FIRST RECORD OF VOCAL MIMICRY IN SCARLET-HEADED BLACKBIRD *Amblyramphus holosericeus* (AVES: PASSERIFORMES) IN THE SOUTHEASTERN BRAZIL

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Abstract: Vocal mimicry is the ability of some bird species to copy heterospecific vocalizations in order to establish deceptive or non-deceptive interactions between an emitter and a receiver. This kind of vocal behavior is well documented in several species of New World Blackbirds (Icteridae family), but not in Scarlet-headed Blackbird (*Amblyramphus holosericeus*). Here we report the first event of vocal mimicry of this species, where a single individual imitated the vocal signals of Smooth-billed Ani (*Crotophaga ani*; Cuculiformes, Cuculidae). We argue that such behavior could have a deceptive role, increasing the predation avoidance and foraging efficiency of *A. holosericeus* by luring heterospecific individuals to form a mixed-flock.

Keywords: bioacoustics; dilution effect; Neotropical birds; vocal imitation; wetlands.

Vocal mimicry refers to the ability of copy sounds produced by other species (Kroodsma & Baylis 1982) and it has a widespread occurrence among birds, especially the oscine passerines (Baylis 1982). Although its function is still not well understood, Kelley et al. (2008) proposes two explanations for heterospecific vocal copying. It can help either avoiding competitors and predators (interspecific communication) or signaling to mates in a sexual context (intraspecific communication) (Kelley *et al.* 2008). The study of vocal mimicry is important since it is related to social and ecological contexts (Hindmarsh 1984), and it evolved through natural and sexual selection to serve as mediator of several aspects of bird's life. Thus, identifying mimic species

is an initial and relevant step in the construction of knowledge about heterospecific vocal copying.

The New World Blackbirds (Icteridae family) are known to be remarkable and accurate mimics, being capable of copying songs from a great diversity of birds, including parrots, hawks and woodpeckers (Fraga 1987, 2011). This phenomenon has been reported in several species of this family, like some species of *Cacicus* (Thieltges *et al.* 2014) and *Icterus* (Fraga 1987), but not in the Scarlet-headed Blackbird, *Amblyramphus holosericeus* (Scopoli, 1786). The species is associated with tropical and warm-temperate wetlands, being abundant in natural marshes with tall herbaceous vegetation (Fraga 2011). Since natural wetlands are threatened

environments in Neotropical regions (Junk 2002), it is important to understand the aspects of life history of *A. holosericeus*, and new findings may add more relevance to the conservation of the species. Therefore, here we report the first record of vocal mimicry of *A. holosericeus* and describe the acoustic structure of this signal.

We recorded one single individual in the Municipal Botanical Garden of Bauru, municipality of Bauru, state of São Paulo, Brazil (22°20'26.73" S, 49°0'55.72" W) in January 21, 2017, at 06:54 h. The Botanical Garden has different vegetal formations of Cerrado and Atlantic Forest domains (Cavassan 2013) being considered a priority area for conservation due to its high biological diversity and its proximity to the urban perimeter (Durigan *et al.* 2007). The recording was made when we were performing an 18-months bird survey near to a flooded area on the banks of the Vargem Limpa stream. This was the only record for the species. We recorded its vocalization using a Yoga HT-81 directional microphone attached to a Marantz PMD66 digital recorded, and recorded digital images of this individual using a Sony Powershot SX40HS digital camera. The footage is available at <https://youtu.be/MjGzVFLLFw4>.

The individual was perched in a branch of a dead tree inside the flooded field. It was detected through its song, as the bird was mimicking Smooth-billed Ani (*Crotophaga ani* Linnaeus, 1758; Cuculiformes, Cuculidae) vocalization. Since *C. ani* form homospecific flocks, we actively searched for individuals of this species amidst the vegetation. Contrary to our expectations, we found a single individual of *A. holosericeus* performing a possible mimicry. Later, the subject vocalized three more times and then flew away from the observers, where it remained silent until the end of the survey. Later that day, at 08:54 h, we found a group of *C. ani* and recorded vocalizations from a single individual for further analysis with the same devices mentioned above.

After this, we sought for sound files containing similar vocalizations in databases of bird sounds, such as Xeno-Canto (xeno-canto.org) and Wikiaves (wikiaves.com.br). We searched for *A. holosericeus* whistled vocalizations with gradual frequency increase, resembling the morphology of our recording in the spectrogram. Thus, we found three sound files with such features: XC174707,

WA3110500 and WA2995870. Once we had all the vocalizations, we generated spectrograms of frequencies (Hanning window, FFT = 512 points, overlap = 93.75%) to perform a preliminary recognition of vocal fine structure from both recordings using the Sonic Visualizer 3.0 software. We visually inspected the vocal emissions to characterize its morphological structure as appeared on the spectrogram (Figure 1).

All the digital sound files were standardized (44.100 Hz, 16 bits of resolution, .wav format) using Sony SoundForge Pro 11.0. We measured the acoustic variables of all vocalizations of one bout employing the oscillogram (Hanning, resolution = 1024 points) for temporal variables and the amplitude spectra (Hanning, resolution = 1024 points) for spectral ones. To avoid the low-frequency bands of environmental noise, we set a threshold of -15 dB below the peak amplitude in the frequency measurement. We measured the following variables: length of vocalization, in seconds; maximum frequency, in kHz; minimum frequency, in kHz; frequency bandwidth, in kHz; and peak frequency, in kHz.

We found a remarkable resemblance between vocalizations of *A. holosericeus* and *C. ani* from the same location. Regarding morphological structure, *A. holosericeus* mimic vocalization presented a fundamental harmonic structurally similar to the *C. ani* one, where elements presented a whistled configuration, with a low magnitude frequency variation. Both the mimic and *C. ani* vocalizations had a distinct feature: a "hoarse" element composed by an abrupt frequency modulation in the ending of the whistled note (Figure 1). We also found a difference between species on the superior harmonic, which is louder on *C. ani* vocalization.

When we compared our recording with other *A. holosericeus* vocalizations, it is possible to see resemblances among them. All the three recordings displayed whistled elements with some smooth increase in frequency. The first song (WA2995870) had a "curve" morphology, with a rapid increase in frequency at the beginning of vocalization, followed by a decrease in magnitude of spectral variation. The other two (WA3110500 and XC174707) were also whistled songs, but they had a constant and almost linear increase in frequency. Moreover, the most distinct feature was the absence of the "hoarse" element at the ending of these vocalizations.

The acoustic structure had some differences between individuals (Table 1). Overall duration was longer in *A. holosericeus* imitation, whereas maximum and minimum frequencies reached more extreme values on *C. ani* vocalizations. As consequence, frequency bandwidth was wider in *C. ani* vocalizations, while peak frequency reached higher values on *A. holosericeus* vocalization. However, the magnitude of differences appeared to be larger when we compared different *A. holosericeus* vocalizations. Duration was considerably shorter in

the three database recordings. Overall frequencies were lower in the recording WA2995870 and remarkably higher in the recordings WA3110500 and XC174707. Thus, vocal differences were more pronounced among conspecific individuals than between species.

Vocal mimicry could occur by learning or convergence (Kelley *et al.* 2008). In learning processes, individuals may include heterospecific vocal signals in a sensitive phase of its vocal development (Beecher & Brenowitz 2005). On the
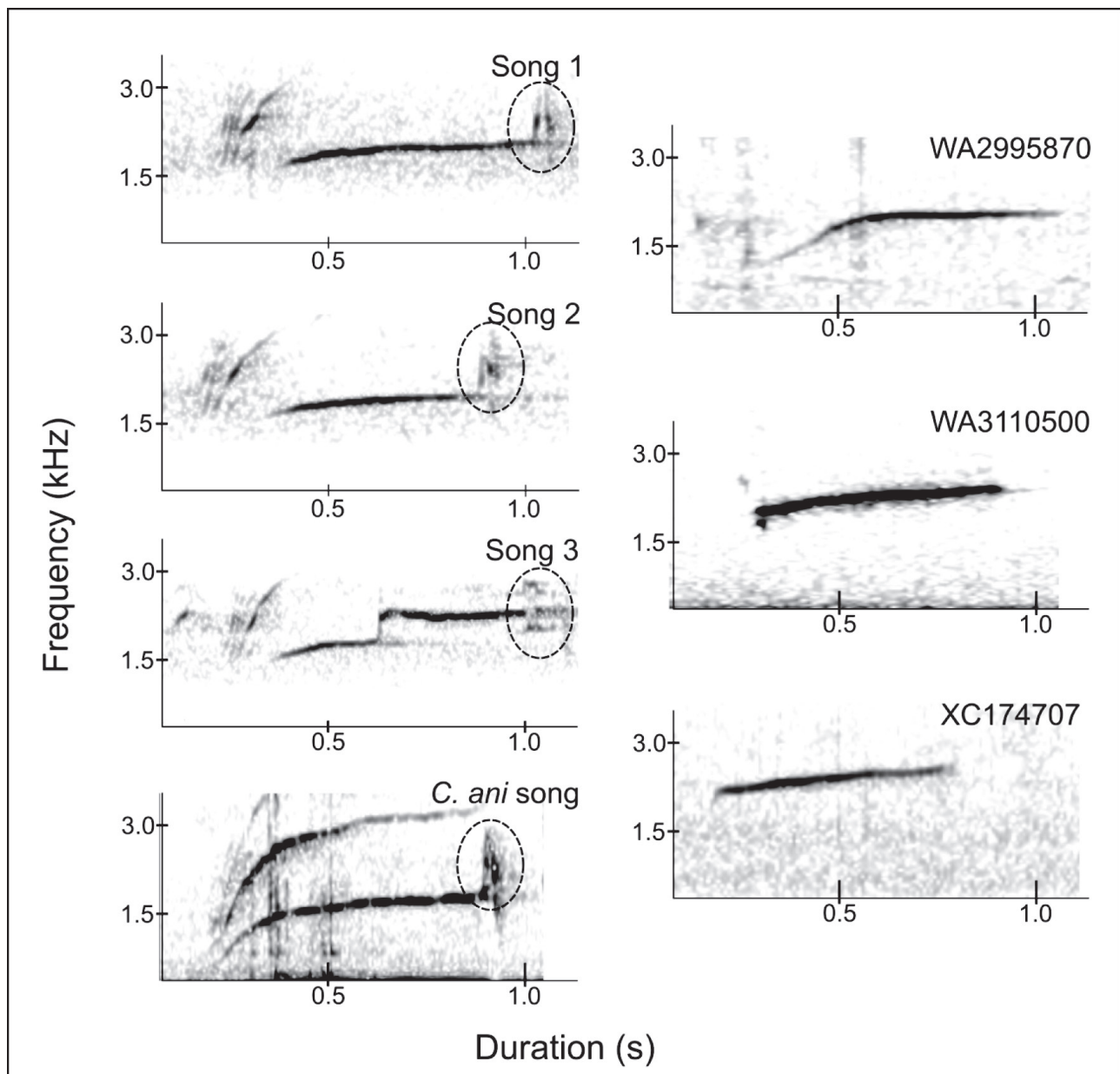

Figure 1. Spectrogram of frequencies extracted from *Amblyramphus holosericeus* (Passeriformes, Icteridae; this study, XC174707, WA3110500 and WA2995870) and *Crotophaga ani* (Cuculiformes, Cuculidae) vocalizations. The spectrograms of songs 1 to 3 were extracted from the mimic songs. Circles evidence the ending note ("hoarse note"), which have overlapping frequencies and short duration.

Table 1. Acoustic features measured on vocalizations of each individual of *Amblyramphus holosericeus* (Passeriformes, Icteridae; AmbHol) and *Crotophaga ani* (Cuculiformes, Cuculidae; CroAni). Values are represented by mean ± SD. N = number of vocalizations; Source = Source of vocalizations; Dur. = Duration of vocalization; Max.= Maximum Frequency; Min. = Minimum Frequency; Ban. = Frequency Bandwidth; Pea. = Peak Frequency.

Species	Source	N	Dur. (s)	Max. (kHz)	Min. (kHz)	Ban. (kHz)	Pea. (kHz)
AmbHol	This study	3	0.835 ± 0.119	1.974 ± 0.032	1.500 ± 0.022	0.474 ± 0.091	1.808 ± 0.033
AmbHol	WA2995870	2	0.653 ± 0.023	1.739 ± 0.033	1.426 ± 0.065	0.374 ± 0.016	1.623 ± 0.022
AmbHol	WA3110500	8	0.670 ± 0.031	2.373 ± 0.051	1.874 ± 0.032	0.495 ± 0.053	2.170 ± 0.037
AmbHol	XC174707	1	0.515 ± 0.000	2.687 ± 0.000	2.194 ± 0.000	0.546 ± 0.000	2.412 ± 0.000
CroAni	This study	5	0.789 ± 0.046	2.057 ± 0.118	1.254 ± 0.092	0.802 ± 0.069	1.751 ± 0.053

other hand, evolutionary convergence is likely to happen in related taxa, where similar evolutionary pressures select the structure of the vocalization based on ecological features (Kelley *et al.* 2008). While the first phenomenon is strongly connected to learning ontogeny, the second one is a result of selective pressures on genetic structure of sister taxa. There is a third way in which individuals could copy the vocalizations from another subject, which is called "vocal matching" or "equivalent vocal response" (Todt 1981). This process often involves conspecifics answering to the signaler with a song with similar structure, and it mediates contexts of social interaction such as territory defense and agonistic interactions (Todt & Naguib 2000).

In our findings, the recorded imitation seems to mediate heterospecific interaction between the *A. holosericeus* and *C. ani,* which would characterize a vocal mimicry. The occurrence of evolutionary convergence between both species is improbable, since they are not closely related species and they are subject to different selective pressures on their vocalizations. Thus, it seems plausible for us that an individual of *A. holosericeus* has learned to use *C. ani*'s vocalization for self-favoring in certain situations. Since recordings of *A. holosericeus* songs are scarce, we were unable to perform effective quantitative comparisons to test the difference of our recording with those obtained on the databases. However, we find structural differences pointing the divergences between them, which may indicate that the mimic vocalization is not part of a shared repertoire of the species.

Vocal mimicry could have deceptive and non-deceptive roles on heterospecific interactions (Dalziell *et al.* 2015). It is unlikely that this event of vocal mimicry is associated with non-deceptive and homospecific interactions because we did not found any other individual in the Botanical Garden during our avian survey. Hence, the *A. holosericeus* mimicry seems to be included in the first category of interactions. In deceptive roles, the receiver seems unable to distinguish between the mimic and model, leading it to misidentification of emitter subject (Wickler 2013)based on a three-part interaction system of a mimicked organism or object (called model). Therefore, other heterospecific individuals are lured to the same site where the mimic is located (Goodale & Kotagama 2006). By mimicking *C. ani* vocalizations, *A. holosericeus* could benefit from the emerging effects of mixed flocks, both in predation avoidance by recruitment of mobbers (Caro 2005) and in foraging by attracting new associates (Dobkin 1979).

The gregarious behavior of *C. ani* could give protection to a single individual. Hence, attracting more individuals using vocal imitations could reduce the risk of predation for the signaler, since this display could attract more preys or could confuse the predator with several individuals (Caro 2005). Meanwhile, this kind of imitation could increase the efficiency of foraging by the formation of mixed-species flocks. Since *A. holosericeus* is an omnivore species (Wilman *et al.* 2014), it could

benefit from flock formations because several *C. ani* individuals could disturb insects that *A. holosericeus* could prey (Satischandra *et al.* 2007). It can either take advantage of dilution effect while foraging both insects and fruits (Satischandra *et al.* 2007).

Our findings open new possibilities for the study of vocal mimicry. The structure of *A. holosericeus* vocalization is quite similar to the model, and it could lure other individuals of *C. ani* to the same site, which could benefit the caller through dilution effects. Further studies should address broader aspects of this behavior, such as its relevance to homospecific and heterospecific interactions, and its impact on the life history and ecology of the species.

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