SHORT COMMUNICATIONS

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RED IMPORTED FIRE ANTS CAN DECREASE SONGBIRD NEST SURVIVAL

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Abstract. Invasive species are often implicated in population declines of native species because of predation. The red imported fire ant (*Solenopsis invicta*) has been documented to prey on songbird nests. We conducted a replicated manipulative experiment to determine the decrease in nest survival caused by *S. invicta*. In 2006 and 2007 we monitored 71 nests, 44 of the White-eyed Vireo (*Vireo griseus*) and 27 of the Black-capped Vireo (*V. atricapilla*), in nine patches of 36–103 ha each in central Texas. We prevented *S. invicta* from preying on nests by applying insect-specific chemical and physical barriers at individual nests. Excluding *S. invicta* increased nest survival from 10% to 31% for the White-eyed Vireo and from 7% to 13% for the Black-capped Vireo. Our results suggest the decrease in nest survival of songbirds susceptible to predation by *S. invicta* may be substantial in the areas this ant occupies.

Key words: Black-capped Vireo, invasive species, nest predator, nest success, Solenopsis invicta, *Texas,* Vireo atricapilla, Vireo griseus, *White-eyed Vireo.*

La Hormiga Importada *Solenopsis invicta* Puede Causar Disminuciones en la Supervivencia de los Nidos de Aves Canoras

Resumen. Las especies invasoras frecuentemente están implicadas en las disminuciones de las poblaciones de especies nativas debido a la depredación. Se ha documentado que la hormiga importada *Solenopsis invicta* depreda nidos de aves canoras. Realizamos un experimento de manipulación con réplicas para determinar la disminución en la supervivencia de los nidos causada por *S. invicta*. En 2006 y 2007, monitoreamos 71 nidos (44 de *Vireo griseus* y 27 de *V. atricapilla*) en nueve parches de 36–103 ha en el centro de Texas. Impedimos que las hormigas depredaran los nidos aplicando barreras físicas y químicas específicas para insectos. La exclusión de *S. invicta* aumentó la supervivencia de los nidos del 10% al 31% en *V. griseus* y del 7% al 13% en *V. atricapilla*. Nuestros resultados sugieren que la disminución en la supervivencia de los nidos de aves canoras que son susceptibles a la depredación por parte de *S. invicta* podría ser considerable en las áreas que ocupa esta hormiga.

Invasive species are often implicated in population declines of native species because of competition and predation (Caughley and Gunn 1996). Invasive ant species are more abundant and forage more intensely than native ants (Holway et al. 2002). The red imported fire ant (*Solenopsis invicta*) is an invasive ant considered a threat to native species in the United States (Taber 2000, Allen et al. 2004), Caribbean (Davis et al. 2001), Australia (Moloney and Vanderwoude 2002, 2003), New Zealand (Pascoe 2001), and China (Zhang et al. 2005).

In the United States researchers have documented the detrimental effects of *S. invicta* on native arthropods (Porter and Savignano 1990, Gotelli and Arnett 2000), birds, mammals, and herpetofauna (Allen et al. 2004). *Solenopsis invicta* is a known predator of nests of several songbird species in the Mississippi alluvial valley (Twedt et al. 2001) and of the Black-capped Vireo (*Vireo atricapilla*; Stake and Cimprich 2003) and Barn Swallow (*Hirundo rustica*; Kopachena et al. 2000) in Texas. Removal of *S. invicta* from areas where ground-nesting birds breed increased nestling or fledgling survival of colonial water birds (Drees 1994), the Least Tern (*Sternula antillarum*; Lockley 1995), and Northern Bobwhite (*Colinus virginianus*; Allen et al. 1995, Mueller et al. 1999). To our knowledge no one has yet evaluated the effects of *S. invicta* on nest survival of birds nesting off the ground, particularly that of songbirds.

The potential negative effects of *S. invicta* on nest survival could be important to productivity because nest predation is the primary cause of nest failure for many songbird species (Nice 1957, Ricklefs 1969, Martin 1993). Removing nest predators to improve nest survival is occasionally suggested as a management technique to aid in recovering threatened or endangered songbirds (U. S. Fish and Wildlife Service 1991, Cain et al. 2003). Predator–prey interactions involving songbird nests, however, are complex; some predator removal experiments have led to increased nest survival (Jackson 2001, Schmidt et al. 2001), whereas others have resulted in little change (Beauchamp et al. 1996, Schmidt et al. 2001).

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We investigated the effect of *S. invicta* on nest survival of the federally endangered Black-capped Vireo and the co-occurring White-eyed Vireo (*V. griseus*). We selected these species because *S. invicta* has been identified as a primary nest predator of the Black-capped Vireo in central Texas (Stake and Cimprich 2003) and the White-eyed Vireo nests in the same habitat. We conducted a replicated manipulative experiment to determine if *S. invicta* causes nest survival over the entire nesting cycle to decrease by 10% or more. We tested for a reduction in nest survival of ≥10% because sensitivity analyses of other songbirds suggest a reduction of this size may be biologically significant for populations (Powell et al. 1999, Donovan and Thompson 2001).

METHODS

STUDY AREA

We studied both vireo species on nine sampling units located on 11 private properties in the Leon River watershed in Coryell County in east-central Texas. Because we had permission to access only some private properties, sampling-unit selection was limited. The nine sampling units, 36–103 ha each, were the only patches of vegetation where Black-capped Vireos had been detected on previous presence–absence surveys of 33 properties within a 140 000-ha area. Vegetation on sampling units consisted of mid-successional woody vegetation similar to that of areas occupied by Black-capped Vireos in the nearby Lampasas Cut Plains (Grzybowski et al. 1994, Bailey and Thompson 2007) and ecotones between mature oak–juniper (*Quercus–Juniperus*) woodland and grassland. In the study area, private lands were used primarily for ranching, farming, and hunting.

Our target population consisted of the Black-capped Vireos nesting in the study area. We included the White-eyed Vireo, which occurs with the Black-capped Vireo in this area, to broaden the information on effects of *S. invicta* on nesting songbirds and to increase sample size. We assumed *S. invicta* would prey opportunistically on any songbird nest it finds while foraging (Wilson 1962) because all songbird nestlings provide a similar source of protein (Stein et al. 1990). We included nests found 0.4 to 4.2 m above the ground because that is the height range of Black-capped Vireo nests in our study area and typical of the placement of Black-capped Vireo nests in general (Graber 1961, Grzybowski 1995).

MANIPULATIVE EXPERIMENT

We used behavioral cues and systematic searching (Martin and Geupel 1993) to locate active songbird nests from 15 March to 31 July in 2006 and 2007. We visited active nests every 3 or 4 days to determine outcome (i.e., nest fledged at least one young or failed). We considered a nest successful if we saw adults carrying food to fledglings or if we detected fledglings by sight or sound near nests that on our previous visit had large nestlings near fledging age. We considered nests failed if they were empty after having eggs or if we did not detect fledglings or observe adults carrying food near nests that previously had nestlings.

We assigned each nest to either the treatment or control group by using a probabilistic starting point (coin toss) for the first nest found, followed by systematic assignment (alternating between treatment and control) for each additional nest. This method of assigning treatments allowed treatment and control nests to be interspersed in space and time within each sampling unit (sensu Hurlbert 1984). We did not include nests in our analysis if they failed before treatment could be applied or if we could not determine whether young had fledged from the nest. We treated individual nests rather than reducing numbers of *S. invicta* by broadcasting ant-specific poison baits, as is typically done in research on *S. invicta* (e.g., Martin et al. 1998, Calixto et al. 2007). Our method avoided the unknown effects of removing *S. invicta* from the nest–predator assemblage (e.g., cause a population response of other nest predators).

We prevented *S. invicta* from preying on treatment nests by applying a chemical barrier (Spiral Wrap Arinix Nix of America, San Jose, CA) and a physical barrier (Tree Tanglefoot Pest Barrier, Tanglefoot Co., Grand Rapids, MI) to branches supporting nests. The Spiral Wrap is a 5-cm-long flexible plastic containing 8.6% permethrin, a pesticide of low toxicity, and was designed to prevent small insects from entering automobile vents. The Spiral Wrap releases permethrin slowly from the plastic and stops ants from crossing. Tanglefoot is a gum resin that catches crawling insects, stopping them from climbing trees and damaging agricultural products. We applied the Tanglefoot Pest Barrier to the branch ≥0.25 m from each treatment nest. We then placed a Spiral Wrap on top of the Tanglefoot Pest Barrier, allowing the Tanglefoot to fill gaps between the branch and Spiral Wrap. Vireo nests are built on a single isolated branch, enabling the ant barrier to block the only access point from which *S. invicta* could reach the nest. We assumed the barrier did not deter other predators (e.g., snakes, birds, mammals) from preying on nests because these predators could easily maneuver past the insect-specific 5-cm barrier. If the barrier deterred other nest predators, then observed treatment effects would be due to treatment nests being protected from *S. invicta* plus other nest predators. To control for potential effects of applying the Spiral Wrap at treatment nests, such as attracting nest predators, we attached an inert Spiral Wrap to branches supporting control nests.

STATISTICAL ANALYSES

We defined nest survival as the probability that a nest fledges at least one young and daily survival rate as the probability that a nest survives one day. We determined the magnitude of nest predation by *S. invicta* from estimates calculated with the nest-survival analysis (Dinsmore et al. 2002) in the program MARK (MARK 5.1, G. C. White, Colorado State University, Fort Collins, CO). We estimated daily survival rate for each species of vireo and each treatment separately. We estimated nest survival over the entire nesting cycle by raising each estimate of daily survival rate to the power of the number of days in the nesting period (Mayfield 1961), 27 days for the White-eyed Vireo (Hopp et al. 1995), 30 days for the Black-capped Vireo (Grzybowski 1995). We calculated 95% confidence intervals of nest survival by using the delta method (Powell 2007). We analyzed data from 2006 and 2007 together because we were interested in the overall effect of *S. invicta*, not annual differences, and we did not have sample sizes large enough to analyze each year independently. We used the 95% confidence intervals to compare estimates of nest survival and daily survival rate under the two treatments.

RESULTS

We monitored 71 nests, 44 of the White-eyed Vireo and 27 of the Black-capped Vireo. For the White-eyed Vireo, nest survival over the entire nesting cycle was 21% higher for treatment nests than for control nests; the estimate of nest survival for treatment nests was outside of the 95% confidence interval for control nests (Table 1). For the Black-capped Vireo, nest survival was 6% higher for treatment nests than for control nests, but the estimate for treatment nests was within the 95% confidence interval for control nests (Table 1).

TABLE 1. Daily survival rate and nest survival over one nesting cycle of White-eyed and Black-capped Vireo protected or not from predation by the imported red fire ant, estimated with the program MARK. Nests were monitored on private land in central Texas in 2006 and 2007.

	Daily survival rate	95% CI	Nest survival	95% CI	*n*
White-eyed Vireo					
Control	0.917	0.880–0.944	0.096	0.0–0.239	26
Treatment	0.957	0.927–0.976	0.308	0.123–0.493	18
Black-capped Vireo					
Control	0.916	0.861–0.951	0.073	0.0–0.262	14
Treatment	0.935	0.886–0.964	0.132	0.0–0.347	13

DISCUSSION

We found that preventing *S. invicta* from preying on nests increased nest survival of the White-eyed but not the Black-capped Vireo by more than the 10% we suggested might have a biologically significant effect on populations (Powell et al. 1999, Donovan and Thompson 2001). Because our experiment was manipulative, the results suggest White-eyed Vireo nest failure due to *S. invicta* occurred in addition to failure from other nest predators. *Solenopsis invicta* was likely a primary cause of nest failure because this species alone accounted for 20% of nest failures we observed. Anecdotally, we observed *S. invicta* preying on Black-capped Vireo nestlings in two control nests. We did not observe *S. invicta* trapped in the Tanglefoot pest barrier at treatment nests, suggesting the chemical barrier of the Spiral Wrap prevented the ant from preying on nests. Stake and Cimprich (2003) reported *Solenopsis* spp. in 11% of Black-capped Vireo nests on Fort Hood, Texas; Twedt et al. (2001) reported it in 10% of songbird nests on cottonwood (*Populus* spp.) plantations in Louisiana and Mississippi. Our estimates of nest survival for Black-capped Vireos protected from *S. invicta* predation are within previous estimates (Kostecke et al. 2005), suggesting the treatment did not deter or attract other nest predators. Although our treatment method acted as a barrier to all ant species, in our study area *S. invicta* was the most abundant ant, detected at 83% of ant-sampling stations near songbird nests (Campomizzi 2008), suggesting it poses the greatest threat to songbirds.

Interestingly, preventing nest predation by *S. invicta* caused a substantial increase in nest survival of the White-eyed but not the Black-capped Vireo. Both species nested in the same area, but small-scale nest-site characteristics may differ enough to enable other nest predators to attack Black-capped Vireo nests more frequently than White-eyed Vireo nests. White-eyed Vireos initiated their first nest of the season about 2 weeks earlier than Black-capped Vireos, potentially reducing their exposure to nest predators that are more active later in the breeding season. By using behavioral cues we found Black-capped Vireo nests easier to locate than White-eyed Vireo nests, suggesting visual predators may find Black-capped Vireo nests easier to locate as well. These spatial, temporal, and behavioral differences between the two species may suggest why the Black-capped Vireo's nest survival was lower. Increased predation on Black-capped Vireo nests by other predators would decrease the relative effect of *S. invicta*, explaining why for the Black-capped Vireo survival of treatment nests was not substantially higher than that of control nests.

The potential effects of *S. invicta* on nest survival of songbirds are substantial because of this ant's extensive and expanding worldwide range (Morrison et al. 2004, Sutherst and Maywald 2005). If our results are representative of the ant's effects, then nest survival of susceptible songbirds may be negatively affected over the 3.2×10^8 ha *S. invicta* currently occupies in the United States (USDA 2007). We expect the effects of *S. invicta* on songbirds' nest survival to vary spatially and temporally with the ant's distribution and abundance patterns, the complex interactions of nest-predator assemblages (Beauchamp et al. 1996, Jackson 2001, Schmidt et al. 2001), and other causes of nest failure.

Suppression of *S. invicta* in the breeding habitat of susceptible songbirds of conservation concern (i.e., threatened, endangered, locally rare) may be a management action to consider to increase the birds' productivity. Numbers of *S. invicta* may be suppressed through integrated pest management (Drees and Gold 2003, Pereira 2003). Our methods excluded *S. invicta* from nests, altering only the ant's function as a nest predator, not its numbers. Further research is needed because suppression of *S. invicta* in songbirds' breeding habitat may have ecological consequences on the nest-predator assemblage, such as an increase in snake or rodent populations, that are not yet realized.

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