

# Use of auditory predation cues in the Ruby-throated Hummingbird (*Archilochus colubris*)

Amelia K. Whitear<sup>1</sup> and Ivana Stehlik<sup>2</sup>

<sup>1</sup>Fourth Year Undergraduate Student, Zoology Specialist, University of Toronto. <sup>2</sup>Lecturer, Department of Ecology and Evolutionary Biology, University of Toronto; email: ivana.stehlik@utoronto.ca. Corresponding author: Amelia K. Whitear, a.whitear@utoronto.ca.

## Abstract

The predation risk hypothesis states that foraging behaviour, and therefore nutrient intake, should be reduced when individuals perceive a predator threat. A variety of cues – visual, auditory, olfactory – are used to detect the presence of predators. In birds, many species use visual cues while foraging in flocks. This ensures at least one individual is vigilant within the group, and the individual is able to warn the other group members of impending danger. Conversely, some bird species are solitary foragers and do not rely on conspecifics to warn of impending danger. Therefore, we sought to test whether solitary foraging birds use auditory cues to assess predator presence using the Ruby-throated Hummingbird (*Archilochus colubris*) as our model organism. We played recordings of predatory Blue Jay (*Cyanocitta cristata*) and Sharp-shinned Hawk (*Accipiter striatus*) calls in the vicinity of foraging Ruby-throated Hummingbirds. The subsequent number of sips taken from nectar feeders was recorded as a measure of foraging intensity. Foraging intensity under perceived threat was compared to foraging intensity while non-predatory American Goldfinch (*Carduelis tristis*) call was played and while no simulated call was played. Foraging intensity was significantly reduced under predator call playback relative to foraging intensity under the control treatments. There was no significant difference between the two negative control treatments, which suggests playing back a previously recorded bird call had no significant effect on foraging intensity. Auditory cues are therefore important for the Ruby-throated Hummingbird, and possibly other solitary foraging bird's assessment of predator risk.

## Introduction

For many animal species, foraging in the open poses a risk for predation. A tradeoff occurs while foraging under these conditions; individuals must allocate enough time to obtain sufficient nutrients while conversely reducing the time spent foraging to avoid possible predation. Concurrently, the predation risk hypothesis states during periods of low predation risk, foraging will be relatively high as compared with periods of high predation risk [1].

There are several behavioural adaptations in animals to help assess predation risk. Some adaptations include the use of auditory, olfactory and visual cues to perceive the presence of a predator. Bumblebees, for example, use indirect olfactory evidence of its common ambush predator by avoiding flowers that have the scent of a freshly killed bumblebee [2]. In birds, visual cues are often used to detect approaching predators. Many species will flock, foraging in tightly packed groups to reduce the risk of predation, as more than one individual at a time is presumably looking out for predators using visual cues [3, 4]. Solitary foraging birds cannot rely on this 'many eyes' vigilant mechanism and therefore, must use other cues to detect predator presence.

The Ruby-throated Hummingbird (*Archilochus colubris*) is an example of a solitary foraging bird. These hummingbirds do not depend on cues from conspecifics to assess whether it is safe to forage. Predators of this hummingbird species, such as the Blue Jay (*Cyanocitta cristata*) and Sharp-shinned Hawk (*Accipiter striatus*) are common throughout the Ruby-throated Hummingbird's summer range. As the Ruby-throated Hummingbird is a small bird with a high metabolism; it forages most of the day to obtain

enough stored nutrients to survive the night [5]. In addition, Ruby-throated Hummingbirds spend a long time taking sips from nectar feeders which is often done with their back exposed, in a position that does not allow visual cues to be used (*pers. obs.*). This species should therefore demonstrate a clear tradeoff between obtaining enough nutrients for survival, due to its high metabolic demand, while reducing time at risk of predation.

We sought to test whether Ruby-throated Hummingbirds use auditory cues to assess predator presence, and if foraging will decrease when a predator is perceived to be in close proximity. If auditory cues are used by the Ruby-throated Hummingbird, we expect foraging intensity to be modified according to perceived severity of predation risk. The Sharp-shinned Hawk is a common predator of this hummingbird species, thus we expect foraging intensity to decrease significantly while a hawk call is within range, relative to foraging under other simulated bird calls.

## Materials and Methods

### The Study System

This study was carried out at the Koffler Scientific Reserve at Jokers Hill, King City, Ontario (44° 03' N, 79° 29' W). The Ruby-throated Hummingbird breeds in the area, and pairs have been observed in suitable habitats during breeding season [6]. As the Ruby-throated Hummingbird has a high metabolism, it must forage steadily throughout the day, which makes observations on its foraging behaviour relatively easy. The American Goldfinch is also present throughout the summer, along with the predatory Sharp-shinned Hawk and Blue Jay [6]. Therefore, the Ruby-throated Hummingbird potentially encounters

these species regularly, and must display vigilant behaviour to avoid predator encounters.

### Sampling

Sampling took place across four sites within the study site: outside the classroom, Racing Barn, mansion garden and Willow Ridge (Fig. 1). Nectar feeders were set up at all of these sites. The hummingbirds were habituated to the feeders for at least 24 hours and allowed to forage *ad libitum*.

### Experimental Method

One of four sound treatments was administered over a period of 10 minutes. No simulated call and the American Goldfinch call were played to simulate the absence of a predator (control treatments) whereas the Blue Jay call and Sharp-shinned Hawk call were played to simulate the presence of a predator. Intensity of foraging was measured by counting the number of 'sips,' beak insertions into the nectar feeder, during each treatment. During the 10 min treatment, each 15-second call was played once a minute. There was a five minute habituation period before the start of treatments where the experimenter would sit in position while no call was played. Treatments were applied one after the other in random order. Two to eight replicates were performed at each site.

### Statistical Analysis

A chi-squared goodness of fit test was used to determine if there was a difference between the number of sips observed during each treatment. One outlier was not included in the data (day: 2, sample: 2, site: Racing Barn). We used the Chi-squared test to compare foraging intensity across all four treatments. P-values were adjusted for six *post hoc* Chi-squared tests by applying a Bonferroni correction.

### Results

The number of sips observed at each location during each treatment were significantly different ( $X^2 = 70.52$ ,  $P_{\alpha=0.05} < 0.001$ , d.f. = 9; see Fig. 2). Foraging intensity was not significantly different between the American Goldfinch call and no simulated call ( $X^2 = 0.066$ ). Similarly, foraging intensity was not significantly different between the Sharp-shinned Hawk call and Blue Jay call ( $X^2 = 5.429$ ). All other comparisons of foraging intensities between treatments were found to be significantly different (Fig. 2).

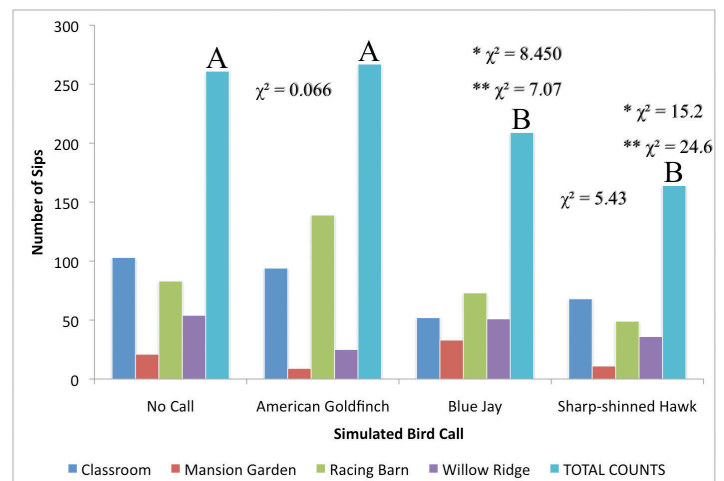
### Discussion

Foraging intensity significantly decreased while both predator calls, the Sharp-shinned Hawk and Blue Jay were played relative to foraging intensity recorded under the American Goldfinch and no simulated call (Fig. 2). We conclude auditory cues are used by the hummingbird as predator detection mechanisms in the absence of other cues. In this experiment, visual cues did not factor into vigilant behaviour as bird calls were played from computer speakers to simulate predator presence. There was no significant difference between foraging intensity under the American Goldfinch call and no simulated call treatment (Fig. 2). This suggests playing a sound of a non-threatening bird call has no effect on foraging behaviour. In addition, it indicates that the hummingbirds were not just reacting to the 'noise' of the Sharp-shinned Hawk and the Blue Jay call playback.

Predator detection using auditory cues may be a primary vigilant mechanism, as foraging was often resumed within seconds of



**Figure 1. Location of study sites within Koffler Scientific Reserve at Jokers Hill, King City, Ontario. (1) Willow Ridge, (2) Classroom, (3) Racing Barn, and (4) Mansion Garden. (Google Earth)**



**Figure 2. Effect of location and bird call treatment on foraging counts in Ruby-throated Hummingbirds (*Archilochus colubris*) (n=20).** 'Total' data points labeled with different letters are significantly different from each other. There was a significant effect of location on foraging intensity ( $\chi^2 = 70.52$ ,  $p < 0.01$ , d.f. = 9). Foraging intensity under the two control treatments did not differ and similarly, foraging under the two predatory birdcall treatments did not differ. Foraging under the predatory birdcalls (Blue Jay and Sharp-shinned Hawk) differed in comparison to each control (No call and American Goldfinch). '\*' and '\*\*' denote significance from foraging counts under no call and American Goldfinch treatment, respectively.  $\chi^2$  values are shown in the figure. Comparisons were found to be significantly different if the calculated Chi-squared statistic exceeded the tabulated Chi-squared statistic at  $\alpha=0.008$  level of significance (obtained from the Bonferroni correction; tabulated  $X^2_{\alpha=0.0083} = 6.97$ , d.f. = 1)

the call being played. Hummingbirds would hear the call, stop foraging, look around, and then continue foraging after no predatory bird was in sight. Hence, visual cues may be used to confirm predator threat, after auditory cues initially indicate possible danger.

Under the hawk call treatment, foraging tended to decrease compared to foraging under the Blue Jay treatment, though not

significantly (Fig. 2). Nevertheless, a clear pattern described by the predation risk hypothesis is seen. When predators were not perceived present (under the control treatments), foraging was at a relative maximum, while foraging behaviour under predator treatments significantly decreased to ensure safety from predators. Skals et. al. found similar results when testing the effect of auditory cues from predatory bats on the silver Y moth, *Autographa gamma* [7]. The authors found the moths alter their foraging behaviour in response to simulated predatory bat calls. When encountered with auditory stimuli from predators, fewer moths reached the odorous food resource [7]. The moths that did reach the food resource, took 250% more time in reaching it [7].

Habituation to the simulated bird call may have occurred over time as the hummingbirds learned there was no immediate threat associated with the call. However, Quinn et al. found chaffinches (*Fringilla coelebs*) did not habituate to noise over the duration of his experiment, which tested the effect of background noise (or 'white noise') on vigilant behaviour [8]. As calls in our experiment were played through computer speakers, background noise, in the form of static, associated with the recordings may have been an issue. Quinn et al. found background noise hindered auditory cue detection in chaffinches and this was compensated through an increase in rate of visual scanning, thus decreasing the time spent foraging [8]. However, the background noise in Quinn et al.'s study reached up to 75 decibels [8]. This was similar to the bird call volume within our experiment, but not with the background noise associated with it.

The location to which we sampled had a significant effect on the foraging behaviour of Ruby-throated Hummingbirds ( $X^2 = 70.52$ ,  $P_{\alpha=0.05} < 0.00$ , d.f. = 9; Fig. 2). This result may be due to the novel appearance of the nectar feeders on our study sites. The nectar feeders located outside the classroom were already established prior to the start of the experiment, whereas the other nectar feeders were put in place a couple of days before the start of the experiment. The hummingbirds took longer to locate the newly stocked sites. Each of these sites also differed in plant composition and refuge cover. Some bird species are known to increase scanning with increasing distance to refuge [9]. As scanning increases, foraging counts decrease. Thus, differences in refuge between the four sites may have led to the significant effect of location.

## Conclusion

Ruby-throated Hummingbirds showed a clear tradeoff between maximizing foraging behaviour under no risk of predation while reducing foraging behaviour under perceived risk of predation. Auditory cues were used to assess this predatory risk. Use of this type of cue may only be a primary vigilant mechanism, as scanning often occurred during and shortly after predator call playback. The type of refuge available may also have had an effect between foraging at the different locations as birds often respond to uncertain environments by increasing scanning, thus reducing foraging counts [9]. Similar experiments in testing other solitary foraging birds in their ability to detect predator presence through auditory cues offer future studies as this subject is poorly known.

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