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Behavioral and Vocal Responses of the American Goldfinch (Carduelis Tristis) to Predatory Bird Calls

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A particular reaction to a given predator is dependent on the level of danger perceived by an animal. American Goldfinches (*Carduelis tristis*) are preyed upon by highly threatening predators that commonly attack songbirds at feeders (feeder predator) and less threatening predators that rarely attack songbirds at feeders (non-feeder predators). This study measured the behavioral and vocal reactions of American goldfinches to these different levels of predatory threat and examined the effect of threat level on the trade-off between foraging and anti-predatory behaviors (vigilance). We hypothesized that if goldfinches respond to predatory cues based on the level of threat associated with a particular predator species, then goldfinches should respond more strongly (i.e. become vigilant, feed less, abandon feeder) to feeder predators than non-feeder predators. We observed goldfinches at two established feeders and used playbacks of two predator types (feeder predators = high risk and non-feeder predators c::: lower risk) and control species (non-predators) recordings to measure behavioral and vocal responses to auditory predator cues by counting the number of seeds consumed, the time a goldfinch spent vigilant, and whether or not a bird fled the feeder. We planned to measure fluctuations in number and type of calls (e.g., contact versus alarm calls), but no vocal responses were produced by the goldfinches during the trials. We found no difference in behavioral reactions to predator types, and our hypothesis that responses to predators would differ with threat level was not supported. However, vigilance increased significantly from control (unthreatening) species to predator species ($F=0.27$, $p= 0.0008$) which decreased seed consumption ($F""1.4$, $p""0.25$), indicating that vigilance is greatly increased when birds forage for food under predatory pressure. This trade-off is a major consequence of predation and is a driving force in organizing avian communities such as flocks.

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BEHAVIORAL AND VOCAL RESPONSES OF THE AMERICAN GOLDFINCH

(*CARDUELIS TRISTIS*) TO PREDATORY BIRD CALLS

By

Kate Marsh with Dr. Jamie Cornelius

A Senior Thesis Submitted to the

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Abstract

A particular reaction to a given predator is dependent on the level of danger perceived by an animal. American Goldfinches (*Carduelis tristis*) are preyed upon by highly threatening predators that commonly attack songbirds at feeders (feeder predator) and less threatening predators that rarely attack songbirds at feeders (non-feeder predators). This study measured the behavioral and vocal reactions of American goldfinches to these different levels of predatory threat and examined the effect of threat level on the trade-off between foraging and anti-predatory behaviors (vigilance). We hypothesized that if goldfinches respond to predatory cues based on the level of threat associated with a particular predator species, then goldfinches should respond more strongly (i.e. become vigilant, feed less, abandon feeder) to feeder predators than non-feeder predators. We observed goldfinches at two established feeders and used playbacks of two predator types (feeder predators = high risk and non-feeder predators = lower risk) and control species (non-predators) recordings to measure behavioral and vocal responses to auditory predator cues by counting the number of seeds consumed, the time a goldfinch spent vigilant, and whether or not a bird fled the feeder. We planned to measure fluctuations in number and type of calls (e.g., contact versus alarm calls), but no vocal responses were produced by the goldfinches during the trials. We found no difference in behavioral reactions to predator types, and our hypothesis that responses to predators would differ with threat level was not supported. However, vigilance increased significantly from control (unthreatening) species to predator species (F=0.27, p= 0.0008) which decreased seed consumption (F=1.4, p=0.25), indicating that vigilance is greatly

increased when birds forage for food under predatory pressure. This trade-off is a major

consequence of predation and is a driving force in organizing avian communities such as

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Introduction

Predation is recognized as an important factor in organizing communities

(Cockrem and Silverin 2002; Lima and Valone 1991; Caro 2005). Animals are able to

recognize whether or not they are in danger and protect themselves by forming

mutualistic groups, increasing group size, and avoiding settling in areas where they

perceive a high risk of predation (Lima and Valone 1991; Griffin 2004; Caro 2005).

Many species prefer to forage in areas of high coverage or with quick escape routes

(Lima and Valone 1991) or to feed in large groups to benefit from other member's

vigilance (Sirot 2006). Because prey species may respond differently to predation,

studying a particular species' responses to threat will provide a better understanding of

specie-specific trade-offs and perceived predation risk.

Predation is a main factor affecting behavioral and reproductive decisions in wild

populations (Tilgar and Moks 2015). A number of studies have demonstrated that

anti-predator behaviors are both inherently aversive as well as learned through repeated

exposure (reviewed in Griffin 2004). For example, fish can learn to avoid habitats after

they have become associated with the presence of predator danger through visual and

olfactory cues (Chivers and Smith 1995), and rhesus monkeys (*Macaca mulatta*) respond

fearfully to snakes after watching another monkey's response to them (Mineka and Cook

1993). Mother moose (*Alces alces*) have been known to behave more cautiously in response to howls if they have already lost an offspring to wolves (*Canis lupus*) (Berger *et al.* 2001), and Australian kangaroos (Macropodidae) display anti-predator responses such as fleeing the area and foot thumping when they believe they are in danger (Griffin and Evans 2003). Predator avoidance due to social information has received much more attention in the field of anti-predator behavior than has behavioral responses due to direct exposure.

Predation is the leading cause of death for many bird species, primarily due to predatory birds (Templeton *et al.* 2005). As an important agent of natural selection, predatory threat has had a strong influence on the evolution of a number of bird behaviors (Childress and Lung 2002). The risk of death due to predators is a severe threat to songbirds, and group vigilance and alarm calling behaviors have developed as a response to this predatory pressure. Individual vigilance is highest when foraging alone, as there is a negative correlation between group size and vigilance (Elgar 1989), however, birds are expected to make a trade-off between feeding efficiency and anti-predatory behaviors. Food availability and location often forces birds away from protection from predators, so it is necessary to increase vigilance while foraging even though it decreases optimum foraging efficiency.

Like many animals, birds can distinguish between high-risk and low-risk predators (Cockrem and Silverin 2002). A difference in threat level may affect the trade-off decision between feeding and vigilance. For example, feeder predators and non-feeder predators represent a difference in threat to a songbird due to the hunting

behavior of the predator. Birds that attack prey birds directly from perches (i.e. bird feeders) are called feeder predators. Non-feeder predators represent a less severe predatory threat; they are less likely to attack other birds while they feed at bird feeders because, though they occasionally hunt birds, small mammals are their primary prey. Non-feeder predators typically prey on mammals on the ground, and therefore are not likely to attack birds at feeders (Alderfer 2005). A particular reaction to a given predator, from a lack of response to a quick escape, is dependent on the level of danger perceived by the animal (Macedonia and Evans 1993; Seyfarth and Cheney 2003; Cockrem and Silverin 2002). Whether or not a bird perceives a particular predatory stimulus as a high or low level of threat will inherently change its behavior towards that stimulus, and it may influence a bird's decision to make the trade-off between feeding and scanning. For example, a perceived high level of threat may result in a particular bird becoming more vigilant and therefore decreasing its time spent foraging or foraging efficiency, whereas a perceived low level of threat might allow a bird to be minimally vigilant and continue foraging for a longer period of time or more efficiently.
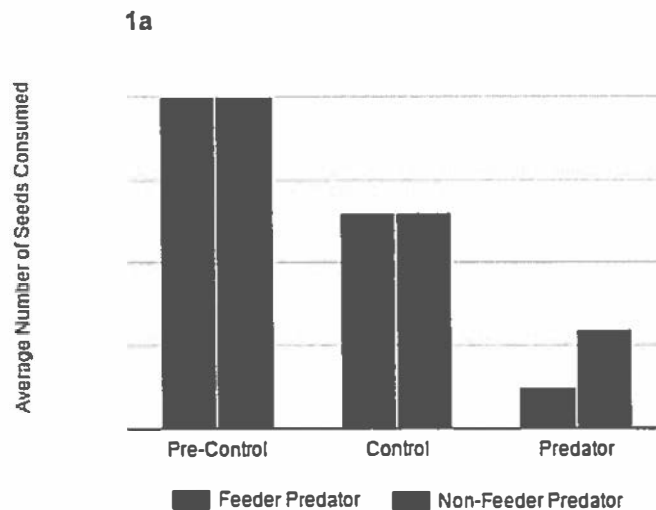
Whether or not a bird reacts to a predatory cue may depend on if the bird is likely to be attacked from the ground or from above, the frequency of which a particular predator may attack such a bird, or even the presence or absence of a flock or mate (Templeton *et al.* 2005; Sirot 2006; Macedonia and Evans 1993). Many studies have observed vocal reactions to predators in various species of birds (Goodale and Kotagama 2008; Sullivan 1985), but few studies have incorporated visual observations on responses to predators along with vocal responses. Potential behavioral responses include a

decrease in foraging, an increase in vigilance, or abandoning the feeder, and vocal responses can vary greatly within bird species. The act of alarm calling can depend on the presence and composition of a flock and the presence of a mate or young (Macedonia and Evans 1993), and some species are known to use alarm calling more than others. Measuring a bird's behavioral and vocal responses can help us to understand the ways in which specific species of birds react to different levels of threat in predators and whether or not specific behaviors are correlated to specific levels of predation (i.e. leaving the feeder upon hearing a predator associated with a high level of threat). To understand a species' behavioral response to predators and to investigate the trade-off between anti-predator behavior and foraging behavior, it is necessary to observe whether or not birds increase their vigilance after hearing a predatory call, the immediateness of their response in terms of fleeing the feeder, and what type of predators and variables induce specific alarm calls.

The primary goal of this study was to measure behavioral reactions to different levels of predatory threat in the American Goldfinch (*Carduelis tristis*) while also observing vocal reactions. As a common North American songbird with a variety of feeder and non-feeder predators, goldfinches represent a species of bird that should be familiar with different levels of predatory threat and whose behaviors might change accordingly. If goldfinches respond to predatory cues based on the level of threat associated with a particular predator species, then they should respond more strongly to feeder predators than non-feeder predators. To measure perceived threat level and it's affect on behavior, we used recordings of predator and control species calls and counted

the number of seeds eaten by the focal bird and recorded the amount of time the focal bird spent scanning the area for predators during each twenty-second treatment (i.e. silence, control species, predator species). In addition, we noted whether a bird abandoned the feeder and planned to measure fluctuations in number and type of vocal responses given from focal and nearby conspecific birds. We predicted that the goldfinches would become more vigilant, consume fewer seeds, abandon the feeder more often, and produce more vocal warnings following feeder predator playback than non-feeder predator playback. Within trials, we predicted that the number of seeds consumed would decrease from control to predator playback (Figure 1a), and that vigilance would increase from control to predator playback (Figure 1b).
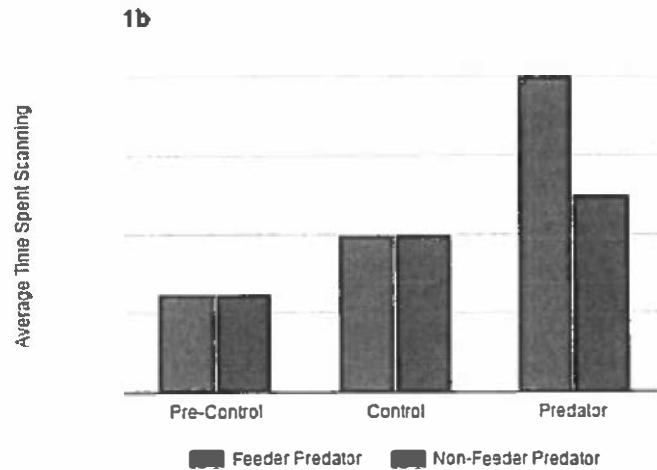
1a

Feeder Predator   Non-Feeder Predator

1b

Average Time Spent Scanning

Pre-Control   Control   Predator

■ Feeder Predator   ■ Non-Feeder Predator

Figure 1a and 1b: Prediction figures showing the expected trends for average number of seeds consumed and average time spent scanning within trials and between predator types.

Materials and Methods

Study Species: The American Goldfinch (*Carduelis tristis*) is a common North American songbird belonging to the Order *Passeriformes* (perching birds) in the family Fringillidae (buntings and finches)(Sibley 2009). The breeding male is especially recognizable due to its bright lemon-yellow colored body with white undertail coverts, black cap, and black wings (Alderfer 2005). They are very social birds, common in flocks, with a distinct high song (Robbins *et al.* 1983). As a medium-sized songbird that lives year round in much of North America, the goldfinch has a variety of predators, both mammals and birds (Sibley 2009). The Cooper's Hawk (*Accipiter cooperii*) and the Sharp-shinned Hawk (*Accipiter striatus*) are common North American feeder predators. The high chattering *kew-kew-kew* of a Sharp-shinned Hawk and the low *keh-keh-keh* of a

Cooper's Hawk are distinct calls made by these predators (Alderfer 2005). Songbirds, such as goldfinches, make up the majority of these bird's diets (Templeton *et al.* 2005). Examples of non-feeder predators that prey on animals on the ground, as opposed to feeders, include the Rough-legged Hawk (*Buteo lagopus*) and the Red-tailed Hawk (*Buteo jamaicensis*).

Study Sites: Trials were completed at two separate feeders in Southeast Michigan. These feeding sites were chosen based on the medium-high density of goldfinches previously observed in the area. One site (site A) was a residential neighborhood where a large number of goldfinches were heard in the surrounding trees in the mornings and evenings. It is likely that there were plenty of feeders in the area that the birds could rely on for food. The second site (site B) was less residential with more forest and edge habitats. Though goldfinches were heard at this location in the surrounding trees, the birds visited our feeder less often. This resulted in a lower number of trials done at this location and the feeding sites being used unequally (site A: n=32, site B: n=16).

Experimental Design: To measure behavioral and vocal responses to predators we observed goldfinches at two established feeders and used playbacks of predator and control species recordings to measure behavioral and vocal responses to auditory predator cues. We used a randomized collection of three different recordings acquired from the Cornell Lab of Ornithology for each predator and control species (indicated as "a." "b." or "c."; see below). Using multiple replicates of each call type eliminated the possibility of reactions to the playback being from an unintended aspect of one recording (e.g., noise in background; Cortopassi and Bradbury 2006). We measured the responses of

goldfinches to auditory predator cues by comparing behavior between goldfinches exposed to the calls of a control (i.e., non-predatory) species and either a common feeder predator species or a non-feeder/rare predator species.

Two controls were built into our design. First, we allowed each individual to feed at the feeder for twenty seconds while measuring behavior prior to any playbacks. Second, the focal bird was played one replicate of a control species (Control 1a, 1b, 1c or 2a, 2b, 2c) for an additional twenty seconds. After the pre-control (silence) and control, playback of a feeder predator (Feeder Predator 1a, 1b, 1c or 2a, 2b, 2c) or a non-feeder predator (Non-Feeder Predator 1a, 1b, 1c or 2a, 2b, 2c) was played for a final twenty seconds.

We performed trials twice each week, allowing at least twenty-four hours between sampling (to allow for a more randomized sample of birds each time), for twelve weeks during the months of May to August. Total sampling resulted in forty-eight birds tested (N=48 responses to controls; N=24 responses to feeder predators; N=24 responses to non-feeder predators) throughout the study. We allowed at least one hour to elapse following presentation of a predator call to minimize the influence of prior exposure on focal bird behavior (Devereux *et al.* 2006).

Predator Species Selection: Two types of predatory birds were used to evaluate behavioral and vocal responses. Two predatory groups were chosen because some predators may be more threatening to goldfinches and might cause a stronger response than other species (Seyfarth and Cheney 2003). For "Feeder Predators," which represent a high level of predatory threat who are likely to attack birds from bird feeders, we chose

to use the Cooper's Hawk *(Accipiter cooperii)* and the Sharp-shinned Hawk (*Accipiter striatus*) because they have been observed frequently during Feeder Watches (a citizen science program run by Cornell University) and because songbirds make up the majority (i.e., >90%) of their diet (Templeton *et al.* 2005). "Non-feeder Predators," which are less likely to attack a goldfinch at its feeding perch, included the Rough-legged Hawk (*Buteo lagopus*) and the Red-tailed Hawk (*Buteo jamaicensis*). These birds were chosen because they are rarely observed during Feeder Watches and prey most heavily on small mammals, but songbirds are supplemental to their diets (Templeton *et al.* 2005). The control species were chosen based on their overlapping range with American Goldfinches and non-predatory characteristics. The Dark-eyed Junco (*Junco hyemalis*) and the Black-capped Chickadee (*Poecile atricapillus*) are familiar and non-threatening to goldfinches and therefore should cause little to no behavioral or vocal response from the goldfinches (Dunn 2001).

Measures of Behavioral Response: Three measures were taken to determine whether predator type influenced behavior. We measured reactions to predatory calls by recording how many seeds the focal bird consumed within the twenty seconds of each playback (pre-control, control, predator) and by recording the total time a bird spent scanning the area for potential predators per each twenty-second interval. In addition, we recorded whether a not a bird left the feeder upon a specific playback along with how much time had passed. These specific variables were chosen to emphasize the vigilance-foraging trade-off by measuring the number of seeds consumed during each trial along with the time spent vigilant.

Measures of Vocal Response: In addition to behavioral responses to predatory calls, we planned to measure fluctuations in number and type of calls (e.g., contact versus alarm calls and variants within those categories) given from focal and nearby conspecific birds. However, no vocal responses were produced by the goldfinches during the trials.

Data Analysis: A repeated measure design was used to analyze behavioral data. To determine if predator type affected the number of seeds consumed or vigilance during these phases we used a repeated-measures MANOVA with predator type (feeder or non-feeder) as the predictor variable. We then combined the results of the two predator types, because there was no significant difference between them, and used t-tests to compare means of specific groups.

Results

Seeds Consumed: The number of seeds consumed by the goldfinches was not statistically different between feeder and non-feeder predator groups (repeated measures MANOVA; $F=0.19$, $p=0.66$; Figure 2). Combining the feeder and non-feeder trials together (Figure 3), the average number of seeds consumed was greatest during the pre-control (absence of playback), lower while a control species was played, and lowest when a predator was played (repeated measures MANOVA; $F=1.4$, $p=0.25$): there was a strong trend for seed consumption during predator playback to decrease relative to pre-control feeding rates ($p=0.11$). The change in the average number of seeds consumed from control to predator playback, however, was not significant ($p=0.34$).
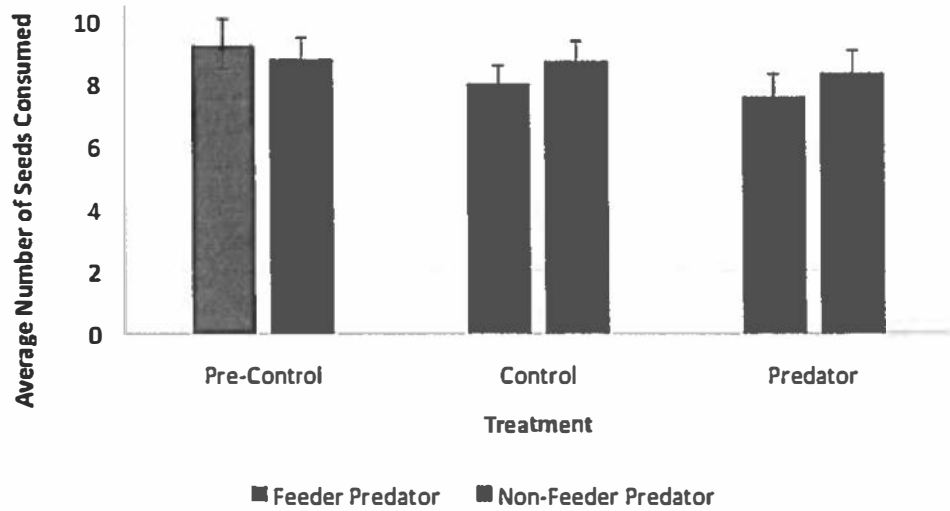
Figure 2: Average number of seeds consumed per each treatment (Pre-Control, Control, and Predator) and between predator types (Feeder Predator and Non-Feeder Predator).
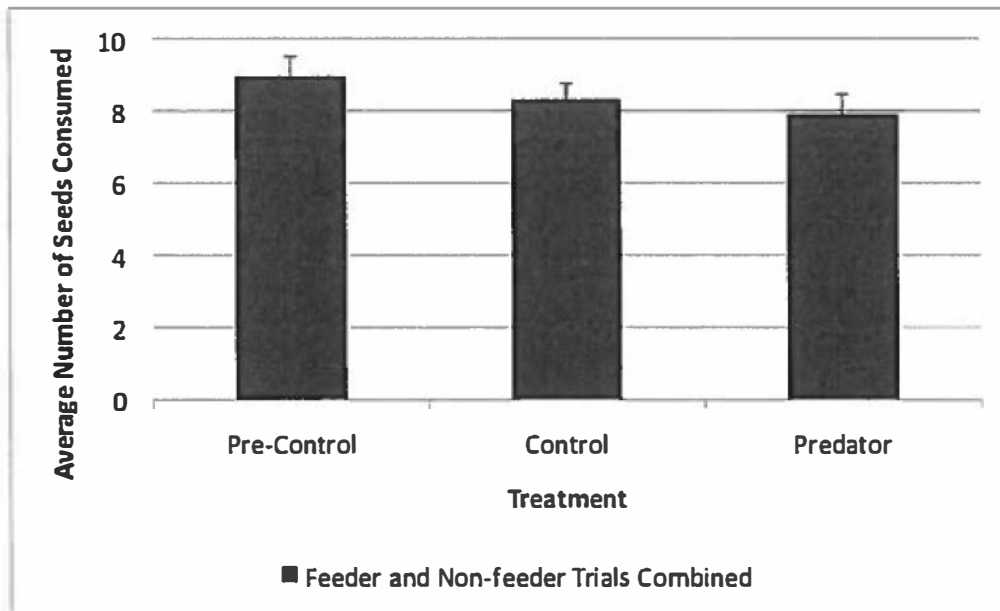

Figure 3: Combined Feeder Predator and Non-Feeder Predator data for average number

of seeds consumed per each treatment (Pre-Control, Control, and Predator).

Vigilance: As with seed consumption, there was no difference in vigilance between predator types (repeated measures MANOVA; F=0.57, p=0.45) (Figure 4). However, when predator types are combined, the time a particular bird spent looking away from the feeder, or scanning the area for predators, increased with threat level (Figure 5). The difference between the predator playbacks and the pre-control playbacks was highly significant (F=0.66, p= <0.0001). When comparing the predator playbacks to the control of an unthreatening heterospecific, the difference in vigilance remains significant (F=0.27, p= 0.0008).
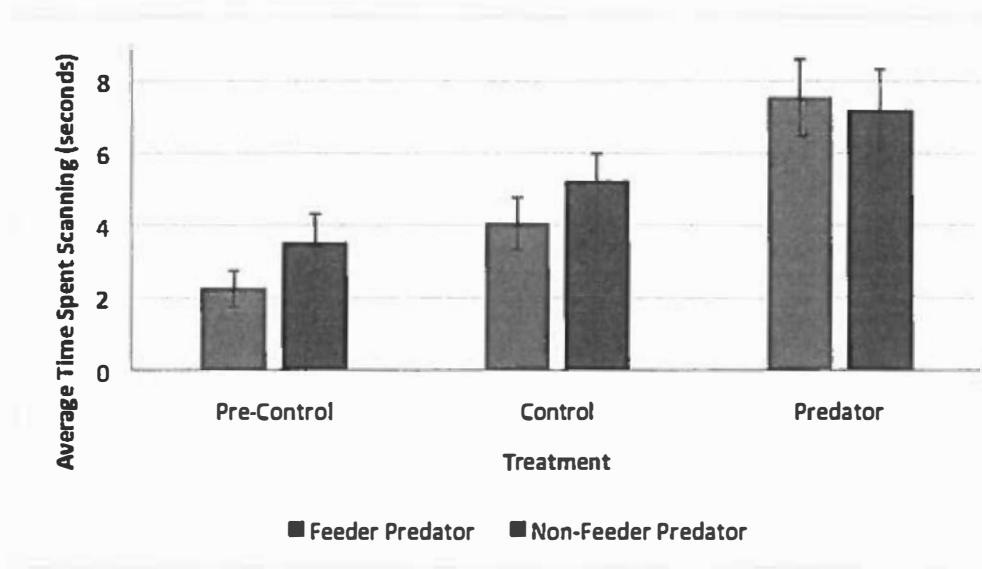

Figure 4: Average time spent scanning per each treatment (Pre-Control, Control, and Predator) and between predator types (Feeder Predator and Non-Feeder Predator).
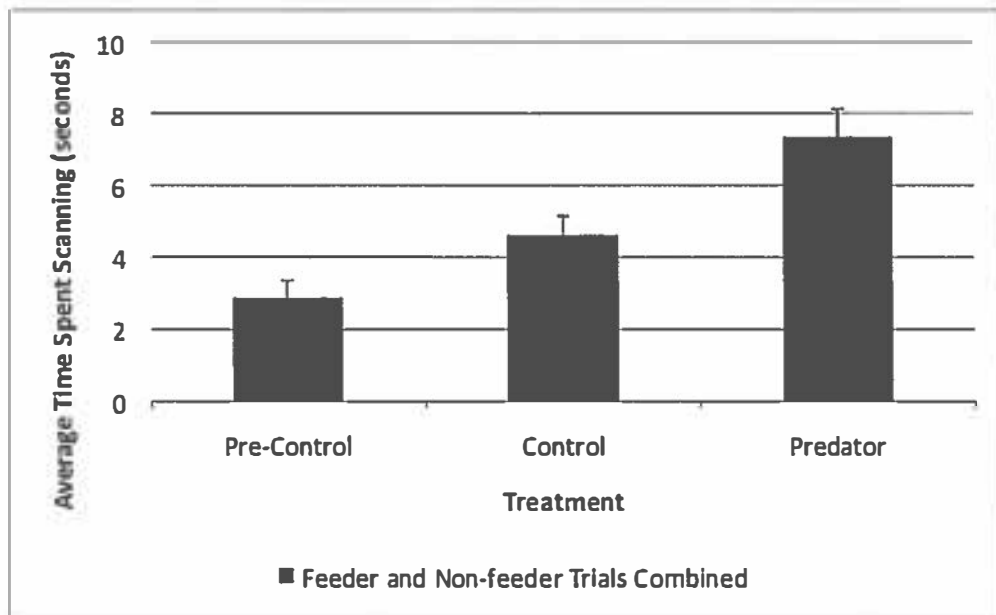
Figure 5: Combined Feeder Predator and Non-Feeder Predator data for average time spent scanning per each treatment (Pre-Control, Control, and Predator).

Fleeing the Feeder: Out of 46 trials, only two birds left the feeder before the entire trial (1 minute in length) was complete. One of the birds belonged to the feeder predator trials, and one belonged to the non-feeder trials. Each left the feeder during the predator playback after over half (10 seconds) of the trial was complete.

Vocal Responses: No goldfinches responded vocally to any of the trial playbacks. In one instance, a bird was singing with another in the tree from which the feeder was hanging, but stopped well before actually perching on the feeder.

Discussion

While the results of our study did not support our hypothesis that American

Goldfinches would respond more strongly to differences in threat level associated with feeder and non-feeder predators, the birds were able to recognize a predatory threat from an unthreatening control and increase their vigilance accordingly. Vigilance increased and foraging decreased on average after a feeder predator playback, but these responses were not substantially different when compared to the non-feeder predator playbacks. Given that vigilance between control playback and predator playback increased considerably regardless of predator type, these data suggest that finches can recognize the threat associated with their predators and increase their vigilance correspondingly. This presumably affects the foraging-vigilance trade-off, resulting in decreased feeding. A larger sample size might help to determine if these trends are real.

Behavioral Responses to Predation: Results for seed consumption followed that of our hypothesis (i.e. seed consumption decreased with increased threat level), and the pattern is most likely explained by the reported increase in vigilance - which affects the feeding-vigilance trade-off. There are at least three possible explanations for the lack of a statistically significant difference in seed consumption between feeder and non-feeder predator treatments. First, the significant difference in vigilance but not seeds consumed suggests that our sample size was not large enough. There is an apparent trend for seeds consumed to decrease with increasing threat level (as to be expected as a result of increased vigilance), but the trend is not statistically significant. With a larger sample size, this trend may become more apparent. Second, it is possible that the goldfinches did not perceive a difference in threat level between the two predator types. Because all of the hawks in our study will prey on goldfinches, it is reasonable to conclude that any risk

of death would induce the same response. Third, the birds might not have perceived a real threat due to our experimental design. This is supported by the fact that the difference in average seeds consumed before the trial began (pre-control) and seeds consumed during predator playback was also not significant. This may be evidence that the birds were not fooled by the recorded predator calls, or that the absence of a visual threat (upon scanning) was enough to render the recordings unthreatening. A study by Cockrem and Silverin (2002) resulted in a significant difference in the response of Great Tits (*Parus major*) to high-risk predators and low-risk predators. This study differed chiefly in the use of visual predator models in place of vocal recordings, further suggesting that our results might have been more clear if we opted for a visual threat. It is evident, though, that the perceived threat was not severe enough to our finches to significantly influence feeding efficiency when comparing predator playbacks to non-threatening birds or between predator types.

Another issue with our experimental design was the use of a predator call to signify a hawk that would naturally be silent while hunting. Hawks use their calls for communicating with each other and refrain from making noise when actively hunting prey. Therefore, using a predator call originating close to the feeder itself may have resulted in an abnormal hunting scenario. Hearing calls of a predator might have lessened the behavioral and vocal reactions from the finches because they did not see a visual representation of the predator where the call was emanating from, or because a hunting hawk would not announce itself at all.

The major finding of our study is that there is a significant change in vigilance

from the control to the predator playbacks. Although it did not matter whether that predator was a non-feeder or feeder predator, the finches recognized the predators as a threat and increased their vigilance to scan the area. This result is ultimately what caused the trends for the reduced number of seeds consumed due to the trade-off that is made between foraging and vigilance. This is evidence that American Goldfinches can recognize the calls of their predators, have associated those calls with a threat level different than that of their non-threatening heterospecifics, and will increase their vigilance while feeding as a way to lower that risk. In addition, this research further supports the hypothesis that vigilance is greatly increased when birds forage for food (Sirot 2006). One example is a study that found that European Starlings (*Sturnus vulgaris*) increase their vigilance and decrease feeding with increasing threat level (Devereux *et al.* 2006). However, this research focused on threat level associated with their degree of visibility rather than predator type. Because food availability often forces animals away from protection from predators, they increase their vigilance while foraging, thereby decreasing foraging efficiency.

Similar to the number of seeds consumed, vigilance increased as expected from pre-control, to non-threatening heterospecific, to predator, but there was no difference between the feeder-predator trials and the non-feeder trials. The lack of a significant difference in goldfinch vigilance between the predator types can be interpreted similarly to the lack of difference in seeds consumed between predator types (i.e. unconvincing calls, strange hunting context, and lack of visual threat). There was a definite increase in vigilance between the pre-control and predator trials; however, this may be unrelated to

threat level completely. A similar study has found that vigilance is highest during instances of loud noise (Klett-Mingo *et al.* 2016). Although this study focused on the biological implications of the feeding-vigilance trade-off due to anthropogenic noise, the dramatic increase in vigilance and decrease in feeding was a direct cause of noise where there was previously silence. Because the pre-control trial consisted of no playback sound, it is natural that a call played from a nearby speaker, predator or non-threatening, would induce a significant response from the finches. This noise from the speaker, which was not there previously, could have ultimately caused the heightened vigilance and therefore, decreased feeding. We ran our experiment with controls in addition to pre-controls for both predator types with this in mind. While there were small increases in vigilance, there was clearly a stronger response to predator playback than control playback, which suggests that the presence of a sound had an impact on behavior in both cases, but the context of the sound (i.e., predator versus control) was important. In a future study, the use of visual models instead of predator calls might provide additional insight, particularly if predator calls are not characteristic of a high predation scenario. Further, it may be more realistic to make the speaker less obvious and the calls softer, in addition to adding visual models.

Vocal Responses to Predation: None of the focal finches in our study gave any sort of vocal response to a predator or control playback. In a related study, variables such as the presence or absence of conspecifics or mates greatly affected whether danger was perceived by the focal bird and dictated whether a vocal response was warranted (Macedonia and Evans 1993). In our study, goldfinches arrived at our feeders either as

individuals, or in pairs (male-male and female-female pairs, and as assumed mating pairs). If a mate or flock was present, we may have expected the finches to vocalize as a warning to their conspecifics. However, the goldfinches did not respond vocally in any of the scenarios. It is possible that a lack of vocalization may indicate that there was not another bird in close proximity or within the flock to warn of the predator (Macedonia and Evans 1993). However, multiple different pairs of birds were seen in nearby trees and frequently visited the feeder, so this explanation seems unlikely.

Again, the issue could lie with our experimental design where predator playbacks indicated the presence of a predator whom would naturally be silent while hunting. Although we expected vocalizations from the finches, the presence of a loud, distinct predator call nearby might have rendered any vocalizations to conspecifics redundant. Because hawks are typically silent while hunting, the finches might not have been threatened by the predator playback and, therefore, did not warn other finches. Additionally, if finches could hear the predator calls clearly from a nearby source, they might know that other birds in the area could hear them as well, making a warning call unnecessary. The presence of a visible speaker that produced a predator call close to the feeder, rather than a hidden speaker with a visual predatory threat, could have caused the lack of vocalization altogether.

Conclusion: Although there was a lack of significant difference in seed consumption between control and predator trials, we found that American Goldfinches can decipher between non-threatening (control) calls and predator calls and increase their vigilance accordingly. However, they were either unable to perceive a difference between feeder

and non-feeder predators, or the difference in threat was unimportant and rendered the same reaction. Our research is consistent with aforementioned studies that indicate that foraging decreases and vigilance increases with perceived threat level. This trade-off is a major consequence of predation and is a significant force organizing animal communities. It is possible that some species, like goldfinches, may be unable to distinguish between high-risk threat and low-risk threat as well as other species can. This is perhaps a reason why goldfinches, and many species of birds, form flocks (Lindstrom 1989). Compared with solitary individuals whose time spent foraging decreases as vigilance increases, scanning rate decreases with increasing group size (Sirot 2006; Childress and Lung 2002). To benefit the group, these animals tend to aggregate and increase cohesion under conditions of high predation risk from other birds (Gamero and Kappeler 2015) regardless of the severity of the threat.

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