handling time, and was the simplest to administer. Modifications to our suture technique likely would result in similar retention times, but would still require additional handling time and complexity in attaching transmitters. © 2011 The Wildlife Society.

KEY WORDS Alectoris chukar, chicks, chukar, Colinus virginianus, northern bobwhite, radiotelemetry, transmitters.

Radiotelemetry is a vital tool for analyzing how animals use space and time in response to environmental factors. Although it has been ≥40 yr since the development of radiotelemetry, there remains uncertainty about the effects of transmitters on individually marked birds and consequent effects on the resulting information (e.g., Guther and Lusk 2004, Barron et al. 2010). The increasing miniaturization of transmitters has enabled the use of radiotelemetry for young, including prefledged and fledged, chicks. In some cases, attachment of radiotransmitters is known to adversely affect behavior (Greenwood and Sargeant 1973, Perry 1981), growth (Hubbard et al. 1998), and survival (Marks and Marks 1987). Practical issues, such as species and age, should be considered when deciding on the most appropriate attachment technique. Some studies have evaluated potential impacts of different transmitter attachment methods on adult avian species (Sykes et al. 1990, Woolnough et al. 2004), but the efficacy of affixing radiotransmitters to young individuals has received less attention.

Studies have described the use of telemetry to monitor chick survival and cause of mortality of galliform chicks (Riley et al. 1998, Larson et al. 2001, Burkepile et al. 2002, Spears et al. 2005, Gregg et al. 2007). These studies suggest success with various attachment techniques, but report low chick survival rates. Burkepile et al. (2002), Spears et al. (2005), and Gregg et al. (2007) did not report whether transmitters contributed directly or indirectly to low chick survival. However, Riley et al. (1998) and Larson et al. (2001) retrieved a high percentage of transmitters placed on chicks during their studies and reported minimal to no impact of transmitters on chick survival. Field studies using radiotransmitters affixed to chicks should maximize the quantity and quality of data. Therefore, it is important to demonstrate that there is relatively little negative effect of radiotransmitters on survival or behavior of the study species.

In our study, we examined 4 techniques for attaching radiotransmitters to chicks of a small-sized galliform—the northern bobwhite (Colinus virginianus, 140–170 g), and a medium-sized galliform—the chukar (Alectoris chukar, 550–675 g). The study was conducted in a captive setting to allow for controlled assessment of the effects of radiotransmitters and attachment techniques on chick behavior, body mass, and feather development without the complication of daily tracking and predation. We present recommendations for the most appropriate attachment technique for chicks of these 2 species and those for galliform chicks of similar size, growth rate, and development patterns.
METHODS

We conducted a 2-phase study at the Colorado Division of Wildlife, Foothills Wildlife Research Facilities in Fort Collins, Colorado (40° 35’ 25” N, 105° 9’ 30” W) where information obtained on one species was used to determine the attachment techniques to be used on the next species. Bobwhites were used in phase I and chukars in phase II. We used 25 bobwhite and 25 chukar chicks obtained from Field Trial Gamebirds (Fort Collins, CO) at ≤2 days of age. Each chick was individually marked with a colored plastic leg band at the initiation of each phase. Chicks <27 days of age were housed indoors in groups of 5 in brood boxes (1 m in length × 0.5 m in width × 0.6 m in height) containing a heat lamp, wood shavings, a gravity-fed water container, and food pan; at ≥27 days of age, chicks were moved to an outdoor aviary. The outdoor flight pen (23 m in length × 3 m in width × 3 m in height) contained natural substrate flooring, a plastic shelter (5 m in length × 1 m in width × 1 m in height) fitted with heat lamps, gravity-fed waters, and food pans. Chicks were fed commercially prepared game bird feed ad libitum.

We evaluated 4 attachment techniques: tissue glue (latex-based surgical glue, Whittier and Leslie 2005), silicone gel, suturing (Mauser and Jarvis 1991, Burkepile et al. 2002), and leg harness (Rappole and Tipton 1991). Chicks were randomly assigned into either the control group or 1 of 4 treatment groups at the initiation of each phase, such that there were 5 chicks/5 groups (25 total chicks/species). For all treatment groups, chicks were handled once daily for physical examination and to place transmitters. Behavioral observations were conducted twice daily during husbandry care to determine whether transmitters influenced activity and/or foraging behavior of the birds. Behavioral observations were subjective and categorized as either impact or no impact. Chicks were handled once daily for physical examination and to measure body mass. Hereafter, we refer to chicks as either bobwhites or chukars.

We present methods and results of each study phase separately because information obtained during phase I was used to determine the attachment techniques used in phase II. We defined retention success as the number of transmitters per attachment technique that remained attached for each size of transmitter 12 days after placement for small transmitters and 30 days after placement for large transmitters. We defined a behavioral impact as an observed difference in activity and/or foraging behavior between treatment and control groups. The study was approved by the Colorado Division of Wildlife Animal Care and Use Committee (permit no. 02-2007).

PHASE I

Methods

Bobwhites ≤2 days old were randomly placed into 1 of 5 groups: A) suture, B) tissue glue, C) silicone gel, D) leg harness, and E) control. Bobwhites in the control group were handled for approximately 5 min, the average handling time for the treatment groups.

The suture technique consisted of suturing the anterior and posterior end of the transmitter to the dorsal midline, similar to the method described by Burkepile et al. (2002) for greater sage-grouse (Centrocercus urophasianus) chicks. The transmitter was sutured at the interscapular region, resulting in the anterior end of the transmitter sitting just below the neck. This placement is higher on the back than suggested by Burkepile et al. (2002) because the surface area is smaller for bobwhites (approx. one-third the area of greater sage-grouse chicks). For the small and large transmitters, we used an absorbable monofilament suture (4-0 PDS II and 3-0 or 4-0 Monocryl™, Ethicon, NJ, respectively) with a FS-2 cutting needle. The absorbable material has the advantage of allowing the transmitter to detach, but also could allow premature detachment.

The tissue-glue technique was similar to that described by Spears et al. (2002, 2005) and Whittier and Leslie (2005). We first clipped down feathers of the interscapular region, and then placed a small amount of tissue glue (Nexaband S/C™; Abbott, North Chicago, IL) approximately 3 mm in width. This ligature material is different than described by Rappole and Tipton (1991) and others (e.g., Neudorf and Pitcher 1997, Sanzenbacher et al. 2000, Mattsson et al. 2006) because it is flat rather than round.

For the small transmitters, we used 61 mm of the elastic material. Each end of the material was connected at 30 mm
from the end making a loop, with 1 mm in between the 2 loops (Fig. 2A). The transmitter was attached to the 1-mm area in the center of this design. For the large transmitter, we used 110 mm of the elastic material where 2 loops measuring 55 mm were attached in the middle, creating a figure-8 design (Fig. 2B). The loops were placed over the legs such that the transmitter sat on the back or synsacrum. Cyanoacrylate glue (Loctite Easy Squeeze Super Glue Gel; Loctite, Düsseldorf, Germany) was used to attach the transmitter to the elastic material. The transmitters with the leg-harness technique were made in advance (>1 day), allowing ample time for the cyanoacrylate glue to dry prior to placement on chicks.

When we attached the large transmitters, we selectively mixed bobwhites among the 5 groups to determine whether different transmitter attachment techniques resulted in prolonged effects on feather development. For example, one bobwhite from the silicone-gel group was switched to the control group, and one bobwhite from the control group was placed in the silicone-gel group. Seven bobwhites remained within their original groups, including 3 control birds, to allow us to evaluate captive-rearing protocols.

Results

No mortalities occurred for bobwhites <27 days. Of the 25 bobwhites ≥27 days, 2 chicks died due to hypothermia and 3 chicks disappeared from the outdoor aviary. Time and effort varied substantially between attachment techniques. Suturing required 2 people (1 person to hold the bird and 1 person to suture on the transmitter), and it took approximately 10 min. The tissue-glue technique required 1 person and took approximately 1 min. The silicone-gel technique required 1 person, but necessitated holding the chick for ≥10 min to assure adequate adhesion. The leg-harness technique required 1 person and took approximately 5 min to attach the small transmitter and ≤1 min for the large transmitter. We observed no impact on behavior for either the small or large transmitters.

On day 1 of the experiment, bobwhite body mass averaged 7.47 g (SD = 0.54, range = 6.35–8.85); the small transmitters were 4.7% of mean body mass. The large transmitters were 2.7% of mean day-12 body mass (22.83 g; SD = 2.58, range = 18.16–29.08). One bobwhite was <20 g until day 15; at which point the small transmitter was replaced with the large transmitter using the leg-harness technique. An additional bobwhite did not have its transmitter replaced at day 12. This transmitter was attached with silicone gel and we were unable to detach the transmitter without cutting or removing feathers. The transmitter fell off at day 23 and we continued to monitor this bobwhite to determine any adverse signs caused by the silicone gel.

The suture technique was successful for 3 of 5 bobwhites with the small transmitters, but unsuccessful for the large transmitters, with detachment ≤26 days after placement (Table 1). Based on daily examination, the loosening of the suture knots was the primary reason for detachment. It was unclear if the knots loosened due to the type of suture material used, administer error, slight “rocking” movement of the transmitter across the dorsal midline, or as a result of bobwhites pecking at each other’s sutures. The posterior knot untied first on all bobwhites and we were unable to detach the transmitter without cutting or removing feathers. The transmitter fell off at day 23 and we continued to monitor this bobwhite to determine any adverse signs caused by the silicone gel.

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Table 1. Retention success, mean number of days, and range of days transmitters remained attached on captive northern bobwhite and chukar chicks for the 4 transmitter attachment techniques employed (2007). Each treatment group consisted of 5 individuals.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Small transmitter</th>
<th>Large transmitter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Success</td>
<td>Mean</td>
</tr>
<tr>
<td>Phase I: bobwhites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suture</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Tissue glue</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Silicone gel</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Leg harness</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Phase II: chukars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suture with silicone gel</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Silicone gel then leg harness</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Suture with glued knots</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Leg harness</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

a No. of chicks retaining the small transmitter for 12 days and the large transmitter for 30 days.
b 0.35-g transmitter (LB-2N; Holohil Systems, Ltd, Carp, ON, Canada) with a predicted battery life of 12 days.
c 0.62-g transmitter (BD-2; Holohil Systems, Ltd, ON, Canada) with a predicted battery life ≥25 days.
d Tissue glue was attempted but unsuccessful.
e Transmitters retained for duration of small or large transmitter longevity.

resulting in the formation of a skin tag (i.e., a small piece of soft, hanging skin) below the neck.

The tissue-glue technique was unsuccessful for both the small and large transmitters (Table 1). The small transmitters detached <12 days after placement and the tissue glue did not adhere to pin feathers when attaching the large transmitters; however, the tissue glue did not appear to hinder feather development.

The silicone-gel technique was successful for only 1 of 5 small transmitters, and unsuccessful for the large transmitters (Table 1). The single successful small transmitter remained attached for 22 days. Silicone gel was not observed to negatively influence feather development.

The leg-harness technique was successful for all of the small and large transmitters (Table 1). Minor skin irritation (e.g., redness, scabbing, or thickening of the skin) occurred in the inguinal fold and/or synsacrum region for 2 and 3 bobwhites with the small and large transmitters, respectively. This irritation probably was caused by 1) the harness becoming too tight, 2) the clear elastic material being too wide, and/or 3) the rough surface where the transmitter attached to the clear elastic material. We modified the design of the leg harness for the large transmitters by 1) decreasing the width of the polyurethane clear elastic material to 1.5 mm, 2) increasing the length of the harness loops to 65 mm or 75 mm, and 3) placing a small piece of felt (<11 mm in length × 5 mm in width) on each transmitter with cyanoacrylate glue so that the felt side of the transmitter rest on the synsacrum (added <0.02 g). We replaced transmitters attached with the leg harness using our modified design at day 26. Two bobwhites still experienced minor skin irritation (redness) in the inguinal fold, but to a subjectively lesser degree than observed prior to these changes.

We did not observe substantive differences between the treatment groups and the control group for daily weight gain or behavior for either-size transmitter; no deaths were caused by transmitters or attachment technique. Bobwhites were observed pecking at each other’s transmitters, but we did not observe any physical injuries from this behavior.

PHASE II

Methods

Based upon the results of phase I, we removed tissue glue as a treatment technique and modified the remaining attachment techniques. The attachment techniques used for phase II included: A) suture with silicone gel, B) silicone gel for small transmitter, then leg harness for large transmitter, C) suture with glued knots, and D) leg harness. Five chukars were randomly placed in 1 of the 4 treatment groups or the control group and remained in their assigned group throughout the 42-day trial. Control group individuals were handled for approximately 5 min, the average handling time for each treatment group, so that all chukars were exposed to similar handling period. As in phase I, small transmitters were replaced with large transmitters on day 12.

Technique A consisted of suturing as described in phase I with the addition of a drop of silicone gel placed between the transmitter and chukars’ dorsal midline to prevent movement of the transmitter across the dorsal midline. An absorbable monofilament suture (4-0 MonocrylTM; Ethicon, NJ), with a FS-2 cutting needle, was used for both sizes of transmitters.

For Technique B, we attached the small transmitter with a drop of silicone gel on the interscapular region. The large transmitter was attached using the leg-harness design illustrated in Figure 2B with our modifications of 1.5-mm-width material and felt on the back of the transmitter. The length of the leg loops was 70 mm or 80 mm depending on the body mass of the chukars at placement.

Technique C consisted of suturing as described in phase I, with the addition of a drop of cyanoacrylate glue placed on each of the suture knots. Technique D used the leg-harness design in Figure 2B, and the material and felt modifications as described above for Technique B. The length of the leg loops was 45 mm for the small transmitters and 70 mm or 80 mm for the large transmitters, depending on chukar size.

Results

No chukar mortality occurred during the experiment. Similar to phase I, time and effort varied between attachment tech-
The 2 techniques involving suturing (Techniques A and C) required 2 people and took approximately 10 min. The silicone-gel attachment used in Technique B was administered by 1 person, but required the chick to be held >10 min to assure adequate adhesion. The leg-harness techniques (Techniques B and D) required 1 individual and took ≤1 min.

Chukar body mass averaged 14.9 g (SD = 1.23, range = 12.8–17.6) on day 1 of the experiment. We did not document any differences in growth rate due to the transmitter or the attachment method (Table 2). Sexual dimorphism was noted based on plumage characteristics by day 35 of the study. The control group had the highest proportion of males (4 of 5), which may explain why the growth rate of the control group was slower than that of the treatment groups (Table 2). Pin feather development did not appear to be affected in any of the treatment groups. Minor skin irritation (i.e., redness and scabbing) was observed in the inguinal fold on 2 of the chukars that were in the 2 treatment groups using leg-harness technique. We observed no effect on chukar mobility or foraging activity, nor did we observe chukars pecking on each other’s transmitter as observed with bobwhites.

For Technique A, the small transmitters stayed attached in all cases, but all the large transmitters detached prematurely (Table 1). For the large transmitters, the posterior suture detached first, followed by the anterior suture. Technique B was unsuccessful for the small transmitters (Table 1). Technique C was successful for all the small transmitters, but unsuccessful for all large transmitters. Either the anterior or posterior knot loosened 1–5 days prior to the transmitter detaching. In Techniques B and D the leg-harness attachment was 100% successful (Table 1).

### DISCUSSION

The leg-harness technique was the most reliable of the 4 external techniques used for mounting radiotransmitters on captive bobwhite and chukar chicks. This technique also is likely to be the most appropriate method for other species, particularly those of similar body size and body characteristics to our test species. Our leg-harness design had minimal attachment time, ≤1 min compared to that required for the other methods (≥5 min). Bedrosian and Craighead (2007) suggested this technique takes ≥15 min. We decreased attachment time by 1) preparing the leg harnesses with the transmitter in advance, and 2) using ligature material of 100% polyurethane clear elastic that stretches (manufacture suggests up to 5 times its original size), thus expediting attachment. Additionally, because the polyurethane elastic material we used is flat, we were able to decrease its width, thus minimizing the abrasions in the inguinal folds noted with round elastic yarn or thread (e.g., Sykes et al. 1990, Keedwell 2001, Mattsson et al. 2006). By placing a small piece of felt over the rough surface on the back of the transmitter, we eliminated the abrasions on the synsacrum of chukars as compared to those noted on the bobwhites.

Techniques involving suturing had the second highest level of success (3 bobwhites and 10 chukars out of 40 total treatment individuals). When suturing failed, it was due to loosening of the knots and/or absorption of the suture material. These problems could be resolved by applying cyanoacrylate glue to the knots and using a nonabsorbable monofilament. However, Houston and Greenwood (1993) and Rotella et al. (1993) suggest that placing cyanoacrylate glue on the suture knots and using a nonabsorbable monofilament is not reliable either. Regardless, the attachment time required by suturing was considerably longer (approx. 10 min) than for the leg-harness technique (≤1 min) and required an additional person to hold the chicks. Moreover, the suture technique may have limited applicability in some species, depending on physical stature and size; we found it difficult to suture transmitters to 1-day-old bobwhites and chukars because of the small surface area of their backs. This technique may be more appropriate for medium to large-sized birds with day-old chicks ≥20 g.

Our success in using liquid glues or gels to attach transmitters was similar to that reported in other studies (e.g., Sykes et al. 1990, Woolnough et al. 2004, Whittier and Leslie 2005). Tissue glue may be an adequate attachment method for studies that require only a few days of tracking; however, see Spears et al. (2002, 2005). We did not document any negative impacts from residual tissue glue on skin, downy feathers, or pin feather growth. We used silicone gel in our study because we assumed it would last longer and allow more flexibility than tissue glue. On the 2 chicks where the transmitter did adhere, the retention time was greatly improved (1–22 days) compared to the tissue-glue technique (≤12 days). However, silicone gel requires holding chicks longer (range = 10–30 min) than may be practical for most field studies.

Based upon the slope coefficients, and the respective standard deviation and confidence intervals, for the linear trend in growth rates for the treatment groups and controls, it does not appear that radiotransmitters of the sizes we used influenced growth rates of chukar chicks (Table 2). This is similar to other captive studies using various external attachment

### Table 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Slope</th>
<th>SE</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
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</thead>
<tbody>
<tr>
<td>Sutures with silicone gel</td>
<td>4.30</td>
<td>0.04</td>
<td>4.22</td>
<td>4.39</td>
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<td>Silicone gel then leg harness</td>
<td>4.28</td>
<td>0.04</td>
<td>4.20</td>
<td>4.37</td>
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<tr>
<td>Control</td>
<td>4.17</td>
<td>0.03</td>
<td>4.10</td>
<td>4.24</td>
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<tr>
<td>Suture with glued knots</td>
<td>4.65</td>
<td>0.05</td>
<td>4.54</td>
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<tr>
<td>Leg harness</td>
<td>4.39</td>
<td>0.04</td>
<td>4.31</td>
<td>4.46</td>
</tr>
</tbody>
</table>

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techniques in small passerines (Sykes et al. 1990), pheasant (Phasianus colchicus) chicks (Ewing et al. 1994), turkey (Meleagris gallopavo) poults (Hubbard et al. 1998), and doves (Zenaida spp.; Schulz et al. 2005, Small et al. 2005). Additionally, we observed no adverse behavioral effects, in terms of mobility or foraging activity, with any of the attachment techniques used.

Our study is one of only a few conducted to determine the most appropriate method of attaching radiotransmitters to galliform chicks (e.g., Mauser and Jarvis 1991, Ewing et al. 1994, Hubbard et al. 1998). We found that miniaturized radiotransmitters had no impact on behavior, body mass and growth, or physical development no matter which attachment technique we used on galliform chicks. This assessment is an important finding for future studies using radiotelemetry on chicks to aid management and conservation programs (Guthery and Lusk 2004, Barron et al. 2010). However, radiotransmitter attachment techniques varied in their longevity in staying adhered to chicks. This finding needs to be considered when designing field studies so the results reflect biological inferences and not field techniques (e.g., sampling process).

MANAGEMENT IMPLICATIONS

As the use of radiotelemetry in avian studies progresses, there is a need for further studies on the effect of radiotransmitters and the different attachment methods on all aspects (e.g., survival, behavior, growth) of a species, especially for chicks. Our leg-harness technique was the most reliable technique for attaching radiotransmitters to captive galliform chicks and also required minimal handling time. This technique is likely to be the most appropriate method for chicks of other species, particularly those of similar body size and body characteristics to our test species. Additionally, the leg-harness technique may be suitable for adults. We encourage others to critically assess the best method for attaching radiotransmitters to birds, especially young individuals such as newly hatched chicks, before embarking on field telemetry studies.

ACKNOWLEDGMENTS

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