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Perceived predation risk does not affect bat foraging in the Mojave Desert

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ABSTRACT

We observed the effect of predator presence on bat foraging behavior. Birds of prey are known to incidentally predate on bats and alter their foraging behavior; however, their effect on species of different sizes is not well-studied. We predicted that small and big bats would have different foraging responses in the presence of predators, due to the relative risks and rewards of foraging. We studied California bat species during their peak foraging times of dusk and pre-dawn over four days at the Sweeney Granite Mountains Desert Research Center. At four sites in the reserve, we performed three auditory treatments that each lasted 10 minutes: a playback call of a great horned owl, which incidentally predate on bats; a lesser nighthawk, another nocturnal bird that does not predate on bats, and silent observation. We recorded bat calls using the EchoMeter bat detector and measured the total number of calls and time until the first call (in seconds) for small and big species groups. We found no differences in number of calls and time until the first call within or among size groups. Therefore, neither big nor small species responded differently to the treatments. Seasonality and environmental factors such as drought and resource availability may factor into these findings. Further work exploring the effects of incidental predation on bats across seasons and across environmental gradients (i.e. xeric to mesic) could shed light on the differences of predation risk across bat species of different sizes.

Keywords: *Chiroptera*, foraging, predation risk, predator calls, Mojave Desert

INTRODUCTION

The pressure of predation can play a large role in shaping an organism's foraging ecology. Cues of predator presence can significantly alter foraging patterns, with individuals having to make behavioral tradeoffs to balance foraging efficiency against risk of predation in order to maximize their fitness (Rogers 1987, Houston and McNamara 1993, Macleod and Gosler 2006). For example, tadpoles, *Hyla japonica,* reduce active foraging activity in the presence of predator chemical cues (Takahara et al 2012) and kangaroo rats and pocket mice reduce foraging in the open when birds of prey are audibly detected (Brown et al. 1988). However, the risk of predation may not be equal across individuals and may vary with body size

(Taylor and Cox 2018). Individuals with varying body sizes within a population or community may perceive predator cues with different degrees of risk, thus affecting their foraging behaviors differently.

The effects of cues from incidental predators on prey behavior are lesser known in comparison to well-established predator-prey dynamics. Incidental predation, or predation by organisms that do not commonly feed on a given focal prey species, may shape that prey's foraging behavior. One example where incidental predation affects foraging behavior is that of birds of prey predating on bats exiting diurnal roosts (Baker 1962). It has been suggested that certain bat species may specifically time and coordinate their exits from roosts as an anti-predator tactic, often forgoing the peak of pre-sunset insect foraging potential to minimize the risk of predation (Rydell et al.). Outside of these few specialized individuals, and beyond specific diurnal roost sites, birds of prey only incidentally catch and consume bats such that bats make up only a small portion of their diet as a whole in temperate latitudes (Speakman 1991). The incidental nature of birds of prey feeding on bats beyond roost site entrances makes bat and bird of prey interactions a well-suited system for studying effects of incidental predation on foraging.

We decided to look at how the presence of an incidental predator differentially affected bats across a community wide size range. We specifically decided to look at the effect of great horned owl (*Bubo virginianus*) calls on the foraging behavior across the community level bat assemblage in the Granite Mountains.

Great horned owl activity overlaps with bat foraging activity for much longer than other birds of prey; their effects on foraging behavior are likely sustained for the longest duration. Bats have previously been shown to decrease foraging in response to all ambient night noise including predator calls (i.e. diurnal woodpeckers, frogs, and train horns, and nocturnal predators), but there was no difference in the effect of predatory calls compared to ambient noises (Baxter et al. 2006). Subsequent work using a nocturnal bird control, the common nighthawk, instead of a diurnal woodpecker to account for bats being unfamiliar with the call of a diurnal bird also found no effects of the predator calls compared to the other noises (Janos and Root 2014). Previous studies looked at the effect of predator calls on bats as a taxonomic group, but did not account for how the variability in average size of bats at the species level may affect the risks individuals incur during foraging. It is possible that different size classes of bats respond differently to potential predators. In bats, larger species have higher mortality risk from starvation than by predation because the ratio of fat stores to overall skeletal sizes decreases as skeletal size increases (Higginson et al. 2012). Because the risk of starvation is higher for larger bats, they may display riskier behavior when foraging.

We hypothesize that bat size could predict response to owl calls in one of two different ways. First, larger bats could be more likely to alter their foraging behavior in response to owl calls. Previous studies have shown that increased mass within individuals of a species reduces an individual's ability to evade predation (Lima 1986, Witter and Cuthill 1993, Brodin 2001). This increased risk of predation could translate to a greater decrease in foraging compared to smaller bats. Alternatively, since larger bat species face a greater risk from starvation than from predation, they may demonstrate riskier behavior and be less reactive to the great horned owl calls (Higginson et al. 2012). Because the risk of starvation is higher for larger bats, larger bats may display riskier behavior than smaller bats.

METHODS

We conducted our study at the University of California Natural Reserve System's Sweeney Granite Mountains Desert Research Center, located in the East Mojave Desert, from May 4–7, 2022. Habitats within the reserve include granite outcroppings, ephemeral springs, mixed creosote bajadas, and washes, which offer multiple suitable night shelter options and foraging sites for bats.

We sampled three locations near a water source: directly on a spring where water collects during wet years, and two sites at the bottom of granite outcroppings with mixed creosote shrubs; and one foraging site located along the main road with mixed creosote shrub directly adjacent. Sites were selected based on bat activity during our pilot study. Over the four days, we sampled during peak bat foraging times: an hour and a half predawn, 4:00–5:35 AM, and an hour before and after sunset, 7:30–9:30 PM (Rydell et al. 1996). For each sampling period, we randomly selected one of our established sites and implemented three treatments: a great horned owl call, Lesser nighthawk call, and silent observation. We chose the great horned owl because they are found in the area and are known to be incidental bat predators of bats (Speakman 1991). The lesser nighthawk served as our positive control because it is a non-predatory nocturnal bird that is also found in the reserve (Smith et al. 2003). The silent observation provided a baseline measurement for the bat calls. Each treatment occurred in 10 minute intervals, during which we played the bird calls in the first 30 seconds. We used the Merlin Bird ID application for the bird call playbacks (Cornell University 2022). We monitored for bat echolocation calls using the Wildlife Acoustics EchoMeter bat detector for the remainder of the treatment time. We rotated the order of the treatments at each sampling site.

For each treatment, we compiled a list of observed bat species and organized them into two size groups: big and small (Table 1). We used the "AutoID" feature of the EchoMeter to identify the bat species, which we cross-referenced with echolocation records of California bat species (Szewczak 2018), and grouped the bat species based on average weight using the Mammals Peterson Field Guide (Burt and Grossenheider 1980).

For each treatment, we measured the number of calls for each bat size group. We counted the calls based on the number of recordings we collected for each treatment, such that rapid pulses were grouped together as a single instance of calling rather than multiple calls. We subtracted the number of big bat calls from small bat calls to find the difference between the two groups.

We also measured the time until the first bats called in each treatment. We subtracted the start time of each treatment from the time of the first recordings. This value represented the amount of time (in seconds) until bats first called. Finally, we calculated

Table 1. We organized all the bat species into two size groups based on their average weight. We presented the weight range of each species, as this changes depending on the season The cut-off we chose was 9 g, which gave us groups with a similar number of species.

Small Bat Species (<9 grams)	Weight (g)	Big Bat Species (>9 grams)	Weight (g)
California Myotis (*Myotis Californicus*)	3 – 5	Big Brown Bat (*Eptesicus Fuscus Pallidus*)	14 – 23
Yuma Myotis (*Myotis Yumanensis*)	6 – 8	Pallid Bat (*Antrozous Pallidus*)	16 – 19
Western Small-Footed Myotis (*Myotis Ciliolabrum*)	3 – 6	Hoary Bat (*Lasirius Cinereus*)	23 – 27
Canyon Bat (*Parastrellus Hesperus*)	3 – 6	Townsend Big-Eared Bat (*Plecotus Townsendii*)	7 – 12
Long-legged Myotis (*Myotis Volans Interior*)	5 – 7	Western Red Bat (*Lasiurus Blossevillii*)	10 – 15
Fringed Myotis (*Myotis Thysanodes*)	3 – 6	Silver-haired Bat (*Lasionycteris Noctivagans*)	6 – 12
		Mexican Free Tailed Bat (*Tadarida Brasiliensis*)	11 – 14
		Western Mastiff Bat (*Eumops Perotis*)	80 – 100

the differences between the times of small bat and big bat calls.

2.1 Statistical Methods

We conducted our statistical analyses with JMP statistical software V16 (SAS Institute Inc). We performed log transformations for our data except for the differences in call numbers, which were normal. We used ANOVA to compare the three treatments (great horned owl, lesser nighthawk, silence) across the response variables (number of small and big bat calls, differences between calls, time until first small and big bat calls, and the differences in time). We also included random effects (site, time, day) in our analyses to account for any variation they created in the data. These tests allowed us to examine variation within and between the bat size classes.

We compared the total number of calls from both big and small bats as well as the difference in calls between big and small bats among the three treatments. We conducted the same analyses for the amount of time before the first bat calls. We analyzed the times until small and large bats first called, then compared the difference (time until first small bat call - time until first big bat call).

RESULTS

3.1 Number of Calls

Overall, we recorded 223 bat calls, 137 of which belonged to small bats and 86 to big bats. Of the 137 small bat recordings, we captured 122 *Myotis* sp. calls and 15

Parastrellus hesperus calls. Of the large species, we documented 20 *Lasirius cinesereus* calls, 16 *Eptesicus fuscus pallidus* calls, and 15 *Lasionycteris noctivagans* calls.

We found no differences among the three playback treatments in the total number of calls of small bats (Nowl = 12, Nnighthawk = 13, Nsilent = 13, F = 0.93, p = 0.41) or large bats (Nowl = 12, Nnighthawk = 13, Nsilent = 13, F = 0.005, p = 0.99). We also did not find any differences in the calls between size groups. (Nowl = 12, Nnighthawk = 13, Nsilent = 13, F = 0.30, p = 0.74, Fig. 1).

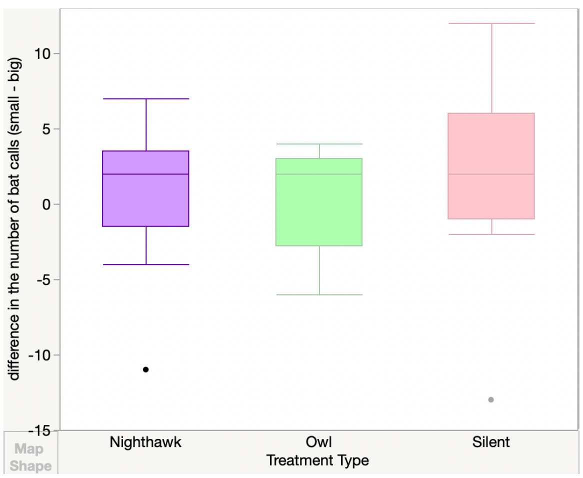

Figure 1. Effect of treatments on the relative number of bat calls. The x-axis represents the treatment types: nighthawk calls (purple), owl calls (green), and silence (red). The y-axis represents the total calls of the big bat group subtracted from the total calls of the small bat group. We found no differences between the size groups among all three treatments.

3.2 Time until First Calls

We found no variation in the amount of time when bats first called. We found that, within groups, small bats (Nowl = 8, Nnighthawk = 10, Nsilent = 10, F = 0.93, p = 0.41) and big bats (Nowl = 8, Nnighthawk = 9, Nsilent = 11, F = 0.17, p>0.05) did not vary across the three treatments. We also found no differences in the time between groups (Nowl = 5, Nnighthawk = 6, Nsilent = 7, F = 0.25, p = 0.78, Fig. 2).

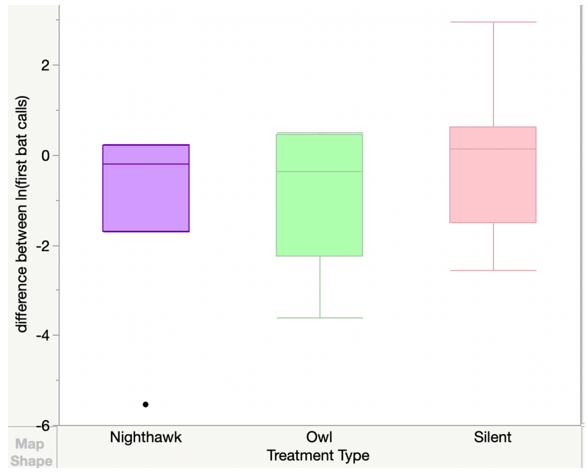

Figure 2. Effect of treatments on the relative time until first bat call. The x-axis represents the treatment types: nighthawk calls (purple), owl calls (green), and silence (red). The y-axis represents the time until the first big bat called subtracted from that of the small bat group. We found no differences between the size groups among all three treatments.

DISCUSSION

Our findings suggest that great horned owl calls do not affect foraging behavior of bats across size categories. It is possible that bats across size classes uniformly do not respond to great horned owl calls. This result may be because bats may not associate owl calls as a predation cue. Great horned owls perform aerial predation silently, and calling is a territorial and mate searching behavior largely performed from perches (Baumgartner 1938). Alternatively, our results could be explained by bats not perceiving owls as predators in the Granite Mountains. Given what we know about the incidental nature of predation on bats by great horned owls, it is entirely possible that great horned owls in the Granite mountains may not be feeding on bats at all. Both big and small bat size groups may correctly associate owl calls with owls but given low to no predation, may not consider it energetically efficient to alter foraging activity in their presence.

In contrast to previous studies (Baxter 1962, Janos & Root 2014), we found no effect of our control sound treatment on the foraging behavior of either of our bat size groups. We believe this divergence from previous studies may be due in part to conducting our surveys during the spring. In the springtime, several resident bats emerge from hibernation in the Granite Mountains and several migratory bats arrive in the area (personal communication T. La Doux Ph.D.). Most bats are in their lowest body condition of the year at this time (Jonasson et al 2016). Additionally, females of most bat species also pup during the early spring and are lactating through spring (Jonasson et al 2016). These conditions could make bats more focused on foraging to replenish body reserves at this time of year and may make them less inclined to alter their foraging behavior. California was also experiencing a two-year drought during this period. This likely negatively impacted insect biomass, further straining bat foraging behavior, and making response to noise disturbance less likely (Western Regional Climate Center).

We propose further work in this system and other related systems explore the potential effects of environmental stressors on bat response to predator presence. For example, looking at bat response to predator presence along a gradient of xeric to mesic systems could shed light on how food availability affects bat risk assessment while foraging. Looking at long term temporal shifts in bat foraging behavior with seasonality could also prove to be of further interest. These different framings of the effects of incidental predation on bat foraging could highlight differences in bat response based on size if any such relationship exists.

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