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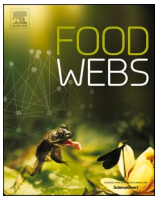

A simple trail camera modification reveals red-bellied woodpeckers as important egg predators of box-nesting wood ducks

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ABSTRACT

Artificial nesting structures have been used to aid the recovery and maintenance of certain avian populations such as the wood duck (*Aix sponsa*). The success of nest boxes for wood ducks relies on excluding common nest predators such as raccoons (*Procyon lotor*) and rat snakes (*Pantherophis* spp.) via the use of predator guards; however, woodpeckers cannot be excluded. Red-bellied woodpeckers (*Melanerpes carolinus*) are foraging generalists and have been anecdotally observed preying on wood duck eggs where documenting predation events is difficult to accomplish through traditional nest box monitoring. Here, we used custom-modified trail cameras to document egg depredations and foraging events by red-bellied woodpeckers and the removal of damaged eggs by wood ducks during the laying and incubation periods. We captured 35,686 videos and documented 1173 different events consisting of 608 (51.8%) videos of red-bellied woodpeckers and 565 (48.2%) of wood ducks. We determined 38 (30.6%) eggs were depredated during the laying period and 14 (11.3%) during incubation. Wood ducks removed 23 (60.5%) eggs depredated during the laying period and 13 (92.9%) depredated during incubation. We found no difference in the daily number of times red-bellied woodpeckers visited boxes with nests in the laying or incubation period ($t = -0.967$, df = 14.699, $P = 0.349$). Red-bellied woodpeckers depredated 1.0 $\pm$ 0.2 eggs during each event and returned to forage on previously depredated eggs 5.3 $\pm$ 4.4 times each day spending 2.1 $\pm$ 1.1 min during each return. Our results suggest that red-bellied woodpeckers forage on eggs when nests are unguarded, and they have previously been under-recognized in the literature as predators of wood duck eggs. Future nest box programs should consider the impact red-bellied woodpeckers have on wood duck egg loss and nest survival.

Artificial nesting structures have been used to aid the recovery and maintenance of certain avian populations (Bellrose and Holm, 1994; Libois et al., 2012; Gowaty and Plissner, 2015). For example, wood duck (*Aix sponsa*) populations declined during the early 1900s partially due to the loss of tree cavities used for nesting (Bellrose and Holm, 1994); nest box programs helped them recover by providing additional nest sites on the landscape. Today, wood duck populations are stable or increasing (Baldassarre, 2014; United States Fish and Wildlife Service, 2023) and nest box programs are still maintained throughout the species' range to bolster local abundance.

The success of nest boxes for wood ducks relies on excluding common nest predators (Bailey and Bonter, 2017) such as raccoons (*Procyon lotor*) and rat snakes (*Pantherophis* spp.) using various types of predator guards (Bellrose and Holm, 1994). While these efforts have proven to be effective, some avian nest predators such as woodpeckers cannot be excluded. For example, red-bellied woodpeckers (*Melanerpes carolinus*) are foraging generalists (Hazler et al., 2004) and have been documented opportunistically preying on wood duck eggs (Semel and Sherman, 1986; Semel et al., 1988; Yetter et al., 1999). Semel and Sherman (1986) anecdotally observed red-bellied woodpeckers foraging on wood duck eggs ($n = 12$ nests) when the boxes were vacant and found the nest host removed damaged eggs ($n = 5$ egg removals). However, beyond these anecdotes, the pervasiveness and intensity of woodpecker predation remains unclear. In fact, identifying any individual predator or predation event, quantifying the extent of egg depredation, documenting the removal of egg remains, and determining the timing of each event is difficult to accomplish through traditional nest box monitoring.

Here, we custom-modified Bushnell Nature View trail cameras to document activity inside wood duck nest boxes. Briefly, we replaced the threaded ring around the camera lens with one that accommodated an Alilusso 7.5 mm iPhone fisheye lens (Fig. 1), using J-B Weld Waterweld Epoxy Putty to attach it. Following these modifications, we drilled a hole

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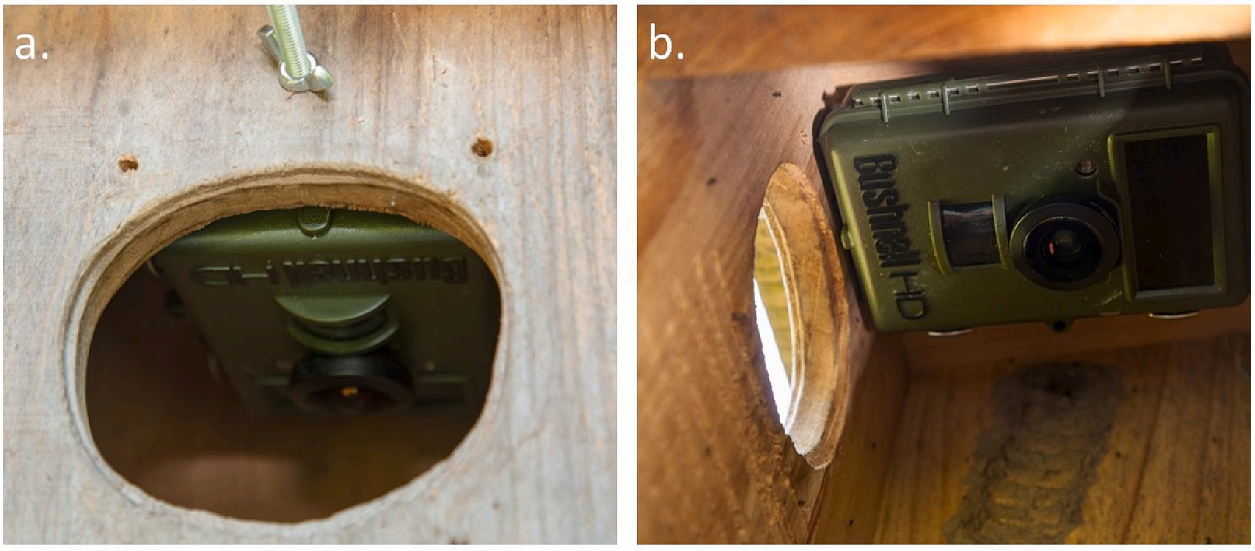

Fig. 1. Modified Bushnell Nature View trail camera equipped with an Alilusso 7.5 mm iPhone fisheye lens used to monitor nest boxes for wood ducks (*Aix sponsa*). Cameras were mounted inside nest boxes using a threaded rod and wing nut (a) providing a top-down view inside (b).

in each nest box ~5 cm above the center of the entrance hole and used a threaded rod and wing nut to mount the camera inside the nest box, giving us a bird's eye view inside (Fig. 1). We programmed cameras to capture 10-s videos with a 1-s delay between recordings each time motion was detected.

We deployed these modified trail cameras in 9 nest boxes located at Sherburne Wildlife Management Area, Louisiana (30.433262, −91.652588) from 17 April – 24 June 2021. We monitored boxes at weekly intervals and replaced camera batteries; occasionally batteries were drained before they could be replaced. After the conclusion of the monitoring period, we reviewed videos and recorded events related to predation. For red-bellied woodpeckers, we classified predation events as when we observed ≥1 egg pecked open, foraging instances where individuals returned to feed on previously depredated eggs, and all other woodpecker activity was assigned as prospecting events. For wood ducks, we identified removal events when depredated eggs were removed from the nest box; all other activity was assigned as occupancy. We considered a > 5-min gap between video clips to represent different events. We determined if each event occurred during the laying or incubation period using data collected at the nest.

We compared the number of visits made by red-bellied woodpeckers during the laying and incubation period using *t*-tests in R version 4.2.1 (R Core Team, 2022). All other measures are reported as means ± standard deviation. We conducted our work under U.S. Fish and Wildlife Service banding permit #06669 and Special Use Permit 43,614–20-04; Louisiana Department of Wildlife and Fisheries state collecting permits WDP-20-037 and WDP-21-060, and Wildlife Management Area Permit WL-Research-2020-03; Louisiana State University Institutional Animal Care and Use Protocol A2019–27.

We captured 35,686 videos and documented 1173 different events. Trail cameras captured 608 (51.8%) videos of woodpeckers composed of 119 (19.6%) depredation events, 374 (61.5%) foraging events, and 115 (18.9%) prospecting events. We observed wood ducks in 565 (48.2%) videos, and we recorded 499 (88.3%) box occupancy events and 66 (11.7%) egg removals. For wood duck videos, we determined 262 (46.4%) were captured during the laying period, 44 (7.8%) during the incubation period, and 259 (45.8%) videos were unassigned. We monitored a total of 11 nests with trail cameras, consisting of 6 (54.5%) that failed during the laying period, 3 (27.7%) that failed during the incubation period, and 2 (18.2%) that were successful. During the laying period, an average of 5.2 ± 5.0 eggs were depredated from each nest and 60.5% were removed. During the incubation period, an average of 3.2 ± 2.9 eggs were depredated from each nest and 92.9% were removed.

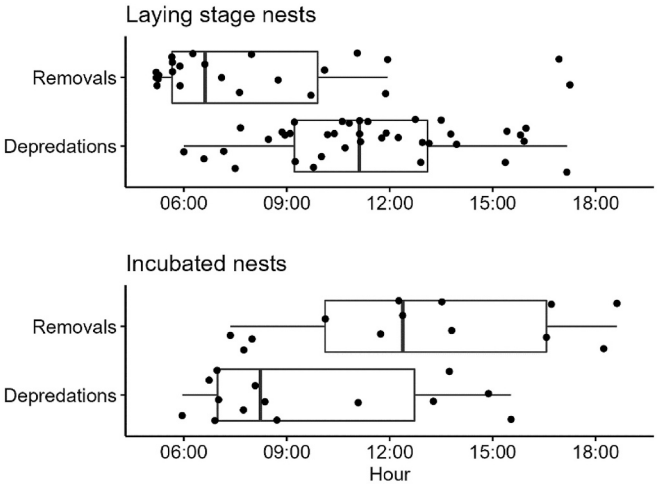

Fig. 2. Time of wood duck (*Aix sponsa*) egg depredations by red-bellied woodpeckers (*Melanerpes carolinus*) and removal of damaged eggs by the nest host during the laying and incubation periods. Observations were made in Louisiana from 17 April – 24 June 2021. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

We found no difference in the daily number of times red-bellied woodpeckers visited boxes with nests at the laying stage ($\bar{x}$ = 3.49, SD = 3.18) compared to nests that were being incubated ($\bar{x}$ = 4.50, SD = 2.92, t = −0.967, df = 14.699, P = 0.349). During the laying period, the timing of egg depredations ranged from 06:00–17:10 ($\bar{x}$ = 11:20, SD = 2.83 h, n = 38) with egg removals occurring from 05:12–17:15 ($\bar{x}$ = 08:11, SD = 3.58 h, n = 23; Fig. 2). During the incubation period, the timing of egg depredations ranged from 05:57–15:32 ($\bar{x}$ = 09:39, SD = 3.36 h, n = 14) with egg removals occurring from 07:21–18:37 ($\bar{x}$ = 12:51, SD = 3.89 h, n = 13; Fig. 2).

Considering all observations (including those unassigned to the laying or incubation period), red-bellied woodpeckers on average depredated 1.0 ± 0.2 eggs during each event, and 124 eggs were lost across all events. Red-bellied woodpeckers returned to boxes to forage on previously depredated eggs 5.3 ± 4.4 times each day spending 2.1 ±

Fig. 3. The sequence of events showing the depredation of a wood duck (*Aix sponsa*) egg by a red-bellied woodpecker (*Melanerpes carolinus*) and the removal of the damaged egg during the laying period in Louisiana in 2021. Following egg-laying which occurs at dawn, red-bellied woodpeckers forage on eggs (a) which are then removed by the nest host the next morning (b), reducing the clutch size (c). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

1.1 min during each return. Red-bellied woodpeckers only used nest boxes when they were vacant, and we observed no physical interaction between red-bellied woodpeckers and wood ducks.

The simple modification of a commonly available trail camera allowed us to quantify wood duck egg depredations via red-bellied woodpeckers. The standard lenses that come with the Bushnell Nature View trail camera can be used to monitor nest boxes; however, modification to the nest box itself may be necessary to achieve the correct focal distance (Surmacki and Podkowa, 2022). Documentation of individual egg predation and foraging events would not have been possible through conventional nest monitoring and observation, and although the review of video footage is laborious, the modified trail cameras we used here provided new insights into the importance of red-bellied woodpeckers as wood duck nest predators.

Our results extend and emphasize the observations made by Semel and Sherman (1986), as we found that red-bellied woodpeckers were the most common and damaging predator at our sites in Louisiana, destroying 124 eggs. Wood ducks lay one egg in the morning each day

during the laying period, and nest boxes remain vacant for the remainder of the day. Red-bellied woodpeckers took advantage of unprotected nests by depredating eggs (generally ~1 egg per box each day) and returning multiple times throughout the day to forage on them. Egg-laying wood ducks that returned the following morning first removed any depredated eggs before laying the next egg in the clutch (Fig. 3). Red-bellied woodpeckers continued to depredate eggs during the incubation period when the wood duck female was absent during morning and afternoon incubation recesses. In such cases, depredated eggs were also removed by the nest host before incubation resumed.

We found predation rates were similar for all nests during the laying stage with 6 clutches transitioning into the incubation period. We determined predation rates were also similar among nests being incubated. Here we report coarse estimates of egg depredations occurring at two discrete stages of the nesting cycle; however, to better understand egg-loss scenarios that result in nest failure, future research should determine the frequency with which egg depredations occur at finer temporal scales. We hypothesized overall nest survival (i.e., the decision to abandon a clutch) would be lower for nests repeatedly losing eggs during conservative days compared with those that only occasionally lose eggs to predators. It is possible that red-bellied woodpeckers are unusually abundant in our study site; however, we have observed them using nest boxes in a wide range of habitats around Louisiana.

Our methods have a wider application beyond assessing predator-prey relationships, as they can also be used to study interspecific interactions at nest boxes. During our monitoring of 11 nests, we found 2 nests containing eggs of parasitic black-bellied whistling-ducks (*Dendrocygna autumnalis*; hereafter, whistling-duck). After reviewing trail camera videos from these nests, we anecdotally observed woodpeckers selecting wood duck eggs after attempting to peck open whistling-duck eggs, suggesting that they may have harder shells to penetrate. Although these observations were infrequent, if woodpeckers do prefer wood duck eggs, there would be a cost to wood ducks incubating clutches containing eggs of both species as egg mortality of their eggs would be higher than that of the parasitic eggs.

Here we documented egg depredations occurring in all 11 nests we monitored. Additionally, 52 (41.9%) egg depredations occurred in nests that were both initiated and terminated between weekly visits. That is, because of woodpecker predation, clutch initiation and egg-laying activity would have been undetectable without the use of nest box cameras. Our results suggest that red-bellied woodpeckers have previously been under-recognized in the literature as predators of wood duck nests and future nest box programs should consider their impact on egg loss and nest survival.

Declaration of Competing Interest

None.

Acknowledgements

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