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Author(s): Matthew D. Johnson, Daniel R. Ruthrauff, Joshua G. Jones, James R. Tietz, and Jennifer K. Robinson
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Short-term effects of tartar emetic on re-sighting rates of migratory songbirds in the non-breeding season

Matthew D. Johnson,[1] Daniel R. Ruthrauff, Joshua G. Jones, James R. Tietz, and Jennifer K. Robinson

Department of Wildlife, Humboldt State University, Arcata, California 95521 USA

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ABSTRACT. Forced regurgitation by oral administration of tartar emetic has been used frequently to examine avian diets because it does not require killing birds directly, but indirect (delayed) mortality by this technique is not well studied. We examined the effects of tartar emetic on re-sighting rates of insectivorous migratory songbirds in Jamaica during the non-breeding season. The re-sighting rate of Black-throated Blue Warblers (*Dendroica caerulescens*) experimentally treated with tartar emetic was significantly lower than for control birds. The re-sighting rates of American Redstarts (*Setophaga ruticilla*), Black-and-white Warblers (*Mniotilta varia*), and Prairie Warblers (*Dendroica discolor*) treated with tartar emetic were also lower than those of birds that were banded and released without treatment. Pre-release mortality rates were low (<3%), but two treated Black-throated Blue Warblers were found dead up to 22 h after release. Our results suggest application of tartar emetic is an effective but invasive method for collecting diet samples from birds. Researchers should consider alternatives, and future administration of tartar emetic should be conducted conservatively and with acknowledgment of its occasionally lethal results.

SINOPSIS. **Efecto a corto alcance de eméticos de tártaro en la tasa de reavistamiento durante la temporada no reproductiva de aves canoras migratorias**

La utilización de eméticos tartáricos para forzar el vomitar, ha sido utilizado con mucha frecuencia para examinar la dieta de aves. Estas sustancias son utilizadas porque no requieren el matar el pájaro, pero la mortalidad causada indirectamente por esta técnica no ha sido estudiada. Estudiamos el efecto de estas sustancias en la tasa de reavistamiento, durante la época no reproductiva, de aves canoras que pasan el invierno en Jamaica. La tasa de reavistamiento de Dendroica caerulescens fue significativamente menor que la del grupo control. La tasa de reavistamiento de *Setophaga ruticilla*, *Mniotilta varia*, *Dendroica discolor*, tratado con el emético resultó también más baja que aquellas aves que fueron capturaras, anilladas y luego liberadas. La tasa de mortalidad pre-liberación resultó baja (<3%), pero dos aves (*D. caerulescens*) fueron encontradas muertas 22 horas más tarde de haber sido liberada. Nuestros resultados sugieren que la aplicación de eméticos de tártaro es un método invasivo pero efectivo para coleccionar muestras de la dieta de aves. Los investigadores deben buscar otros métodos como alternativa. La administración futura de estos eméticos debe llevarse acabo conservadoramente con el conocimientos de que ocasionalmente van a resultar letales.

Key words: diet, food, insect, regurgitation, survival, warbler

Data on food preferences are critical for studies of avian biology, but most techniques to obtain them are invasive to birds. Of the many methods used to collect avian diet samples, forced regurgitation by oral administration of tartar emetic has been used frequently because it does not require killing birds directly (see review, Rosenberg and Cooper 1990). Early examinations of possible indirect (delayed) mortality by this technique, however, are equivocal. Lederer and Crane (1978) documented reduced recapture probabilities for treated birds, and Zach and Falls (1976) found higher mortality for treated birds in captivity, but other studies failed to demonstrate significant effects (Prys-Jones et al. 1974; Tomback 1975). More recent analyses have corroborated the absence of significant detrimental effects (Poulin et al. 1994), prompting the conclusion that the administration of tartar emetic is "an efficient and harmless technique to investigate food preferences of birds from any feeding habit" (Poulin and Lefebvre 1995:897).

Such appraisal of tartar emetic is premature, however, because the technique has not been tested adequately. Reports that only about 2% of birds die within 15 min of administration of the emetic (i.e., "pre-release mortality," Poulin et al. 1994; Poulin and Lefebvre 1995) are misleading because mortality, when it has been documented, has usually been after several days

[1] Corresponding author. Email: <mdj6@humboldt.edu>

(Zach and Falls 1976; Lederer and Crane 1978). A recent observation that recapture rates were similar for treated and untreated birds (Poulin and Lefebvre 1995) also fails to support the tartar emetic procedure unambiguously. This study was designed primarily to examine breeding phenology in relation to food availability (Poulin et al. 1992), and it was conducted on paired plots in which birds did and did not receive the emetic treatment. Recapture rates of (untreated) birds often differ among replicate study plots of similar habitats (e.g., Wunderle 1995; Sherry and Holmes 1996). Thus, while the data from that study are very useful from an ecological perspective and because the sample sizes were very large, the design was inadequately controlled to evaluate the emetic technique itself because effects of treatment and study plot on recapture rate were confounded.

Additional experiments on the effects of tartar emetic are needed to evaluate its potential to provide diet samples without killing birds. Controlled experiments on recapture rates for treated and untreated birds are helpful, but because treated, stressed birds may avoid nets more than untreated birds, studies involving the re-sighting of individually marked birds are also needed. Searching study areas intensively for marked birds also has the advantage of potentially revealing dead birds (Lederer and Crane 1978), whereas delayed mortality is impossible to distinguish from desertion with recapture rates. Only one previous study of tartar emetic has examined the re-sighting rates of individually marked birds (Prys-Jones et al. 1974). Prys-Jones et al.'s work was conducted on omnivorous House Sparrows (*Passer domesticus*) during the breeding season, and no significant differences between treated and untreated birds were found. Studies of non-breeding insectivores are needed.

We examined the effects of tartar emetic on re-sighting rates of insectivorous migratory songbirds in Jamaica during the non-breeding season. We conducted a controlled experiment on Black-throated Blue Warblers (*Dendroica caerulescens*), and we investigated general re-sighting rates of four other warbler species: American Redstarts (*Setophaga ruticilla*), Black-and-white Warblers (*Mniotilta varia*), Northern Parulas (*Parula americana*), and Prairie Warblers (*Dendroica discolor*). Specifically, we tested the null hypothesis that the short-term re-sighting rate of warblers that were captured, banded, treated with tartar emetic, and released was not lower than for those that were captured, banded, and released without treatment.

STUDY AREA AND METHODS

Our study area was within the Baronhall Coffee Farm, Clarendon Parish, Jamaica (18°13′N, 77°22′W). This farm is a mid-elevation (550–560 m) shade-grown coffee plantation located in Jamaica's interior, which receives a moderate amount of rainfall annually (250–375 cm, Lack 1976). Habitat at the plantation was comprised of two distinct vegetation layers: an overstory shade canopy dominated by *Inga vera* (and to a minor extent banana trees, *Musa* spp.) and an understory that consisted solely of cultivated coffee rows (*Coffea arabica* var. *typica*). Depending on the age of the shade trees on the site, the canopy varied from tall (12–18 m) and moderately closed (45–70% cover) to short (4–6 m) and relatively open (20–60% cover). Due to the infrequent pruning of coffee trees over most of the plantation, the understory was relatively tall (1.8–3 m) and dense. However, we worked in a 5-ha study area within the plantation, of which approximately 2 ha had recently been severely pruned (spring 1999), leaving a much shorter understory (<1.5 m). The study area was flagged and gridded at 50 m intervals to aid in re-sighting efforts.

To examine the effects of tartar emetic on insectivorous migratory songbirds, we ran 9–13 mist nets (12-m, 30-mm mesh) at various locations among the coffee rows between 07:00 to 16:00 CST daily between 11–15 March 2000 (nets were closed at mid-day on 15 March). To maximize warbler capture rates over the entire 5-ha study area, we erected and frequently moved nets to positions where unbanded warblers were observed. Nets were occasionally closed during periods of low bird activity. Over the five-day netting period, we accumulated 272.5 net-hours in approximately 50 locations. All birds caught were subsequently banded with a unique combination of a U.S. Fish and Wildlife aluminum band and two plastic colored leg bands.

For our experiment, Black-throated Blue Warblers were alternately assigned to either the

Table 1. Comparison of re-sighting frequencies for control and experimental Black-throated Blue Warblers at Baronhall Coffee Farms, Jamaica. Fisher's Exact Test for difference between treatments: $P = 0.015$.

Treatment	*N*	Number of birds re-sighted	Number of birds not re-sighted	% re-sighted
Control (banded and released)	9	7	2	77.8
Experimental (banded, treated with tartar emetic, and released)	9	1	8	11.1
Total	18	8	10	

control or experimental treatment (with the first bird assigned randomly). Control birds were banded and released; experimental birds were treated with an emetic solution to induce regurgitation (Tomback 1975; Poulin et al. 1994). After banding, birds were given 0.8 cm^3 of a 1.5% solution of antimony potassium tartrate per 100 g of body mass. This solution was administered orally through a 1.5-mm diameter flexible plastic tube attached to a 1 cm^3 syringe. The plastic tube was inserted into the bird's bill and gently pushed along the esophagus into the proventriculus. The emetic was then administered at a rate of approximately 0.02 cm^3/sec, after which the birds were placed in a small covered box. Birds were released 15 min later, which allowed time for regurgitation and some recovery.

For the four other warbler species in our study, we aimed to obtain an emetic sample from every individual captured using the procedures described above. However, some birds were banded and released without emetic treatment because of temporarily high capture rates that resulted in no empty boxes in which to place newly banded birds for regurgitation, or because some clinical sign of stress or deteriorating health prompted us to release without emetic administration, or because of accidental premature release. These banded but untreated birds (approximately 20%) allowed later (uncontrolled) re-sighting comparisons between treated and untreated birds of these four species.

Re-sighting of color-banded treated and untreated birds of all five warbler species occurred from 06:30–11:30 and 15:15–17:15 on 18 March 2000, three to six days after the birds had been captured and (some) treated. A total of five observers were present, for a cumulative total of thirty five re-sighting hours. Each observer was equipped with a map showing initial capture locations of all color-banded birds to aid in re-sighting efforts. See Holmes et al. (1989) for details of this methodology. Although we concentrated our efforts in capture locations, observers worked individually or in pairs in searching the entire study area.

RESULTS

We captured and banded a total of 18 Black-throated Blue Warblers in the experimental study. The sex ratio of the experimental and control groups was identical (5 male:4 female) and re-sighting frequency was similar between sexes (Fisher's $P = 0.67$), so sexes were pooled for subsequent analyses.

The re-sighting rates of Black-throated Blue Warblers experimentally treated with tartar emetic were significantly lower than for control birds (Table 1). Three days after we terminated netting on the study site, we re-sighted only one of the nine Black-throated Blues that had been treated with the emetic. At least two of the remaining eight birds that could not be re-sighted were confirmed dead; the first was found approximately two hours after release, the second was found the day following treatment, approximately 22 h post-treatment. Both confirmed mortalities were male; the only re-sighted experimental bird was female.

We captured a total of 74 other warblers of the other four species, of which 61 were treated with the emetic (Table 2). Although statistical power was too low to detect subtle differences, re-sighting rates of treated warblers were relatively similar to each other (10%, 14%, 16%, and 13% for American Redstart, Black-and-white Warbler, Prairie Warbler, and Northern Parula, respectively; $\chi^2_3 = 0.31$, $P = 0.96$). Therefore, we pooled these species for subsequent analyses.

The re-sighting rates of American Redstarts,

Table 2. Comparison of re-sighting frequencies for warblers treated with tartar emetic versus those banded and left untreated at Baronhall Coffee Farms, Jamaica. Fisher's Exact Test for difference between treated and untreated birds (for three species combined): $P < 0.006$.

Species	Treatment	*N*	Number of birds re-sighted	Number of birds not re-sighted	Combined % re-sighted
American Redstart	Untreated	3	2	1	
	Treated	20	2	18	
Black-and-white Warbler	Untreated	8	5	3	
	Treated	14	2	12	
Prairie Warbler	Untreated	2	1	1	
	Treated	19	3	16	
Northern Parula	Untreated	0	—	—	
	Treated	8	1	7	
Species combined	Untreated	13	8	5	61.5
(Northern Parula excluded)	Treated	53	7	46	13.2

Black-and-white Warblers, and Prairie Warblers treated with tartar emetic were lower than re-sighting rates of birds that were banded and released without treatment (13.2 vs. 61.5%; Table 2). The re-sighting rate of treated Northern Parulas was similar to that for the other warblers, but all captured parulas (eight) were treated with the emetic (no controls), so they were excluded from this analysis. No mortalities following a successful release were detected, but on two occasions, treated and released American Redstarts were observed foraging on the ground and making uncharacteristically short, awkward flights.

Pre-release mortality rates were low, as reported in other studies. Of 70 total birds treated with the emetic, one Black-and-white Warbler and one Prairie Warbler died before release from unknown causes, but presumably due to handling or the administration of the emetic. No pre-release mortality occurred in the other species.

Overall, the efficacy of the tartar emetic was high; 81.4% ($N = 70$) of the treated birds regurgitated in the holding box (Table 3). Among the species studied, the emetic was least effective for Prairie Warblers; only 10 of 19 treated birds yielded regurgitation samples. The other species showed high rates of regurgitation; the number of birds not regurgitating was one out of 20, 9, 14, and 8 for American Redstart, Black-throated Blue Warbler, Black-and-white Warbler, and Northern Parula, respectively. Among the birds that were treated with the emetic (all species combined), the re-sighting frequency tended to be higher for birds that did regurgitate than for those that did not (Table 3), but this difference was not statistically significant.

DISCUSSION

Our results indicate that administration of tartar emetic significantly reduced the re-sighting frequency of Black-throated Blue Warblers. Results also strongly suggest reduced re-sighting frequencies in four other species of warblers.

These results are likely due to mortality and not reduced conspicuousness or emigration. Two treated Black-throated Blue Warblers were

Table 3. Comparison of re-sighting frequencies for banded warblers that did and did not regurgitate after treatment with tartar emetic at Baronhall Coffee Farms, Jamaica. Fisher's Exact Test for difference between groups was not significant ($P > 0.05$).

	N	Number of birds re-sighted	Number of birds not re-sighted	% re-sighted
Regurgitated	57	8	49	14.0
Did not regurgitate	13	1	12	7.7
Total	70	9	61	

found dead on the study site shortly after treatment, and two treated American Redstarts were observed making awkward flights after successful release from the emetic treatment. Laboratory tests indicate that emetic-induced mortalities often result from a refusal to forage in the two to three days post-treatment (Zach and Falls 1976). In our study, three to six days transpired between the administration of the final emetic and subsequent re-sighting effort, an adequate length of time to allow affected birds to recover if able.

Our results also suggest species-specific differences in sensitivity to the emetic technique, both in pre-release mortality effects and probability of regurgitation. All pre-release mortalities were either Black-and-white or Prairie Warblers; the other species suffered no pre-release mortality. In addition, species-specific differences existed in rate of regurgitation, with Prairie Warblers proving least likely to respond to the emetic technique. This is of particular concern because previous studies have detected increased mortality (Poulin and Lefebvre 1995) and decreased re-sighting frequency (Prys-Jones et al. 1974) in those birds that did not regurgitate.

Poulin and Lefebvre (1995) recommend a revised protocol for birds less than 10 g in body mass, but we chose to follow the standard protocol to minimize mortality specifically for Parulidae. Poulin and Lefebvre (1995) found that administering 0.8 cm^3 of a 1.5% solution of antimony potassium tartrate per 100 g of body mass and adding additional water to the solution such that at least 0.1 cm^3 total of fluid was administered reduced pre-release mortality rates for small birds. For Parulidae, however, this revised protocol did not significantly reduce pre-release mortality (1.5% vs. 1.3%; Poulin et al. 1994; Poulin and Lefebvre 1995). The revised protocol did increase the percentage of birds not regurgitating (7% vs. 24%), and as previously mentioned, other studies have suggested higher mortality for birds that fail to regurgitate. Our own field trials on American Redstarts have corroborated that the revised protocol produced lower rates of regurgitation than the standard protocol (M. Johnson, unpubl. data).

In conclusion, application of tartar emetic is an effective but invasive and occasionally lethal method for collecting diet samples from warblers. The technique effectively yields regurgitation samples, and these often contain high numbers of prey items (Poulin et al. 1994; Poulin and Lefebvre 1996; Strong 2000). However, given the extremely low re-sighting frequency for Black-throated Blue Warblers, caution should be employed in implementing the tartar emetic technique for small and/or rare songbirds. A refinement of techniques through laboratory study may reduce mortality, but given species-specific differences in sensitivity such an undertaking may prove unfeasible both logistically and ethically. Researchers will need to assess the benefit of such a procedure and determine if a less destructive method will produce the same data (e.g., water flushing, fecal sampling; Rosenberg and Cooper 1990). Alternatively, thought should be given to collection of specimens (Zach and Falls 1976). Collection and immediate preservation of gut contents provides the best assessment of a songbird's diet, and since administering tartar emetic may kill birds, it may be preferable to collect and use entire specimens than to release the birds to possibly die. At least for some species of warblers, administration of tartar emetic is far from harmless. While the tartar emetic technique can provide valuable diet information (Robinson and Holmes 1982), this invasive technique should be applied conservatively and with the acknowledgment of its occasionally lethal results.

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