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EFFECT OF FOOD RESOURCES ON THE ABUNDANCE OF *DENDROBATES PUMILIO* TERRITORIES

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Abstract: The poison dart frog *Dendrobates pumilio* defends reproductive resources in territories year-round (Donnelly 1989). We hypothesized that *D. pumilio* territory abundance was also related to the abundance of food resources. We predicted that there would be fewer territories in areas with lower insect abundance than in areas with higher insect abundance. We measured insect and frog territory abundances in two forest types. Secondary forests were found to have higher insect and frog abundances than primary forests, and *D. pumilio* territory abundance increased with increasing small insect abundance. We suggest that the density and location of *D. pumilio* territories may be determined by food abundance in addition to reproductive resources.

Key Words: food availability, frog density, strawberry poison dart frog

INTRODUCTION

The strawberry poison dart frog, *Dendrobates pumilio*, is commonly found in tropical lowland forests. They maintain territories year-round by calling, and the number of calling frogs is indicative of the number of territories in an area (Savage 2002). It has been proposed that the main purpose of these territories is to secure reproductive resources such as bromeliad tanks and leaf litter (Donnelly 1989). Because *D. pumilio* require high abundance of small insects (< 3 mm) to meet their metabolic needs (Savage 2002), we hypothesized that *D. pumilio* territories might be

affected by food resources in addition to the availability of reproductive sites. If so, we would expect fewer territories in areas with lower insect abundance than areas with higher insect abundance. We predicted that *D. pumilio* territories would be more abundant in secondary forests than in primary forests, and that they would be correlated with higher insect abundance in secondary forests than in primary forests.

METHODS

We sampled four 50 m trail sections (transects) in primary and secondary forests on alluvial soil along the STR, CCL and CES trails at La Selva Biological Station, Costa Rica on 13 - 15 February 2005. To sample insects, we haphazardly placed four pitfall traps and two sticky traps along each transect within 5 m of either side of the trail. We collected traps after 24 h and quantified insect abundance, grouping insects into two size classes: small (< 3 mm) and large (> 3 mm) body lengths, representing edible and non-edible insect resources. We sampled *D. pumilio* territory abundance by walking along each transect and counting the number of distinct calling individuals within hearing distance, (~ 5 m on each side of the trail). We compared both insect and territory abundance between forest types with one-way ANOVAs. We used a linear regression to examine the effect of insect abundance on frog territory abundance and then compared the means of the residuals for each forest type with a one-way ANOVA to remove the effect of insect abundance. All data met the assumptions of parametric tests and were analyzed using JMP 5.0.1.

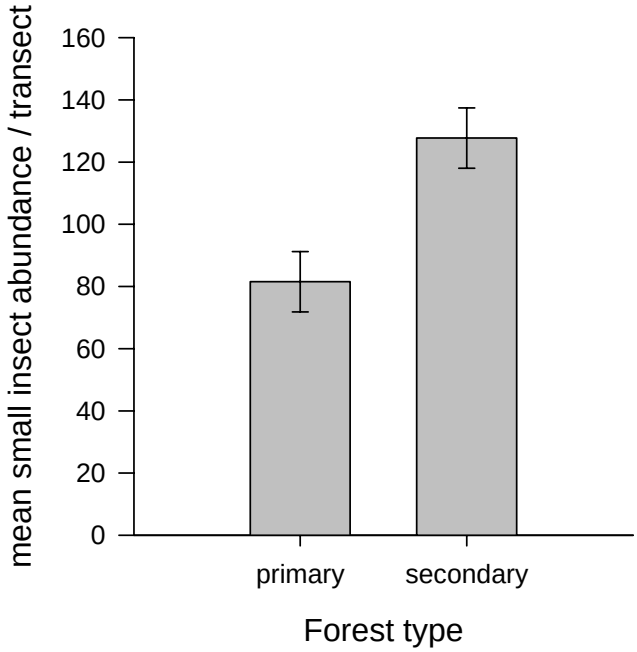

Figure 1. Mean abundance of small insects (body length < 3 mm) in primary and secondary forests transects at La Selva, n = 4, 50 m transects in each forest. There were more small insects in secondary forest than in primary forest.

RESULTS

We sampled four 50 m transects in each forest type. The abundance of small insects (< 3 mm) per transect in each forest type was greater in secondary forest transects (mean = 127.7 ± 9.7 SE) than in primary forest transects (mean = 81.5 ± 9.7 SE; F = 11.37, df = 1, 7, P = 0.015; Fig. 1). Mean abundance of large insects (> 3 mm) per transect did not differ between forest types (primary: 11.8 ± 3.0 SE individuals, secondary: 5.0 ± 3.0 SE individuals; F = 2.55, df = 1, 7, P = 0.16).

Dendrobates pumilio territory abundance per transect ranged from 0 to 3 terri-

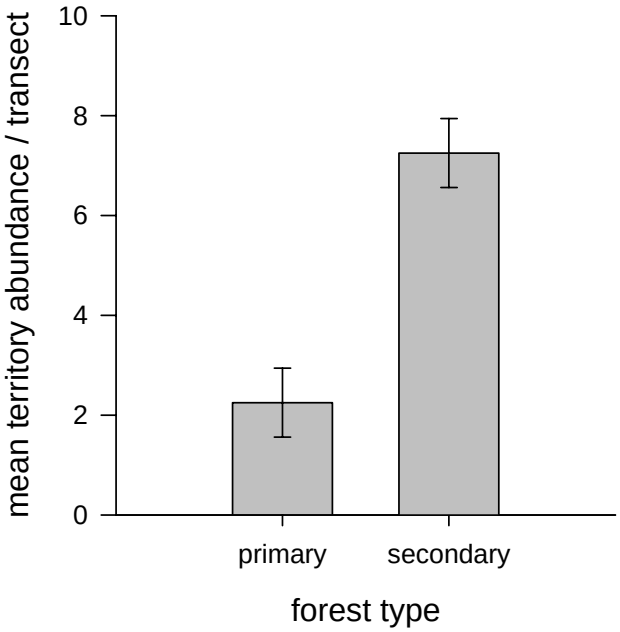

Figure 2. *Dendrobates pumilio* territory abundance in primary and secondary forest transects at La Selva. n = 4, 50 m transects in each forest type. There were more territories in secondary forest than in primary forest.

tories in primary forest and 2 to 9 in secondary forest, with a lower mean number of territories per transect in primary forest (2.3 ± 0.69 SE) than in secondary forest (7.3 ± 0.69 SE; F = 26.09, df = 1, 7, P = 0.002; Fig. 2).

There was a positive relationship between *D. pumilio* territory abundance and small insect abundance across forest types (r^2 = 0.44, df = 7, P = 0.07; Fig. 3). There was no difference in the means of the residuals from this regression (F = 1.86, df = 1, 7, P = 0.22). There was no relationship between large insect abundance and *D. pumilio* territory abundance (r^2 = 0.29, df = 7, P = 0.17).

DISCUSSION

As we predicted, secondary forest had higher small insect abundance compared to primary forest. The physical characteristics of secondary forests, such as a denser understory and increased leaf litter (French 1999), may create the increased abundances of insects.

In addition to higher small insect abundance, secondary forests had increased *D. pumilio* territory abundance; therefore, it was difficult to determine if the increased *D. pumilio* territory abundance was caused by small insect abundance or forest type. When the effect of small insect abundance was removed, there was no difference in residual *D. pumilio* territory abundance between forest types. This suggests that forest type did not drive the observed trend in *D. pumilio* territory abundance; instead, it was driven by small insect abundance.

The location of *D. pumilio* territo-

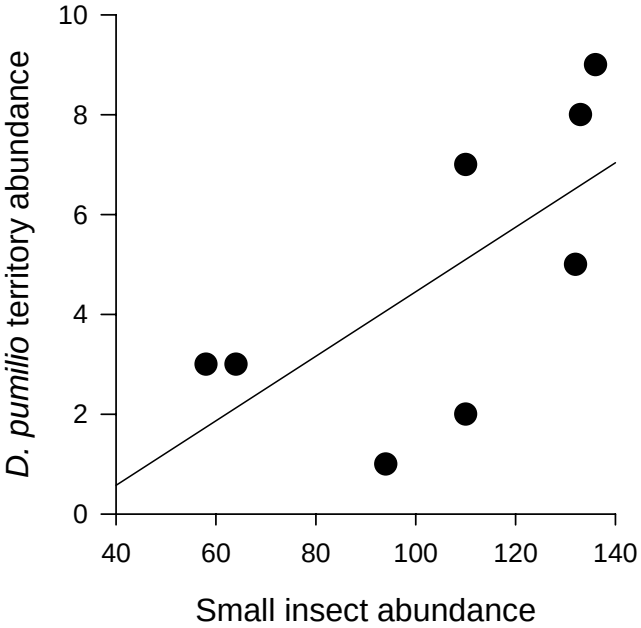

Figure 3. Relationship between *Dendrobates pumilio* territory abundance and small insect abundance across primary and secondary forest transects. The number of territories increases with small insect abundance.

ries appears to be determined by food resources, because *D. pumilio* territory abundance increased in areas with increased small insects, but was not affected by large insect abundance. This indicates that food abundance in addition to reproductive resources might determine territory location and local abundance of *D. pumilio*.

Our study was limited in several ways. We had a low number of transects in each forest due to limitations in time and equipment. Larger sample sizes and more replication would no doubt have improved our ability to make inferences from our results. Also, we were not able to control for variations in reproductive resources between forest types, which we believe is necessary to more fully assess the relative importance of reproductive and food resources in determining *D. pumilio* territory abundance.

ADDENDUM:
Notes on distinguishing between sexes in *Dendrobates pumilio*

Dendrobates pumilio exhibit year-round territoriality in lowland tropical forests in Costa Rica. Males aggressively defend territories against other males by physical combat and aggressive vocalizations throughout the year (Donnelly 1989); however, it is unknown whether males would equally defend their territory against female intruders during the non-breeding season. We had initially planned to determine whether males show differential territorial response to different sex intruders. Male intruders may increase competition for food and reproductive resources, (i.e., mates or bromeliads), and provide no benefit to the resident male. Female intruders may increase competition for food; however, they are a potential mate for the resident male. If this cost-benefit analysis could be shown to be valid, we could predict that males would defend their territories against females during the non-breeding season, but that their response would be less aggressive than towards male intruders.

We found conflicting information in literature and field observations that made the project unfeasible. Donnelly (1989) states that males and females can be identified by differences in coloration and texture on the throat; males have a dark central throat spot due to the presence of a vocal sac. Our preliminary observations revealed that these traits were not always visible on the frogs. Savage (2002) reports that only *D. pumilio* males call; however, we found several calling individuals with typical female coloration. Furthermore, there is disagreement in the literature about the ecology of *D. pumilio*. Savage (2002) describes a year-round mating season and female territoriality, while Donnelly (1989) describes a seasonal mating period with non-territorial females.

These conflicting results cast doubt on whether the sexes or breeding season have been accurately identified. Future researchers should take caution when designing studies that require identification of the sexes or specifics regarding the mating season in *D. pumilio*.

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DUNG PREFERENCE AND DIURNAL FORAGING IN DUNG BEETLES

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Abstract: Scarabaeinae dung beetles are a major consumer of feces in tropical rain forests. Past studies have indicated that dung beetles prefer human over horse feces, but it is unclear how much they discriminate or whether it is due to nutritional value. We tested whether they prefer omnivore (protein-rich) over vegetarian feces, and whether different species are more active in the day or night. Contrary to our predictions, there were more beetles at the vegetarian feces, although the difference was not significant. Beetles were more active at night, especially larger species, suggesting a possible trade-off between increased competition and decreased predation at night.

Key Words: Coleoptera, decomposition, Scarabaeinae, temporal variability

INTRODUCTION

Dung has been known to disappear from tropical forest within hours of being deposited, largely due to the activity of dung beetles and fly larvae (Forsyth and Miyata 1984). Dung beetles (Coleoptera: Scarabaeidae) that roll balls of dung away from the dung source and bury them, have been shown to prefer human feces to horse feces, suggesting that the beetles perceive human feces to be more nutritious and are able to sense and act on this difference (Cook et al. 1993). The extent of beetles' ability to discriminate between the nutritional values of dung sources has not been thoroughly tested. To test the ability of dung beetles to assess the value of dung, we used feces from human omnivores and vegetarians, assuming that the omnivore dung would be more nutritious and protein-rich than vegetarian dung (Forsyth and Miyata 1984). We predicted that more beetles would be attracted to traps baited with omnivore feces.

Dung beetles are active during the night and day, although more active at night (Alexander et al. 2002). We hypothesized that different types of dung beetles would utilize feces at night compared to day. Specifically, we predicted that certain beetles would forage during the day, risking greater predation for less competition, while other beetles would forage only at