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ABSTRACT

I studied feeding preferences of hummingbirds in the presence and absence of a simulated predator at feeders with varied nectar concentration. Using nectar concentration of 15% and 25% with and without predators, I counted visits over eleven sessions of one hour apiece. I found no significant patterns in number of visits (p= .379) or number of species visiting (p= 0.413) across all treatments. The hummingbirds showed no avoidance of the predator nor preference for nectar concentration. Although no statistically significant patterns were found, these findings are biologically relevant because they indicate possible behavioral responses to fragmentation and environmental disturbances.

RESUMEN

Estudie las preferencias alimenticias de colibríes en la presencia y ausencia de un depredador en comederos con concentración de azúcar diferentes. Use concentraciones de 15% y 25% con y sin depredadores. Conté las visitas en 11 periodos de una hora. No encontré muestras significas en el número de visitas (p= 0.379) o en el número de especies diferentes que visitaron (p= 0.413) para todas las pruebas. Los colibríes no mostraron comportamiento de evitar el depredador o una preferencia para una concentración de azúcar. Aunque no se encontraron patrones significativos, estos resultados son importantes biológicamente porque indican repuestas de conductas posibles a un ambiente fragmentado y con alteraciones.

Introduction

Hummingbirds are primarily nectivorous and have extremely high metabolic rates and high energy needs. Despite the use of behavioral adaptations such as perching and torpor to minimize energy expenditure, they still must spend the majority of their time and energy foraging (Long 1997). Foraging decisions must effectively balance energy needs and expenditures in order to avoid starvation and enhance fitness.

A hummingbird's decision to forage is based on its assessment of many factors that may potentially impact its overall fitness. Hummingbirds try to balance maximum benefit, such as obtaining high quality nectar, while at the same time trying to minimize costs, such as potential predation or handling time (Krebs and Davies 1991). Above all, hummingbirds must ultimately satisfy dietary needs in order to survive. This sometimes entails taking risks that can be potentially detrimental to fitness. Recognition and avoidance of predators is a major component of a hummingbird's decision to forage at a particular time and place. A hummingbird must assess whether the benefit of foraging is sufficient enough to neutralize the cost of foraging near a predator.

Hummingbirds possess an exceptional ability to learn about food sources quickly and retain information about which sources are dependable and which should be avoided

(Hurly 1996). Studies have shown that hummingbirds can distinguish between different concentrations of sucrose. For example, in laboratory observations hummingbirds most frequently visited feeders with the highest available sucrose concentration when presented with feeder concentrations diverging anywhere from 10%- 45% (Roberts 1996).

In addition, laboratory studies indicate hummingbirds consistently return to feeders with high quality nectar while visiting empty or low quality feeders at much lower rates (Hurly 1996). Recognition of energetically unprofitable actions, such as visiting a depleted or low nutrition food source, is very important to an individual's fitness. Hummingbirds minimize costs of excess energy expenditure by visiting foraging sites that are high in calories and minimize handling time (Roberts 1996).

Hummingbirds must be able to recognize potential threats to their fitness, such as a waiting predator. Hummingbirds have many predators such as hawks, tree-climbing snakes and cats (Long 1997). Predation in nature is extremely variable and hummingbirds frequently encounter new situations and new "decisions" that may be the difference between life and death. Hummingbirds must create an effective balance between predation risk and caloric intake in order to satisfy their high energy needs.

I chose to use cats as predator models because of general observations that cats are very generalist predators and extremely agile and proficient hunters of small, quick animals such as hummingbirds. In addition, I observed two cats actively stalking hummingbirds at a nearby residence.

The objective of my study was to evaluate whether a hummingbird would risk potential predation in order to obtain a high quality food source or avoid the predator and consume nectar at a site with lower risk. I hypothesize that I will observe higher visitation at sites without a predator based on the assumption that the benefits of foraging with lower risk will outweigh the cost of potential predation and the need for higher concentration nectar.

Methods

Research was conducted in a small patch of forest on private land in Monteverde, Puntarenas Province, Costa Rica from November 8 to November 16. Observations were made between 6:30AM and 10:30AM. I set four feeders in a staggered row, approximately four meters apart (Figure 1). The feeders were numbered one through four, each one keeping the same number throughout the study. Feeders one and three were filled with sucrose concentration of 15% (low) and feeders two and four were filled with sucrose concentration of 25% (high). I allowed one week for attraction to the feeders and acclimation to the different concentrations, making general observations of foraging behavior. I then placed one stuffed cat at a feeder with high sucrose concentration and one at a feeder with low concentration, the other two remained clear. I varied the positioning and location of the predator models and placed them at different combinations of high and low concentration feeders. For example, one day I put predator models at feeders one and two and the next day I moved the predators to feeders two and three, always using one high and one low concentration feeder. I recorded all visits in a one hour session, noting time and species for 11 observation periods over eight days. I recorded a visit when a hummingbird put its bill in the feeder hole (possibly multiple times) and then left the area. If a bird consumed nectar and then perched nearby and returned repeatedly, I recorded one visit. I did not record data on days that varied significantly from normal weather conditions, such as excessively windy or rainy mornings, in order to minimize variables that might influence visitation.

Results

Overall, there was no significant effect across all treatments. The mean number of visits to feeders with varied nectar concentrations and predator presence was not significantly different (Figure 2). A 2-Way ANOVA was run to test for differences in number of visits using factors of predator presence and nectar concentration. No significant difference was found between high and low nectar concentrations ($p= 0.445$, $f= 0.595$). Furthermore, predator presence did not show a significant effect on visitation frequency ($p= 0.922$, $f= 0.010$). The combined effects of high and low concentration and the presence of a predator did not result in a significant effect on visitation ($p= 0.379$, $f= 0.792$).

Additionally, the number of species visiting the feeders did not vary significantly from session to session or for the entire study (Figure 3). A 2-Way ANOVA was run to test for differences between species richness for factors of predator presence and nectar concentration. The presence of a predator did not show a significant effect on species richness ($p= 0.870$, $f= 0.027$). In addition, nectar concentration did not have an influence on the number of species visiting the feeders ($p= 0.413$, $f= 0.683$). Furthermore, the combined effect of predator presence and varied concentration did not influence the number of species visiting the feeders ($p= 0.413$, $f= 0.683$).

Additional observations that were relevant in foraging behavior were also noted. The hummingbirds behaved in a very bold manner, often hovering extremely close to me as I changed the feeders. Also, I frequently observed them inspecting the predator models at a close distance, using energetically expensive hovering (Tiebout 1993) to determine the nature of the cat models. In addition, they would investigate anything red in the vicinity, such as my socks, pocket knife and extra feeders in my backpack. Also, on many occasions a large group (4-7 birds) would arrive at the feeders at the same time but no visits were recorded because of the chasing and jockeying among the birds was such that none could obtain position for long enough to feed. I frequently observed hummingbirds choosing the feeder they encountered first upon entering the study site, regardless of predator presence or nectar concentration.

Discussion

I hypothesized that hummingbird visitation to feeders without a predator present would be higher because the hummingbirds would not want to risk predation. On the contrary, I found that hummingbirds did not show preference toward any particular feeder across all treatments. There are a variety of possible reasons for these results.

The forest used in this study was a relatively small fragment surrounded by human development roads, houses, cattle pastures, etc. The hummingbirds, therefore, have been exposed to the effects human encroachment has on the environment. Most likely they will encounter dangerous stimuli more regularly than in an unfragmented area that they must negotiate effectively in order to survive. For example, domesticated house cats are predators that often come with the presence of humans. The hummingbirds have, presumably, dealt with the presence of cats around artificial feeders and have a sense of what a cat is and its general behavior. The behavior of model predators did not influence the hummingbirds' visitation or species richness possibly due to pre-exposure to cats in the vicinity.

It is also possible that the benefits of feeding near a predator outweighed the cost associated with risk of predation (Krebs and Davies 1991). For example, the overall food supply may be at a seasonal low in this particular area and the benefits of avoiding starvation are greater than the cost of the presence of a predator.

Another possibility is that the predator models were not seen as a serious threat. It is possible that they have encountered cats before and have "determined" that they do not pose a serious threat to fitness. The hummingbirds, therefore, might have recognized the presence of the cats and not considered them a legitimate danger.

It is also feasible that the hummingbirds recognized that the predator models did not exhibit the same behavior as a real cat and therefore dismissed them as inanimate objects and not a predator. The predator models did not stalk, lunge, or swipe as a live cat might and therefore may have been only inanimate blobs in the eyes of the hummingbirds.

Nectar concentration did not play a role in feeder choice or species richness. Studies have shown that hummingbirds do learn and remember spatial patterns based on energetic profitability, however, in my study it seems that divergence in profitability between feeders was not significant enough to influence foraging decisions (Sutherland and Gass 1995). Nectar with greater nutritional value is more viscous and thus takes a longer time to extract, therefore exposing an individual to greater risk of predation (Roberts 1995). However, my study did not reveal similar results. Visitation appeared to occur on a completely random basis without preference for high nutrition nectar or avoidance of extended exposure.

It is also possible that the abundance of nectar (other feeders were available within 250 meters in addition to some flowers blooming in the vicinity) afforded an individual the luxury of selecting the feeder that appeared first in its flight path. The hummingbirds could have become accustomed to a consistent food supply and were able to obtain sufficient caloric intake without having to choose between nectar concentrations.

The combined effects of predators and varied nectar concentrations did not influence total visitation or the overall number of species visiting the feeders. This behavior, I believe, indicates that the hummingbirds acknowledged the presence of the predator models introduced into their environment, but the bold nature of these hummingbirds might explain why the predators did not influence their foraging behavior. They may not have seen the cat models as a significant deterrent to foraging and therefore, the hummingbirds placed an equal opportunity cost on all four feeders with regard to potential predation (Krebs and Davies 1991).

This study, although not statistically significant, was biologically significant because it indicates behavioral patterns relevant in today's often fragmented environment. Animals must adapt to human disturbances or be pushed to extinction. This often incurs taking more risks and/or altering foraging behavior.

Future improvements could be made by creating a more significant difference between nectar concentrations. High concentration could be raised to 45% and low concentration would be raised to 20%. I base this on studies that indicate increases in visitation to feeders with sucrose concentrations upwards of 45% (Roberts 1996). In addition, predator models could be changed to mimic a more natural predator rather than a domesticated cat with a limited range. A hawk or a snake might be more appropriate. Also, movement of the predator model could be introduced in order to more closely imitate predator behavior. There are many possible variables that could have had a profound influence on all of my results. Future experimentation will be required in order to determine which factors are the most important determinants of hummingbird foraging patterns.

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Experimental Design

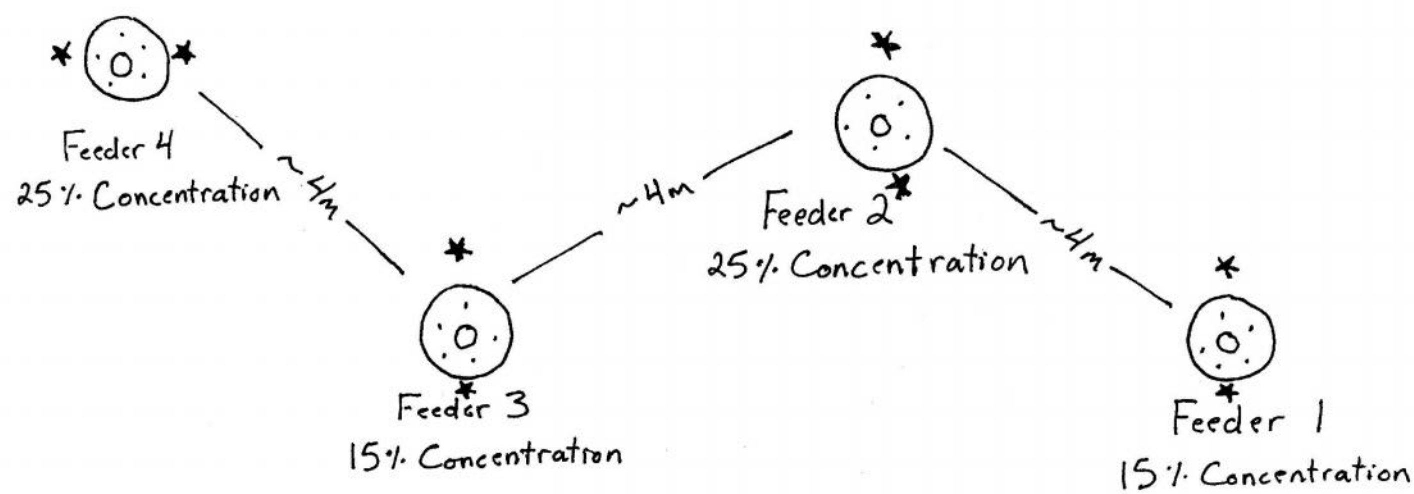

Figure 1: Feeders placed approximately four meters apart. Concentrations remained consistent throughout the study. Stars represent various positions of predator models.

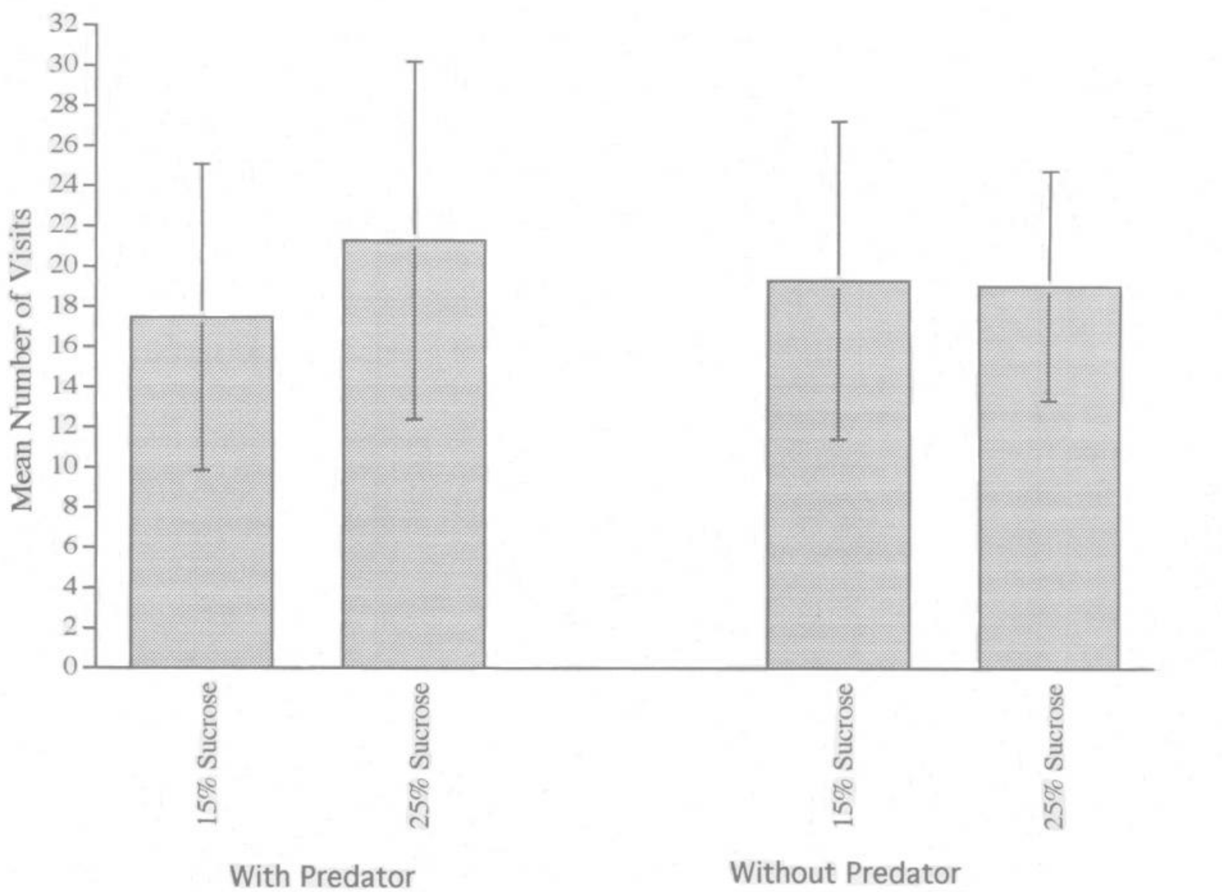

Figure 2. Mean number of hummingbird visits to four different feeders. Two feeders had 15% sucrose concentrations and two more had 25% concentrations. Two predator models were placed close to feeders, one near high concentration and one near low concentration, the other two without predators. Data was taken in one hour observation periods with a total eleven separate sessions.

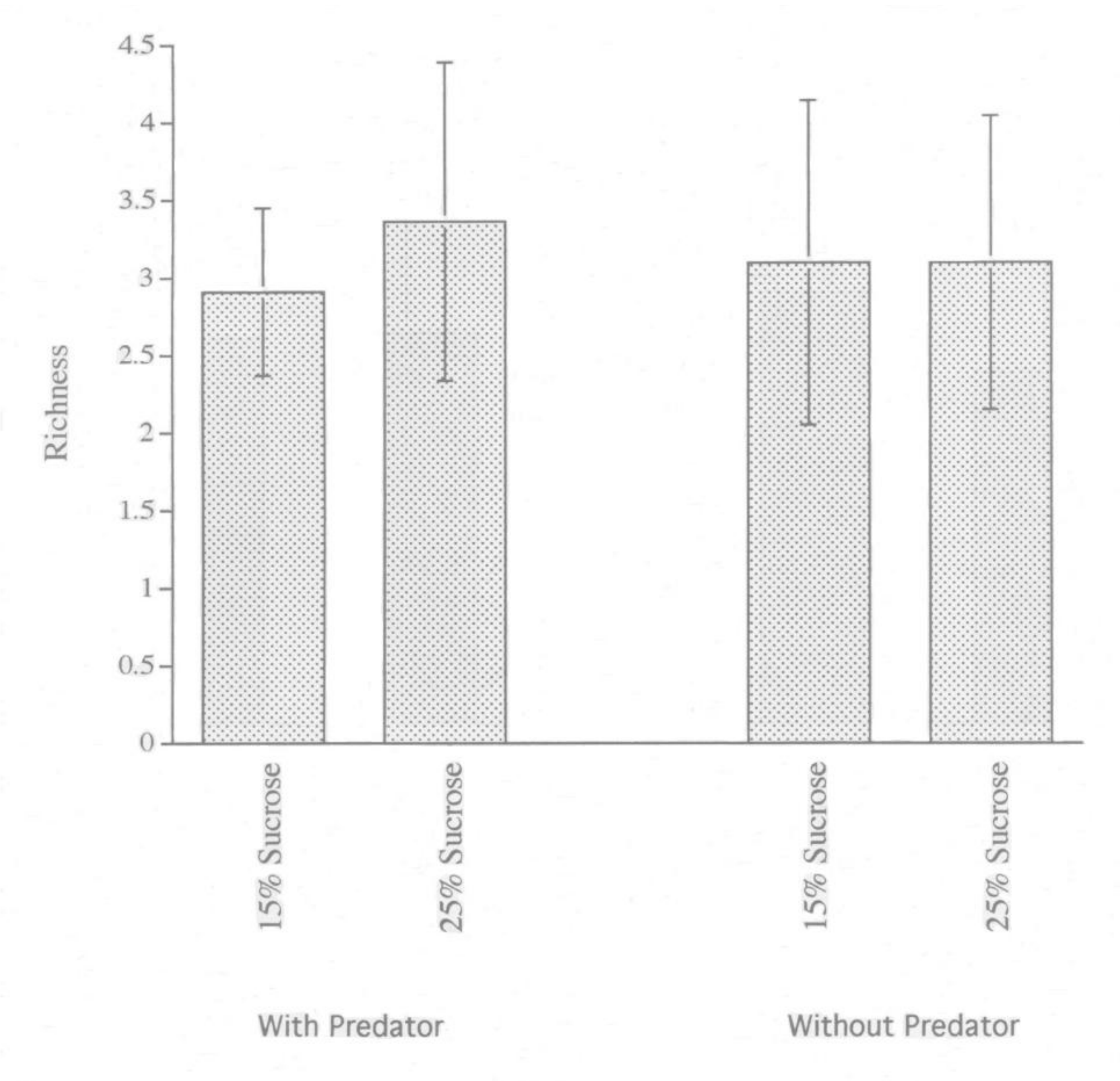

FIGURE 3. Species richness for varied sucrose concentrations and predator presence. Two feeders had 15% sucrose concentration and the other two had 25% sucrose concentrations. A predator model was placed at a feeder with high concentration and one at a feeder with low concentration. Data were taken in one hour increments with a total of eleven sessions.