Acta Herpetologica 4(2): 191-194, 2009

Ratsnake response to bottomland flooding: implications for avian nest predation

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Submitted on: 2009, 25th June; revised on 2009, 26st August; accepted on 2009, 28th August.

Abstract. Lower predation has been documented for birds' nests located over water and a recent study found lower predation on wood duck (*Aix sponsa*) nests in bottomland forest during flooding. In a three-year study we used radio telemetry to determine whether flooding affected use of bottomlands by ratsnakes (*Elaphe obsoleta*) and thus might explain reduced nest predation. Of the 22 ratsnakes we tracked, only five used bottomlands and three of them did so exclusively, suggesting a surprising degree of habitat specialization by individual snakes. Those individuals regularly moved into flooded forest and their frequency of movement and distance moved appeared unaffected by flooding. Although it seems unlikely that ratsnakes leave bottomlands during floods, they may prey more extensively on small mammals that are restricted to trees when the forest is flooded, thereby reducing predation pressure on nesting birds.

Keywords. *Elaphe obsoleta*, avian nest predation, radiotelemetry.

Despite the importance of nest predation for birds, ornithologists generally can only infer predator behavior from patterns of predation. A fuller understanding of nest predation requires that we study the predators directly (Weatherhead and Blouin-Demers, 2004). There is considerable evidence that birds reduce nest predation risk by nesting over water (e.g., Weatherhead and Robertson, 1977; Jobin and Picman, 1997; Sanchez-Lafuente et al., 1998; Hoover, 2006). Also, birds nesting in bottomlands experience less predation when those habitats are flooded (Kennamer, 2001; Roy Neilsen and Gates, 2007). The latter result suggests that predators alter their behavior in response to flooding. Here we investigate how ratsnakes (*Elaphe obsoleta*) responded to bottomland flooding to determine whether changes in their behavior could account for reduced nest predation.

Roy Neilson and Gates (2007) studied wood ducks (*Aix sponsa*) nesting in bottomland and adjacent upland forest in southern Illinois, a state located within the 'midwestern' region of the USA. In a year of intensive study they found no predation in bottomland nests during a four-week flood, and a retrospective analysis of earlier data revealed lower

predation during floods for bottomland but not upland nests. Ratsnakes and raccoons (*Procyon lotor*) were identified as the two principal nest predators based on direct observation and the state of nests following predation. Roy Neilson and Gates (2007) speculated that lower predation during floods could result from predators moving less, leaving the flooded area, dying, or switching prey. Here we use data from a telemetry study of ratsnakes to assess the first three of these hypotheses. Ratsnakes exploit a suite of prey (Fitch, 1963), with birds an important component of the diet of snakes at our study site (Carfagno et al., 2006). Coincidentally, our study was also conducted in southern Illinois and overlapped temporally with Roy Neilson and Gates' (2007) study. Although respective study sites were in different locations, they were located in adjacent counties within 60 km of each other.

We used radio telemetry to study habitat use (Carfagno and Weatherhead, 2006) and movement (Carfagno and Weatherhead, 2008) of ratsnakes at the Cache River State Natural Area in Johnson County, Illinois (37° 23' N, 88° 54' W) from 2002 to 2004. Similar to the habitat at the wood duck study sites (Ryan et al., 1998), our snakes primarily used a mixture of upland and periodically flooding bottomland forests within an agricultural matrix. Bottomland forest, including areas classified as bottomland edge (within 15 m of open habitat) comprised approximately 23% of the habitat in our study area.

We captured ratsnakes opportunistically and as they emerged from hibernacula. We surgically implanted radio transmitters in 22 ratsnakes and usually relocated them every other day throughout the active season (see Carfagno and Weatherhead, 2006, 2008 for details). We did not document flooding per se, but recorded whether the habitat was flooded each time we located a snake in the bottomland. Although there were permanently flooded forests near our study area, all the bottomlands in our study area flooded only seasonally (usually spring). Snake locations were mapped using GPS. We calculated frequency of movement as the probability that a snake had moved each time it was relocated and the distance moved as the straight-line distance between consecutive locations.

Over three field seasons we relocated snakes in bottomlands 420 times. All of these observations came from only five (2 females, 3 males) of the 22 ratsnakes we tracked. Furthermore, three of those five individuals used bottomlands exclusively, suggesting some ratsnakes are bottomland specialists. Four of those five individuals came from the same hibernaculum. That hibernaculum and the one used by the fifth individual were both located on the edge of bottomland forest, whereas all other ratsnakes we tracked (i.e., those using exclusively upland habitats) hibernated in sites in upland forest.

We relocated ratsnakes in flooded areas 24 times. The snakes were always in trees when in flooded habitat. All 24 observations came from the three snakes that used only bottomlands. On nine occasions a snake moved from dry to flooded bottomland, and each time moved back to dry bottomland after remaining in the flooded area for 1 - 7 relocations. Ratsnakes in flooded bottomlands moved slightly more often than when in dry bottomlands (85.3 ± 5.3% vs. 73.1 ± 2.5%) but moved slightly shorter distances (92.2 ± 28.5 m vs. 117.9 ± 7.7 m). At our study site, the spatial distribution of snakes was not found to be related to the distribution of small mammals (Carfagno et al., 2006), but nest predation risk did increase when ratsnakes were most active (Weatherhead et al., in press).

We found a surprising degree of habitat specialization among the ratsnakes we tracked, with only five of 22 individuals using bottomlands at all, and three of those five using bottomlands exclusively. There also appeared to be segregation between hibernation

sites of snakes that used upland and bottomland habitats. Many of the other ratsnakes we tracked hibernated within several hundred meters of bottomland forest, so their failure to use bottomlands was not a consequence of that habitat being unavailable to them. A consequence of habitat specialization was that the observations relevant to our objectives came from a small number of snakes and thus must be interpreted cautiously. We found no evidence to suggest that flooding altered ratsnake use of bottomlands. Snakes moved into flooded areas and appeared to behave similarly in flooded and dry forest in terms of how often and how far they moved.

Studies in Canada have shown that ratsnakes do not spend much time in water, but they do use wetlands and readily cross open water (Weatherhead and Hoysak, 1989; Blouin-Demers and Weatherhead, 2001). In a study conducted near our site in Illinois, Hoover (2006) found that apparent snake predation on nests of prothonotary warblers (*Protonotaria citrea*) did not decline with water depth, further supporting the view that water is not a deterrent to ratsnakes. Therefore, it seems unlikely that the decline in wood duck nest predation during floods reported by Roy Neilson and Gates (2007) resulted from ratsnakes leaving (or dying in) bottomlands when they flooded, or moving less when in flooded bottomlands.

If ratsnakes remain in bottomlands during floods, how can we explain the complete absence of nest predation during a four-week flood reported by Roy Neilson and Gates (2007)? Absence of raccoons from flooded areas (Cagle, 1949; Hoover, 2006) may account for some but not all of the reduced predation. Roy Neilson and Gates (2007) suggested that nest predators might switch to alternative prey during floods (e.g., Pehrsson, 1985; Summers, 1986), which could apply to ratsnakes. Ratsnakes' prey primarily on small mammals, and in our study area the white-footed mouse (*Peromyscus leucopus*) is the principal mammalian prey (Carfagno et al., 2006). In a study in a floodplain in Illinois, Batzli (1977) found that *Peromyscus leucopus* responded to flooding by moving into trees. With both the mice and snakes restricted to trees during floods, it may be most profitable for the snakes to prey almost exclusively on mice, thereby reducing or eliminating snake predation on birds' nests. Testing this idea will require analyzing the diet of ratsnakes in bottomland forest during flooded and dry conditions.

ACKNOWLEDGEMENTS

We thank K. Bugle, A. Hagen, R. Kelly, and E. Tetauer for assisting with snake fieldwork, J. Whittington for assisting with surgeries, the Illinois Department of Natural Resources and the U.S. Fish and Wildlife Service for providing support and accommodation, L. Luiselli and an anonymous reviewer for comments that improved the manuscript, and the University of Illinois and The Nature Conservancy for financial support.

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