Response of Western North American Birds to Black-Capped Chickadee (*Poecile atricapillus*) and Mountain Chickadee (*Poecile gambeli*) Mobbing Calls

BIOS 35503-01: Practicum in Field Biology - West

Madeline Wroblewski

Advisor: Dr. David Flagel

2016

Abstract

Birds use alarm calls to avoid predation. A type of alarm call is the mobbing, whichs function to draw birds towards a predator for defense. Birds in the family *Paridae,* particularly the black-capped chickadee (*poecile atricapillus)* are well documented in eastern North America producing mobbing calls which non-chickadee species respond to, however less research has been done on western birds and the effect familiarity with a call has on response. I studied, using a playback experiment, the response of western North American birds to supposedly common black-capped chickadee mobbing calls, supposedly less common mountain chickadee mobbing calls (*poecile gambeli*), and a noise control and noted birds that were attracted to the mobbing calls. On average more individual birds, agitated birds, and more species of birds responded to the mountain chickadee call than black-capped chickadee call, and there was a trend of more time spent near the speaker during mountain chickadee mobbing playback. However, there was no difference in the diversity of bird species responding, suggesting the same species, namely mountain chickadees and red-breasted nuthatches (*Sitta Canadensis*) respond more consistently to mountain chickadee mobbing calls rather than a more diverse group of species responding. The more pronounced response to mountain chickadee mobbing calls may be reflective of mountain chickadees actually being more common in western forests than black-capped chickadees. However, the lack of diversity in responding birds and mild response suggests that mobbing call recognition and response may not play as large of a role in western forests.

Introduction and Background

Animals have evolved many defenses against predation to aid in their survival. Alarm calls are one such mechanism that help animals avoid and escape predators, as well as help members of their own species escape predation. Birds use alarm calls to communicate danger, and bird species have been demonstrated using a wide variety of alarm calls, such as high pitched trills in the white-browed scrubwren (*Sericornis frontalis*) (Leavesly and Magrath 2004), and a high pitched noise followed by a long, variable low element in the domestic chicken (*Gallus gallus*) (Bayley and Evans 2003). Although such altruistic behavior may initially seem counterintuitive, as it may alert a predator to the prey's location, alarm calls serve three main purposes that are beneficial for the caller, either directly or indirectly. Alarm calls and behavior communicate to the predator that they have been spotted (Zuberbühler et al. 1999), warn conspecifics of danger or protect kin (increasing inclusive fitness) (Krams et al. 2006, Griesser and Ekman 2005), and occasionally function to draw other birds to the area to fend off a predator, or mobbing behavior (Russell and Wright 2008).

Mobbing behavior in birds consists of a bird or groups of birds approaching a predator with the intent of either driving it away or the intent of gaining more information about a predator. There are two forms of mobbing behavior; active mobbing and passive mobbing (Shields 1984). Active mobbing is more dangerous, involving a close-quarters approach, and is more commonly done by birds with young in the area in an effort to protect offspring (Shields 1984, Zimmermann and Curio 1988). Birds without young often mob passively, without close approach, and this form of mobbing functions to gain information (Shields 1984).

Interestingly, unrelated groups of birds will actively mob a predator, even when they do not have offspring directly in harm's way. One proposed mechanism for this behavior is byproduct mutualism. Regardless of one bird's relationship to another, mobbing is beneficial because effectiveness increases with number of individuals (Russell and Wright 2008). Another mechanism is reciprocal altruism, that birds recognize neighbors that have helped them in the past and preferentially aid them (Wheatcroft and Price 2008, Krama et al. 2012). In either case, unrelated individuals or those who do not appear to directly benefit do partake in mobbing activity.

Alarm Calling and Mobbing in the Family Paridae

One group of bird species that produce mobbing calls are the tits, family *Paridae,* and particularly chickadees in the genus *Poecile*. Chickadees produce a complex mobbing call (the "chick-a-dee" call), with multiple species documented producing mobbing calls including the well-studied and ubiquitous black-capped chickadee (*Poecile atricapillus*) and Carolina chickadee (*Poecile carolinesis*) (Templeton et al. 2005, Soard and Ritchison 2009). Certain species of chickadee, particularly the black-capped chickadee, have mobbing calls that appear to be widely recognized by other bird species. In previous research, multiple species of North American birds have been shown to respond to the black-capped chickadee mobbing call (24 in Hurd 1996, 50 in Gunn et al. 2000). Birds also respond independently of season, even in the winter (Turcotte and Desrochers 2002). Additionally, Carolina chickadees respond to the tufted titmouse (*Baeolopus bicolor*) mobbing call, another species in the *Paridae* family (Hetrick and Sieving 2011). Remarkably, North American birds even respond to the black-capped chickadee's mobbing call out of context while migrating (Nocera et al. 2008). The mobbing calls produced by this group of birds are apparently widely understood by many sympatric species. There is also evidence that birds may differ their response based on call type. White-breasted nuthatches (*Sitta carolinesis*) have even been shown to discriminate between chickadee mobbing call types, selectively responding only to calls indicating high threat (Templeton and Greene 2007).

There are multiple mechanisms which can explain how birds recognize heterospecific alarm calls. One mechanism is that the intrinsic characteristics of alarm calls are universally recognized, regardless of previous exposure. For example, apostlebirds (*Struthidea cinerea*), an Australian species, respond to the mobbing call of the Carolina wren (*Thryothorus ludovicianus*), a North American species, despite the two never having been in contact (Johnson et. al. 2003). The second mechanism is that alarm calls are learned through association. Only North American migrants responded to black-capped chickadee mobbing calls played out of context in Central America; non-migratory species (which had never previously experienced the call) did not respond (Nocera et al. 2008). This shows that learning may play a role in alarm call recognition.

Chickadee Species of Western North America

There are two common chickadee species present in Western North America, the black-capped chickadee and the mountain chickadee (*Poecile gambeli*). The black-capped chickadee is common, and found in montane conifer forests, streamside thickets, and cottonwood-juniper bottomlands, while the mountain chickadee is uncommon, and is found primarily in montane conifer forests (US Fish and Wildlife Service, Birds of the National Bison Range). As previously noted, substantial research has been done on black-capped chickadee heterospecific mobbing call recognition (Hurd 1996). However, less research has been done on the mobbing call of the mountain chickadee. The mobbing call ('chick-a-dee' call) is similar in both species, however it has been demonstrated that chickadees can discriminate well between either species' mobbing call (Guillette et. al 2010). The two species tend to congregate in mixed species flocks, in which mountain chickadees are typically subordinate to black capped chickadees (Grava et. al 2012). While these two species are highly similar, little research has been done on differential recognition of each species' mobbing call by other species of birds.

Objectives

The first objective of this study is to determine if local western birds respond to chickadee mobbing calls, specifically the mobbing calls of the black-capped chickadee and mountain chickadee. The second objective is, if they respond, to which species of chickadee do they respond, what variety of local species that do respond, and with what intensity. The third objective is to determine if chickadee calls are learned, or are chickadee calls innately recognized by all local species regardless of frequency heard. The hypothesis being tested is that chickadee mobbing calls are learned, which will be tested using playback of both black-capped chickadee and mountain chickadee mobbing calls. If the hypothesis is supported, response by local birds will be more intense to the ubiquitous black-capped chickadee mobbing call playback. Mobbing response will be apparent for the black-capped chickadee call in terms of all measured variables, including time individual birds spend in the radius, diversity of species attracted, number of birds attracted, and number of agitated birds. This is because the black-capped chickadee is widespread and dominant, and therefore most bird exposure will have been to this call. This exposure gives more opportunity for the call to be learned. Mobbing response will be less pronounced in response to the mountain chickadee mobbing call, again in terms of time spent in radius, attracted species, number of birds, and number of agitated birds.

Methods

Audio Selection

To test these objectives, a playback experiment was used. There were four treatments; a recording of the black-capped chickadee mobbing call; a recording of the mountain chickadee mobbing call; a audio file of pink noise, meant to control for the fact that audio is being played and the effect that may have; and lastly a second silence control, to control just for the random movement of birds and the observer's presence.

The black-capped chickadee mobbing call was recorded in Port Wing, Wisconsin in March of 2016, and consists of a flock of black-capped chickadees mobbing a saw-whet owl or boreal owl. The audio was recorded with an iPhone, and contains multiple individuals making ‘chick-a-dee’ calls. Background noise includes an American crow call and faint car noise. The track was two minutes and 27 seconds long and was played on loop for the duration of the trial.

The mountain chickadee mobbing audio was recorded on the National Bison Range and consists of a flock of mountain chickadees mobbing in response to black-capped chickadee song playback and ‘phishing’ noises, and was recorded on an iPhone 6s. The audio was layered over itself in version 2.1.2 of the audio editing software Audacity® (Audacity Team, 2016) to simulate the mobbing intensity of the black-capped chickadee audio file used. Audacity was also used to remove background noise. The track was two minutes and 30 seconds long and was also played on loop for the duration of the trial. Background sounds includes two ‘chick-a-dee’ calls from black-capped chickadees, American robin song, and wind.

The acoustic noise used for the control was pink noise generated in Audacity. The track was six minutes long and played on loop for the duration of the trial.

Site Location and Selection

Trials were conducted at six sites on the National Bison Range in northwestern Montana (47°33’N, -114°22’W). All sites have evidence of chickadee habitation, which is defined as having observed both black-capped and mountain chickadees previously in the area. This assured that resident birds had been exposed to the two species’ mobbing calls. The habitats relatively open forest, dominated by coniferous ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*) and at elevations higher than 850 meters (US Fish and Wildlife Service, Birds of the National Bison Range). There were four sites in the forested areas on Wild Horse Mountain, one site in the forest on Red Sleep Mountain, and one site adjacent to the Jocko River. Coordinates of the six sites can be found in appendix A. Of note, one site on Wild Horse Mountain (site T1) had some trees removed by construction machinery near the end of data collection, but the area was determined to remain densely forested enough to continue with trials.

Trial Structure and Methods of Recording

Trials were preformed between June 28th and July 30th of 2016. Each treatment was preformed twice at each site, with up to two trials occurring at each site in one day. Trials were completed in semi-random order. Trial order was randomized using random.org, however due to logistics of travel time between sites and setup time required, sites were paired based on distance (with sites on Wild Horse Mountain being visited together, and the Red Sleep Mountain and Jocko River sites also visited together). Trials were selected so one of the conducted trials was a random control treatment (silence or noise) and the other a random experimental treatment (black-capped or mountain mobbing audio). In total, there were twelve replicates per treatment, with a total of 48 trials conducted. All trials were performed between 6 A.M and 10 A.M., when birds were most active, and trials were not conducted when was rain or substantial wind.

Study sites consisted of an area with a ten-meter radius, defined using natural markers and flags, which were placed at the beginning of the first trial at the site then removed after the second trial at the site for the day was completed. The center of the radius was moved up to 50 meters between trials to prevent habituation. The speaker was placed in the center of the radius at a height ranging from 10-50 cm above the ground.

Each trial consisted of a ten-minute acclimation period where the observer sat in silence in order to control for their presence. Then, the audio, or silence control, was played over the next ten minutes using an Anker A3143 (Anker Technology Co. Limited, Reading, United Kingdom) speaker at maximum volume, which approximates the sound level of the natural call. During that time, all birds that enter the ten-meter perimeter were recorded. The recorders were stationed outside of the perimeter to additionally control for their presence once the trial has begun.

Before each trial, time and weather condition (sunny, sunny few clouds, partly cloudy, or cloudy), wind condition (no wind, very light wind, light wind), and temperature (using a Kestrel 3000 pocket weather meter) were noted. During each trial, all birds and their species that entered the ten-meter radius were recorded, as well as the time they enter the ring and the time they left the ring. Whether or not the bird was agitated, defined as quick movements, calling, tail flicking, or alertness, was also assessed and recorded.

Statistical Analysis

Data collected was tested for normality using a Shapiro-Wilks test. As data was not normally distributed, statistical analysis consisted of five Kruskal-Wallis tests. These Kruskal-Wallis tests compared treatment (call type and control type) and the total number of birds that responded, the amount of time birds spent within the ten-meter radius, the calculated Shannon’s Diversity index of species that responded, and the total number of species that responded to each treatment, and the total number of birds defined as agitated during each treatment. Post-hoc analysis was done using a Conover-Inmen test. Statistics were preformed using SYSTAT version 13.00.05 (Systat Software Inc., San Jose, California).

Results.

A total of 12 confirmed bird species and 20 unconfirmed observations were reported across all trials, with nine confirmed species and six unknown observations during black-capped chickadee call playback and four confirmed species and four unknown observations during mountain chickadee call playback (Table 1).

Birds spent the longest amount of time in the radius during the mountain chickadee audio playback, spending an average of 121.02 seconds (+/- a standard error of 20.3 seconds, n=56) in the ten-meter radius (Figure 1). The second longest time spent in the radius was during the black-capped chickadee audio playback with an average of 65.47 seconds (+/- 18.29 seconds, n=30) spent in, followed by 55.79 seconds (+/-21.97, n=14) for the silence control and 35.6 seconds (+/- 13.18, n=30) for the static control, however the difference in time was not significant (p-value = 0.087, H=6.558, df = 3).

Two measures of diversity were used to analyze the species that responded to the audio playbacks; Shannon's Diversity Index, calculated using the number of species that responded, and the raw number of species that responded without taking into account evenness. There was no statistical difference between the calculated Shannon's Diversity Index and any of the four trials (p-value = 0.6536, H=1.6257, df = 3) (Figure 2). However, in terms of number of species responding (Figure 3), on average the most species responded to the mountain chickadee mobbing audio, with an average of 2.5 (+/- 0.47, n=12) species responding, and the fewest to the static control with an average of 0.83 species (+/- 0.34, n=12) (p-value = 0.0361, H = 8.5383, df

= 3). Only the difference between the number of species responding to the mountain chickadee audio and static control were significant (Conover-Inman p-value = 0.003).

In terms of total number of birds that responded, the most individual birds entered the radius during the mountain chickadee audio playback, with an average of 4.17 birds (+/- 0.89, n=12), and the fewest birds entered during the static control, with an average of 1.17 birds (+/- 0.48) (p-value = 0.04, H= 8.29, df = 3) (Figure 4). Again, only the difference between the static control and mountain chickadee audio was significant (Conover-Inman p-value = 0.004).

The most agitated birds (defined as rapid movement, alertness, tail flicking, and calling), were observed during the mountain chickadee audio playback with an average of 3.25 birds (+/- 0.98, n = 12), an average of 1 bird (+/- 0.74, n = 12) during the black-capped chickadee audio playback, and the fewest agitated birds was zero (+/- 0, n = 12) observed during the silence control (p-value < 0.001, H = 17.62, df = 3) (Figure 5). The difference between the black-cap audio and silence, black-cap and static, mountain chickadee and silence, and mountain chickadee and static were significant (Conover-Inman p-values = 0.001, 0.026, < 0.001, and 0.002, respectively).

Discussion

It was found that there were significantly more birds responding to mountain chickadee audio playback in terms of number of species and number of birds, and between mountain chickadee and black capped chickadee audio in terms of number of agitated birds (figures 2, 3, and 4). However, for the number of species and number of birds responding, there was only significant difference found between the mountain chickadee mobbing audio and the noise control. For number of agitated birds, there was a difference between the noise and silence control and the mountain chickadee and black-capped chickadee audio, but not between the treatments and controls themselves.

The mountain chickadee mobbing audio saw both the greatest number of birds attracted and the greatest number of species. This contradicted the hypothesis that most birds would be attracted to the black-capped chickadee mobbing audio. However, although more species on average were attracted to the mountain chickadee mobbing audio, this is not because a larger variety of species were attracted. Instead the same species, being mountain chickadees, red-breasted nuthatches, American robins, and western-wood pewees, were attracted more consistently, versus fewer, more random species or no birds at all arriving during the other trials (Table 1, Figure 3). The lack of significance in the averaged calculated Shannon's Diversity Index shows that the birds attracted to the mountain chickadee audio were not more diverse than the other treatments. In addition, the number of birds and species of birds responding only differed from the static control.

The relative lack of birds observed during the static control was observed in terms of number of birds, number of species, and number of agitated birds. An explanation as to why so few birds were observed during the static control could be because of acoustic interference. Birds have been shown to increase call volume in response to increased acoustic noise, and the maximum detection radius for other bird songs decreases with increased noise (Lohr et al. 2003). While the noise did not bother local birds, evidenced by no increase in agitated birds during the static trials (Figure 4), the lack of observations could be because birds were avoiding areas with benign acoustic noise. The increase in non-harmful noise may have made it more difficult for local birds to give and receive acoustic messages, and thus they avoided the area where the sound originated to facilitate ease of communication.

Overall, however, the most significant response was to the mountain chickadee mobbing audio, in terms of number of birds, number of species, number of agitated birds, and a trend in the amount of time birds spent within the radius (Figures 1,2,4, and 5). This contradicts the hypothesis that the most pronounced response would be to the black-capped chickadee audio, because the more common black-capped chickadee would give other birds more exposure to its mobbing call. The question is why birds displayed the opposite behavior, responding more intensely to the mountain chickadee audio rather than the black-capped chickadee. First, it cannot be entirely ruled out that because the mountain chickadee audio was recorded in the same location where trials were conducted, local birds potentially could have been more acoustically familiar with the recorded mountain chickadee call. Birds have been shown to respond differently to different dialects of song (Danner et al. 2011, Milligan and Verner 1971, Hahn et al. 2016). It should also be noted that an increase in response to mountain chickadee audio by American robins (Table 1) could be due to the robin song in the background of the mountain chickadee audio. However, with chickadee species, both mountain chickadees and black-capped chickadees can discriminate between new and novel call types, as well as being able to correctly categorize the new and novel calls into the correct species (Bloomfield et al. 2008). Therefore, the novelty of the call may not be that important in terms of chickadee ability to recognize a call and its meaning and respond.

Another explanation as to why birds responded more intensely to mountain chickadee audio is that mountain chickadees are simply more prevalent in the montane forests on the National Bison Range, where all trials were conducted. Although it is listed on the National Bison Range bird list that black-capped chickadees are more common (US Fish and Wildlife Service, Birds of the National Bison Range), no black-capped chickadees were observed during any of the trials (Table 1). While black-capped chickadees were observed around six study sites, mountain chickadees were heard and seen at a much higher frequency. More research is needed to confirm if mountain chickadees are, in fact, more common in the National Bison Range's coniferous forests. If mountain chickadees are more common, then the original hypothesis would be reversed. A more intense reaction would be expected in response to mountain chickadee mobbing playback opposed to a black-capped chickadee mobbing playback, which is what was observed.

Overall, however, local birds on the National Bison Range do not intensely respond to chickadee mobbing audio. Unlike eastern North American studies (Hurd 1996, Gunn et al. 2000), mobbing call playback did not attract many species other than chickadees and closely associated nuthatches. Possible reasons for this lack of response could be there is not a high enough density of chickadee species for local birds to learn the mobbing response. Also, because the effectiveness of mobbing increases with the number of participants (Russell and Wright 2008), it is possible songbird density at the study sites were not high enough to warrant a response, as mobbing behavior with fewer individuals is not effective. Further studies relating chickadee and songbird density with the corresponding intensity of mobbing response could confirm if there is a relationship.

Another explanation for the lack of response is that the predators and threats that western songbirds face, especially western songbirds in relatively open coniferous forest, may not be of the type where mobbing behavior is beneficial to songbirds and their offspring. For example, nest predators are shown to increase with increased coniferous and deciduous tree cover (LaManna et al. 2015). With relatively open coniferous forest at the study sites, nest predation may have played a low role in mortality, thus making mobbing behavior less necessary. Other unknown differences in predation between eastern deciduous forests, continuous western forests, and the patchier forests on the National Bison Range could also play a role in dictating mobbing response.

If mountain chickadees are more common than black-capped chickadees, this suggests that learning may play a role in call recognition, supporting the original hypothesis, as the call to which birds had the most exposure (mountain chickadee) was the call to which most birds responded. However, response even to mountain chickadee calls was not that intense, usually only differing from the noise control, thus mobbing behavior may not play a large role in western bird behavior. Thus, while the results indicate that learning may play a roll in call recognition, further replication and confirmation that mountain chickadees are in fact more common at the study sites is needed.

Outside of just implications about avian learning, chickadee mobbing call playback has been used as a tool in conducting other research, namely as a census method of breeding birds (Gunn et al. 2000) and as a tool to experimentally manipulate the behavior of both chickadees and other birds (Bélisle and Desrochers 2002, St Clair et al. 1998, Sieving et al. 2004, Desrochers et al. 2002). My study has found that mobbing audio, particularly mountain chickadee mobbing audio, may be used to draw in chickadees and closely associated species such as red-breasted nuthatches. However, other species seem unaffected by mobbing audio, and even response by chickadees and allies is not that intense. Thus, on the National Bison Range and in open western coniferous forests, mobbing audio could be a potential tool for future research on chickadee species, but my research indicated that it is not a useful tool to study the behavior or abundance of non-chickadee or associated species.

Acknowledgements

I would Laura Erickson for the use of her black-capped chickadee mobbing audio, which was used in the study. I would also like to thank The Bernard J. Hank Family Endowment for their funding and support, and I would also like to thank my mentor Dr. David Flagel for his guidance, Amanda Keyes for accompanying and helping me every morning out in the field, and Sarah Russ and Kate Barrett for all their help with data collection and statistics. I would also like to thank Dr. Gary Belovsky for all the guidance and for making this program and research possible. Lastly, I would like to thank the UNDERC West class of 2016 for their immense amounts of help, kindness, and support.

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Tables

	BCCH	MOCH	Noise	Silence
Mountain Chickadee	4	20	1	5
American Robin	5	10	2	3
Red Breasted Nuthatch	2	9	2	1
Western Wood Pewee	1	6	3	5
Chipping Sparrow	2	-	-	3
Clark's Nutcracker	1	-	-	-
House Wren	2	-	-	1
American Kestrel	1	-	-	1
Vireo spp.	1	-	-	-
Pine Crossbill	-	-	2	1
Northern Flicker	-	-	1	-
Unknown	6	4	2	8

Table 1. Total number of each species responding to the black-capped and mountain chickadee mobbing audio, as well as the noise and silent controls. BCCH = Black-capped chickadee mobbing call, MOCH = Mountain chickadee mobbing call.

Figures

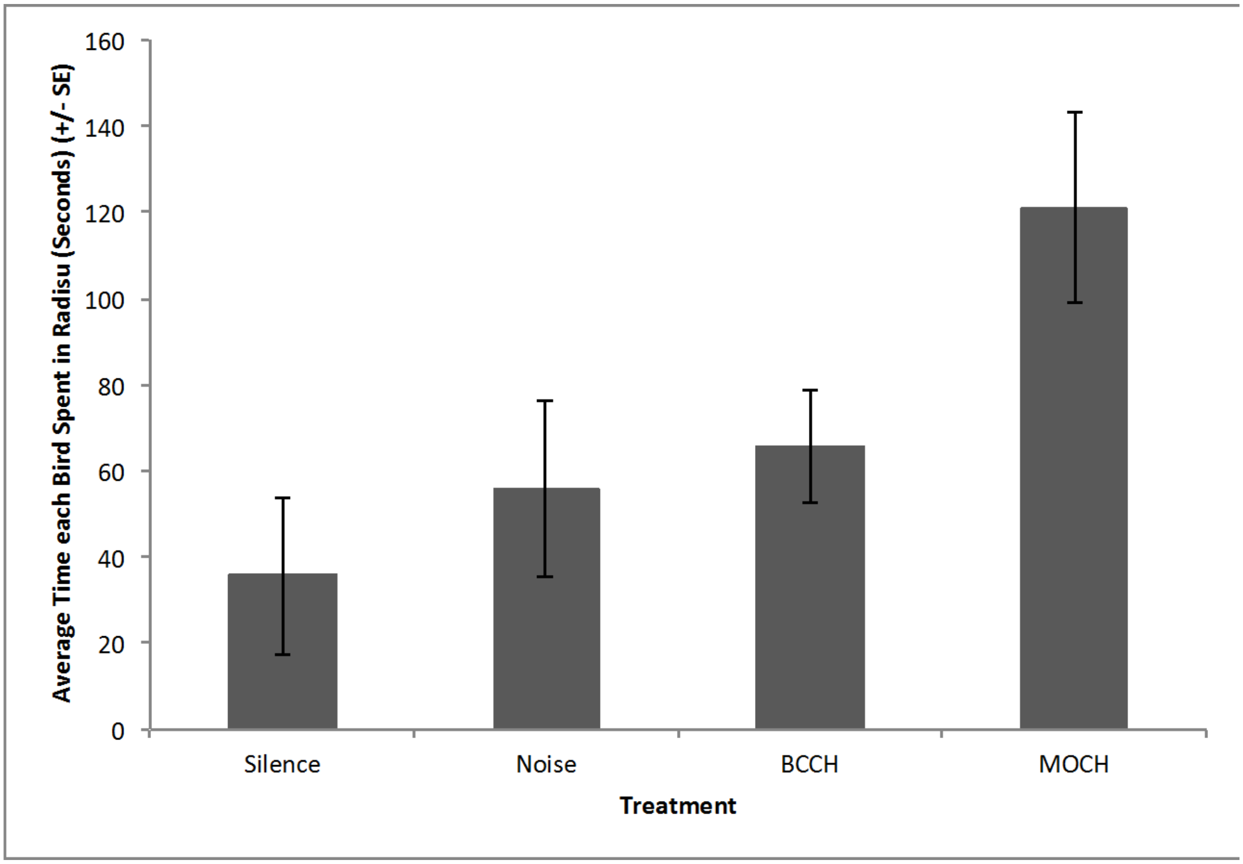

Figure 1. Average time individual birds spent within the 10-meter radius in response to a silence control (n=30), noise control (n=14), black-capped chickadee (BCCH) mobbing call playback (n=30), and mountain chickadee mobbing call playback (MOCH) (n=56), with standard error. The variation in time spent showed a trend but was not significant (p-value = 0.087, H=6.558, df = 3). BCCH = Black-capped chickadee mobbing call, MOCH = Mountain chickadee mobbing call.

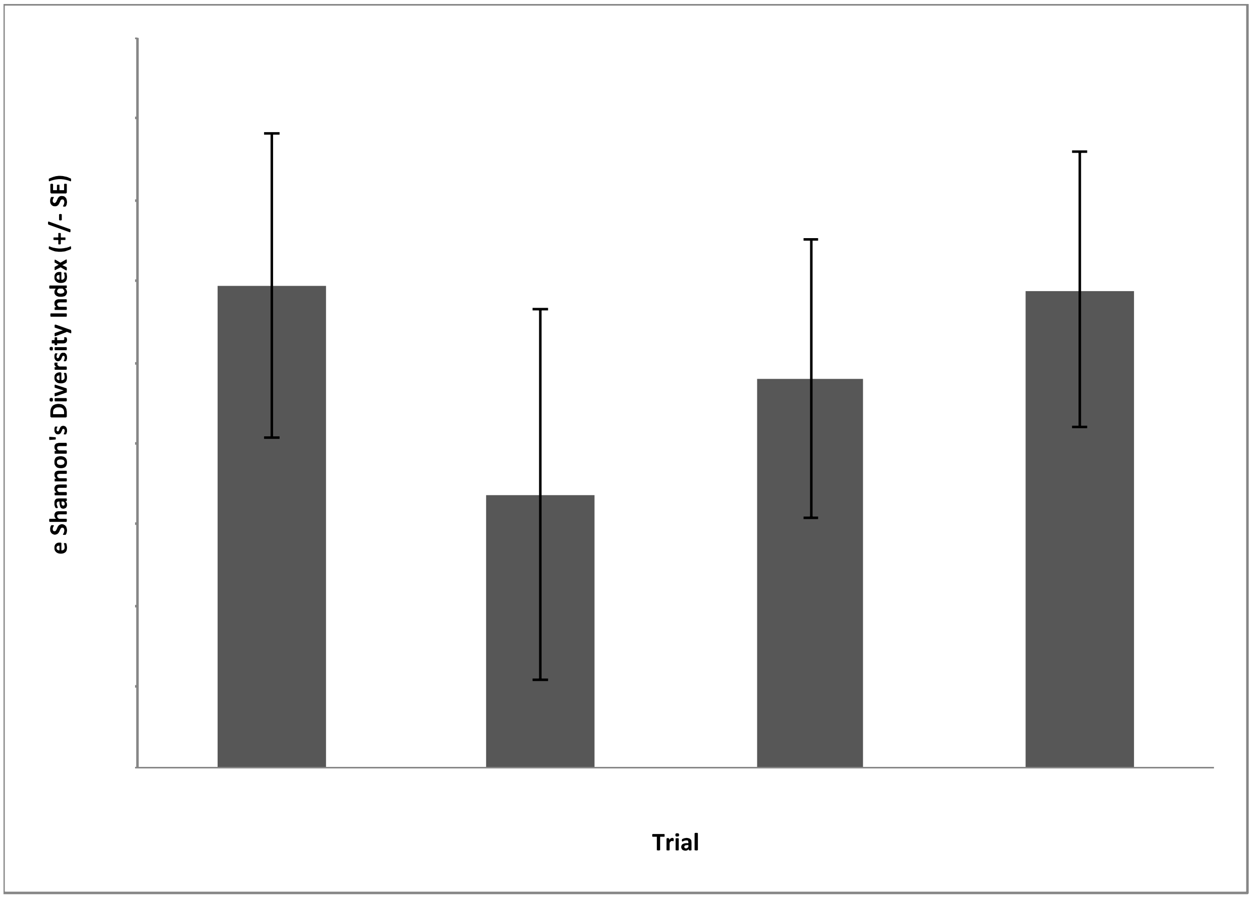

Figure 2. Average calculated Shannon's Diversity Index. Error bars represent standard error (silence n=8, static n=6, BCCH n=10, MOCH n=11). Difference between treatments was not statistically significant (p-value = 0.6536, H=1.6257, df = 3). BCCH = Black-capped chickadee mobbing call, MOCH = Mountain chickadee mobbing call.

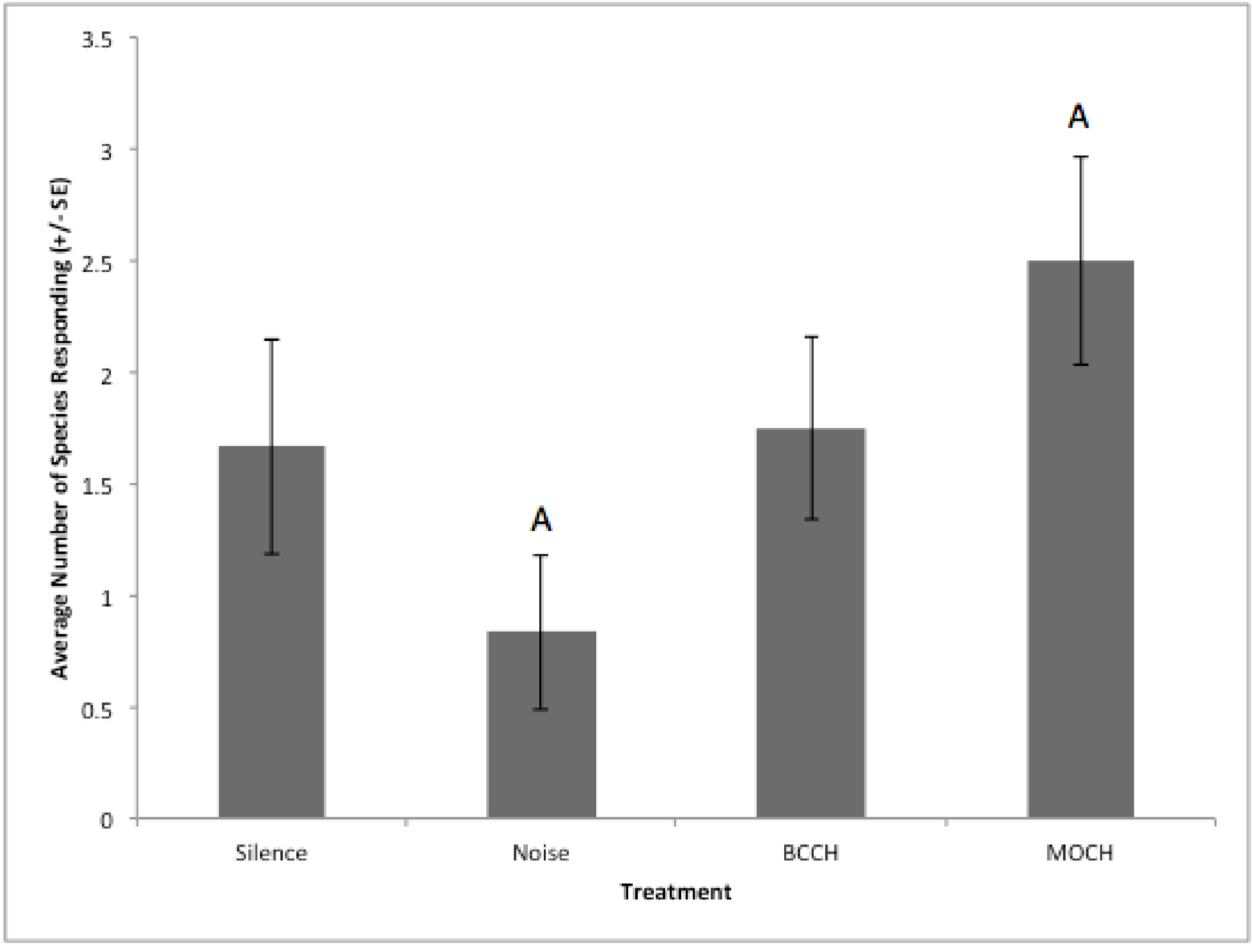

Figure 3. Average number of species responding, with standard error (n for all treatments = 12). Difference between the treatments was statistically significant (p-value = 0.0361, H = 8.5383, df = 3). Letters indicate statistical difference from the Conover-Inmen test with a p-value of < 0.01. BCCH = Black-capped chickadee mobbing call, MOCH = Mountain chickadee mobbing call.

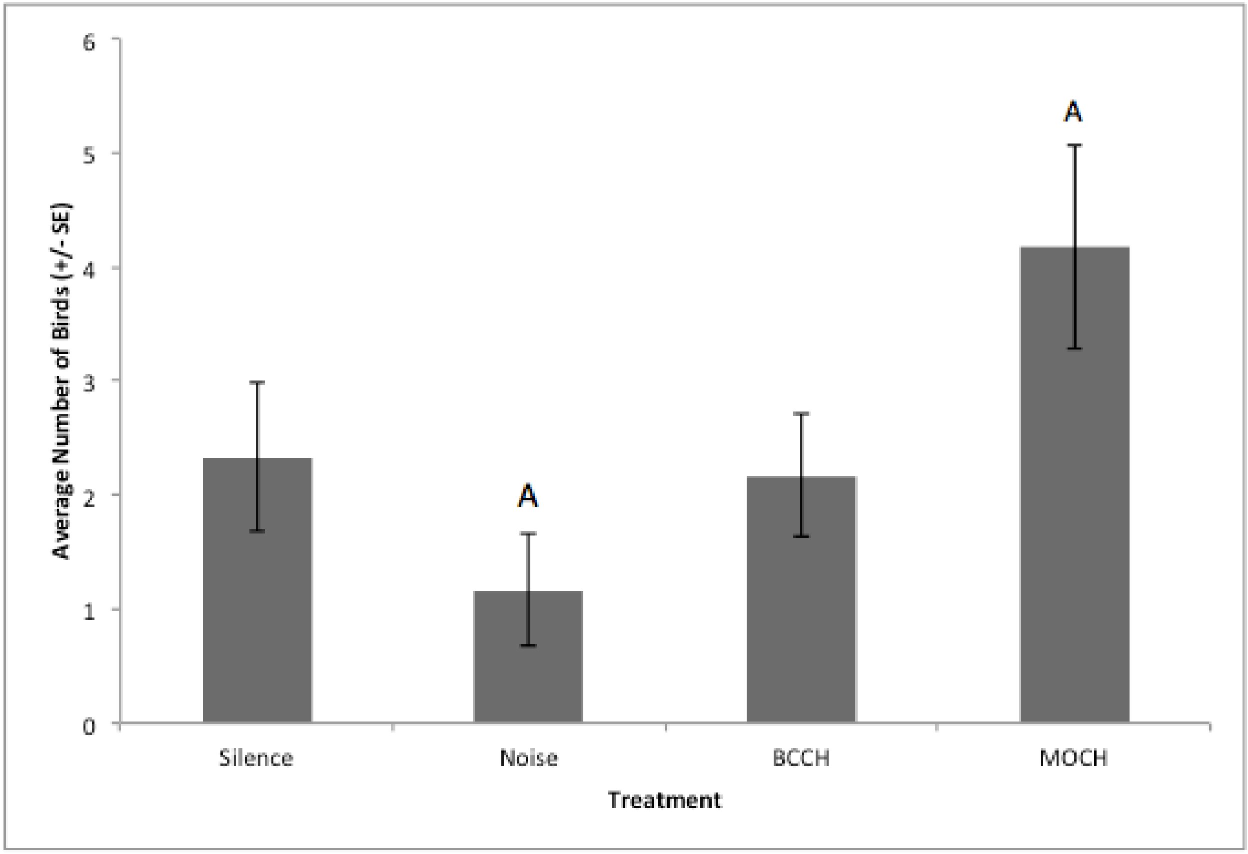

Figure 4. Average total number of birds observed in the radius during the treatments, with standard error (n=12 for all treatments) (p-value = 0.04, H= 8.29, df = 3).). Letters indicate statistical difference from the Conover-Inmen post-hoc test with a p-value of < 0.01. BCCH = Black-capped chickadee mobbing call, MOCH = Mountain chickadee mobbing call.

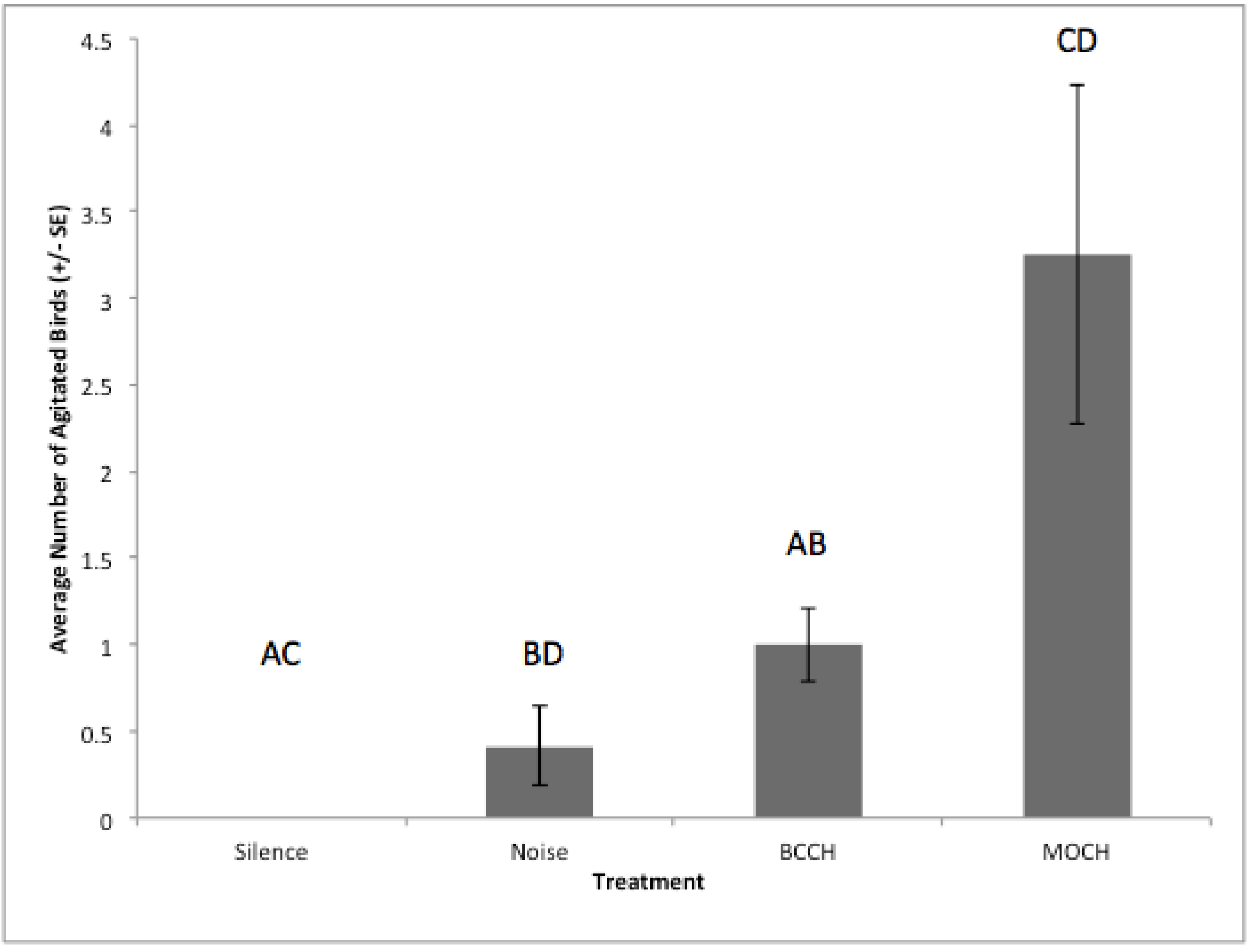

Figure 5. Average number of agitated birds observed during each treatment, with standard error (n for all treatments = 12) Difference between treatments was statistically significant (p-value < 0.001, H = 17.62, df = 3). Letters indicate statistical difference from the Conover-Inmen post-hoc test with a p-value of < 0.05. BCCH = Black-capped chickadee mobbing call, MOCH = Mountain chickadee mobbing call.

Appendix

Location	Name of Site	Coordinates
Wild Horse Mountain	T1	N47.3293 W114.2325
	T2	N47.3280 W114.2305
	T3	47.32490 W-114.2320
	T4	N47.3238 W114.2374
Red Sleep Mountain	Red Sleep	N47.3200 W114.2064
Jocko River	Jocko River	N47.2902 W114.2307

Appendix A. Sites and site coordinates