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Texas Ratsnake Predation on Southern Flying Squirrels in Red-cockaded Woodpecker Cavities

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Abstract - *Elaphe* spp. (ratsnakes) are frequent predators on cavity-nesting birds and other vertebrates, including *Glaucomys volans* (Southern Flying Squirrels). They are known predators of *Picoides borealis* (Red-cockaded Woodpeckers), especially during the nestling phase. *Picoides borealis* cavities are frequently occupied by Southern Flying Squirrels, often several squirrels per cavity. Behavioral aspects of ratsnake predation on flying squirrels in woodpecker cavities is an important component required for a full understanding of the potentially complex interaction between Red-cockaded Woodpeckers, Southern Flying Squirrels, and ratsnakes. We induced previously captured *Elaphe obsoleta* (Texas Ratsnake) to climb boles of pine trees and gain access to Red-cockaded Woodpecker cavities known to contain Southern Flying Squirrels, and observed the resulting predatory interactions. Eight of nine ratsnakes successfully captured 14 of 22 Southern Flying Squirrels present in the cavities.

Introduction

Picoides borealis (Vieillot) (Red-cockaded Woodpecker), *Glaucomys volans* L. (Southern Flying Squirrel), and *Elaphe* spp. (ratsnakes) have a close interacting relationship involving cavity use and predator-prey interactions in the fire-maintained pine forests of the southeastern United States (Conner et al. 1996; Kappes 2004, 2008; Laves and Loeb 1999; Mitchell et al. 1999; Rudolph et al. 1990a, b). Red-cockaded Woodpeckers excavate cavities used by all three taxa, and Southern Flying Squirrels are competitors for Red-cockaded Woodpeckers cavities. In turn, ratsnakes are predators on both woodpeckers and squirrels. However, the impact of these interactions at the population level and appropriate management responses in relation to the endangered Red-cockaded Woodpeckers are subject to debate (Conner et al. 2001; Kappes 2004, 2008; Rudolph et al. 1990b, 2004; Walters 1990; Withgott et al. 1995).

Elaphe spp. frequently attempt to climb trees containing Red-cockaded Woodpeckers cavities, especially during the nesting season (Jackson 1974, 1978; Neal et al. 1993). *Elaphe* spp. are also potential predators on secondary cavity users of Red-cockaded Woodpecker cavities. Based on frequency of use, Southern Flying Squirrels would presumably be the most important

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potential prey species. Given the importance of the interaction between Red-cockaded Woodpeckers, Southern Flying Squirrels, and ratsnakes, additional information on specific aspects of this interaction is desirable. Here we report the results of climbing trials of *Elaphe obsoleta* (Say) (Texas Ratsnake) on trees containing Red-cockaded Woodpecker cavities occupied by Southern Flying Squirrels and the resulting predation attempts.

Materials and Methods

The study was conducted in Red-cockaded Woodpecker cavity tree clusters on the Angelina and Davy Crocket National Forests in eastern Texas. The habitat was *Pinus palustris* Mill. (Longleaf Pine) or *P. taeda* L. (Loblolly Pine)/*P. elliotii* Engelm. (Shortleaf Pine) forest with a variable mixture of hardwoods. We selected Red-cockaded Woodpecker cavities that were not recently used by the woodpeckers and in which the resin barrier was sufficiently degraded to allow snakes to climb to cavity entrances. Selected cavity trees were climbed using sectional climbing ladders. The contents, including number of Southern Flying Squirrels, were determined using a mechanics mirror and flashlight. Cavities containing Southern Flying Squirrels were used for trials. Elapsed time between climbing of tree to determine number of squirrels and initiation of snake climbing ranged from 20–90 min. All trials were conducted between March and August of 1991–92. Trials were conducted during daylight hours, when temperatures were 24–30 °C.

Elaphe obsoleta of sufficient size (>105 cm total length [TL]) to easily consume an adult flying squirrel were obtained opportunistically or by trapping. Nine snakes were used in 9 independent climbing trials. Snakes were held in the laboratory for periods up to two weeks prior to trials. Snakes were provided with water, but not fed, during captivity. Snakes were transported to cavity trees in cloth bags, removed from the bags, and placed in a vertical orientation on the bole of the pine directly below the cavity entrance. The snake's head was initially placed approximately 2 m above ground level. The typical response of snakes was to initiate climbing, although it was occasionally necessary to initially steer the snake with an aluminum pole to insure that it continued to climb vertically and remained on the side of the bole with the cavity. Date, time, cavity height (m), entrance diameter (mm), elapsed time to reach cavity, and outcome of the predation event were recorded.

Results

Nine individual *E. obsoleta* (TL 105–165 cm) were placed on boles of Red-cockaded Woodpecker cavity trees, each containing a cavity known to be occupied by 1–4 adult Southern Flying Squirrels. In all instances, the snakes proceeded to climb to the vicinity of the cavity entrance and orient toward the entrance. After climbing sufficiently to have an anterior segment of the body in position, the snakes rapidly thrust the anterior portion

of their bodies into the cavity. This thrust into the cavity frequently elicited vocalizations from the squirrel(s), followed by a period of relative quiescence during which the snake ingested the squirrel. If additional squirrels were present, this period was followed by additional movements by the snake as it captured another squirrel. Elapsed time to climb to cavities ranged from 7 to 38 min. In 8 of the 9 instances, the snakes were successful in capturing at least one squirrel, and ultimately captured 14 of the 22 squirrels present in the cavities (Table 1). After all squirrels were consumed, or escaped, the snakes completely entered the cavities, where they presumably remained to digest their meal. Two cavities were checked the next day and the snakes were still present.

Five of the snakes captured and consumed all squirrels (n = 1–3) present in the cavities. If multiple squirrels were present in the cavities, the snake's body, approximately 50% of which remained outside the cavity, blocked the entrance sufficiently to prevent escape of the additional squirrels. In one cavity containing 3 squirrels, one squirrel was able to squeeze out of the cavity past the snake's body after considerable effort. However, the snake pinned the squirrel to the bole of the tree using the mid-portion of its body. After consuming the two squirrels remaining in the cavity, the snake brought the anterior portion of its body out of the cavity and consumed the third squirrel.

In four cases, one or more of the squirrels were able to escape (Table 1). One cavity had two entrances, and 2 squirrels escaped out the second entrance while the snake was capturing and consuming the third squirrel. In another instance, one of two squirrels present in a cavity with a slightly enlarged entrance was able to escape past the snake's body while the snake was consuming the remaining squirrel. In a third case, the snake experienced considerable difficulty during the final approach to the cavity entrance due to smooth bark and the presence of resin. Consequently, its initial thrust into the cavity was not sufficient to allow it to capture a squirrel before both squirrels were able to escape past the snake's head and neck. In the fourth instance, the smallest of the 9 snakes (TL = 105 cm) totally entered the cavity, allowing 3 of the 4 squirrels present to escape out the unblocked entrance.

Table 1. Outcomes of *Elaphe obsoleta* (Texas Ratsnake) predation on *Glaucomys volans* (Southern Flying Squirrel) in *Picoides borealis* (Red-cockaded Woodpecker) cavities in eastern Texas during 1991–1992.

Snake TL	Cavity height	Cavity diameter	# of *G.v.*	# predated	Comments
117	9.2	47	2	2	
139	5.8	46	1	1	
147	6.0	46	3	3	
161	8.1	50	3	3	
165	7.0	49	2	2	
105	6.7	51	4	1	3 escaped after snake completely entered cavity
129	6.8	43/47	3	1	2 escaped out second entrance
136	7.7	61	2	1	Cavity enlarged and 1 escaped past snake
141	7.3	45	2	0	Difficult climb and snake's initial strike ineffective

In at least two cases, one or more of the squirrels detected disturbance outside the cavity, either that of the researchers or of the climbing snake. In both cases, a squirrel peered out of the cavity entrance and observed the snake climbing. When the snake was within approximately 0.5 m of the cavity entrance each squirrel retreated back into the cavity. Both were ultimately consumed by the snakes.

Discussion

Southern Flying Squirrels are abundant in southeastern US forests and are frequent occupants of Red-cockaded Woodpecker cavities (Conner et al. 1996, Dennis 1971, Harlow and Lennartz 1983, Loeb 1993, Rudolph et al. 1990a). Red-cockaded Woodpeckers excavate cavities with an entrance tube diameter of approximately 40–50 mm, and these are frequently enlarged by secondary cavity users, especially other species of woodpeckers (Loeb 1993, Rudolph et al. 1990a). Southern Flying Squirrels prefer un-enlarged Red-cockaded Woodpecker cavities, presumably due to the increased protection from larger predators (Loeb 1993, Rudolph et al.1990a). However, the preference of Southern Flying Squirrels for cavities with un-enlarged entrances makes them vulnerable to snake predation as they are frequently unable to exit the cavities due to the presence of the snake's body.

These trials were artificial in the sense that the snakes did not select trees to climb. They were initially attempting to escape from a potential predator, the researcher, by climbing up the bole of the pine. However, at some point they detected the presence of the cavity or squirrels, presumably using visual and/or olfactory cues, and commenced predatory behavior. Consequently, these data do not address search behavior of *E. obsoleta*, only their behavior at the cavity.

Available data suggests that Southern Flying Squirrels do not select or avoid cavities with an actively maintained resin barrier (Loeb 1993, Rudolph et al. 1990a). There is some evidence that Southern Flying Squirrels seek to avoid direct contact with the resin barrier (Schaefer and Saenz 1998); however, they are able to land directly at the cavity entrance and thus utilize cavities with an actively maintained resin barrier. Presumably however, Southern Flying Squirrels have not evolved the behavioral mechanisms to maximize the potential benefits of the presence of resin barriers in reducing snake access.

In two instances, Southern Flying Squirrels observed the approach of the snakes from the cavity entrance, and then retreated back into the cavity. This behavior exposes the squirrels to almost certain predation, whereas exiting the cavity would provide almost certain escape from the approaching snake. However, Southern Flying Squirrels exiting cavities during daylight are potentially exposed to a variety of diurnal predators. Saenz and Schaefer (1995) observed the capture of a Southern Flying Squirrel that they disturbed from a cavity while they were climbing the tree, by a waiting *Buteo platypterus* (Vieillot) (Broad-winged Hawk). It is also possible that Southern

Flying Squirrel behavior was still influenced by the prior disturbance due to researcher activity.

Ratsnakes are diurnally and nocturnally active predators with marked arboreal tendencies. Ratsnakes frequently target Red-cockaded Woodpecker cavities, especially during the nestling period (Neal et al. 1993). However, based on surveys of occupants of Red-cockaded Woodpecker cavities, Southern Flying Squirrels potentially represent a larger prey resource available to ratsnakes than Red-cockaded Woodpecker nestlings (Harlow and Lennartz 1983, Loeb 1993, Mitchell et al. 1999, Rudolph et al. 1990a). In eastern Texas, surveys found that Southern Flying Squirrels, often more than one individual, were present in 19.3 to 29.5% of Red-cockaded Woodpecker cavities (Conner et al. 1997, Rudolph et al.1990a). In addition, Pierce et al. (2008), also working in eastern Texas, found that Texas Ratsnake arboreal behavior occurred throughout the active season. There was no evidence of a peak in arboreal activity during the avian nesting season, and much of the arboreal behavior may have been directed at non-avian prey.

The interactions between Red-cockaded Woodpeckers, Southern Flying Squirrels, and Texas Ratsnakes are complex. Texas Ratsnakes are efficient predators on Southern Flying Squirrels occupying Red-cockaded Woodpecker cavities, and this fact suggests that the complex interactions hypothesized by Kappes (2004) deserve more investigation.

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