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# Radio-transmitters do not affect seasonal mass change or annual survival of wintering Bicknell's Thrushes

Jason M. Townsend,[1,3,4] Christopher C. Rimmer,[2] and Kent P. McFarland[2]

[1] *College of Environmental Science and Forestry, State University of New York, 1 Forestry Drive, Syracuse, New York 13210, USA*

[2] *Vermont Center for Ecostudies, P.O. Box 420, Norwich, Vermont 05055, USA*

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ABSTRACT. Studies of the effects of transmitters on passerines have provided mixed results, but many have revealed no negative impacts. Most such studies have been conducted during the breeding season and, as a result, little is known about the possible effects of transmitters on wintering birds. We examined the effects of transmitters on Bicknell's Thrushes (*Catharus bicknelli*) wintering in the Dominican Republic. We used long-term mark-recapture data to compare birds with radio-transmitters ($N = 5$ years, 64 individuals) to birds banded, but not radio-tagged ($N = 10$ years, 164 individuals). For a subset of birds in each category, we measured the change in mass between early-winter and late-winter and, for all birds, we calculated return rates and modeled annual survival by sex and age classes. Return rates of radio-tagged (16%) and banded-only individuals (17%) did not differ, and survival models including the effect of transmitter attachment were poorly supported. We also found no sex or age-specific effects of transmitter attachment. Radio-tagged and banded-only birds did not differ either in the proportion of birds gaining mass during the winter or amount of mass gained. Our results indicate that attaching light-weight transmitters (<5% of body mass) to wintering Bicknell's Thrushes did not adversely affect either body condition or annual survival.

RESUMEN. **Radiotransmisores no afectan los cambios estacionales en masa o sobrevivencia anual en individuos invernales de Catharus bicknell**

Estudios sobre el efecto de radiotransmisores en paserinos, han provisto resultados mixtos, aunque muchos no han revelado impacto negativo. La mayoría de estos estudios han sido conducidos durante la época de reproducción, y como resultado, se conoce poco sobre el posible efecto de los radiotransmisores en aves invernales. Examinamos el efecto de transmisores en Catharus bicknell, que pasaron el invierno en República Dominicana. Utilizamos datos de recaptura de aves marcadas previamente, para comparar con aves con radiotransmisores (N = 5 años, 64 individuos), y aves anilladas, pero sin radiotransmisores (N = 10 años, 164 individuos). Para un subconjunto de aves, en cada categoría, medimos el cambio en masa entre temprano y luego tarde en el invierno, y para todas las aves calculamos la tasa de retorno y modelamos la sobrevivencia anual por sexo y grupo de edad. No encontramos diferencias en la tasa de retorno entre aves con radiotransmisores (16%) e individuos solamente anillados (17%) y los modelos de sobrevivencia, que incluyeron el efecto de los radiotransmisores, tuvieron poco apoyo. Tampoco encontramos efectos específicos de los radiotransmisores relacionados con la edad o sexo de las aves. Con respecto a la proporción en ganancia de peso durante el invierno o la ganancia de peso en general, no hubo diferencia, entre aves con radiotransmisores o anilladas. Nuestros resultados indican que el colocarles un radiotransmisor liviano (< 5% de la masa corporal) a individuos invernales del Zorzal de Bicknell no tiene efecto adverso en su condición corporal o en la sobrevivencia anual.

*Key words:* Catharus, Dominican Republic, Hispaniola, migratory songbird, Neotropical, radio telemetry

The results of several studies suggest that radio-transmitters have minimal impact on songbirds, with no effect on nestling feeding rates (Neudorf and Pitcher 1997, Hill et al. 1999, Gow et al. 2011), nestling survival (Hill et al. 1999, Gow et al. 2011), fledging success (Hill et al. 1999), juvenile survival and dispersal (Naef-Daenzer et al. 2001), breeding season inter-annual return rates (Powell et al. 1998, Anich et al. 2009), levels of stress hormones (Davis et al. 2008, Gow et al. 2011), migratory ability (Powell et al. 1998), and body condition during fall premigratory fattening (Rae et al. 2009). Other studies, however, have documented negative impacts of transmitter attachment for songbirds, including reduced interannual return rates (Samuel and Fuller 1996), declines in body mass (Sykes et al. 1990), increased

[3]Corresponding author. Email: jmt344@cornell.edu

[4]Current address: Cornell Lab of Ornithology, 159 Sapsucker Woods Road, Ithaca, NY 14850, USA.

levels of stress hormones (Suedkamp-Wells et al. 2003), and increased mortality of juveniles (Mattsson et al. 2006) and adults (Dougill et al. 2000).

The effects of radio transmitters on songbirds may also differ between breeding and non-breeding seasons. However, we are aware of only one study of the effect of transmitters on songbirds during winter, with Davis et al. (2008) finding no effect of transmitters on hematological stress indices of Hermit Thrushes (*Catharus guttatus*) wintering in the southeastern United States. To our knowledge, the possible effects of transmitters on a Nearctic-Neotropical long-distance migrant during the winter have not been examined. Events during winter, such as inter- and intraspecific competition for spatial and food resources, and food scarcity during the late winter dry season, can be physiologically taxing on overwintering migrants and can limit populations (Sherry and Holmes 1996, Holmes 2007). Individuals surviving the winter in optimal physical condition are energetically better prepared for spring migration, and may arrive earlier and in better condition in breeding areas, with attendant increases in reproductive fitness (Norris et al. 2004) and greater interannual survival (Marra and Holmes 2001).

Although radio-transmitters could interfere with the winter-long challenge of maintaining physical condition, this potential effect has rarely been evaluated (Barron et al. 2010). We compared interannual return rates of radio-tagged and banded-only Bicknell's Thrushes (*Catharus bicknelli*) at wintering sites in the Dominican Republic, and used these data to model annual survival. We further compared in-season changes in body condition for a subset of radio-tagged and banded-only individuals captured during early-winter and again in late-winter prior to migration. We hypothesized that if the added weight of transmitters negatively impacted individuals, then body mass would decrease during the period when birds were radio-tagged and return rates and estimates of annual survival for individuals with radio-transmitters would be lower than for banded-only individuals. We also postulated that, among radio-tagged birds, the lightest individuals (females and yearlings, J. M. Townsend, unpubl. data) would have the lowest return rates. Finally, we examined the possibility that lightweight cotton quilting thread used for backpack harnesses in our study would degrade naturally, potentially precluding the need to recapture birds to remove transmitters in future studies.

## METHODS

We conducted mark-recapture mist-netting in the Dominican Republic from 2000 to 2010 at a high-elevation cloud forest site in the Sierra de Bahorucos (18°12' N, 71°32' W), and from 2004 to 2010 at a mid-elevation rainforest site in the Cordillera Septentrional (19°25′N, 70°8′W). Both sites represent preferred habitat for Bicknell's Thrushes, and supported similar population densities (Townsend et al. 2010). We captured birds in 6- and 12-m, 36-mm-mesh mist-nets using both passive netting and playback of conspecific vocalizations. Captured birds were banded with a USGS aluminum band and weighed (±0.1 g). We also measured unflattened wing chord and tail (±0.1 mm) and tarsus (±0.01 mm). Birds were aged as second year (SY) or after second year (ASY) by the shape of their rectrices (Collier and Wallace 1989), and blood samples were analyzed by polymerase chain reaction to determine sex (Griffiths et al. 1998, Townsend et al. 2010). From 1 January to 1 March 2005 – 2008, we fitted a subset of birds ($N = 64$) with 1.2-g radio transmitters (Model BD-2G, expected battery life = 43–74 days; Holohil Systems, Carp, ON, Canada). Transmitters constituted < 4.5% of the mean mass of wintering Bicknell's Thrushes (26.7 ± 0.08 [SE] g, range = 22 – 34 g, $N = 280$). Transmitters were never attached to birds weighing less than 24 g.

Among wintering Bicknell's Thrushes, body size (based on a prinicipal components analysis of the combined measurements of wing, tail and tarsus, $N = 235$, J. M. Townsend unpubl.data) and mass vary with sex and age. Second-year females are the smallest-bodied individuals and ASY males the largest. After-second-year females and SY males are similar in size and are intermediate between SY females and ASY males. Among radio-tagged birds in our study, SY females (mean mass = 25.2 ± 0.5 g, $N = 9$) were the lightest, ASY males (mean mass = 27.1 ± 0.2 g, $N = 25$) were the heaviest, with ASY females (mean mass = 26.7 ± 0.4 g, $N = 8$) and SY males (mean mass = 26.5 ± 0.4, $N = 22$) in between. After-second-year males were significantly heavier than thrushes in other age-sex categories (ANOVA, $F_{3,61} = 5.5$, $P = 0.0011$).

We attached radio-transmitters using a backpack harness (Rappole and Tipton 1991) that consisted of a loop harness of cotton thread (50 weight; Gütermann, Gutach-Breisgau, Germany) run under each upper thigh (weight of thread < 0.1 g). We used cotton thread because we believed it would deteriorate faster than synthetic materials, allowing transmitters to fall off after batteries died. We attempted to recapture radio-tagged and banded-only individuals during late-winter (15 March–30 April) to assess changes in body condition over the season. Although Bicknell's Thrushes are secretive and quickly become attuned to netting efforts, we recaptured seven radio-tagged individuals and 13 banded-only individuals. We weighed recaptured birds (±0.1 g) for comparison with weights when initially captured. Mass measurements were adjusted for time of day based on the positive relationship of time of day to mass revealed by an ANCOVA of body size, time of day, sex, and season for 228 wintering Bicknell's Thrushes captured between 1999 and 2010 (J. M. Townsend, unpubl. data). In subsequent years, we attempted to recapture all radio-tagged and banded-only individuals from previous years to determine recapture rates. Birds were rarely resighted due to the dense vegetation and secretive nature of the species, so return rates were based on recaptures.

To assess changes in body mass, we used ANOVA (Sokal and Rholf 1995), with change in mass as the dependent variable and sex, age, telemetry status (radio-tagged or banded only), and interactions of sex × telemetry status and age × telemetry status as effects. We compared recapture rates among sex and age classes for radio-tagged and banded-only birds. Because recapture rates were expressed as proportions, we employed a generalized linear model (GLM) with binomial distribution and logit transformation, weighted by sample sizes (Wilson and Hardy 2002). In this model, the dependent variable was the proportion of thrushes recaptured in a subsequent year, and the independent variables were sex, age, telemetry status, sex × telemetry status, age × telemetry status, and sex × age × telemetry status. Data were analyzed using the statistical program JMP v 9.0 (SAS 2007), and results are presented as means ± SE. We also used Program MARK (version 4.3) to estimate apparent between-year survival probabilities (Cooch and White 2008). We constructed an *a priori* set of 12 candidate Cormack—Jolly–Seber (CJS) models (Lebreton et al. 1992) to evaluate the effect of radio attachment on annual survival and the potential for sex and age classes to be affected differently by radio attachment. The validity of CJS models relies on the assumption that all birds have an equal chance of being recaptured. We used the results of the GLM analysis (above) to test this assumption. We assessed goodness-of-fit of the global model by calculating the median variance inflation factor (c-hat) in MARK, which provides a measure of overdispersion in the data set (Cooch and White 2008). We compared candidate models using Akaike's information criterion adjusted for small sample sizes ($AIC_c$; Akaike 1973, Burnham and Anderson 2002). We ranked models according to their $\Delta AIC_c$, which is the relative difference between the model with the lowest $AIC_c$ (best-fitting model) and each other model, and $AIC_c$ weights ($w_i$), which give a model's relative probability of being the best-supported model. The model with the lowest $\Delta AIC_c$ and highest $w_i$ was chosen as the best explanation of the data, and the relative likelihood of each lower-ranked model was assessed using evidence ratios ($w_1/w_j$, where $w_1 = w_i$ of the best-supported model and $w_j = w_i$ of another model in the candidate set).

## RESULTS

**Seasonal change in mass.** For birds captured both early and late in the winter, mean mass change was positive and did not differ between radio-tagged ($N = 7$) and banded-only ($N = 13$) individuals ($F_{1,14} = 0.4$, $P = 0.50$; Fig. 1). Mass gain was not affected by either sex ($F_{1,14} = 3.6$, $P = 0.08$) or age ($F_{1,14} = 1.0$, $P = 0.33$). Mean mass gain was 0.10 ± 0.37 g for radio-tagged birds and 0.40 ± 0.26 g for banded-only birds. Four of seven radio-tagged birds gained mass (57%) as did seven of 13 banded-only birds (54%); the remaining birds lost or maintained mass. The mean number of days between captures was 57 ± 6 days (range = 28–66 days) for birds with radio-transmitters and 73 ± 11 days (range = 32–89 days) for banded-only birds. All radio-tagged birds still had transmitters attached when recaptured. Several birds had rough, callused skin

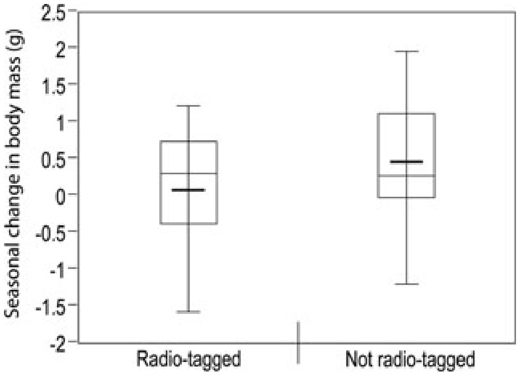


Fig. 1. Changes in body mass of wintering Bicknell's Thrushes with and without radio-transmitters attached between early (December–January) and late (March–April) winter in the Dominican Republic, 2000–2010. Box plots show the upper and lower quartiles. Whiskers show the sample minimum and maximum. The median is represented by a horizontal line spanning the width of the box, and the mean is represented by a partial horizontal line in bold.

along the undersides of their thighs where the cotton string made contact and the skin of one bird had healed over the point of contact with the harness material. Birds had preened feathers over top of the radio transmitters on their backs and there were no signs of skin irritation in this area.

**Recapture rates.** We found no effect of sex, age, radio attachment, or the interaction of these effects on interannual recapture rates (Table 1), although the age × telemetry interaction approached significance ($P = 0.051$), driven by the higher proportion of recaptured radio-tagged SY females (Table 2). Overall recapture rates (Table 2) were 0.17 for radio-tagged birds ($N = 64$) and 0.16 for birds without transmitters ($N = 164$). Among recaptured radio-tagged birds ($N = 11$), only one still had its transmitter attached more than one year later. One bird's transmitter had been removed by field workers the previous winter, but transmitter harnesses degraded naturally for nine of 10 recaptured radio-tagged Bicknell's Thrushes.

**Annual survival.** Our global model (Φ [sex × age × telemetry] *p* [year]) fit the data well ($P = 0.12$) with little evidence of overdispersion (median c-hat = 1.01). We therefore did not adjust for overdispersion, and used $AIC_c$ as the criterion for evaluating our candidate set of models. The best-supported model showed yearly variation in survival with constant recapture probability (Table 3), and the next-best-supported model (constant survivorship and recapture probability) had a $\Delta AIC_c$ value of 2.4, indicating moderate support for a real difference between these models (Burnham and Anderson 2002). We found weak support for all models containing an effect of radio-transmitters or the interaction of sex and age with radio-transmitters; the best-supported model containing an effect of telemetry had a $\Delta AIC_c > 4$ and low $w_i$ (Table 3). Evidence ratios showed the model containing yearly variation in survival and constant recapture probability (Φ [year] *p* [.]) to be nine times more likely to fit the data than the top-ranked model containing an effect of telemetry. The overall sum of weights for models containing no effect of telemetry on apparent survival was 83% compared to 16% for models containing an effect of telemetry.

Table 1. Results from a GLM predicting the effect of sex, age, and radio-transmitter attachment on return rates of overwintering Bicknell's Thrushes in the Dominican Republic.

| Effect | DF | Chi square | *P* |
|---|---|---|---|
| Trans[a] | 1 | 0.3 | 0.60 |
| Sex (male/female) | 1 | 0.6 | 0.46 |
| Age (yearling/adult) | 1 | 0.02 | 0.90 |
| Trans × sex | 1 | 0.4 | 0.53 |
| Trans × age | 1 | 3.8 | 0.051 |
| Trans × sex × age | 1 | 0.01 | 0.92 |

[a]Birds with a 1.2-g radio-transmitter attached versus birds only banded.

Table 2. Annual return rates by sex and age class of wintering radio-tagged and banded-only Bicknell's Thrushes in the Dominican Republic.

| | Male | | Female | | All birds |
|---|---|---|---|---|---|
| | SY | ASY | SY | ASY | |
| Radio-tagged | | | | | |
| *N* | 22 | 25 | 9 | 8 | 64 |
| Proportion returning | 0.18 | 0.12 | 0.33 | 0.13 | 0.17 |
| Not radio-tagged | | | | | |
| *N* | 51 | 63 | 26 | 24 | 164 |
| Proportion returning | 0.10 | 0.21 | 0.12 | 0.21 | 0.16 |

Table 3. Models evaluating the effects of year, telemetry status (radio-attached or banded-only) and the interaction of sex and age with telemetry status on between-year apparent survival (Φ) and detection probabilities ($p$) for Bicknell's Thrushes wintering in the Dominican Republic, 1999–2004. Models are ranked by Akaike's information criterion adjusted for small sample size ($AIC_c$) and the 12 a priori models are shown. K is the number of parameters, $\Delta AIC_c$ is the relative difference between the model with the lowest AIC (best-fitting model) and each other model, $w_i$ describes a model's relative probability of being the best-supported model, and deviance is the amount of unexplained variance. The best model was of yearly variation in survivorship and constant recapture probability. All models including the effect of radio attachment were poorly supported.

| Model | K | $\Delta AIC_c$ | $w_i$ | Deviance |
|---|---|---|---|---|
| Φ(year) $p$(.) | 11 | 0.00 | 0.57 | 142.26 |
| Φ(.) $p$(.) | 2 | 2.35 | 0.18 | 163.64 |
| Φ(telem) $p$(.) | 3 | 4.39 | 0.06 | 163.63 |
| Φ(.) $p$(year) | 11 | 4.39 | 0.06 | 163.63 |
| Φ(sex × telem) $p$(.) | 5 | 5.94 | 0.03 | 161.03 |
| Φ(age × telem) $p$(.) | 5 | 5.97 | 0.03 | 161.07 |
| Φ(telem) $p$(year) | 12 | 6.55 | 0.02 | 146.61 |
| Φ(year) $p$(year) | 18 | 6.72 | 0.02 | 133.18 |
| Φ(age × telem) $p$(year) | 14 | 8.16 | 0.01 | 143.76 |
| Φ(sex × telem) $p$(year) | 14 | 8.24 | 0.01 | 143.84 |
| Φ(sex × age × telem) $p$(.) | 9 | 11.93 | 0.00 | 158.54 |
| Φ(sex × age × telem) $p$(year) | 18 | 14.57 | 0.00 | 141.03 |

## DISCUSSION

We detected no difference in recapture rates or annual survival between wintering Bicknell's Thrushes radio-tagged for at least four weeks and those without transmitters. Recapture rates were similar (16% for radio-tagged birds and 17% for birds without radio tags), and models of annual survival based on these recaptures showed little support for the effect of radio-transmitters; models containing interannual variation in survivorship or constant survivorship were more likely to explain the data. We also found similar seasonal changes in mass between recaptured radio-tagged and banded-only birds, with no significant difference in mean mass increase or proportion of individuals increasing in mass. Many investigators have used trends in seasonal mass change as a proxy for overall condition of wintering migrants (i.e., Latta and Faaborg 2002, Brown and Sherry 2006, Smith et al. 2011) and, although multiple factors can influence mass change during the winter, including temperature, time of year, social hierarchies, food sources, and food abundance (Gosler 1996, Pravosudov et al. 1999, Diggs et al. 2011), birds in the best condition can be expected to increase in mass during late winter as they fatten and prepare for northward migration. Although our body mass results should be viewed with caution because of small sample sizes and the potential for Type II error, they suggest that radio-tagged Bicknell's Thrushes were able to gain mass by late winter at rates similar to banded-only birds.

We also found no sex or age-specific effects of transmitters, although the interaction between age and telemetry status (radio-tagged vs. banded-only) on recapture rates was nearly significant ($P = 0.051$). This was due to the higher recapture rates of radio-tagged SY females, which ran counter to our initial hypothesis that, due to weight constraints, the impact of radio transmitters might be greater for smaller individuals. It is not clear why radio-tagged SY females tended to be recaptured at higher rates in our study, but it likely reflects our small sample size. Overall, our results suggest that attaching radio-transmitters weighing $\leq 4.5\%$ of body weight had no detectable adverse effects even for the lightest Bicknell's Thrushes in the population.

Using cotton harness material, we found that harnesses of nine of 10 birds returning in subsequent years degraded naturally. Powell et al. (1998) found that transmitters on six Wood Thrushes (*Hylocichla mustelina*) fitted with 9-kg test Dacron harness material, a synthetic material, remained intact 9 – 21 months later, whereas transmitters fell off naturally on six of seven birds harnessed with 5-kg test Dacron. Hill et al. (1999) used stretchable milliners elastic with cotton weave to attach transmitters to European Blackbirds (*Turdus merula*) and reported no negative effects; use of this material may alleviate the skin abrasions noted in our study. Cotton quilting thread, milliners elastic, and 5-kg test Dacron may all represent suitable materials that ensure that harnesses degrade. These attachment techniques might alleviate some of the negative impacts of the weather-proof harness materials, collars, and subcutaneous attachment techniques commonly used on non-passerines (Barron et al. 2010).

As with Bicknell's Thrushes in our study, studies of other songbirds have revealed no effect of radio-transmitters on body condition and interannual return rates. For example, Anich et al. (2009) reported similar return rates to breeding areas for radio-tagged and banded-only Swainson's Warblers (*Limnothlypis swainsonii*), and Powell et al. (1998) reported similar results for Wood Thrushes. In addition, interannual mass change did not differ for radio-tagged and banded-only Wood Thrushes, and flight performance models revealed that adding the weight of a transmitter had a negligible impact on their ability to complete migration (Powell et al. 1998). Similarly, the body condition of Savannah Sparrows (*Passerculus sandwichensis*) radio-tagged and recaptured during fall pre-migratory fattening (early August to mid-October) was comparable to that of non-radio-tagged individuals (Rae et al. 2009).

Our results and those of other studies suggest that radio-transmitters weighing $< 4.5\%$ of body mass can be safely used on small, migratory songbirds with minimal effect on their condition and survival. We detected no effect of transmitters on the ability of radio-tagged Bicknell's Thrushes to survive the winter in appropriate condition for spring migration. We recommend the use of radio-telemetry during the nonbreeding season to better understand the behavior and ecology of overwintering Nearctic-Neotropical passerines.

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