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Brittney J. Yohannes

James L. Howitz

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ADULT RED-HEADED WOODPECKER INTERACTION WITH BULLSNAKE AFTER ARBOREAL NEST DEPREDATION

—Nest success rates often are higher among cavity nesting birds than those that nest in open cups or on the ground (Martin and Li 1992, Wesołowski and Tomiłowicz 2005). Among cavity nesting birds, woodpeckers have some of the highest rates of nest success (Johnson and Kermott 1994). A review of woodpecker nesting ecology across species documented nest success ranging from 0.42 to 1.00 with a median of 0.80 ($n = 84$ populations), and that predation was low, ranging from 0.00 to 0.35 with a median of 0.13 ($n = 33$ populations, Paclík et al. 2009). The constrained opening to a cavity nest limits predation to relatively small animals or those able to break open cavity walls (Paclík et al. 2009). Snakes can readily enter cavities, and predation by various snake species has been observed or assumed a significant cause of egg and nestling mortality for red-headed woodpeckers (*Melanerpes erythrocephalus*; Ingold 1991, Hudson and Bollinger 2013).

The bullsnake (*Pituophis catenifer sayi*), a subspecies of the gopher snake (*Pituophis catenifer*), is found throughout the Great Plains region of North America, parts of the Midwest, and northeastern Mexico (Conant and Collins 1998). Gopher snakes typically eat terrestrial and subterranean mammals, but a study of 2,600 preserved specimens demonstrated that 11.9% of ingested prey were bird eggs, 8.1% were birds, and 0.7% were either nestlings or bird eggs, with frequencies regionally greater in the Great Plains (Rodrigues-Robles 2002). In captivity, bullsnakes have been shown to develop an exclusive appetite for bird eggs, preferring eggs over live rodents and nestling birds (Imler 1945).

The literature contains accounts of gopher snakes climbing to reach bird nests. Gopher snakes have been documented depredating arboreal cup nests (Neidrach 1971, Best 1977, Armstrup and McEneaney 1980, Maxson 1981). This snake species also has been documented ascending into cavity nests of cliff swallows (*Petrochelidon pyrrhonota*) and northern orioles (*Icterus galbula*) with restricted entrances (Thompson and Turner 1980, Marr 1985), as well as depredating western bluebird (*Sialia mexicana*) nest boxes (Eichholz and Koenig 1992), black-capped chickadee (*Poecile atricapillus*) cavities (Howitz 1986), and European starling (*Sturnus vulgaris*) cavities (M. T. Stanback, personal observation as cited in Eichholz and Koenig 1992). The only predation event of a woodpecker nest by a gopher snake, to our knowledge, was that of an acorn woodpecker (*Melanerpes formicivorus*) (Macrobarts and Macrobarts 1976, M. T. Stanback and W. D. Koenig, personal observation as cited in Eichholz and Koenig 1992).

During a study in east-central Minnesota of the nesting ecology of red-headed woodpeckers, we observed a bullsnake depredating the nest of a red-headed woodpecker as a color-banded male defended his nest. We also observed a bullsnake climbing another tree and searching cavities about

100 m away from the first observation. To our knowledge, this is the first documented observation of red-headed woodpecker nest depredation by any subspecies of gopher snake, and the first documented case of an adult red-headed woodpecker actively defending its nest against snake predation.

On 10 June 2015, we were monitoring red-headed woodpecker nests at Cedar Creek Ecosystem Science Reserve in East Bethel, MN with a nest cavity camera (IBWO.org, Little Rock, Arkansas) and telescoping pole (Crain, Mound City, Illinois). It was a partly cloudy day with a high of 26.1 °C (National Oceanic and Atmospheric Administration). At 1055 CDT we arrived at a tree with an active red-headed woodpecker nest inside. The nest tree was a living northern pin oak (*Quercus ellipsoidalis*) that was 15.0 m tall with a diameter at breast height of 0.97 m. Entrance to the woodpecker cavity was 2.9 m off the ground. No branches existed below the cavity entrance, but the tree had rough bark. The nest had contained six red-headed woodpecker eggs at our last observation on 8 June. When we arrived at the tree, we observed a bullsnake with its head inside the nest cavity and its body wrapped around the tree. The snake then entirely entered the cavity. With the cavity camera, we observed that three of the six eggs from our last observation were missing. Because we rarely observed partial loss of red-headed woodpecker nests in our study, we assume the three missing eggs had been eaten by the snake just prior to our arrival, although we did not observe any obvious bulges in the snake. The other three eggs appeared intact.

At approximately 1110 CDT, the banded female flew to the tree, climbed to the cavity entrance, looked inside, and flew away without any audible vocalizations. Approximately 10 min later the banded male flew to the tree. He peered into the cavity with no warning calls or vocalizations. He then entered the cavity with the snake still inside. We continued to watch from a distance while the snake and the woodpecker remained in the cavity.

At 1129 CDT, we heard the male woodpecker vocalizing from inside the nest cavity. Using the camera, we recorded three short videos of the struggle occurring inside the cavity. The video showed the snake coiled inside the cavity with the woodpecker pressed against the side of the cavity, but not coiled around the bird. In laboratory tests Hisaw and Gloyd (1926) observed that when bullsnakes are hunting in a confined area they can kill prey by pushing them against a side of an enclosure. The woodpecker had part of the snake's body in its beak, appearing to bite the snake. One of the bird's claws was embedded in the snake's skin. Next, we watched the snake open its mouth around the bird's head, anterior to the beak, and grasp the bird. The snake and woodpecker continued to struggle inside the cavity for approximately 30 min.

At 1148 CDT, the bullsnake rapidly exited the cavity and climbed down the tree. Based on photos of the snake climbing down the tree and subsequent measurements of the tree, we estimated the snake to be ~90–100 cm long snout to tail,

which indicates it was likely either a sub-adult or small adult (Conant and Collins 1998). The male red-headed woodpecker exited the cavity approximately one min later. He had blood on his head and fluttered to the ground. His breathing was labored but after a few seconds he flew to a nearby tree and perched without any obvious trouble. Examination of the nest cavity revealed several contour feathers and three broken, uneaten eggs. We identified the banded male red-headed woodpecker on his original territory 45 days after this event. He and his banded mate both continued to defend their territory following this event through the rest of the summer and fall, but we did not find any evidence that he or his mate attempted a second clutch that season.

Approximately 6 weeks later, on the afternoon of 22 July 2015, we saw a bullsnake climbing a dead tree that was 11.0 m tall with rough bark, patches of bark missing, and numerous cavities. The location of the tree was approximately 100 m south of where we first observed a bullsnake depredating a red-headed woodpecker nest. It was unclear whether this bullsnake was the same individual that depredated the nest on 10 June 2015. We had been monitoring cavities in that tree 2–3 times a week and to our knowledge there was no active bird nest in that tree since a northern flicker (*Colaptes auratus*) nest had been active five weeks prior. The snake systematically climbed up the tree and put its head inside every hole along the way. Once it reached the top of the tree (10.4 m above ground), the snake put its head inside the top-most cavity where the northern flickers had previously nested. The snake descended the tree, again checking cavities it had put its head into on the way up, repeatedly entering cavities with its entire body.

On 16 July 2014 we observed a bullsnake peering from a cavity where three red-headed woodpecker nestlings had fledged 5 days prior. We observed one adult and two fledgling red-headed woodpeckers on nearby trees. The cavity was 4.8 m off the ground in a living northern pin oak. The tree was 16.2 m tall with a diameter at breast height of 1.37 m. The snake remained in the cavity, looking out for approximately 20 min. Then it slowly descended the tree using the available branches for support. We could not see any obvious bulges in the snake to indicate that it had consumed eggs or nestlings.

To our knowledge, this is the first documented case of a bullsnake preying upon a red-headed woodpecker nest, as well as the first documentation of an adult red-headed woodpecker actively defending its nest against any subspecies of gopher snake. This observation demonstrates that bullsnakes might be a more significant predator of red-headed woodpecker nests than previously reported. Bullsnake distribution overlaps broadly with that of red-headed woodpeckers throughout the Great Plains and portions of the Midwest, and bullsnakes frequently inhabit the same oak savanna habitats as red-headed woodpeckers (Conant and Collins 1998, Frei et al. 2015).

In nest studies, researchers sometimes find a nest empty well before potential fledging date and attribute it to snake predation based on the condition of the nest. However, signs of predation are not always a reliable way of determining predator identity and without continuous camera monitoring it is rare to observe the species of snake responsible (Pietz et al. 2012). In our nest monitoring study, we attributed some nest mortality to bullsnake predation, although we lacked direct evidence. Our direct observations now provide evidence that bullsnakes are capable of depredating red-headed woodpecker nests, even in cavities well above the ground.

Our two observations of bullsnakes climbing high in trees, seemingly searching for food in cavities, are noteworthy because no active nests were present. Snakes appeared to search trees systematically by checking each hole along the way up the tree. This would contradict previous results by Eichholz and Koenig (1992), who noted that gopher snakes preferentially climb trees that contain active nests.

Neither sex of red-headed woodpecker gave alarm calls upon looking into the nest cavity with the snake. No audible noise was heard until the male bird was inside the cavity interacting with the snake. We find this noteworthy because red-headed woodpeckers are vocal and elicited alarm calls regularly when we approached nests, as well as when conspecifics or other woodpeckers enter their territory. Additionally, there is little documentation of nesting adult woodpecker interactions with snakes in North America. Delaney et al. (2008) observed no direct aggression from a red-cockaded woodpecker (*Leuconotopicus borealis*) to an eastern ratsnake (*Pantherophis alleghaniensis*) which depredated its nest. Nolan (1959) documented male and female pileated woodpeckers (*Hylatomus pileatus*) attack a pilot black snake (*Pantherophis obsoletus*) which entered their nest cavity. The interaction between the bullsnake and red-headed woodpecker described here is a rarely documented instance of a North American woodpecker actively defending its nest against a snake.

We thank B. Turner for her assistance in documenting these observations, T. Arnold for guidance and editorial comments, and Cedar Creek Ecosystem Science Reserve for use of the study site and field equipment. We also thank Red-headed Woodpecker Recovery for equipment, volunteer help, and funding. This project was also funded by the University of Minnesota Conservation Biology Program, the Wally Dayton Wildlife Fund, Audubon Chapter of Minneapolis, and Patagonia Clothing Company. We thank Mike Eichholz and an anonymous reviewer for their valuable input on an earlier version of this manuscript.—*Brittney J. Yohannes and James L. Howitz. Conservation Sciences Program, University of Minnesota, 135B Skok Hall, Upper Buford Circle, St Paul, MN 55108 (BJY); Red-headed Woodpecker Recovery, Audubon Chapter of Minneapolis, PO Box 3801, Minneapolis, MN 55403 (JLH); Corresponding author's email address: brittneylarson27@gmail.com.*

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Submitted 23 May 2016. Accepted 2 Apr 2017. Associate Editor was Keith Geluso.