From the Field: A method for preventing flying squirrel mortality in PVC pipe treefrog refugia

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Amphibian population declines (Blaustein and Wake 1990) have prompted research focusing not only on issues of decline but also on developing and improving sampling techniques (Heyer et al. 1994, Dodd 2003). One such technique, the use of polyvinylchloride (PVC) pipes, is widely accepted for detecting hylid treefrogs (*Hyla* spp.) (Dodd and Scott 1994, Moulton et al. 1996, Boughton et al. 2000, Zacharow et al. 2003). The PVC pipes offer an artificial refuge site for many arboreal hylid species that would otherwise seek shelter under bark or in natural cavities. Previous studies evaluating the effectiveness of PVC pipes for detecting treefrogs have focused on the influence of pipe size, architecture, and placement. However, to date, no studies have addressed the effects of nontarget captures on hylid treefrog occupancy rates. In the course of using PVC pipes to monitor treefrog activity patterns in Georgia, we observed significant southern flying squirrel (*Glaucomys volans*) mortality in pipes placed on trees. The southern flying squirrel is a common nocturnal mammal found in the eastern United States (Nowak 1999). Flying squirrels occupy cavities in trees and presumably enter tree pipes because they mimic natural cavities (Moore 1947). However, the smooth walls of PVC pipes prevent squirrels from exiting, resulting in mortality. We address the influence of flying squirrel mortality in PVC pipes on treefrog occupancy and introduce a simple method to reduce flying squirrel mortality without affecting treefrog occupancy. This method will have utility for amphibian monitoring studies that incorporate use of PVC pipes (Dodd and Scott 1994, Dodd 2003), particularly within the range of flying squirrels (*Glaucomys* spp.), and in areas with high treefrog diversity such as the southeastern United States.

Methods and materials

We conducted our study at the Joseph W. Jones Ecological Research Center in Baker County, Georgia, USA. Study sites consisted of 5 small hardwood depressions (<1 ha in size) dominated by live oak (*Quercus virginiana*) within a longleaf pine (*Pinus palustris*) forest. At each depression we placed 8 PVC pipes (60 cm long, 5 cm in diameter, schedule 40 weight) on trees ($n = 40$). We capped each pipe at the base to allow rainwater retention and drilled an outflow hole 8 cm above each cap to prevent pipes from overfilling (Boughton et al. 2000). We established 4 pipe stations through the ecotone of each depression. Stations radiated from the center of each depression in the 4 cardinal directions. We placed 2 pipes at each station, 2 m above ground on the north and south faces of a tree (primarily *Q. virginiana*). We monitored sites monthly for 6 months pre-treatment and found 22 dead flying squirrels in pipes. In an attempt to reduce squirrel mortality, in 2002 we installed

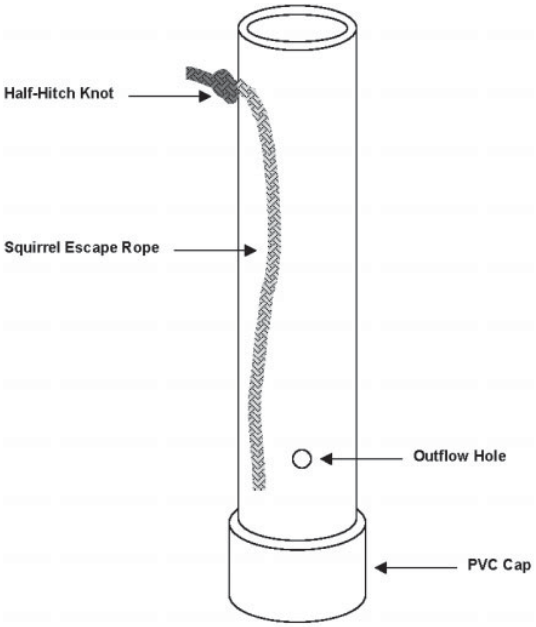

Figure 1. Polyvinylchloride (PVC) tree pipe used to capture treefrogs of the genus *Hyla,* with escape rope for southern flying squirrels (*Glaucomys volans*). Pipes are 60 cm long, 5 cm in diameter, and are schedule 40 weight PVC. Pipes are capped at the bottom and have a small outflow hole for rainwater. The escape rope is 6.4-mm-diameter braided nylon about 55 mm in length.

escape ropes in one pipe at each station. Escape ropes consisted of sections of braided nylon rope 6.4 mm in diameter and about 55 cm long. We attached ropes through a 9.5-mm hole at the top of the pipe about 2.5 cm below the entrance. We then threaded ropes into pipes and held the ropes in place with a half-hitch knot, such that they extended to the bottom of the pipe (Figure 1). We monitored pipes once a month for 18 months post-treatment, and both treefrogs and dead flying squirrels were counted. We used chi-square and Fisher's exact tests to determine whether 1) the presence of dead flying squirrels affected treefrog occupancy in pipes; 2) the presence of ropes reduced squirrel mortality; and 3) ropes affected treefrog occupancy. We analyzed data using SAS software (SAS Institute Inc. 2002).

Results

Four species of treefrog used PVC pipes throughout the study. These included squirrel treefrog (*Hyla squirella*, $n = 497$), barking treefrog (*H. gratiosa*, $n = 20$), Cope's gray treefrog (*H. chrysoscelis*, $n = 7$), and green treefrog (*H. cinerea*, $n = 1$). The presence of dead flying squirrels in pipes significantly affected overall treefrog occupancy ($\chi^2 = 4.84$, df = 1, $P = 0.027$); of 29 pipes with dead squirrels, only 5 had treefrogs (17.2%) compared to 304 occupied pipes [of 628 (48.4%)] without squirrels. Prior to the placement of escape ropes, flying squirrel mortality was observed across all pipes (8 in treated pipes, 14 in untreated pipes). However, following treatment, ropes significantly reduced flying squirrel mortality ($\chi^2 = 4.85$, df = 1, $P = 0.030$). We found no dead squirrels in pipes with ropes, whereas we found 10 dead squirrels in untreated pipes. In addition, treefrog occupancy in pipes with ropes did not differ from pipes without ropes ($\chi^2 = 0.15$, df = 1, $P = 0.698$). During 18 months of post-treatment observation, pipes with ropes contained 238 frogs and pipes without ropes contained 223 frogs.

Discussion

Polyvinylchloride pipes have significant utility in amphibian monitoring programs because the method is simple, inexpensive, and passive (Dodd and Scott 1994, Moulton et al. 1996). However, negative impacts to nontarget species must be avoided whenever possible. Our results indicate that using escape ropes in PVC pipes prevents southern flying squirrel mortality. In addition, ropes did not appear to reduce treefrog occupancy in pipes; in fact, eliminating squirrel mortality increased treefrog captures. Using uncapped pipes could be an alternative method for eliminating mortality of nontarget species but might result in decreased capture success of target species. Capped pipes are more attractive to treefrogs (Boughton et al. 2000), presumably because they create a moist, sheltered environment. Factors that maximize capture success of target species are particularly important if pipes are being used to monitor demographic parameters, but minimizing sampling impacts on nontarget species also is an important consideration. This modification to the PVC sampling technique can readily be used in amphibian monitoring studies within the range of flying squirrels of the genus *Glaucomys* (including the Appalachian Mountains, where two federally endangered subspecies of northern flying squirrels, *G. sabrinus fuscus* and *G. s. coloratus,* occur), and possibly in areas where other volant mammals exist. In addition, the ropes may offer an escape mechanism for other

nontarget species that enter the pipes (e.g., lizards: *Anolis carolinensis, Eumeces laticeps*; and Insects: Coleopterans, Lepidopterans).

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