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THE FLORIDA GOPHER FROG AND THE FLORIDA PINE SNAKE AS BURROW ASSOCIATES OF THE GOPHER TORTOISE IN NORTHERN FLORIDA

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At last year's meeting, John F. Eisenberg showed that the Florida mouse, *Peromyscus floridanus*, was intimately associated with burrows of gopher tortoises, *Gopherus polyphemus*. He indicated that individual mice spent much of their lives in one, two, or rarely three tortoise burrows. He suggested that the mice used tortoise burrows as shelters to escape environmental adversities and as places to reproduce and raise their young.

Today, I would like to discuss studies involving two other burrow commensals: Florida gopher frogs, *Rana areolata aesopus*, and Florida pine snakes, *Pituophis melanoleucus mugitus*. These studies, like that of Eisenberg's, focus on animals occurring on the 3700 hectare (ha) Katharine Ordway Preserve-Swisher Memorial Sanctuary, about 40 kilometers east of Gainesville, Putnam County, Florida. Those people attending tomorrow's field trip to the Preserve will be able to see these study sites first hand and maybe even glimpse these animals in their natural settings.

The Preserve was originally obtained by The University of Florida and the Nature Conservancy about four years ago for the purpose of stimulating research in and conserving examples of unique North Florida sand ridge ecosystems. Because of its location at the southern end of Trail Ridge, the Preserve consists of a mosaic of high pine forests, turkey oak barrens, and xeric live oak hammocks, interspersed with more mesic hardwood forests, wetlands, ponds and lakes.

The study sites discussed today are located on a series of low sandhills on the eastern j side of the Preserve. The areas include important concentrations of gopher tortoises and pocket gophers, *Geomys pinetis*. By their burrowing activities, both of these species create extensive subsurface retreats which are routinely used by the study species, as well as the Florida mouse and other animals. For this essential role, it is fitting that we consider both the tortoise and the pocket gopher as keystone members in these communities of xeric-adapted species.

The studies that I am about to describe are part of a larger, more comprehensive investigation that is attempting to understanding the complex workings of North Florida upland animal communities. To this point, there are currently ongoing studies involving Sherman's fox

squirrels, opossums, raccoons, bobcats, red and gray foxes, pocket gophers, various rodents, kestrels, red-headed woodpeckers, sandhill cranes, alligators, diamondback rattlesnakes, and breeding frogs.

My work focuses on individual movements, habitat use, home range and behavior. I want to emphasize here that these studies are still in progress and that the results presented today are preliminary. The current studies are scheduled to terminate next year.

FLORIDA GOPHER FROG

During the summer of 1983, I learned that gopher frogs had a propensity for entering screen funnel traps placed in the mouths of gopher tortoise burrows. I saw in this discovery an effective method for monitoring gopher frog colonies for extended periods of time. I realized that from such a study it would be possible to evaluate the importance of this burrow to gopher frogs.

I began to mark individual frogs (by toe-clipping) in September 1983 on a 15 ha portion of the Smith Lake Sandhill adjacent to known breeding ponds. Initially, I sampled frogs from 52 tortoise burrows. This number rose to 72 burrows with additional censuses in January and July (1984). I noted the width and mouth orientation of each burrow at the time of discovery and monitored the status (active, inactive, or old) of each burrow throughout the study period. It became apparent that although the number of burrows increased with time, the number of active burrows remained constant ($n = 18$). This suggested that the number of tortoises living on the plot also remained constant. Measurements of existing holes indicated that only large subadult and adult tortoises occurred in this colony.

Each open tortoise burrow was trapped for frogs on two consecutive days each month (usually toward the middle of the month). Traps were set in the early evening and checked the following morning before the tortoises became active. Otherwise, the tortoise would have destroyed the screen funnels on their way in or out of the burrows.

RESULTS

I marked 100 gopher frogs on this plot during the 16-month period ending 13 December 1984. These frogs were caught 190 times, which represented an over-all capture rate of 13.7% based on 1388 trap nights (= one trap per hole per night). More than half of the marked frogs (51.5%) were recaptured at least once, and some as many as 10 times.

Frogs preferred active tortoise burrows over inactive or old burrows, although they used all three types as long as the holes remained open. Many of the frogs were found repeatedly at the same burrows for up to 11 months. Others were caught sporadically at the same burrow, but not monthly. In some cases, frogs disappeared from the study plot, only to reappear at the same site several months to one year later. Others were found at several different sites on the sandhill during the course of the study.

Capture success varied seasonally. The greatest number of captures occurred in May and June, and in September, October and November. The lowest numbers were found in December, January and February.

I believe that at least part of this observed seasonality can best be explained by the frog's natural history. In winter, adult frogs leave sandhill sites and move to breeding ponds. This probably accounts for the dramatic reduction in the number of adult frogs captured at tortoise burrows from December through April. During this time, there were still juvenile and subadult frogs present in some numbers in the sandhill, although trapping success fluctuated with the weather. In 1984, chorusing frogs were noted between early February and mid-April, although calling males were heard occasionally into early May. Choruses were sporadic during the prime breeding season, and it was during periods of reproductive inactivity that adult frogs were occasionally trapped in burrows close to the ponds. In May and June, there were significant increases in the number of adults in the sandhill. Their numbers dropped somewhat later. In September and later, adult frogs again became common on the study plot. It was also at this time that large numbers of unmarked frogs appeared on the plot and that more than one frog was caught in some traps. I believe the best explanation for this fall pattern is as follows. In late spring, after leaving the breeding ponds, adult frogs disperse considerable distances into surrounding sand hills. From September through November, frogs return to the ponds following the same routes that they had used the previous season. This, I believe, not only accounts for the increase in the number of frogs that I observed in fall on the study plot, but also explains why many of the marked frogs suddenly reappeared in the same burrows that they had occupied the previous year.

Transformed frogs appeared in tortoise burrows for the first time from June through November. According to Wright (1932, *Life Histories of the Frogs of the Okefinokee Swamp, Georgia*, p. 348), gopher frogs transform at a snout-vent length (SVL) of 32-35 mm. Transformed frogs entering tortoise burrows at Smith Lake measured 38-40 mm SVL. The size disparity between Wright's observations and mine may suggest that juveniles stay near breeding ponds for a brief period after transformation before migrating to tortoise burrows in the adjacent sandhill.

Gopher frogs grow slowly. Growth data from recaptured individuals indicate that small frogs increase in SVL faster than larger ones. The mean monthly growth rate, however, for all sizes of frogs with known growth histories, was approximately 1.5 mm. This suggests that it takes a frog 46.6 months (or 3.8 years) to grow from 35 mm at transformation to a maximum of 105 mm (maximum recorded size for Smith Lake Sandhill frogs).

FLORIDA PINE SNAKE

In 1984, I radio-tracked 3 male pine snakes for up to 10 months. I had purchased MHz transmitters from AVM Corporation, and with the help of Paul Moler, Joan Diemer, and "Ab" Abercrombie, had them surgically implanted into the posterior region of each snake's body. Each transmitter weighed 27 grams and was powered by a lithium battery with a stated life expectancy of 10 months. An 18-inch (45.7 cm) flexible antenna was threaded forward from the transmitter between the skin and muscle tissue of each snake. The MHz rating for each transmitter was used as the snake's identification number (see below).

Snakes were usually tracked daily. Observations were limited to less than 2 minutes each to minimize the amount of disturbance to the snakes. Snakes were tracked using a Telonics TR- 2 receiver and a small hand-held yagi antenna. This system allowed me to locate snakes to within one foot, even when the snake was below ground. Signals could be detected as much as 0.5 km away from the snake's position. After finding the snake, I plotted its location on Florida Department of Transportation aerial photographs (scale: 1 inch = 200 feet). Data on behavior, habitat, and time of day were noted at the time of location. Movements were measured as a straight line distance between consecutive locations on the photographs.

I calculated monthly and annual home ranges from minimum polygons drawn from the plotted radio fixes on the photographs. Two snakes (# 164.813 and # 164.988) were radio- tracked for 10 months each, while the third was followed for only 6 months until its death, probably at the "hands" of a red-tailed hawk.

RESULTS

The annual home ranges of the three snakes were estimated as 38.4 ha, 92.75 ha, and 28.45 ha (the latter based on 6 months; mean, 53.2 ha). The movement data indicate that pine snakes maintain annual home ranges that include both areas of concentrated use (or core areas) and areas associated with ancillary movements (or forays). Snakes made unidirectional movements away from the core areas and spent 2 to 7 days in previously unrecorded sites before returning to the core areas via either their previous routes or the shortest routes.

Snakes were located 598 times during the study period (4 January 1984 to 8 January 1985). During this time the snakes were located at 207 different sites, including 126 locations (61%) in high pine and turkey oak associations; 50 (24%) in ruderal settings, particularly old pastures; 16 (7.7%) in xeric hammocks; and 15 (7.2%) along littoral margins of clear-water lakes and associated gallberry-fetterbush thickets between the lakes and adjacent xeric hammocks. Pine snakes are extremely fossorial. Of 598 locations, only 92 (15.4%) were above ground. The remainder were in burrows of pocket gophers (56.2%), gopher tortoises (23.6%), or other burrows (4.8%). The pointed snouts and conical heads of pine snakes are beautifully adapted for digging. On six occasions, I watched these snakes excavating pocket gopher mounds in the manner described by Carpenter (1982, J. Herpetol.) for the closely related bullsnake in Oklahoma. This method involved pushing the head into the sand, and then, with the side of the head and neck, scooping the sand out of the excavation.

Pine snakes were active mainly in May, June, July, and October. During these months, snakes made the greatest number of moves (141 vs. 64) and traveled the greatest distances (28,541 m vs. 7131.5 m). It was also during this period that we observed the largest monthly home ranges.

CONSERVATION OF BURROW COMMENSALS

Both the Florida gopher frog and Florida pine snake depend upon underground holes and cavities to escape adverse surface conditions and presumably certain types of predators. In North Florida sandhills, they primarily use the burrows of the tortoise and pocket gopher, since these two burrowing species are responsible for most of the earth moving that occurs in this environment.

Decline in the excavators could potentially cause declines in the commensals. This I would not only affect gopher frogs and pine snakes but would also damage populations of unique arthropods that occur as obligates in these excavations (see Woodruff 1982: Proc. 3rd Ann. Mtg. Gopher Tortoise Council). The gopher frog poses an additional conservation problem. Gopher frogs need special types of ponds for breeding. Of the 54+ bodies of water on the Preserve, we have only found frogs breeding in four. These are typically shallow ponds with dense stands of emergent grasses. Each one periodically becomes dry, so that none is able to support populations of predatory fishes, particularly sunfish, pickerel, or bass. Data from the present study also indicate that frogs stop in burrows adjacent to breeding ponds for an extended period of time during their annual migration before making the final movement into the pond. This suggests that it is essential not only to preserve proper breeding ponds but also to maintain large numbers of open tortoise burrows in the adjoining sandhill habitats.

To me, the North Florida sandhills, with their unique flora and fauna, is an exciting environment that needs conserving. In order to protect it, we must set aside large enough tracts of land to insure that the many and varied species that live in sandhills have the necessary environmental components (i.e., uplands and adjacent wetlands) and space to live normal lives. To me, our job as individuals and as members of the Gopher Tortoise Council goes far beyond seeking protection for individual species. We must actively seek protection for large tracts of land such as that of the Ordway. I hope people will stay over for tomorrow's field trip. I think I you will find the Ordway Preserve a very special place and well worth your visit. Thank you.

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ADDENDUM--On 1 July 1985, the Florida pine snake was listed by the State of Florida as a Species of Special Concern. It is now against the law to possess this snake without a special permit. For more information, contact Don Wood, Florida Game and Fresh Water Fish Commission, Tallahassee, FL.