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Vocal responses of Blue Jays (Cyanocitta cristata) to raptors that differ in predatory threat

Julie Dahl
Eastern Kentucky University

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By

Julie Ann Dahl

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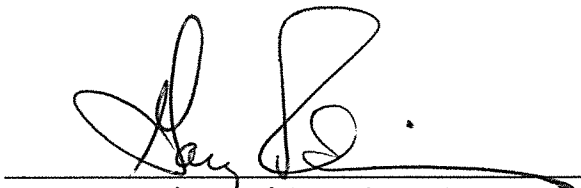

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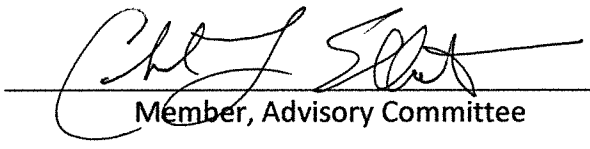

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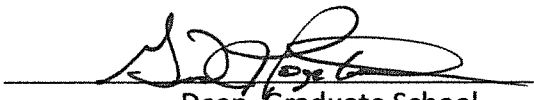

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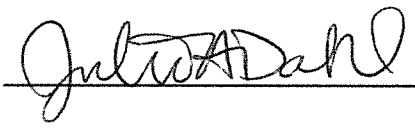
Signature 

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Vocal responses of Blue Jays (*Cyanocitta cristata*) to raptors that differ in predatory threat

By

Julie Ann Dahl

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DEDICATION

This thesis is dedicated to Nicky.

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I would like to thank my major professor, Dr. Gary Ritchison, for his support and knowledge throughout my research. I would also like to thank my committee members, Dr. David Brown and Dr. Charles Elliott, for comments and assistance through all stages of research. I like to express my gratitude to Dr. Kenneth Blank and Dr. John Harley for kindly allowing me to use their properties for this study, Nathan White at the Blue Grass Army Depot for allowing me to conduct research on military property, to the Kentucky Ornithological Society for helping fund this research.

ABSTRACT

Anti-predator defense is an important adaptation in group-living organisms. Some species of flocking birds use referential calls to communicate predator presence and the level of threat posed by predators. Previous studies have revealed that two species in the corvid family, American Crows (*Corvus brachyrhynchos*) and Siberian Jays (*Perisoreus infaustus*), use referential calls to convey information about predator presence and level of threat. Because of their intelligence and flocking behavior, Blue Jays, like American Crows and Siberian Jays, may use referential calls to communicate raptor presence and threat. During the non-breeding seasons of 2014 and 2015, I recorded and subsequently analyzed the vocal responses of Blue Jays to study skins (N = 7) that varied in size and the level of threat they pose. Experiments were conducted at seven different locations in Madison County, Kentucky. The mean number of jays present was 2.6 (range = 1 – 6), and jays uttered five different vocalizations, with ditonal and monotonal jeers given most frequently. The rate at which jays uttered ditonal jeers differed significantly among trials ($P < 0.001$), with the highest rates during trials with an Eastern Screech-Owl (*Megascops asio*) and a Sharp-shinned Hawk (*Accipiter striatus*). I found no differences among trials in the characteristics (duration, low frequency, high frequency, and peak frequency) of either ditonal jeers or monotonal jeers. Assuming that calling rates vary relative to the degree of threat posed by aerial predators, my results suggest that Eastern Screech-Owls and Sharp-shinned Hawks represent the greatest potential threats to Blue Jays in my study area, and other raptors used in my experiments, including

American Kestrels (*Falco sparverius*), Cooper's Hawks (*Accipiter cooperii*), Red-tailed Hawks (*Buteo jamaicensis*), and Great Horned Owls (*Bubo virginianus*), pose lesser threats. Although Blue Jays in my study did respond differently to different predators, their vocal responses were not functionally referential, i.e., the same calls with the same characteristics were used when responding to different predators, only the calling rates differed among trials. Thus, rather than providing conspecifics with specific information about predation risk, Blue Jay calls, especially ditonal jeers, appear to be directed at predators and primarily serve to harass and provoke them into moving elsewhere.

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CHAPTER I

INTRODUCTION

Alarm calls that convey information about the presence of specific predators or types of predators (e.g., ground-based vs. aerial), known as referential calls, have been reported in a variety of mammals including primates such as vervet monkeys (*Cercopithecus aethiops*; Seyfarth et al. 1980), blue monkeys (*Cercopithecus mitis stuhlmani*; Murphy et al. 2013) and meerkats (*Suricata suricatta*; Manser et al. 2001). Less is known about the use of referential calls by birds; to date, the use of such calls has been reported in domestic chickens (*Gallus domesticus*; Evans et al. 1993, Wilson and Evans 2012) and several species of parids (family Paridae; Suzuki 2012) and corvids (family Corvidae; Yorzinski and Vehrencamp 2009). For example, Black-capped Chickadees (*Poecile atricapillus*), small songbirds that form flocks during the non-breeding season, vary the number of "dee" notes in their 'chick-a-dee' calls relative to the degree of threat posed by different raptors, using more 'dee' notes per call in response to the presence of smaller raptors that pose a greater threat (Baker and Becker 2002, Templeton et al. 2005). Such information can be used by other flock members (both con- and heterospecifics; Templeton and Greene 2007) to gauge the level of threat and respond appropriately (e.g., seeking cover vs. continuing normal activities when the threat is minimal). Carolina Chickadees (*P. carolinensis*, Soard and Ritchison 2009) and Tufted Titmice (*Baeolophus bicolor*, Courter and Ritchison 2010) have been found to vary the characteristics of their calls in a similar manner.

Corvids, widely considered among the most intelligent birds (Seed et al. 2009), typically have complex social organizations (Holzhaider et al. 2011) and complex call repertoires (Ellis 2008). To date, referential alarm calls have been reported in two corvid species, American Crows (*Corvus brachyrhynchos*; Yorzinski and Vehrencamp 2009) and Siberian Jays (*Perisoreus infaustus*; Griesser 2009). American Crows vary the rate and duration of calls, as well as intervals between calls, to convey information to conspecifics about the threat posed by predators (Yorzinski and Vehrencamp 2009); Siberian Jays vary the number and types of calls to encode information about predator risk (Griesser 2009). Given that they typically occupy habitats with a variety of predators, often live in groups, and have complex vocal repertoires, other corvids may also use functionally referential alarm calls. Twenty corvid species are found in North America (Stokes and Stokes 2010) and, to date, investigators have examined the vocal responses to predators of just one species (American Crow). Given that little is known about the use of referential alarm calls by birds generally and corvids specifically, additional studies are needed to determine the extent to which birds use such calls and the characteristics of species that select for their use.

Blue Jays (*Cyanocitta cristata*) are a group-living species found throughout much of North America and have an extensive vocal repertoire (Conant 1972, Cohen 1977). Blue Jays are known to be preyed on by a number of aerial predators, including falcons, hawks, accipiters, and owls (Smith et al. 2013). Blue Jays are also known to approach perched raptors when detected and utter a variety of vocalizations (Cohen 1977, Smith et al. 2013), suggesting the possibility that they may use referential calls to convey

information to conspecifics about predator threat. Thus, my objective was to examine the vocal responses of Blue Jays to different raptors that differ in the degree of threat they pose. I wanted to determine if one or more calls in Blue Jays' vocal repertoire could convey information about the threat a predator may pose to conspecifics.

CHAPTER II

METHODS

Blue Jays (hereafter jays) were studied from 22 January 2014 to 7 March 2014 and from 17 November 2014 to 22 February 2015 in Madison County, Kentucky from 08:00 to 12:00 hrs. Study sites (feeding stations) were selected based on frequent jay activity. Feeding stations (N = 7) were located at private residences (N = 5) and at the Blue Grass Army Depot (N = 2), with stations at least 5 km apart (mean = 20.7 ± 2.2 km; range = 5.3 – 48.5 km) to ensure that different jays visited each feeder.

Raptor Presentation Experiments

I presented study skins of six raptors of varying size and differing in the threat they pose to jays, including an Eastern Screech-Owl (*Megascops asio*), American Kestrel (*Falco sparverius*), male Sharp-shinned Hawk (*Accipiter striatus*), Cooper's Hawk (*Accipiter cooperii*), Red-tailed Hawk (*Buteo jamaicensis*), and Great Horned Owl (*Bubo virginianus*). A study skin of a Ruffed Grouse (*Bonasa umbellus*; order Galliformes) was used as a control. American Kestrels pose a limited threat to jays because they typically do not hunt in wooded habitats occupied by jays and their size (~90 – 130 gm; Layne and Smith 1992) limits their ability to take avian prey larger than finches (Collopy and Koplin 1983). Red-tailed Hawks have been known to prey on jays (Gates 1972), but typically prey on small to medium-sized mammals and larger birds found in more open habitats such as Northern Bobwhites (*Colinus virginianus*; Preston and Beane 2009).

Although male Sharp-shinned Hawks (~100 – 180 gm; Bildstein and Meyer 2000) occasionally attack prey as large as Blue Jays (~ 90 gm; Smith et al. 2013), they typically prey on smaller birds (~8.0 – 45 gm; Storer 1966, Roth et al. 2006). Great Horned Owls may occasionally prey on Blue Jays (Smith et al. 2013), but typically prey on mammals and larger birds like ducks and geese (Artuso et al. 2014). In contrast, Eastern Screech-Owls and Cooper's Hawks are known predators of Blue Jays (Bielefeldt et al. 1998, Artuso 2010).

Predator presentation trials were conducted from 22 January 2014 to 7 March 2014 and from 17 November 2014 to 1 February 2015. One trial was conducted per flock (i.e., at each feeder) per day, and all trials were conducted between 08:00 and 12:00 hrs. Subsequent trials at a particular feeder were at least two days apart, with order of presentation of different raptors and controls randomized. Prior to each trial, a study skin (raptor or control) was placed on a 1.5 m tall pole located about 2 m from the feeding station. I stood 10 – 20 m away, depending on the location, where vegetation provided cover, and where jays could still be observed and recorded; the distance was always the same at each feeder. Each trial was 5 min in duration and began when jays were detected (either visually or audibly) approaching the feeder.

For each trial, I recorded: 1) the number of jays present, 2) the closest distance any jay approached the control or study skin of a raptor, 3) jay behavior (mobbing or not mobbing) at the closest distance, and 4) the number of jays that came within 3 m and 1 m of the control or study skin. Jay behavior at the closest distance was categorized as either mobbing, i.e., repeatedly vocalizing in response to the predator or control skin

accompanied by agitated body movements such as raised crest and wing flicks (Conant 1972) or not mobbing, i.e., vocalizing, but apparently not directing calls toward the predator or control skin, and visiting the feeding station during the trial. In addition, all vocalizations uttered by jays were recorded with a digital recorder (Saul Mineroff Electronics, Elmont, NY) and a unidirectional microphone (Sennheiser Electronic GmbH & Co. KG, Germany) or a video recorder (Sony Electronics, Atlanta, GA). To account for differences in flock sizes, I divided the number of different calls uttered by the number of jays present to determine call rate.

Acoustic Analysis

Raven Pro 1.4 interactive sound analysis software (Cornell Lab of Ornithology, Ithaca, NY) was used to analyze jay vocalizations recorded during the experiments. Calls were categorized based on call morphology and characteristics.

For each trial, I noted the number of each call type uttered by jays. Also, for each call, I noted the peak frequency (the frequency at which the most power was concentrated), minimum frequency, maximum frequency, and duration. The number of calls uttered during trials ranged from 0 to 381. For trials where ≤ 70 calls of each type were uttered, I determined the characteristics of all calls. However, for trials where > 70 of a particular call type were uttered, I subsampled in a systematic manner (i.e. measured every other call, every third call, and so on depending on the number of vocalizations uttered during that trial) and determined the characteristics of 30 to 50 calls for that particular call type.

Playback Experiments

I conducted playback trials using calls uttered by jays during the presentation trials from 12 December 2014 to 22 February 2015. Specifically, I used calls given in response to the presence of a Red-tailed Hawk (low-threat predator) and an Eastern Screech-Owl (high-threat predator). As a control, I played back the scolding (i.e., alarm) calls of an American Robin (*Turdus americanus*). Jays at each feeder were tested using calls recorded during the 5-minute predator (or control) presentations with their flock at a volume of 85 dB at 1 m, a volume similar to that of calls uttered by jays (Cohen et al. 1978). To prevent differences in response due to habituation, playback sessions were not conducted on consecutive days, and the order of playback recordings were randomized.

Prior to each playback trial, I placed a speaker (Saul Mineroff Electronics, Elmont, NY) in vegetation about 20 – 30 m from detected jays. During playback trials, I stood 10 – 20 m from the speaker (depending on location of vegetation) and noted: 1) the number of jays present, 2) the closest distance any jay approached the speaker, and 3) the number of jays that came within 1 m and 3 m of the speaker, respectively. I also recorded all vocalizations uttered by jays during playbacks and subsequently (using Raven software) reviewed recordings to determine the rate at which different calls were uttered. I used random sub-sampling to quantify call characteristics when jays uttered numerous vocalizations of one call type.

Statistical Analysis

I used repeated measures analysis of variance to examine possible differences among treatments in call rates, call characteristics, and the distances of Blue Jays from study skins during trials. Prior to these analyses, data were log-transformed to achieve normality. When differences were significant, I used Tukey's post-hoc test to identify differences among treatments. Analyses were conducted using the Statistical Analysis System (SAS Institute, Inc., Cary, NC). Means are reported ± SE.

Procedures implemented in this study were reviewed by Eastern Kentucky University's Institutional Animal Care and Use Committee (IACUC) and approved by protocol # 09-2013.

CHAPTER III

RESULTS

Raptor Presentation Experiments

The mean number of jays present during presentation experiments was 2.6 ± 0.2 (range = 1 – 6), with no difference in the number of jays present during experiments with each raptor or control study skin ($F_{6,36}$ =1.9, P = 0.12) or at the different locations ($F_{6,42}$ = 1.1, P = 0.20). Jays uttered six different vocalizations in response to the predator and control skins, including 2,826 ditonal jeers, 509 monotonal jeers, 125 squeaky gate calls, 65 bell calls, 52 broken ditonal jeers, and 200 modulated ditonal jeers (Fig. 1)[1]. Ditonal jeers, monotonal jeers, squeaky gate calls, and bell calls were all previously described by Cohen (1977) (Fig. 1a-d). However, Blue Jays in my study also uttered two variants of the ditonal jeer, one that appeared and sounded disjointed, the broken ditonal jeer (Fig. 1e), and another that exhibited rapid modulation in frequency, the modulated ditonal jeer (Fig. 1f). Two calls were not included in any analysis because of their rarity and because they were not repeated at other locations. One phrase was uttered twice at one location within the Blue Grass Army Depot in response to two different study skins (Ruffed Grouse and Red-tailed Hawk) and consisted of two notes, seemingly mimicking a Bald Eagle (*Haliaeetus leucocephalus*) call (Fig. 2). The second call

[1] See Appendix for all figures.

was uttered only once at a private residence while the jay was mobbing the American Kestrel study skin (Fig. 3).

The rate at which jays uttered ditonal jeers differed significantly among trials ($F_{6,36} = 5.9$, $P < 0.001$), with significantly higher rates during trials with the Eastern Screech-Owl than during all other trials except those with the Sharp-shinned Hawk (Tukey's test, $P < 0.05$; Fig. 4a). Differences among trials in the rate at which modulated ditonal jeers were uttered were also significant ($F_{6,36} = 6.9$, $P < 0.0001$), with jays giving these calls at higher rates during trials with the Eastern Screech-Owl than during all other trials (Tukey's test, $P < 0.05$; Fig. 4b). I found no differences in call rates among trials with different raptors/control for monotonal jeers ($F_{6,36} = 0.7$, $P = 0.72$), squeaky gate calls ($F_{6,36} = 0.7$, $P = 0.66$), bell calls ($F_{6,36} = 1.3$, $P = 0.28$), or broken ditonal jeers ($F_{6,36} = 0.8$, $P = 0.57$).

The number of jays that came within 1 m of predator study skins differed significantly among trials ($F_{6,36} = 7.0$, $P < 0.0001$), with some jays approaching within that distance during trials with Eastern Screech-Owls, Great Horned Owls, and Red-tailed Hawks, but few or no jays doing so during the other trials (Fig. 5a). I found no differences among trials in either the number of jays approaching within 3 m of study skins ($F_{6,36} = 1.2$, $P = 0.32$; Fig. 5b) or the closest distance of approach ($F_{6,36} = 2.2$, $P > 0.05$).

During trials, I categorized jays as either mobbing or not mobbing (see Methods section for definitions). Jays exhibited mobbing behavior during all (seven of seven) or most (six of seven) trials with the Eastern Screech-Owl, Great Horned Owl, and Sharp-

shinned Hawk, during either four or five of seven trials with the Red-tailed Hawk, American Kestrel, and Coopers Hawk, and during two of seven trials with the Ruffed Grouse (Fig. 6).

Acoustic Analysis

I found no differences among trials in the characteristics of either ditonal jeers (duration, low frequency, high frequency, and peak frequency; all b) or monotonal jeers (duration, low frequency, high frequency, and peak frequency; all $P \geq 0.51$). For squeaky gate, bell, broken ditonal jeer, and modulated ditonal jeer calls, too few calls were given for statistical analysis.

Playback Experiments

Blue Jays uttered ditonal and modulated ditonal calls, as well as monotonal jeers, in response to playback of the calls uttered by jays during trials with Eastern Screech-Owls and Red-tailed Hawks. However, I found no differences among trials in the rate at which those calls were uttered (all $P \geq 0.40$). In addition, there was no difference among trials in the closest distance jays approached study skins, number of jays that approached within 3 m, or number of jays that approached within 1 m (all $P \geq 0.15$).

CHAPTER IV

DISCUSSION

Assuming that calling rates and approach distances vary relative to the degree of threat posed by aerial predators, my results suggest that Eastern Screech-Owls represent the greatest potential threat to Blue Jays in my study area. When responding to Eastern Screech-Owls, Blue Jays uttered ditonal and modulated jeer calls at higher rates and tended to approach the study skin more closely than during trials with study skins of other raptors. Responses by Blue Jays in my study suggest that Sharp-shinned Hawks may also be perceived as a threat. Blue Jays' responses to the other study skins (Great Horned Owl, Red-tailed Hawk, Cooper's Hawk, and American Kestrel) were more limited, suggesting that, based on call rates and approach distances, they were not perceived to be as threatening as Eastern Screech-Owls and Sharp-shinned Hawks. Eastern Screech-Owls and Sharp-shinned Hawks are known predators of Blue Jays (Storer 1966, Gehlbach 1994, Artuso 2010) so responding vocally (i.e., uttering ditonal jeers at high rates) and behaviorally (i.e., approaching closely) in ways that might cause the predators to leave the area would likely be beneficial (i.e., move-on hypothesis; Flasskamp 1994).

Other species of birds preyed on by Eastern Screech-Owls and Sharp-shinned Hawks, including Black-capped Chickadees, Carolina Chickadees, and Tufted Titmice, exhibit behavior similar to Blue Jays when these predators are detected (Templeton et al. 2005, Soard and Ritchison 2009, Courter and Ritchison 2010). However, in contrast to

Blue Jays, chickadees and titmice use functionally referential calls to alert conspecifics, varying the characteristics of calls or using different calls to convey more specific information about the degree of threat posed by different predators (Baker and Becker 2002, Templeton et al. 2005, Soard and Ritchison 2009, Courter and Ritchison 2010).

Although Blue Jays in my study did respond differently to different predators, their vocal responses were not functionally referential, i.e., the same calls with the same characteristics were used when responding to different predators, only the calling rates differed among trials. Gill and Bierema (2013) noted that functionally referential alarm calls may be more likely to evolve in contexts involving mates and/or kin because, in such contexts, calls provide more specific information about predation risk could enhance the fitness of both callers and receivers. However, Krams et al. (2012) suggested that vocal complexity, as exemplified by the calls of chickadees and titmice, is more likely to evolve in species with complex social systems, regardless of whether or not those systems include kin. In support of these hypotheses, species with functionally referential alarm calls are known to occur in flocks or groups that include mates and/or kin (Siberian Jays, Griesser 2008), use their calls to warn their nestlings about nearby predators (Great Tits, Suzuki 2011), or occur in flocks where connections and interactions with unrelated conspecifics can be complex (chickadees, Krams et al. 2012). In contrast to these species, winter flocks of Blue Jays appear to be temporary, with mated pairs from the previous breeding season only temporarily joining other jays to forage or mob predators (Smith et al. 2013). Other investigators have also noted that, during the non-breeding period, Blue Jays appear to have minimal social organization

above the level of mated pairs (Fitch 1958, Cohen 1977). During the non-breeding season, therefore, Blue Jays may not associate with kin and their flocks are apparently temporary, with no complex social interactions beyond those between mated pairs. The absence of any differences in the responses of Blue Jays in my study to playbacks of calls uttered during trials with different raptors (Eastern Screech-Owl and Red-tailed Hawk) also suggests that the primary function of the calls is to harass predators rather than to convey information to conspecifics.

When mobbing a predator, the relatively high-volume ditonal jeer calls of Blue Jays are sometimes heard by nearby conspecifics that, in response, may approach and also begin calling (Fitch 1958, Smith et al. 2013). Attracting conspecifics (and, sometimes, heterospecifics as well, e.g., Tufted Titmice, Carolina Chickadees, and Carolina Wrens, pers. observ.) may not be the primary function of calls uttered by Blue Jays when mobbing predators, but the harassment of predators that results from the presence (and vocalizing) of other Blue Jays and heterospecifics may be beneficial if those predators are then more likely to move elsewhere.

Blue Jays in my study exhibited minimal responses to the control study skin (Ruffed Grouse) and to study skins of a Red-tailed Hawk and an American Kestrel, suggesting that they were not perceived as predatory threats. Available evidence suggests that Great Horned Owls, American Kestrels, and Red-tailed Hawks rarely prey on Blue Jays (Gates 1972, Collopy and Koplin 1983, Artuso et al. 2014). Of the six predators used in my study, Eastern Screech-Owls have been documented preying on jays more than any other raptor (Gehlbach 1994, Artuso 2010). Jays appeared to find

Eastern Screech-Owls most threatening, with significantly high ditonal jeer rates (Fig. 4a) and close mobbing distances (Fig. 5a).

Assuming that higher calling rates and closer approaches during mobbing instances would cause a raptor more stress (e.g., Consla and Mumme 2012) and increase the likelihood that they would move elsewhere, reasons for the limited response of Blue Jays to the Cooper's Hawk study skin are unclear. Cooper's Hawks do prey on Blue Jays (Bielefeldt et al. 1998, Smith et al. 2013), and other investigators have reported that Blue Jays sometimes mob Cooper's Hawks (Ehrlich and Drickamer 1993, Heintzelman 2004, McWhirter 2000, Roth and Lima 2003, 2006). Based on my definition of mobbing (see Methods section), Blue Jays did mob the Cooper's Hawk study skin during four of seven trials, but calling rates were low, few jays approached within 3 m, and no jays approached within 1 m. One possible explanation for this is that some characteristic(s) of the Cooper's Hawk study skin used in my study made it appear less realistic or lifelike. Another possible explanation is that, when only two or three Blue Jays are present (mean number of jays present during my experiments was 2.6), closely approaching a Cooper's Hawk is too risky. Birds mobbing Cooper's Hawks are sometimes killed (Holroyd 2002). With greater numbers of birds mobbing, a Cooper's Hawk may be less able to focus on particular individuals. For example, Ficken (1989) observed five or six Steller's Jays (*Cyanocitta stelleri*) mobbing a Cooper's Hawk and creating a 'confusion chorus' that provoked the hawk to fly away. In addition, Bildstein (1982) noted that mobbing by multiple birds was more likely to drive a raptor away than mobbing by one individual and that the risk of predation for each individual mobber is lower than for an

individual mobbing alone. Given the relatively low number of Blue Jays present during trials in my study, the potential cost of mobbing a Cooper's Hawk may have been greater than the potential benefit of driving it from the area. When jays detected Cooper's Hawks, they uttered few ditonal jeers, and often stayed further away than they did from other potential predators.

In summary, based on their vocal responses, Blue Jays in my study perceived Eastern Screech-Owls and Sharp-shinned Hawks as the predators representing the greatest threat. However, even though Blue Jays did respond differently to different predators, their vocal responses were not functionally referential; the same calls were used in response to different predators, with only the calling rates differing among trials. Thus, rather than providing conspecifics with specific information about predation risk, the calls of Blue Jays, specifically ditonal and modulated ditonal jeers, are likely directed at and serve to harass predators and provoke them into moving elsewhere.

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APPENDIX

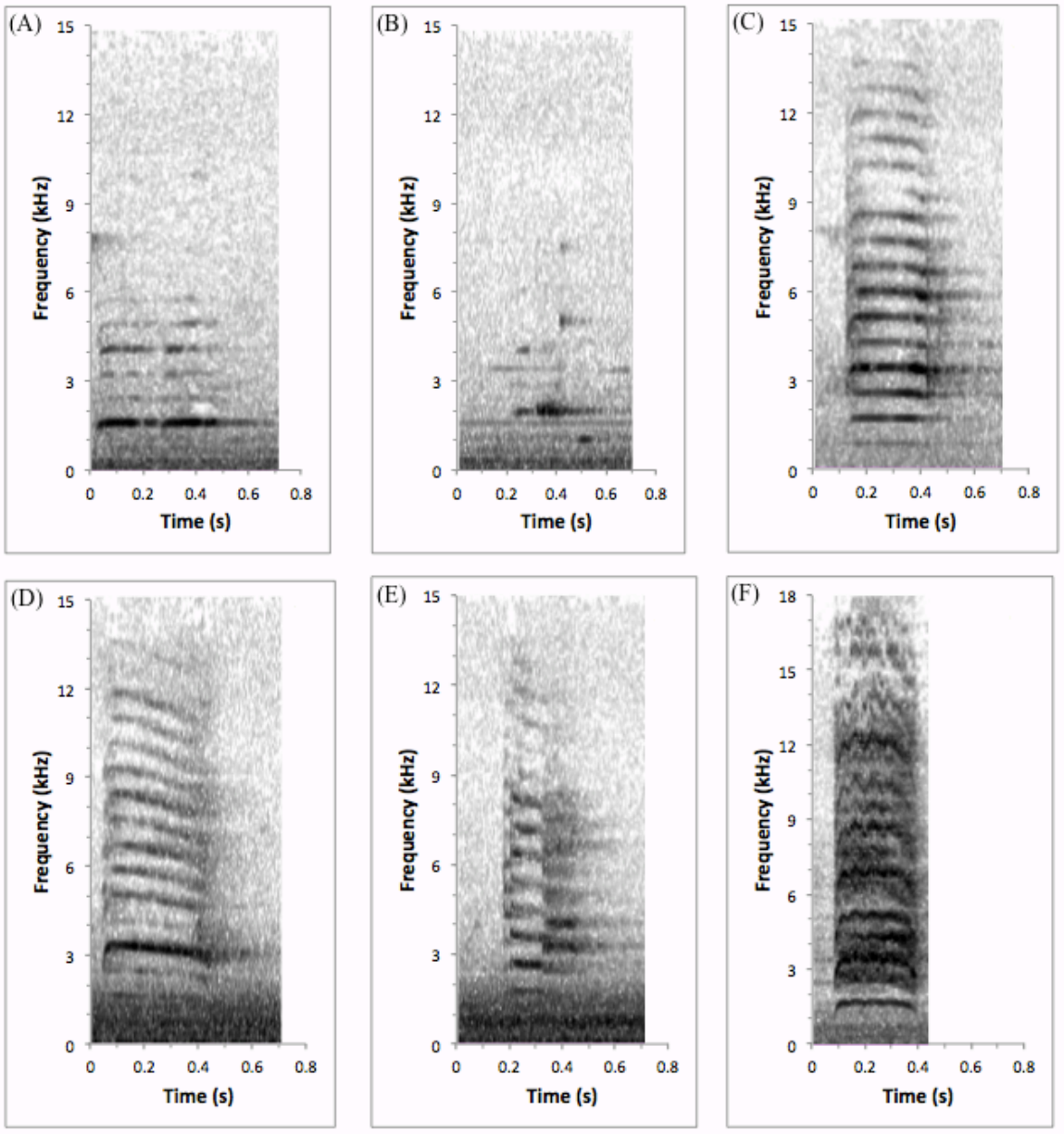

Figure 1. Blue Jay vocalizations given during trials with different predators. A) bell call, B) squeaky gate call, C) monotonal jeer, D) ditonal jeer, E) broken ditonal jeer, and F) modulated ditonal jeer.

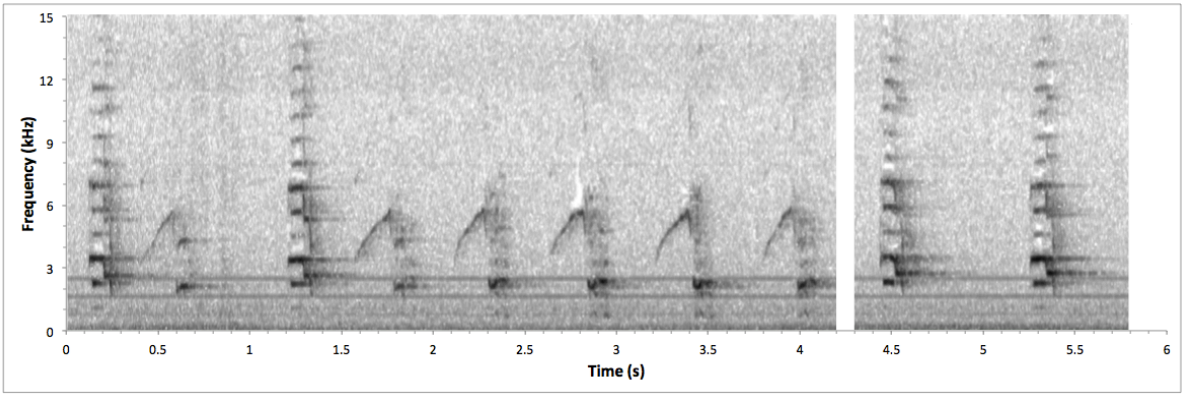

Figure 2. A Blue Jay phrase, consisting of two notes, uttered in response to the study skins of a Ruffed Grouse and a Red-tailed Hawk.

Note: This vocalization was recorded at only one location at the Blue Grass Army Depot.

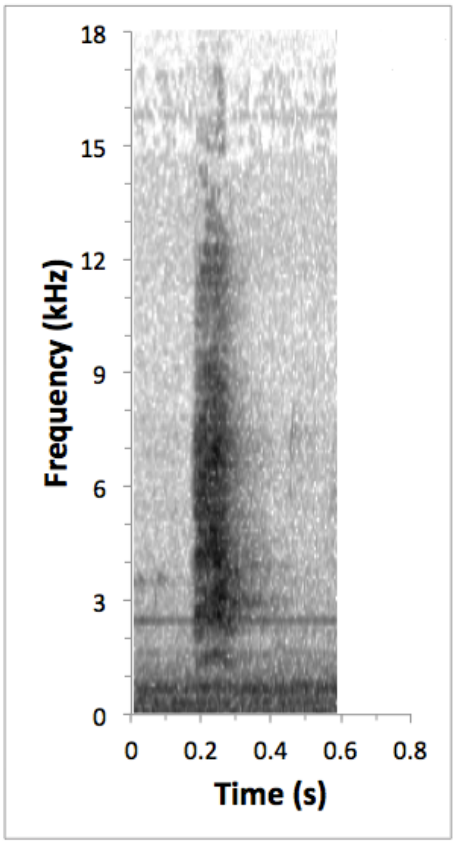

Figure 3. A Blue Jay vocalization uttered while mobbing the study skin of an American Kestrel.

Note: This vocalization was recorded at only one location in Richmond, Kentucky.

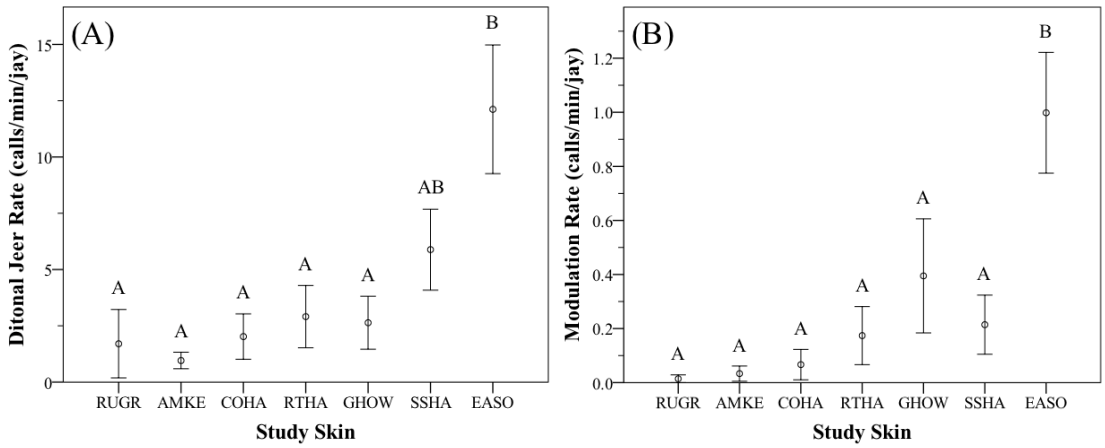

Figure 4. A) Mean rate (± SE) at which Blue Jays uttered ditonal jeer calls (calls min^{-1} jay^{-1}) in response to predator and control study skins. B) Mean rate (± SE) at which Blue Jays uttered modulated ditonal jeers (modulations min^{-1} jay^{-1}) in response to predator and control skins.

Note: Different letters indicate significant differences based on a Tukey's post-hoc test. EASO = Eastern Screech-Owl, SSHA = Sharp-shinned Hawk, COHA = Cooper's Hawk, RTHA = Red-tailed Hawk, GHOW = Great Horned Owl, AMKE = American Kestrel, and RUGR = Ruffed Grouse.

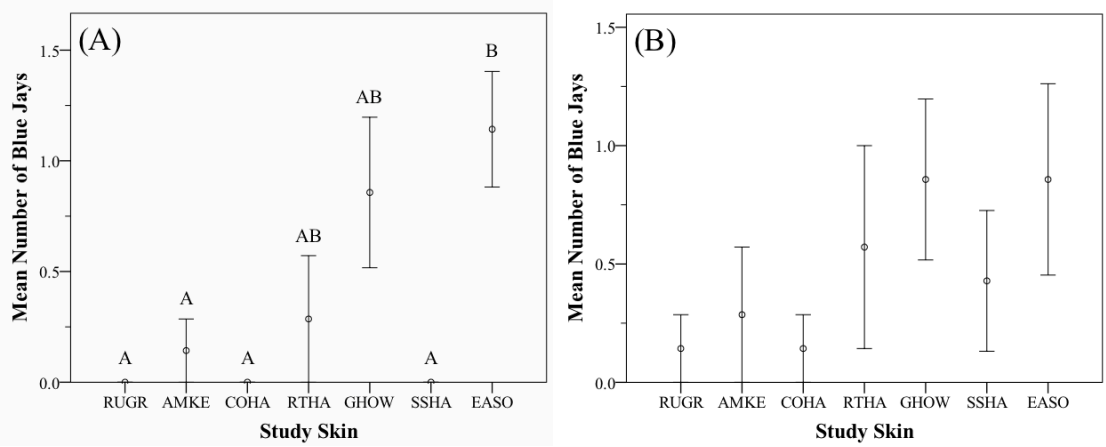

Figure 5. A) Mean number (± SE) of Blue Jays that came within 1 m of study skins during trials with study skins of predators and a control. B) The mean number (± SE) of Blue Jays that came within 3 m during trials with study skins of predators and a control did not differ significantly.

Note: Different letters indicate significant differences based on a Tukey's post-hoc test. EASO = Eastern Screech-Owl, SSHA = Sharp-shinned Hawk, COHA = Cooper's Hawk, RTHA = Red-tailed Hawk, GHOW = Great Horned Owl, AMKE = American Kestrel, and RUGR = Ruffed Grouse.

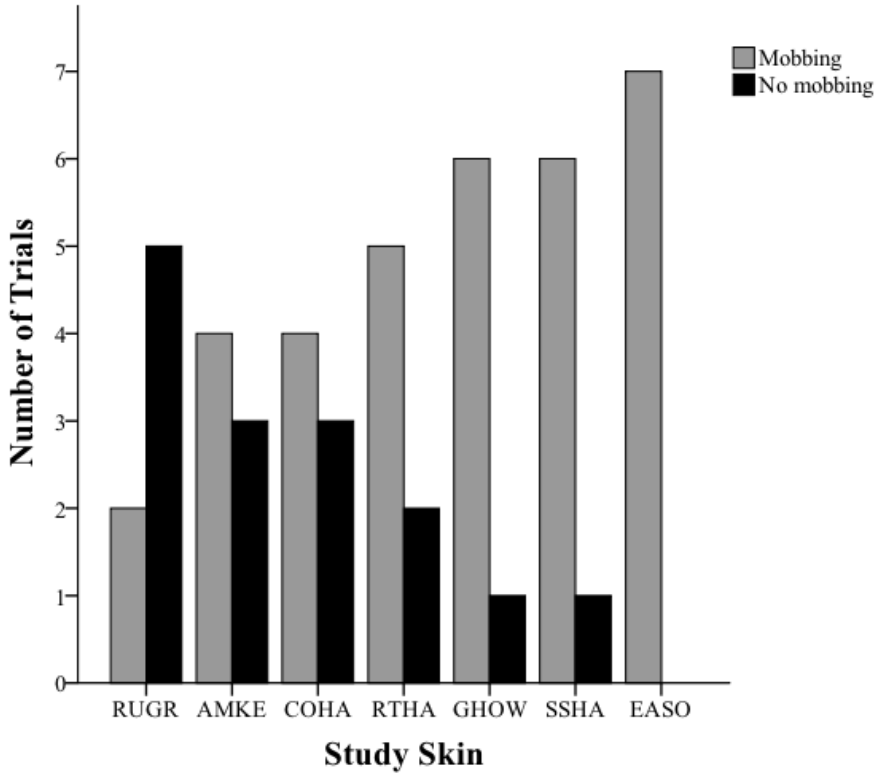

Figure 6. Responses of Blue Jays at different locations (N = 7) to presentation of different predator and control study skins.

Note: Blue Jays exhibited mobbing behavior in response to all predator study skins at some locations, but the intensity of those responses was greatest for Eastern Screech-Owls and Sharp-shinned Hawks. Mobbing behavior consisted of repeatedly vocalizing in response to the predator or control study skin along with body movements such as raised crests and wing flicks. Jays were not mobbing when they were not directing calls toward the predator or control skin and/or were visiting the feeding station to obtain food during the trial. EASO = Eastern Screech-Owl, SSHA = Sharp-shinned Hawk, COHA = Cooper's Hawk, RTHA = Red-tailed Hawk, GHOW = Great Horned Owl, AMKE = American Kestrel, and RUGR = Ruffed Grouse.