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## Collared Forest-Falcon (*Micrastur semitorquatus*) Preying on Chestnut-mandibled Toucan (*Ramphastos swainsonii*) in Costa Rica

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ABSTRACT.—Predator-prey interactions occur regularly in nature; however, predation events are difficult to observe in the canopy of tropical rain forests. We

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describe a successful capture of a Chestnut-mandibled Toucan (*Ramphastos swainsonii*) by a Collared Forest-Falcon (*Micrastur semitorquatus*) in Carara National Park, Costa Rica. The predator-prey interaction lasted for ~30 min from the moment of the first wounding strike in the canopy to the killing of the toucan on the ground. During the predation process, the falcon engaged in multiple attacks from different directions at the sub-canopy level. We video recorded a total of 323.3 sec tracks during the predation event to produce a

detailed description of the behavior of both species. In addition, we analyzed the structure of the call of the toucan while being attacked and compared that with a regular call of another individual recorded at a different time in the same area. The toucan produced a distress call with strong harmonics and a broad-band rattling sound as a threatening call. We comment on the possible function of the calls. *Received 19 May 2012. Accepted 28 September 2012.*

Key words: aggressive displays, Carara National Park, distress calls, prey-predator interaction, prey size, tropical forest.

Tropical raptors, such as the Collared Forest-Falcon (*Micrastur semitorquatus*), prey on a variety of items that include large insects, lizards, snakes, mammals, and birds (Stiles and Skutch 1989, Thorstrom 2000). A detailed study of prey delivery during the nesting period in Guatemala showed that 34.7–43.9% of the Collared Forest-Falcon diet was composed of birds (Thorstrom 2000). Aguiar and others (2007) found that birds comprised 78% of the Collared Forest-Falcon prey in central western Brazil. It has been suggested that the long legs, and great maneuverability provided by their long tails and short wings, enable Collared Forest-Falcons to capture many birds (Thorstrom 2000). Collared Forest-Falcons can take a wide range of avian prey sizes, from birds the size of wrens to turkeys (Thorstrom 2000). This species of falcon hunts by ambush, actively pursuing prey with great agility through the forest and even by running through the understory (Stiles and Skutch 1989, Thorstrom 2000). However, given its relatively low density and secretive hunting strategy, very little is known about the actual predation behavior of this species (but see Robinson 1994). Here, we present a detailed description of a predator-prey interaction between a Collared Forest-Falcon and a Chestnut-mandibled Toucan (*Ramphastos swainsonii*) in Carara National Park, Costa Rica. In addition, we analyze the calls emitted by the toucan while being attacked and discuss the possible function of such vocalizations.

#### OBSERVATIONS

The attack by a Collared Forest-Falcon on a Chestnut-mandibled Toucan occurred in Carara National Park (09° 46' 25.47" N, 84° 36' 19.90" W). The park comprises 5,242 ha of protected forest in the central pacific region of Costa Rica. The specific site of the attack was within the tropical premontane moist forest basal belt transition (Holdridge 1966) at 24 m asl. This type

of wet-to-dry transitional forest receives an average of 2,800 mm of rain annually with well-defined dry and wet seasons.

We were observing a flock of ~five Chestnut-mandibled Toucans feeding in the canopy on 22 June 2007 when the Collared Forest-Falcon attacked. We could not see the initial position of the falcon but heard a loud distressing call by the Chestnut-mandibled Toucan while the other flock members were fleeing. Because the toucan kept calling, we were able to locate it soon after the falcon apparently struck. We noticed that the toucan was moving using very short flights and hops among the branches. Although it is difficult to know if the bird was injured to the point it could not fly, it is likely that the toucan was avoiding long sustained flights to prevent being caught by the highly maneuverable falcon (Robinson 1994). The offensive behavior of the falcon consisted of a perch-wait-attack strategy, whereas the defensive behavior of the toucan consisted of constant scanning for the predator and emitting calls of distress and threat. The toucan used threatening displays and direct offensive attacks with its beak when the falcon was close.

Based on six separate tracks containing a total of 323.3 sec of audio-visual material, we describe the interactions between the falcon and the toucan. In four video tracks covering 241.6 sec, the falcon made eight direct attacks while the toucan attacked the predator twice. These two attacks by the toucan involved direct flights towards the falcon, displacing it from the perch. The toucan also threatened the falcon five times. In the threatening display, the toucan would open its beak and wings, moving its body forward and emitting a broad-band rattling sound. Another type of vocalization that we regarded as a distress call consisted of a high-pitch whistle. Both the rattle and whistle calls were emitted in the context of a direct attack by the falcon. The toucan used the rattle sound when it was threatening and used the distress call both during the attack by the falcon and while the toucan was perching and scanning for the predator. Interestingly, the other toucans in the flock kept calling from afar and using the regular vocalization of the species (see analysis of the calls).

The falcon's attacks involved direct powerful flights towards the perched toucan. In the first recorded attack, the falcon was perched above the toucan and made a vertical drop just touching the toucan while the falcon continued falling. It looked as if the falcon was trying to make the toucan fly.

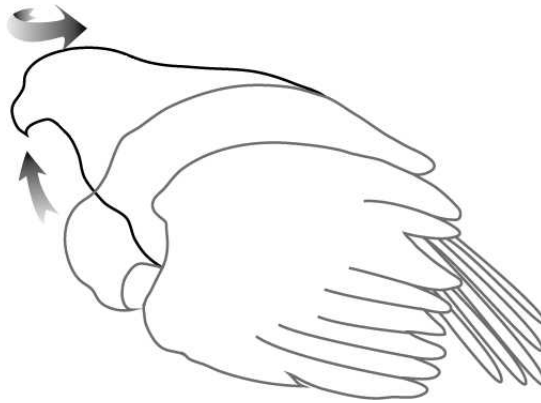


FIG. 1. Diagram showing the Collared Forest-Falcon handling the preyed Chestnut-mandibled Toucan on the forest floor. The toucan was not visible and it was held by the falcon's claws and wings. The falcon repeatedly bit the toucan's neck and frequently scanned the surrounding area by lifting and moving its head in all directions.

Another attack was a powerful flight coming diagonally from above and hitting the toucan. The falcon made a loop to strike the prey again with its claws and injured it near the eye (blood was evident). This highly acrobatic event occurred in 2 sec. Some of the attacks were repelled by the toucan, but on four occasions the falcon clearly injured the toucan with its claws. In the last two successful attacks, the falcon knocked the toucan down to the forest floor and perched about 2 m above. When the toucan attempted to fly away again, the falcon brought the toucan down, held it with its claws, and started to bite its neck. We examined a total of 81.7 sec in two video tracks to describe the actual killing of the prey. The toucan lay on its side on the ground, while the falcon held the toucan with its claws. At one point the toucan managed to flap one wing, and the falcon immediately covered it using both wings. The falcon maintained an arched body position and repeatedly bit the toucan in the neck (Fig. 1). During this time, the falcon kept the toucan covered with its wings and frequently scanned the surrounding area by lifting and moving its head in all directions (Fig. 1). The toucan kept emitting the loud distress call but gradually decreased its intensity until it was finally dead. Then, the falcon carried the toucan away from our sight.

#### ANALYSES OF THE CALLS

We took the video tracks using a Sony Cyber-shot camera, and the sound was recorded at a sample rate of 5 kHz. We extracted the sound from a MPEG file using Adobe Audition version 3.0 and transferring into a .wav file using the same

sample rate. We also obtained one recording of another Chestnut-mandibled Toucan from the Bioacoustics Laboratory of the University of Costa Rica. This recording was made on July 2008 with a Marantz PMD 620 and a Sennheiser ME-66 microphone. We analyzed the calls with Raven 1.2 software (Charif et al. 2004). For spectrogram analysis, we used the Hann window function, a frame length of 512 samples, a filter bandwidth of 124 Hz, and the 'Gray scale' color scheme option. We measured the bandwidth, maximum frequency (frequency with the maximum energy), and duration of the calls. The frequency and time measurements of three types of calls varied (Table 1). The whistled distress call had its maximum frequency on the first harmonic (Fig. 2A). This call was followed in some cases by a short whistle of similar pitch and structure. The broad-band rattling call resembled the song of another toucan species, the Keel-billed Toucan (*Ramphastos sulfuratus*), but at a higher trill rate (Fig. 2B). The whistled call was the most commonly emitted type. From the 97 calls emitted by the toucan, 91 were whistled distressing calls and only 6 were broad-band rattling threatening calls. The regular song of the Chestnut-mandibled Toucan consisted of a slightly descending whistle followed by 2–4 shorter and lower frequency whistles, also showing a strong harmonic structure (Fig. 3).

#### DISCUSSION

It has been suggested that a predator chooses its prey based on the net benefit obtained after the searching and handling effort (Krebs and Davies

TABLE 1. Measurements of the whistled and broad band distress calls from the attacked individual, as well as a song of another co-occurring individual of Chestnut-mandibled Toucan, Carara, Central Pacific region, Costa Rica.

Vocalization	Band width (Hz)	Max. frequency (Hz)	Duration (sec)
Whistled distress call ( $n = 16$ )	55.6 ( $\pm 9$ )	3,090 ( $\pm 133$ )	0.33 ( $\pm 0.16$ )
Broad band distress call ( $n = 6$ )	3,520 ( $\pm 1,067$ )	3,972 ( $\pm 396$ )	0.35 ( $\pm 0.12$ )
Song ( $n = 3$ )	1,244 ( $\pm 421$ )	3,500 ( $\pm 54$ )	0.14 ( $\pm 0.02$ )

1993). For instance, small prey like a 12-g bird might be killed easily by a raptor but would be difficult to find. This would increase searching costs relative to a low energetic reward given the small body mass of the prey. A large conspicuous bird might be easy to locate but difficult to kill. However, one might expect that the large body mass of the prey would compensate for the energetic cost of the killing time used by the predator. Reports of *Micrastur* falcon species hunting prey larger than their own size suggest that this strategy is part of their prey selection strategy (Thorstrom 2000, Aguiar et al. 2007, Röhe and Antunes 2008). In Costa Rica, Stiles and Skutch (1989) reported *Ortalis chachalaca* (500–650 g) as one of the largest prey taken by the Collared Forest-Falcon. Other species of falcons, such as Peregrine Falcon (*Falco peregrinus*), include a broad range of prey sizes even heavier than their own body mass (Slagsvold and Sonerud 2007). In our case, the size of the prey was similar

to that of the predator, and the aggressive behavior of the toucan posed constraints in the handling time and even risks of injuries to the falcon. In addition, the actual killing of the prey took place on the forest floor, putting the falcon under potential predation risk by a mammalian predator. Clearly, the falcon engaged in two mutually exclusive behaviors: biting the neck to kill the prey and surveillance moves (Fig. 1). Also, the constant distress and threatening calls (Fig. 2A, B) emitted by the toucan may have been used to deter the predator. For example, the harshness of distress calls may honestly signal the healthy status of the prey thus its ability to escape or even injure the predator (Laiolo et al. 2004). Despite all of the constraints posed by the toucan to the predator, the falcon completed the hunting process, suggesting that the toucan represents a profitable prey. Thorstrom (2000) reported species of toucans being consumed by the Collared Forest-Falcon in Guatemala; the author identified

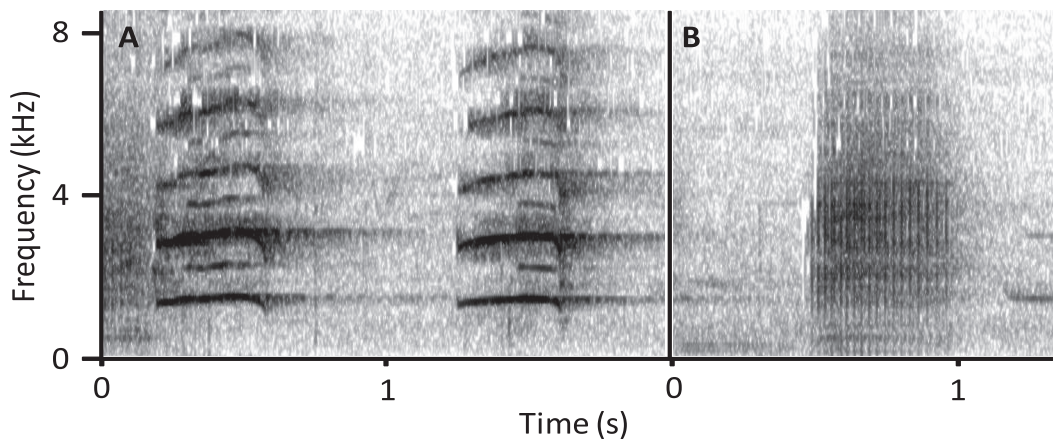


FIG. 2. Spectrogram of the distress call and the threatening call of the Chestnut-mandibled Toucan. The distress call is a high-pitch whistle with slight inverted U shape and strong harmonic structure (A). The threatening call involved a broad-band rattling sound (B).

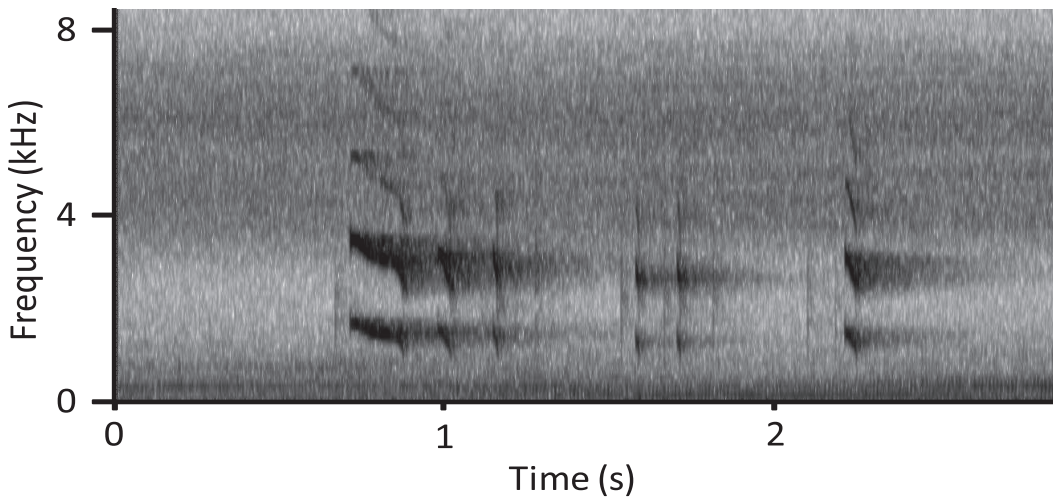


FIG. 3. Spectrogram of the Chestnut-mandibled Toucan song from Carara, Central Pacific region, Costa Rica.

an individual male that preferred to hunt toucans. It is possible that some individual predators learn to prey on certain taxa, thus maximizing the net gain between handling time and energy benefits.

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