Scent deterrence to reduce southern flying squirrel kleptoparasitism of red-cockaded woodpecker cavities

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Abstract: When establishing new populations of endangered red-cockaded woodpeckers (RCW; *Picoides borealis*), cavity kleptoparasites can pose a considerable obstacle to successful restoration. Southern flying squirrels (SFS; *Glaucomys volans*) are the principal kleptoparasite of RCW roost and nest cavities. Managers restoring RCW populations primarily use labor-intensive, direct removal to mitigate cavity competition by SFS. We field tested the use of red fox (*Vulpes vulpes*) urine and rat snake (*Elaphe* spp.) musk as predator scents to examine if SFS could be deterred from using RCW cavities and to observe RCW roost behavior at cavities treated with red fox urine. Scent deterrence proved ineffective in preventing SFS use of RCW cavities, while RCWs showed no behavioral response to scent treatment. Managers should continue using squirrel excluder devices, and direct removal to mitigate SFS kleptoparasitism of RCW cavities when restoring critically endangered populations.

Key words: cavity competition, cavity kleptoparasites, red-cockaded woodpeckers, scent deterrence, southern flying squirrels

Establishing new populations of red-cockaded woodpeckers (RCW; *Picoides borealis*) has become possible with artificial cavity technology and intensive habitat and cavity management. However, when restoring RCW populations, southern flying squirrels (SFS; *Glaucomys volans*) have posed a considerable threat to obtaining this goal. Flying squirrel removal is an essential management action (Gaines et al. 1995, Brown and Simpkins 2003, Hagan et al. 2003, Hedman et al. 2003, Poirier et al. 2003, Stober and Jack 2003) when establishing new RCW populations and is needed only until a population is able to sustain natural levels of nest depredation and cavity kleptoparasitism (Mitchell et al. 1999, Conner et al. 2001, U.S. Fish and Wildlife Service 2003). Reducing cavity kleptoparasites creates opportunities for RCWs to roost in cavities that would otherwise have been occupied and reduces the likelihood of nest depredation (Montague et al. 1995, Stober and Jack 2003).

For example, during the first 3 years of establishing an endangered RCW population at the Joseph W. Jones Ecological Research Center at Ichauway in Baker County, Georgia, a total of 204,161, and 176 flying squirrels were removed from artificial cavities in 2000, 2001, and 2002. There was a slight decrease in SFS abundance in cavities from a high of 22% in 2000 to 14% in 2002. The decrease in SFS abundance from 2000 to 2002 can be attributed to direct removal and harvest of hard-woods, upon which flying squirrels de-pend (Taulman and Smith 2004). This decrease in SFS use of RCW cavities had its desired effect for all RCWs nested successfully and fledged > 1 young during 2001 and 2002.

At Ichauway, kleptoparasitism of RCW cavities include red-headed woodpecker (*Melanerpes Melanerpes carolinus*), white-breasted nuthatche (*Sitta carolinensis*), eastern bluebird (*Sialia sialis*), great crested flycatcher (*Myiarchus crinitus*), tufted titmouse (*Baeolophus bicolor*), and wasp (*Hymenoptera*). If kleptoparasite pop-ulations were not managed, only 50–60% of all cavities would be available for RCW use. Among all cavity kleptoparasites, SFS have been found to be the principal klepto-parasite and competitor for RCW cavities (Loeb and Hooper 1997). Managers of private and public lands who wish to establish populations of RCWs need less expensive and more effective alternative management strategies to resolve the issue of SFS competition for RCW cavities.

Red-cockaded wood-pecker. *(Photo courtesy Richard T. Bryant)*

In a laboratory setting, Borgo et al. (2006*a*) evaluated the use of scents to deter SFS from using nest boxes. They proposed that roost site selection by SFS should be influenced by predator avoidance and that prey species may use olfactory cues to assess predation risk. Flying squirrels spent significantly less time in nest boxes scented with eastern fox squirrel (*Sciurus niger*) fur, bobcat (*Lynx rufus*) fur, red fox (*Vulpes vulpes*) urine, raccoon (*Procyon lotor*) fur, and the presence of king snake (*Lampropeltis getula*) and corn snake (*Elaphe gutta*) scent than unscented boxes. The most significant avoidance by SFS was to red fox urine and snake presence. The olfactory capabilities of RCWs are unknown but are thought to be limited, suggesting that scent deterrence could discourage use of RCW cavities treated without disturbing RCWs.

Given that scent deterrence could be an inexpensive alternative to direct removal, we field tested scent deterrence using red fox urine and rat snake musk (*Elaphe* spp.) to determine if SFS can be deterred from using RCW cavities and to test RCW use of cavities treated with scent.

Study area

The Joseph W. Jones Ecological Research Center (JWJERC) at Ichauway is located on the Dougherty Plain, 20 km south of Newton, Georgia, USA. The 11,300-ha research site is managed with prescribed fire to maintain a forest dominated by longleaf pines (*Pinus palustris*), wire grass (*Aristida stricta*), and herbaceous understory vegetation. With 1 remaining male RCW in March of 1999, the JWJERC began restoration of a viable population of RCWs. A baseline survey found only 8 usable cavities scattered across 8,000 ha of suitable habitat. Four artificial cavity inserts were installed in each of 28 cluster locations occurring at 600-m intervals within approximately 800 ha of longleaf pine habitat (Stober and Jack 2003). Twenty-six sub-adult RCWs were translocated to the site from the spring of 1999 to the fall of 2003. The RCW population expanded from 1 active cluster in 1999 to 18 active clusters in 2005.

The successful population expansion can be attributed to management focused on artificial insert cavities and intensive habitat management. Habitat is managed with prescribed fires during growing and dormant seasons on a 1–2 year rotation and mechanical removal of mid-story hardwoods. Once a cluster is established, woodpecker activity and kleptoparasite numbers are monitored. Due to the transitory nature of avian kleptoparasites, they and their nest are not removed from cavities until nesting attempts are complete. Flying squirrels are removed periodically throughout the year and during the breeding season in active clusters. All SFS were removed from 2000 to 2002 to protect nests and provide available cavities to recruit translocated and fledgling birds.

Methods

We provided 20 artificial insert cavities in 5 recruitment clusters (4 cavities/cluster). One cavity was treated with rat snake musk, 1 with red fox urine (Minnesota Trapline Products, Pennock, Minnesota, USA), and 2 cavities were left untreated as controls. Treatments were assigned to cavities at random within each cluster. During March 2004, clusters were treated on a 3–4-day rotation with the musk or urine applied to the treatment cavities, for a total of 7 trials. Scent was sprayed directly in the cavity chamber. Snake musk was milked from gray rat (*Elaphe obsoleta spiloides*) and corn snakes and diluted in water to a 1% solution and placed in an aerosol can with 6–7 ml sprayed per treatment. Red fox urine was sprayed in the cavity with a hand pump sprayer with 7–8-ml portions for each treatment. All SFS identified in a cavity were removed using a vacuum cleaner with a modified hose, given a unique ear tag, and released into the cluster. During April and May of 2004, the same set of clusters was treated on 7-day intervals with lethal removal of all SFS and treatment of cavities with assigned scent for a total of 8 trials.

Four RCW cavities were treated with red fox urine to determine if the birds would continue to use the cavity. Of the 4 treated cavities, 2 adult female RCWs and 2 RCW helpers roosted in the cavities. Snake musk was not tested due to inadequate supply. Additional suitable cavities were available within the cluster if treatment deterred use of their primary cavities. Cavities were treated every 7–8 days with 7–8 ml of scent sprayed at 1400 hrs, and the resulting bird behavior was observed at dusk.

We rank-transformed (Conover and Iman 1981) the number of SFS observed within a cavity during a given trial and used this value as our dependent variable in further analysis. We used a mixed model analysis of variance (SAS Institute 2003) to determine if our dependent variable differed as a function of treatment using a repeated measures design. Because SFS densities were likely to vary spatially, we treated clusters as a block in the analysis. We used the cavity as the experimental unit and considered occupancy repeated visits. Because scent treatments were first conducted without removal of SFS followed by scent treatments with removal, we analyzed with and without removal, portions of the study separately to avoid confounding with time. We provide percent occupancy of SFS for controls and treatments for both scent deterrent trials as an interpretive aid.

Results

Overall squirrel presence or cavity occupancy for the 5 recruitment clusters examined in this study during the 3–4 scent treatment trial was 20%. Squirrel occupancy fell to 12.5% during the 7-day treatment with removal. These percentages are consistent with the range of occupancy found across all active and recruitment clusters in the Ichauway population, with an average of 14% ranging from 7–22% occupancy from 2000 to 2004. Excluding the pretreatment data during the 3–4-day trial, SFS occupied 20–25% versus 11% for cavities receiving either fox or snake treatments. During the 7-day trial with SFS removal, occupancy was 31% for control cavities and 6% for either the snake or fox treatments.

The 3–4 day scent treatment experiment revealed no differences among the occupancy of cavities by SFS in treated and untreated cavities ($F_{2,44} = 1.37$, $P = 0.268$). Scent treatment on 7-day rotation with squirrel removal yielded similar results ($F_{2,39} = 0.93$, $P = 0.404$).

We observed no detectable response by RCWs to scent treatments. Woodpecker behavior to scents was variable, with some waiting for prolonged periods before entering the cavity to others quickly entering the cavity once it approached the entrance. Occasionally, woodpeckers would wait until after all other birds had entered the roost chamber before entering their cavity. Woodpeckers used the treated cavities in 28 of the 30 trials (93% occupancy). Only twice did 1 RCW utilize a cavity other than the treated cavity in the cluster. SFSs were flushed from the treated cavity during the second to last treatment period. These were the only treatments where the bird did not use a treated cavity.

Discussion

Treating woodpecker cavities with the scent of red fox or rat snake does not appear to deter SFS use. Contrary to a controlled laboratory tests (Borgo et al. 2006*a*) in which squirrels were presented with 2 cavities, available cavities are scarce within pine woodland landscapes. Flying squirrels' risk to predator exposure during diurnal hours exceeds the risk posed by olfactory cues of a potential predator in an available roost cavity. Further studies could use concentrated snake musk to determine if concentration could be increased and possibly deter SFS use. Placing additional exterior nest boxes around cluster sites may increase the effectiveness of the scent treatments and increase the vacancy of inserted woodpecker cavities (Loeb and Hooper 1997). However, exterior nest boxes often confound this benefit by acting as a draw to SFS and other cavity nesters. Future research should examine using the combination of both scent deterrence and nest boxes within clusters. Scent deterrence and the addition of external cavities to remove SFS (Borgo et al. 2006*b*) may provide the most effective method of deterring cavity use and concentrating squirrels for removal. Squirrel exclusion devices are still the most effective deterrent available to RCW managers but require regular maintenance.

Direct removal also is an effective but labor-intensive method of mitigating SFS use for RCW populations with <5 potential breeding groups. Time required for intensive direct removal could be concentrated into a shorter duration if the number of RCWs translocated to critical populations were increased. After a small RCW population achieves 10 potential breeding groups, it may be able to sustain loss of a nest or individuals to SFS (Letcher et al. 1998). Thus, increasing the number of individuals above 10 to be translocated during restoration to a new RCW population could reduce the time necessary for intensive management of SFS (Saenz et al. 2002). Olfactory cues are known to be an undeveloped sense influencing bird behavior. This appears to be the case with RCWs, with little response to treatment of active cavities with a predator scent. The movement by 1 individual to an adjacent cavity in the same cluster during the final treatments was more likely due to SFS competition rather than the scent treatment. Future SFS deterrent work should focus on using the ultra sonic range of squirrels which is currently being defined (M. Gilley, personal communication) and identifying the key habitat features utilized by SFS (Conner et al. 1996) in upland pine communities.

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