or omnivore). In general, herbivore dung contains a large amount of fibrous material. These fibers facilitate the ball rolling process (Janzen 1983). It is possible that the high proportion of *D. carolinus* occurred because they have a preference for cow (herbivore) dung. If other dung were to be used, other beetle species may predominate.

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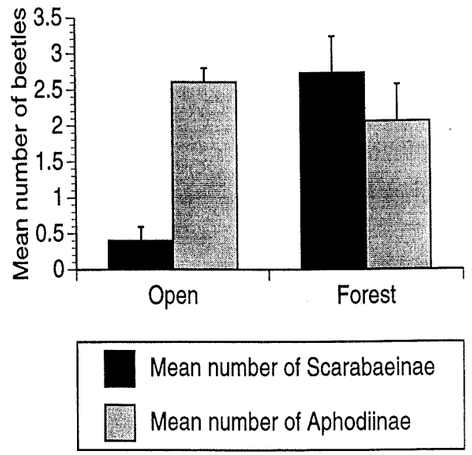

FIG. 1. The mean number of Scarabaeinae and Aphodiinae beetles found in pitfall traps (n=30) in open field and closed forest habitats.

THE EFFECTS OF PREY DENSITY UPON *DENDROBATES PUMILIO* FORAGING BEHAVIOR

ANDREW TOLONEN AND JOSEPH W. GILBERTSON

Abstract. The strawberry poison-dart frog, *Dendrobates pumilio*, feeds primarily upon ants and termites. We found that when presented with both a preferred (termites) and a less preferred (ants) prey species at high, medium, and low overall abundance *D. pumilio* prey selection changed in ways consistent with predictions made by optimal foraging theory. *D. pumilio* optimize foraging efficiency by consuming equal numbers termites and ants when overall food abundance is low, and consuming mostly termites when food is abundant.

INTRODUCTION

Optimal foraging theory predicts that a predator should have a broader diet in an environment with relatively low prey density. Conversely, in areas of high prey density, predators should specialize on the prey items that offer the highest energy returns (Begon et al. 1990). When a predator is confronted with two prey types of equal handling time, one more profitable than the other, the capture rate of the more profitable prey type is the critical factor determining whether the predator consumes the less profitable prey type. If the capture rate of the more profitable prey type is adequately high, then the predator should consume only the more profitable prey regardless of the density of the less profitable prey.

The diet of the poison-dart frog, *Dendrobates pumilio*, consists largely of ants and termites (Crump 1983). While ants have a tough exoskeleton and a high formic acid content, termites have soft, easily digestible bodies. Thus, termites are a more profitable prey item than ants (Donnelly 1991). In this study, we presented *D. pumilio* frogs with worker class termites and minor worker class *Atta* ants. We predicted that the density of the termites affects whether poison-dart frogs eat ants. This prediction was based upon the optimal foraging theory which states foraging preferences for less preferred prey will be determined by the density (search time) of the highly preferred prey. For example, frogs will consume ants if:
Energyants/Handling Timeants > Energytermites/ (Search Timetermites + Handling Timetermites)

We hypothesized that if the density of termites was high enough, the frogs would consume only termites, regardless of ant density. However, in low termite and ant densities, frogs would generalize and feed upon both prey types in equal proportions.

METHODS

We conducted this study on 15-16 February 1997 at the La Selva Biological Station, Costa Rica. We caught 21 *D. pumilio* frogs along the trails behind the station. All frogs were retained in a holding chamber for 16 hours without food.

We conducted prey preference trials in a glass aquarium that we divided into four 10 cm x 15 cm compartments with cardboard partitions. We covered the aquarium with several textbooks and lined the floor with a thin layer of mud. We put a single frog in each chamber. Trials were conducted at three prey densities: low (3 ants and 3 termites), medium (10 ants and 10 termites), and high (20 ants and 20 termites). Seven replicates were run at each of the three prey densities. The frogs were allowed to feed for one hour. At the end of the trial, we counted the number of ants and termites consumed by the frog. In addition, controls were run with no frogs to estimate the escape rates of ants and termites.

RESULTS

In the high density treatment, frogs preferred termites to ants (t-test, t=3.4, df=13, P=0.005). In the medium density treatment there was a trend towards preferring termites (t-test, t=1.93, df=13, P=0.078). In the low density treatment there was no significant preference for ants or termites (t-test, t=0.72, df=13, P=0.48).

Frogs consumed more termites than ants in the treatments of greater prey density (ANOVA, F=3.967, df=20, P=0.037). The number of ants consumed did not change across the density treatments (ANOVA, F=2.10, df=20, P=0.1 5).

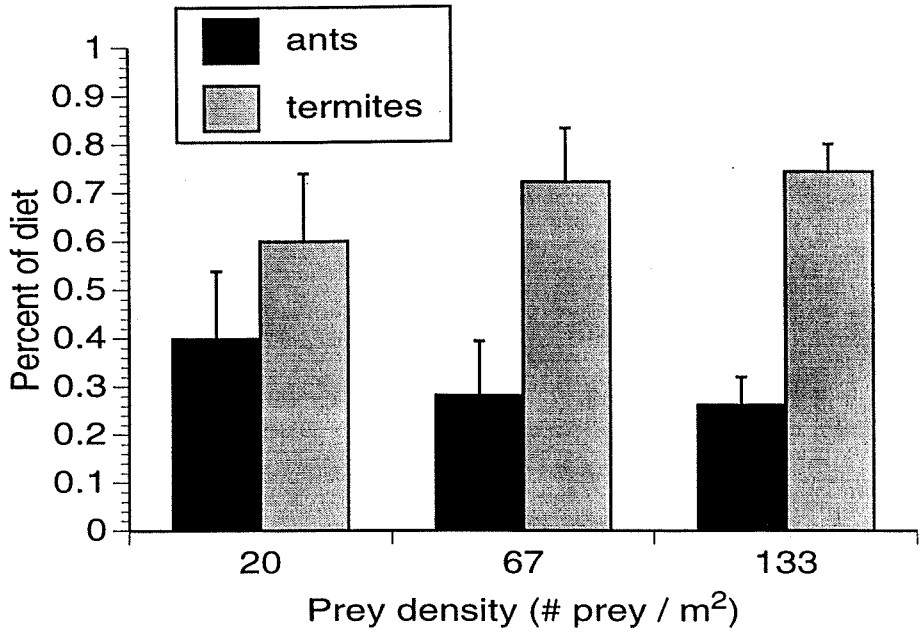

Fig 1. The proportion of *D. pumilio* diet consisting of ants and termites at different prey densities (n=7 replicate trials at each level of prey density).

At low prey density, frogs consumed 40% ants and 60% termites; at medium prey density, 28% ants and 72% termites; at high prey density, 26% ants and 74% termites.

In the control trials the mean escape rate for ants was 0.3/trial, and for termites was 0.14/trial.

Discussion

Optimal foraging theory predicts that the density of a preferred prey species will determine whether or not a less preferred prey species is consumed. (Begon, et al. 1990). We found that *D. pumilio* consumed higher proportions of preferred termites at high termite density (small search time) and lower proportions of less preferred ants at higher prey densities. Yet the number of ants consumed did not decrease as termite density increased, as the model of optimal foraging theory would predict. Perhaps termite density is not high enough in these treatments to cause the frogs to exclude ants from their diet, or perhaps the ants remain an essential part of the diet for other reasons, and this is why we witnessed no significant change in the number of ants consumed across the density treatments. Although a significant decrease in the number of ants consumed at increasing prey densities was not found, a look at the relative proportions of prey species consumed suggests that poison-dart frog prey selection is dependent on the abundances of prey items in a particular habitat. The finding that ants are eaten by poison-dart frogs, even in instances of abundant termite densities, suggests that ants may be important in the diet of frogs at some constant level of consumption.

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