



Toucans descend to the forest floor to consume the eggs of ground-nesting birds



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ABSTRACT

Toucans (Ramphastidae) are mostly frugivorous birds with important links to seed dispersal in the Neotropics. They are less frequently observed to prey upon invertebrates, small vertebrates, and canopy and cavity bird nests. As part of a nest predator study, we created artificial tinamou (Tinamidae) ground-nests and monitored them with camera traps in La Selva Biological Station (Costa Rica) and surrounding forest fragments. The camera traps revealed two species of toucan descend to the ground to consume the eggs. We are unaware of any other reports of toucans depredating nests on the forest floor. We suggest that toucans might be more opportunistic than expected, particularly in disturbed or fragmented habitats where fruiting trees can be sparse. Toucans could conceivably limit the abundance of other birds via nest depredation on the forest floor and exert selection pressure via eco-evolutionary feedbacks.

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Toucans (Ramphastidae) are some of the most recognizable birds of the Neotropics. The different species of toucans, aracarís, and toucanets vary greatly in size and ecology, but all are associated with the forest canopy and mid-story (Skutch, 1971; Sykes, 2014). Their diets also vary but toucans, with their highly adapted bills, are considered to be mostly frugivorous (Ragusa-Netto, 2008; Skutch, 1971). As frugivores, their ecological function is often linked to seed dispersal, particularly due to their long distance movements (Holbrook, 2011). Smaller species consume large fruits in piecemeal and it has been suggested that they are not necessarily gape limited (Galetti et al., 2000).

Toucans are less frequently observed to prey upon invertebrates and small vertebrates (Skutch, 1971). Galetti et al. (2000) recorded 289 feeding bouts of four sympatric toucans and observed insects and larvae to constitute less than 3% of the feeding events. Ragusa-Netto (2008) made similar observations that toucan toucans (*Ramphastos toco*) seldom consumed arthropods in the cerrado of Brazil, however the author made two observations of toucans consuming eggs from the cavity nests of two parrot species. In their study of yellow-rumped cacique

(*Cacicus cela*) nesting behavior, Robinson (1985) observed 32 instances of Cuvier's toucans (*Ramphastos cuvieri*) attacking the hanging canopy nests of the communal birds. These attacks sometimes resulted in nestling and egg consumption when there were not enough caciques to mob the toucans away from the nests.

Cockle et al. (2016) used camera traps to determine nest predators of 25 species of Neotropical birds. They observed toucans and aracarís to contribute to more than half of the depredation events. However, toucans were only detected consuming eggs and nestlings in cup-, closed-, and cavity-nests in the canopy and mid-story, and none were detected at ground-nests. Ground-nesting birds are predisposed to nest predation due to their accessibility to diverse understory predators, such as mammalian mesopredators (Cove et al., 2014; Gibbs, 1991). It is commonplace for researchers to make artificial nests to assess nest predation rates (e.g., Gibbs, 1991), with the assumption that egg remains persist and predators can be identified by the remaining sign. As part of an experiment examining nest predation rates along fragmentation and disturbance gradients, we established artificial tinamou (Tinamidae) nests throughout La Selva Biological Station and additional forest fragments in northeastern Costa Rica. The nest consisted of three chicken eggs that we dyed light blue with scentless food coloring to match the characteristic color of tinamou eggs (*sensu* Gibbs, 1991). We determined specific nest locations by identifying a tree or stump

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that was suitable for ground-nesting habitat. We used remotely-triggered camera traps (Reconyx PC800 or PC850, RECONYX, Inc., Holmen WI, USA) with heat and motion sensors to monitor potential predator activity and photograph depredation events. We mounted camera traps to trees 2–3 m away facing the ground-nests and left them activated for one week at each nest.

On two separate occasions we detected toucans descending to the forest floor and consuming the eggs in the artificial tinamou nests. At 1410 h on June 18, 2016, we detected a collared aracari (*Pteroglossus turquatus* – Fig. 1) come to the forest floor and visit the nest and attempt to consume one of the eggs. The aracari appeared to be unsuccessful and left the nest after 40s of attempting to break through the eggshell. The nest was located in the core of La Selva Biological Station at the base of a large fallen tree that created a gap in the canopy with a fairly open understory. The second observation occurred at 0747 h on July 14, 2016 at a different nest in a forest fragment on the edge of an agricultural plantation. We detected a keel-billed toucan (*Ramphastos sulfuratus* – Fig. 2) come to the forest floor, disturb the artificial nest, move and then consume all three eggs, leaving behind some eggshell fragments.

We did not anticipate obtaining evidence of any toucans in our surveys of ground-nest predators, so to observe two separate events with two of the native toucan species was suggestive that this may occur more frequently than expected based on previous reports. Gibbs (1991) conducted transect counts of mammals because he hypothesized those groups to be the main culprits in nest depredation events. We would not have obtained evidence that the collared aracari tried to consume the eggs in the nest and we likely would have assumed a different terrestrial predator at the nest consumed by the keel-billed toucan if we had not used camera traps. Camera traps should continue to provide useful natural history information about species interactions that are difficult to observe with other survey methods.

We present here the first evidence of toucans coming to the forest floor to depredate ground-nesting birds' eggs. The aracari appeared to be gape-limited and unable to consume the eggs, which is different from their piecemeal consumption of large fruits; yet it is probable that the small toucan species could more easily consume the eggs of smaller birds (e.g., doves [Columbidae]). The sites where these nests were located were relatively open due to a fallen tree creating a canopy gap at the nest visited by the aracari, whereas the site visited by the toucan was disturbed forest edge adjacent to a plantation. This leads to the question: are these visits to the forest floor related to limited understory habitat or resource availability causing toucans to forage elsewhere, or is foraging on the forest floor common? We suggest that toucans might be more opportunistic than expected, particularly in disturbed or fragmented habitats where fruiting trees can be limited. Further



Fig. 1. Collared aracari (*Pteroglossus turquatus*) attempting to consume an egg from an artificial tinamou (Tinamidae) ground-nest in La Selva Biological Station, Costa Rica.



Fig. 2. Keel-billed toucan (*Ramphastos sulfuratus*) consuming an egg from an artificial tinamou (Tinamidae) ground-nest on the edge of a forest fragment adjacent to La Selva Biological Station, Costa Rica.

research with camera traps at nests along disturbance gradients could help identify the ecological drivers of nest depredation.

We introduce toucans as a novel node in a seemingly terrestrial food web, which suggests that we still have much to learn about natural history to construct complete food webs. These observations also showcase that terrestrial and arboreal food webs are closely linked and their decoupling could limit inferences about species interactions and community dynamics (Giery et al., 2013). Toucans are potential competitors of terrestrial (mostly mammalian) nest predators, which could result in strong interactions. For example, birds have better color vision than most mammals because they retain four of their ancestral cone visual pigment genes compared to two genes in most mammalian predators (Hunt et al., 2009). Consequently, diurnal birds like toucans might be better suited to find ground-nests containing bright blue tinamou eggs than their nocturnal mesopredator competitors. Depending on the synergistic effects of predator competition and anthropogenic habitat changes, eco-evolutionary feedbacks could lead to selection for dull and less conspicuous eggs. Therefore, toucans could play a functional role in reducing ground-nesting bird abundance and further exert selection pressure via nest depredation.

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References

- Cockle, K.L., Bodrati, A., Lammertink, M., Bonaparte, E.B., Ferreyra, C., Di Sallo, F.G., 2016. Predators of bird nests in the Atlantic forest of Argentina and Paraguay. *Wilson J. Ornith.* 128, 120–131.
- Cove, M.V., Spínola, R.M., Jackson, V.L., Saénz, J.C., 2014. The role of fragmentation and landscape changes in the ecological release of common nest predators in the Neotropics. *PeerJ* 2, e464.
- Galetti, M., Laps, R., Pizo, M.A., 2000. Frugivory by toucans (Ramphastidae) at two altitudes in the Atlantic forest of Brazil. *Biotropica* 32, 842–850.
- Gibbs, J.P., 1991. Avian nest predation in tropical wet forest: an experimental study. *Oikos* 60, 155–161.
- Giery, S.T., Lemoine, N.P., Hammerschlag-Peyer, C.M., Abbey-Lee, R.N., Layman, C.A., 2013. Bidirectional trophic linkages couple canopy and understory food webs. *Funct. Ecol.* 27, 1436–1441.

- Holbrook, K.M., 2011. Home range and movement patterns of toucans: implications for seed dispersal. *Biotropica* 43, 357–364.
- Hunt, D.M., Carvalho, L.S., Cowing, J.A., Davies, W.L., 2009. Evolution and spectral tuning of visual pigments in birds and mammals. *Philos. Trans. R. Soc. B* 364, 2941–2955.
- Ragusa-Netto, J., 2008. Toco toucan feeding ecology and local abundance in a habitat mosaic in the Brazilian cerrado. *Ornitol. Neotrop.* 19, 345–359.
- Robinson, S.K., 1985. Coloniality in the yellow-rumped cacique as a defense against nest predators. *Auk* 102, 506–519.
- Skutch, A.F., 1971. Life history of the keel-billed toucan. *Auk* 88, 381–396.
- Sykes, J.M., 2014. Piciformes (Honeyguides, Barbets, Woodpeckers, Toucans). *Fowler's Zoo Wild Anim. Med.* 8, 230.