



Short communication

More than Froot Loops: Keel-billed toucans (*Ramphastos sulfuratus*) consume vertebrate carrionAndrea Romero^{a,*}, Anthony Soto Cedeño^b, Jessica Montaño^c, Gonçal Oliveros Layola^d^a Department of Biology and Department of Geography, Geology, and Environmental Science, University of Wisconsin-Whitewater, 800 W Main St., Upham Hall, Whitewater, WI, 53190, USA^b University of Puerto Rico at Ponce, Ponce, 00734, Puerto Rico^c Metropolitan State University of Denver, Denver, CO, 80204, USA^d No academic affiliation, Barcelona, Spain

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ABSTRACT

The ecological role of scavenging is underestimated, in part, because of limited data on facultative scavengers. Here, we describe a keel-billed toucan (*Ramphastos sulfuratus*) sequestering vertebrate carrion ~1 m off the ground. This observation is the first record of a toucan species supplementing their diet with carrion, and expands the list of facultative scavengers in the Neotropics, an area where scavenging is poorly understood. We caution that vertebrate remains found in gut-content analyses for toucans may be from scavenging, and we highlight that the consumption of vertebrate carrion by toucans could have landscape-level implications in the redistribution and movement of carcass nutrients and energy.

Resumen: El papel ecológico de los carroñeros usualmente se subestima debido, en parte, a la falta de datos robustos sobre carroñeros facultativos. En este trabajo describimos un tucán pico iris (*R. sulfuratus*) alimentándose de carroña de vertebrados a ~1 m del suelo. Esta observación es el primer registro de una especie de tucán que complementa su dieta con carroña, y amplía la lista de carroñeros facultativos en el Neotrópico, un área donde información ecológica sobre carroñeros es precaria. Llamamos la atención que los restos de vertebrados que se encuentran en los análisis del contenido intestinal de los tucanes pueden provenir del consumo de carroña, y destacamos que el consumo de carroña de vertebrados por parte de los tucanes podría afectar el flujo de los nutrientes y la energía proveída por la carroña.

Scavenging is phylogenetically widespread, but our understanding of the important ecological role of scavengers is hindered by limited data. For example, facultative scavengers are more common than obligate scavengers, yet even basic information on the identity of facultative scavengers is lacking (Olea et al., 2019; Wilson and Wolkovich, 2011). Here, we describe the sequestering of vertebrate carrion by a keel-billed toucan (*Ramphastos sulfuratus*), which to our knowledge is the first report of a toucan consuming carrion. Scavenging has widespread and profound impacts on food webs, ecological communities, and ecosystems, and results in important movement of energy through trophic levels and the recycling and dispersal of carcass nutrients across the landscape (Beasley et al., 2015). Nevertheless, scavenging is overlooked or underestimated in food-web and ecological research (Buechley and Sekercioğlu, 2016; Olson et al., 2012).

Areas such as the tropics have been identified as ecosystems where

scavenging is poorly understood (Olea et al., 2019; Sebastián-González et al., 2019). This is particularly true for the Neotropics, where a lot of the focus on scavenging research has been on arthropods and vultures (Gómez et al., 1994; Houston, 1986; Houston, 1988; Lemon, 1991; Villegas-Patraca et al., 2012), and facultative scavengers are beginning to be documented (Arroyo-Arce et al., 2016; O'Donnell, 1995; Romero et al., 2020; Ucha and Santos, 2017). We aim to expand the list of known facultative scavengers in the Neotropics, and highlight how organisms that have been well studied, such as toucans, may in fact be part of the complex scavenging interactions in these ecosystems.

Keel-billed toucans are mostly frugivorous and eat the fruits of palms, figs, and various other plants (Skutch, 1971). Remsen Jr et al. (1993) reported that 80.8% of 26 individuals whose stomach content were analyzed contained only fruit, and the remaining 19.2% had arthropods and fruit. In addition to supplementing their diet with

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Fig. 1. A keel-billed toucan (a) looking at a deployed mouse carcass, (b) beginning to grab the carcass, and (c) finally sequestering the carcass before flying off. The arrows indicate the position of the mouse carcass.

arthropods, keel-billed toucans can also consume snakes, bird eggs, and nestlings (Cove et al., 2017; Skutch, 1971). Keel-billed toucans typically forage in the forest canopy and mid-story, although there are some reports of this species feeding on the forest floor as well (Cove et al., 2017; Davlantes and Howe, 2018).

Our observation of a keel-billed toucan sequestering vertebrate carrion occurred on 28 June 2018 in La Selva Biological Station ($10^{\circ}26'N$, $83^{\circ}59'W$), Costa Rica (Fig. 1). La Selva is situated in the NE Caribbean lowlands of Costa Rica and is composed of a mixture of primary and secondary forests of various ages (McDade and Hartshorn, 1994). This short communication is a result of a scavenging project conducted in the area, where we used euthanized feeder mice (mice fed to pet snakes) to mimic fresh vertebrate carrion on different strata of the forest. We purchased feeder mice from a supplier used by serpentaria in Costa Rica. The mice had white pelage, mimicking the white underside of many native rodent species (Reid, 1997). Approximately half of the feeder mice were placed above ground level ($n = 100$) and the other half on the ground ($n = 102$). Mouse carcasses positioned above ground level were placed ~ 1 m high on naturally level areas of branches or lianas, and secured with clear, monofilament fishing line around a mouse leg. Each deployed mouse was paired with a trail camera, placed ~ 0.5 – 5 m away set to the most sensitive trigger settings to record 30 s video. Our toucan observation was recorded by a Foxelli Outdoor Gear Camera (Tualatin, OR, USA).

At 1054 h we placed a thawed feeder mouse weighing 10.4 g in between the crevice of two branches of a tree in secondary forest within La Selva. Although we placed the mouse carcass in the open, we expect vertebrate carrion to be present at various strata of the forest, such as in nests and tree holes. On the same day, our trail camera recording showed a keel-billed toucan sequestering the mouse carcass at 1246 h (Fig. 1). During this observation, there was no rain, and the trail camera indicated the temperature was $26^{\circ}C$.

In the 3-video sequence, a keel-billed toucan comes into frame at 1243 h and lands on a tree near the deployed feeder mouse (Video S1). In the next video, which starts at 1245 h, two toucans can be seen at the beginning of the recording, with a keel-billed toucan perched on the tree where the mouse is deployed. The keel-billed toucan shifts from one of the tree branches to the other, remaining a short distance above the carcass. During this time period, the toucan is facing down and moves its head from side to side in the direction of the carcass. The toucan then moves to an adjacent liana, where it is now level with the mouse carcass. After 7 s on the liana, the keel-billed toucan uses its beak to grab the mouse carcass. A couple of seconds after the keel-billed toucan begins to grab the carcass with its beak, two chestnut-mandibled toucans (*Ramphastos ambiguus swainsonii*) fly toward the bird that is grabbing the carcass, with one of the individuals landing on the tree branch where the carcass was placed and the keel-billed toucan had originally perched. The keel-billed toucan flies off with the carcass in its beak when the chestnut-mandibled toucans fly in its direction (Video S2). In the final video, two chestnut-mandibled toucans are seen in the frame, one of them near the area where the carcass had been placed, and at a similar height above ground as where the feeder mouse had been deployed

(Video S3).

This novel observation of a keel-billed toucan sequestering a vertebrate carcass indicates that the diet of this organism is also supplemented with carrion. However, we do not know to what extent toucans consume carrion, and how widespread this behavior may be across various toucan species. It is notable that both keel-billed and chestnut-mandibled toucans showed interest in the area where the carcass had been placed, and located the carcass within two hours of deployment. While this was the only observation of a toucan consuming carrion during our study, the keel-billed toucan was one of only five vertebrate species we recorded scavenging on our deployed feeder mice. Vertebrate scavengers are more dominant in temperate areas than in the Neotropics for this size of carcass, because in the tropics arthropods quickly sequester and outcompete vertebrates for this rich nutrient resource (Romero, 2020). This observation may indicate that toucans could be a consequential component of the vertebrate scavenger guild for this size of carcasses, although more data are needed to fully understand their role as facultative scavengers.

No information exists on scavenging rates or the scavenger community at the canopy level, though carrion is likely common given the high diversity and abundance of arboreal species. We expect keel-billed toucans to be facultative scavengers in the canopy and the mid-level strata of the forest, since those are their preferred foraging areas (Davlantes and Howe, 2018). We note, however, that our observation occurred at ~ 1 m above the forest floor, indicating that toucans descend to lower areas to opportunistically sequester carrion. This supports other observations of toucans descending to the ground, including to predate eggs (Cove et al., 2017; Davlantes and Howe, 2018).

Toucans play an important ecological role in seed dispersal and regeneration because of their frugivorous diet, along with their ability to fly great distances (Graham, 2001a; Graham, 2001b). If toucans are also facultative scavengers, this may have implications at the landscape level in terms of how nutrients from carrion get dispersed. Carrion is a unique resource that impacts ecological communities because it is so nutrient-rich and relatively quick to decompose and/or be consumed, and its spatiotemporal patchiness leads to cascading effects on soils, microbes, plants, trophic webs, nutrient cycling, and species diversity (Barton et al., 2013; Bump et al., 2009; Hocking and Reynolds, 2011; Towne, 2000; Yang, 2004). This relocating of nutrients from carrion across the landscape could benefit regenerating and secondary forests, where the soil may be highly degraded. We, of course, need more data on the role of toucans as facultative scavengers to better understand scavenging in these ecosystems, how prevalent carrion is in toucan diet, and potential landscape-wide implications. Finally, we hope that this short communication spurs interest in the potential role of toucans as facultative scavengers, and we caution that toucan diet studies focusing on content analysis should not assume that animal matter found is from predation events, as it could also be from facultative scavenging.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.fooweb.2022.e00223>.

Data availability statement

Data sharing is not applicable to this article. The video recordings are provided as supplemental material.

Declaration of Competing Interest

None.

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