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COMMENTARY

Comment on "Mixed effects of geolocators on reproduction and survival of Cerulean Warblers, a canopy-dwelling, long-distance migrant"

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ABSTRACT

A recent paper published in *The Condor: Ornithological Applications* by Raybuck et al. (2017) described the results of an analysis of potential effects of light-level geolocators on reproductive parameters and apparent annual survival of Cerulean Warblers (*Setophaga cerulea*). In a comparison of geolocator-tagged birds and color-banded control birds, the authors reported no discernible differences in several standard reproductive parameters, but a significant difference in apparent annual survival. Here, we show that the reported overall geolocator effect on annual survival may have obfuscated a large effect in one year, when one geolocator model and harness method were used, compared with no effect on annual survival in the second year of their study, when a different geolocator model and harness method were used. These more nuanced results suggest that Raybuck and colleagues may have identified variation in effects between geolocator marking methods for Cerulean Warblers, rather than a general geolocator effect on annual survival.

Keywords: geolocator effects, harness, migration, marking methods, passerine

Comentario sobre "Efectos mixtos de geo-localizadores en la reproducción y la supervivencia de *Setophaga cerulea*, un migrante de larga distancia habitante del dosel"

RESUMEN

Un artículo recientemente publicado en *The Condor: Ornithological Applications* por Raybuck et al. (2017) describe los resultados de un análisis sobre los potenciales efectos de geo-localizadores de nivel liviano sobre parámetros reproductivos y la supervivencia anual aparente en *Setophaga cerulea*. En una comparación de aves marcadas con geo-localizadores y aves control marcadas con anillos de color, los autores presentan que no existen diferencias discernibles en varios parámetros reproductivos standard, pero que sí existe una diferencia significativa en la supervivencia anual aparente. Aquí mostramos que el efecto global presentado del geo-localizador en la supervivencia anual puede ofuscar un gran efecto en un año, cuando se usaron un modelo de geo-localizador y un método de arnés, en comparación a la falta de efecto en la supervivencia anual en el segundo año de su estudio cuando se usaron un modelo de geo-localizador y un método de arnés diferentes. Estos resultados más matizados sugieren que Raybuck y sus colegas pueden haber identificado variación entre métodos de marcación con geo-localizadores para *Setophaga cerulea*, más que un efecto general del geo-localizador en la supervivencia anual.

Palabras clave: arnés, efectos del geo-localizador, métodos de marcación, migración, paserinos

In a recent paper published by Raybuck et al. (2017) in *The Condor: Ornithological Applications*, the authors described marking a small sample ($n = 10$) of adult male Cerulean Warblers (*Setophaga cerulea*) in 2014 with Intigeo W-30 geolocators (Migrate Technology, Coton, Cambridge, UK) using a harness method "recommended by the manufacturer" and citing Rappole and Tipton (1991). The authors then described marking a second, considerably larger sample ($n = 39$) of adult male Cerulean Warblers with a different geolocator model (MK6040, Biotrack, Wareham, UK) in 2015 using a different harness method, citing Streby et al. (2015). A sample of control birds was also marked in 2014 ($n = 14$) and 2015 ($n = 38$) with colored leg bands. Although the differences in geolocator marking methods were described as slight, we argue that they were significant and should be considered in more detail.

The geolocator model used in the first year by Raybuck et al. (2017) was 3.6–4.0% of body mass, while the model used in the second year was 33% heavier, at 4.8–5.3% of body mass. Shape also differed slightly, with the unit used in the first year having an irregular ventral surface compared with the flat surface of the device in the second year. Neither model included a light stalk, a feature that may increase drag (Bowlin et al. 2010).

The harness method used in the first year involved running harness material through tubes in the front and

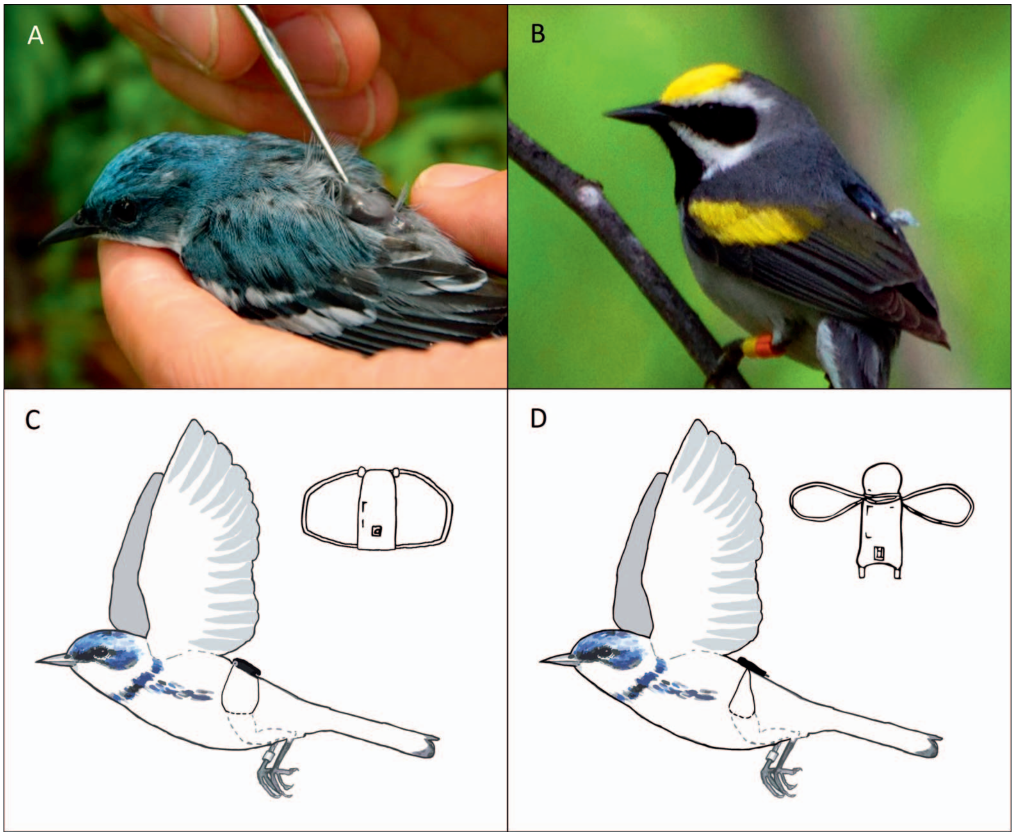

FIGURE 1. Marking methods used by Raybuck et al. (2017) on Cerulean Warblers (*Setophaga cerulea*). Pictured are (**A**) a geolocator attached to a Cerulean Warbler using the the Φ harness in the first year of their study (photo credit: Nathan Weyandot), and (**B**) a geolocator attached to a Golden-winged Warbler (*Vermivora chrysoptera*) using the Streby et al. (2015) harness, the harness that Raybuck et al. (2017) used on Cerulean Warblers in the second year of their study (photo credit: Gunnar Kramer). Illustrated are (**C**) the Φ harness and (**D**) the Streby et al. (2015) harness on Cerulean Warblers (illustrations by Sarah Fischer).

back of the geolocator, after which the ends of the harness were crimped on both sides of the device (Figure 1). This method, which we refer to as the Φ harness due to its shape, does not resemble the figure-8 harness described by Rappole and Tipton (1991), although that paper is routinely cited in studies using the Φ harness. We think that the Φ harness produces distinct pressure points on the bird, one under the entire geolocator and one point under each leg. In our observations, this method allows for considerable movement of the harness. In addition, the Φ harness places the entire geolocator flat on the bird's back, which may have consequences for skin abrasion, conductive heat and moisture transfer between the bird and the geolocator, feather growth under the geolocator, and the bird's ability to preen under the geolocator.

The harness method used in the second year by Raybuck et al. (2017) is described by us and other authors in Streby et al. (2015), has been used with no discernible effects on other migratory warblers (Peterson et al. 2015), and is recommended by the U.S. Geological Survey (USGS) Bird Banding Laboratory for use with geolocators on small songbirds. The Streby et al. (2015) method includes a harness that is fully prepared prior to capturing birds and thus can be applied quickly in the field with no additional attachment materials. This method is a true figure-8 harness (sensu Rappole and Tipton 1991) that fits around the bird's legs and back with the pressure spread evenly around the entire harness. Any marking device, including a geolocator, can be attached to this harness with no loops, tubes, or other manufacturer add-ons (Streby et al. 2015). The Streby et al. (2015) method involves closed harness loops that meet at a single point under the geolocator, minimizing the potential area of skin abrasion and prohibiting rotational movement of any portion of the marker or harness against the bird's legs or back. This method holds the geolocator slightly above the bird's back (i.e. on top of the harness), thus allowing regular feather growth and regular preening under the geolocator (G. Kramer and H. Streby personal observations), limiting potential thermal conductance or water transfer between the geolocator and the bird, and minimizing potential shading of light sensors by feathers, making light stalks unnecessary (Peterson et al. 2015).

Raybuck et al. (2017) reported that the univariate effect of year (i.e. geolocator type) was not included among the top models of Cerulean Warbler return rate, although the top models did include an interaction term between group (i.e. bird marked with a geolocator or not) and year. It is possible that poor support for a univariate model including only the year parameter was driven by sparse data (24% of the total sample) in the first year of the study.

Regardless of univariate model results, chi-square tests of independence can be used to evaluate geolocator effects from these data. Through communication with the lead author of Raybuck et al. (2017), we obtained the raw apparent survival data for each group during each year, which were not reported in the published paper. In the first year of geolocator recovery, following the use of the lighter geolocator and the Φ harness design, apparent survival of marked birds was 10% (1 of 10) and apparent survival of control birds was 50% (7 of 14). In the second year of geolocator recovery, after the authors switched to using heavier geolocators and the Streby et al. (2015) harness method, apparent survival of marked birds was 18% (7 of 39) and apparent survival of control birds was 29% (11 of 38). Return rates of migratory songbirds can vary greatly among years, including those of Cerulean Warblers (Jones et al. 2004). It is therefore important that return rates of birds marked with geolocators in different years be compared only with each other in the context of contemporaneous control birds (as also suggested by the group*year interaction in Raybuck et al. [2017]). The return rates of marked birds appear similar between year 1 (10%) and year 2 (18%). However, the return rates of control birds in year 1 (50%) and year 2 (29%) are the contemporaneous expected return rates for each year. Therefore, the effective return rates of marked birds (i.e. the return rate of marked birds as a function of the return rate of same-year control birds) differed considerably between years: 20% in year 1, compared with 62% in year 2.

A chi-square test of the overall apparent survival for both years combined corroborates the conclusion of Raybuck et al. (2017) of a significant geolocator effect ($\chi^2 = 4.41$, $P = 0.04$). Although the small sample sizes led to undesirably low expected values in the first-year data, a chi-square test nonetheless indicates that there was a geolocator effect in that year ($\chi^2 = 4.20$, $P = 0.04$). A similar analysis of the second-year data, with heavier geolocators and the Streby et al. (2015) attachment method, did not lead to rejection of the null hypothesis of no effect ($\chi^2 = 1.30$, $P = 0.25$). This new analysis demonstrates that the overall geolocator effect was driven by the large difference in apparent survival between marked and control birds in the small first-year sample, a pattern that was not repeated in the second year. It is possible that the difference in group-specific survival that we associate here with marking method was instead driven by another annual variable that somehow affected marked and control birds differently in different years, but we believe that the marking method is a reasonable explanation for the difference between years. Interestingly, the negative geolocator effect was present in the year in which Raybuck et al. (2017) used a considerably lighter geolocator, suggesting that geolocator mass may be less important than harness type when marking Cerulean Warblers with geolocators.

To our knowledge, no other studies have reported return rates of a single species marked with multiple geolocator harness types. However, a team in Tennessee, USA, recently recovered 31% (5 of 16) of Louisiana Waterthrushes (*Parkesia motacilla*) marked with geolocators using the Streby et al. (2015) harness method and 31% of control birds, with search efforts still underway when we submitted this manuscript (R. Huffines personal communication). That study followed multiple attempts by other groups to track Louisiana Waterthrushes using the Φ harness method, each of which resulted in very low return rates and serious injuries to birds consistent with those described above (R. Huffines personal communication). Increasing numbers of migratory birds are being marked with geolocators and other tracking devices each year. It is becoming increasingly important to assess the potential impacts of markers and marking methods and to share those results in the literature. Properly analyzing and interpreting the results of such studies is necessary for guiding decision making about future research into each method and species.

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