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## **Eastern Fox Squirrel (*Sciurus niger*) Observed Using a Gopher Tortoise (*Gopherus polyphemus*) Burrow**

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**Abstract** - Many sympatric species use *Gopherus polyphemus* (Gopher Tortoise) burrows as refugia from predators, extreme temperatures, and fire. As part of an ongoing project involving trail-camera monitoring at Gopher Tortoise burrows, we observed a *Sciurus niger* (Eastern Fox Squirrel) sheltering in an occupied burrow twice in a single day. Eastern Fox Squirrels primarily forage on the ground, and Gopher Tortoise burrows likely offer refuge from avian predators but could expose Eastern Fox Squirrels to increased predation risk from mammalian and reptilian predators. Alternatively, the squirrel may have been seeking refuge from higher-than-average temperatures. Our observation further demonstrates the importance of Gopher Tortoise burrows to vertebrate fauna in the southeastern United States.

*Introduction.* In an unpredictable environment, refugia provide animals with areas of relative safety (Sih 1992). Animals may seek refuge to avoid potentially lethal threats, e.g., predators (Lima and Dill 1990, Sih 1992), thermal stress (Pike and Mitchell 2013), and fire (Knapp et al. 2018). Terrestrial animals use a variety of landscape features as refugia, including burrows made by fossorial or semi-fossorial species. In the *Pinus palustris* Mill. (Longleaf Pine) forests of the southeastern United States, the semi-fossorial reptile *Gopherus polyphemus* Daudin (Gopher Tortoise) digs burrows in sandy soils that can be ≥4 m long (Ultsch and Anderson 1986). Over 300 species of invertebrates and over 60 species of vertebrates have been documented using Gopher Tortoise burrows (Cox et al. 1987, Dziadzio and Smith 2016, Frank and Lips 1989, Jones and Franz 1990, Lips 1991). Tortoise burrows offer tortoises and commensal species a refuge from predators (Derrick et al. 2010) and fire (Knapp et al. 2018). Temperatures inside Gopher Tortoise burrows remain cooler than surface temperatures on hot days, and warmer than surface temperatures on cold days, providing a thermal and physical refuge for the tortoise and for many commensal species (Ultsch and Anderson 1986). An individual Gopher Tortoise digs several burrows (Wilson et al. 1997), and a burrow persists in the environment after a Gopher Tortoise abandons it. Thus, Gopher Tortoise burrows can be important long-term resources for a range of species that may become resident in an abandoned burrow, or may use the burrow transiently (Dziadzio and Smith 2016).

Several species of small rodents, including *Podomys floridanus* Chapman (Florida Mouse; Jones and Franz 1990, Layne and Jackson 1994), *Peromyscus gossypinus* Le Conte (Cotton Mouse; Derrick et al. 2010), *Sigmodon hispidus* Say and Ord (Hispid Cotton Rat) and *Peromyscus polionotus* Wagner (Oldfield Mouse) (Pike and Grosse 2006), use Gopher Tortoise burrows. However, the use of Gopher Tortoise burrows by a larger rodent species, *Sciurus niger* L. (Eastern Fox Squirrel), is much less understood. The Eastern Fox Squirrel is a highly mobile (Conner 2000, Potash et al. 2018), large-bodied squirrel that spends the bulk of its time foraging on the ground (Weigl et al. 1989), putting it at potential risk from a variety of terrestrial and avian predators (Koprowski 1994, Potash et al. 2019).

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When threatened, Eastern Fox Squirrels typically flee on the ground towards a nearby tree (McClerey 2009) and seek refuge in nests built in canopies of large trees or tree cavities (Conner and Godbois 2003, Koprowski 1994). Moore (1957) reported several instances of humans chasing Eastern Fox Squirrels into Gopher Tortoise burrows. However, subsequent research studies on Eastern Fox Squirrel habitat and refugia have not mentioned use of Gopher Tortoise burrows (e.g., Edwards et al. 1989, Conner and Godbois 2003, Perkins and Conner 2004, Prince et al. 2016, Weigl et al. 1989) while others (Kantola and Humphrey 1990, Wooding 1997) have explicitly stated that they did not observe Eastern Fox Squirrels using Gopher Tortoise burrows as described by Moore (1957). Eastern Fox Squirrels have been observed moving across the apron of sand outside Gopher Tortoise burrows (Dziadzio and Smith 2016; M. Dziadzio, Florida Fish and Wildlife Conservation Commission, Tallahassee, FL, personal comm.), but to our knowledge, evidence of Eastern Fox Squirrels entering burrows without responding to a human-induced stimulus has not been described. In this manuscript, we present our observation of an Eastern Fox Squirrel repeatedly using a Gopher Tortoise burrow.

*Field-site description.* The observations occurred at The Jones Center at Ichauway (Ichauway), an 11,736-ha private research site located in Baker County, GA. Ichauway is dominated by second-growth Longleaf Pine savanna and is managed with prescribed burns on an ~2-year return interval. Mean temperatures in March are 8.5–22.5 °C (University of Georgia 2019). Gopher Tortoises and their burrows are common on upland soils on the property (Smith et al. 2006).

*Methods.* As part of a larger study on vertebrate refugia in the Longleaf Pine ecosystem, we deployed 34 game cameras (UWAY Model VH400; UWAY Outdoors Canada, Lethbridge, AB, Canada) at Gopher Tortoise burrows in Longleaf Pine savanna. We mounted the cameras facing down on wooden frames ~1 m directly over the burrow opening. We set the cameras to time-lapse mode, which took a photo every 30 seconds as well as when the passive infrared sensors were triggered. We left each camera out for 10 days at a time during fall, winter, and spring, only visiting each camera after 5 days to change batteries and memory cards and on the final day to retrieve them. All methods were approved by the University of Georgia Institute of Animal Care and Use Committee (IACUC A2018 01-007-Y2-A1).

*Observations.* On 13 March 2019 at 14:48:27 EDT (18:48:27 UTC), an Eastern Fox Squirrel was detected exiting a Gopher Tortoise burrow (Fig. 1). Although the camera had been active at this burrow since March 11, we did not record images of the individual entering the burrow. Additional photos (at 30-second intervals) of the squirrel exiting and remaining at the edge of the burrow were taken until 14:57:54, after which the squirrel was no longer visible. The camera recorded a temperature of 29 °C during this time. At 15:56:18 on the same day, we recorded another series of photographs of the same Eastern Fox Squirrel exiting the same burrow. We did not get images of it re-entering before the second observation, but at 15:55:48 we recorded an image of the pine litter moving outside of the burrow, which was most likely the Fox Squirrel entering the burrow. We identified the Eastern Fox Squirrel as the same individual from earlier in the day based on unique pelage markings (Tye et al. 2015). The squirrel exhibited vigilant behavior by standing bipedally with its head raised above its shoulders (Makowska and Kramer 2007) in all photos until 16:07:45. The squirrel remained at the edge of the burrow, standing quadrupedally, until 16:18:00. The temperature varied from 24 to 25 °C during this period. The burrow was occupied by a Gopher Tortoise during this time, but the tortoise was not surface active.

*Discussion.* To our knowledge, our observation of an Eastern Fox Squirrel using a Gopher Tortoise burrow is the first of an individual that was not injured (shot) or distressed (chased by humans) and was not responding directly to apparent human stimulus. This

camera trap was only visited by researchers 2 days prior to the observation, and the monitored burrow was located ~70 m from the nearest private dirt road with little traffic and ~660 m from the nearest public road, in an area with little to no foot traffic (Fig. 2).

Wooding (1997) suggested that Moore's (1957) observations were of desperate individuals and hypothesized that Eastern Fox Squirrels would not select a Gopher Tortoise burrow as refuge over a tree. Our observation supports this idea as the squirrel appeared to be exhibiting vigilant behavior (Lima and Dill 1990), and in both instances, spent several minutes exiting the burrow. These behaviors suggest that the squirrel was wary of leaving the refuge, which could indicate that it had recently been exposed to a predation risk cue (Tromborg and Coss 2015), that the environment had high ambient predator density, or that the squirrel had low escape ability from the refuge (Sih 1992). Our cameras were not positioned to detect the presence of nearby Eastern Fox Squirrel predators, and no predators were observed entering the burrow around the time of our observation. However, observations from a monitored track line ~300 m away from the burrow show *Canis latrans* Say (Coyote), *Lynx rufus* Schreber (Bobcat), and unidentified snake presence in 2019 (L.M. Conner, unpubl. data). Gopher Tortoise burrows may therefore provide a potential source of safety for a fleeing squirrel. However, a variety of Eastern Fox Squirrel predators also use Gopher Tortoise burrows, including *Mustela frenata* Lichtenstein (Long-tailed Weasel; Frank and Lips 1989) as well as *Urocyon cinereoargenteus* Schreber (Gray Fox) and many species of large snakes (Cox et al. 1987, Dziadzio and Smith 2016, Means 2017). Thus, Eastern Fox Squirrels may generally avoid using Gopher Tortoise burrows due to the risk of encountering a predator inside the burrow.

The Eastern Fox Squirrel observed in our study may also have used the Gopher Tortoise burrow as refuge from higher-than-average temperatures (Jones and Franz 1990). Although



Figure 1. Photographs of an Eastern Fox Squirrel using a Gopher Tortoise burrow at a camera trapping site in southwestern Georgia.

our observation was made in March, abnormally high temperatures on the day of our observation may have caused the squirrel to seek thermal refuge during the hottest part of the day. While the temperature did not change between the first and last photo of the first observation, the temperature decreased from 25 °C to 24 °C during the second instance when the squirrel used the burrow.

Although animals seek refuge in Gopher Tortoise burrows to escape fire (Knapp et al. 2018), we consider this explanation for our observation unlikely. There was no fire in the surrounding area around the time of our observation (C.M. Murphy, pers. observ.). Thus, it is most likely that the squirrel we observed was either fleeing from a predation threat or was seeking refuge from high surface temperatures.

Our finding further emphasizes the importance of Gopher Tortoise burrows in Longleaf Pine forests (Eisenberg 1983). Although we cannot determine whether our observation is an anomaly or a common Eastern Fox Squirrel behavior, our observation confirms that Eastern

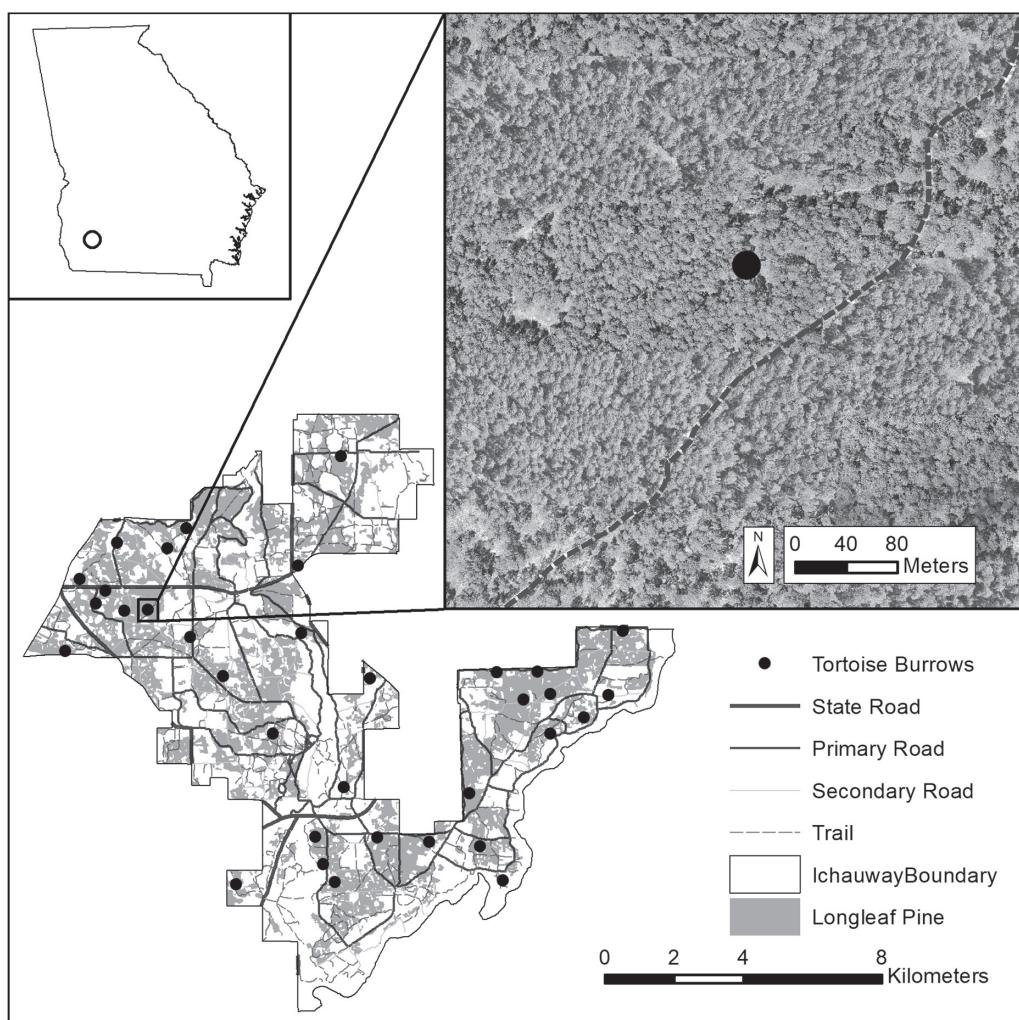


Figure 2. Locations of Gopher Tortoise burrows monitored for wildlife activity. The expanded window shows the Gopher Tortoise burrow and surrounding Longleaf Pine forest used by an Eastern Fox Squirrel.

Fox Squirrels use Gopher Tortoise burrows. We observed an Eastern Fox Squirrel using a Gopher Tortoise burrow only once out of 340 camera trap nights, suggesting that this is an uncommon behavior (Wooding 1997). However, our observations, in addition to those by Dziadzio and Smith (2016), suggest a potentially more complex relationship between the 2 species than previously thought. Additional studies and observations are needed to fully understand the extent of interactions between Eastern Fox Squirrels and Gopher Tortoises.

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