LITERATURE CITED

Donnelly, M. A. 1989. Demographic effects of reproductive resource supplementation in a territorial frog, *Dendrobates pumilio*. Ecological Monographs, 59: 207-221.

French, E. A. 1999. Differences in soil properties between primary and secondary forests. Dartmouth FSP Studies, p. 67-68.

Savage, J. M. 2002. The amphibians and reptiles of Costa Rica: a herpetofauna between two continents, between two seas. University of Chicago Press: Chicago.

DUNG PREFERENCE AND DIURNAL FORAGING IN DUNG BEETLES

RICHARD W. TRIERWEILER AND DANIEL J. MADIGAN

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

night, minimizing predation but increasing competition for the dung resource.

METHODS

We set 20 pit fall traps in primary forest along the CES trail (between 150 - 750 m) at La Selva Biological Station, Costa Rica. Traps consisted of a tablespoon of human dung placed in a spoon, inserted in the ground at an angle of approximately 30°. Below the dung, a 20 oz Dixie cup was inserted into the ground, flush with the ground surface, to collect beetles.

We set traps in 10 pairs approximately 50 m apart along the trail. We baited one trap in each pair with herbivorous (vegetarian) dung, and the other with omnivorous (meat and vegetable consuming) dung obtained from several different individuals. We set traps within pairs approximately 1 m apart. We baited traps with fresh dung and collected beetles in the morning (0800) and evening (1800) on 2 days, 13-14 February 2005.

Beetles captured were placed in ethanol and categorized by morphotype and by size class: small (< 9 mm), medium (9 - 15 mm), and large (> 15 mm). Morphotypes were then identified to genus using the ALAS arthropod collection. We used a two-way ANOVA to analyze differences in the total number of beetles collected and morphotype abundances with respect to time of day (day or night) and dung type (herbivorous or omnivorous). We used a contingency analysis to compare frequencies of beetle size classes to time period. Data were statistically analyzed using JMP v. 5.0.1. Abundance data were log transformed to meet assumptions of statistical analyses.

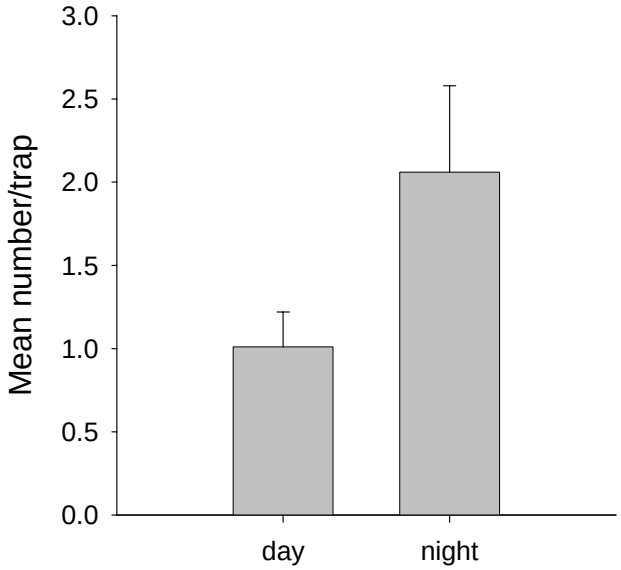

Figure 1. Mean beetles per trap (+ 1 SE) for day and night treatments (n = 80 traps). There were more beetles caught per trap at night than during the day (P = 0.07).

RESULTS

We caught a total of 127 beetles, representing 14 different morphotypes within 8 genera (Table 1), all in the subfamily Scarabaeinae. The difference in abundance of beetles caught per trap during the day (1.01 ± 0.21) and during the night (2.06 ± 0.52) was marginally significant (2-way ANOVA, F = 3.30, df = 1, 78, P = 0.07; Fig. 1). There was no difference in the number of beetles caught per trap between herbivorous (1.80 ± 0.38) and omnivorous (1.27 ± 0.42) dung (2-way ANOVA, F = 1.82, df = 1, 78, P = 0.18; Fig. 2). There was no interaction between time period and dung type (2-way ANOVA, F = 0.06, df = 1, 78, P = 0.81). Different dung beetle morphotypes foraged at different times of the day (X^2= 39.45, df = 125, P < 0.0001). Large (genus *Dichotomius*) and medium (genus *Copris*) morphotypes were caught only at night,

Table 1. Genera and numbers of beetles collected (n = 127) along the CES trail, La Selva Biological Station, Costa Rica. All genera identified were within subfamily Scarabaeinae. Relative size, total found, and number and percentage caught at night are shown for each genus.

Genus	Size class*	Total found	number (%) caught at night
Canthidium	small	10	2 (20%)
Canthon	small	3	2 (67%)
Onthophagus	small	47	28 (60%)
Scatinus	small	11	9 (82%)
Unidentified	small	4	3 (75%)
Copris	medium	37	37 (100%)
Dichotomius	large	15	15 (100%)

* small (< 9 mm), medium (9-15 mm), and large (> 15 mm).

while small morphotypes were caught both during the day and at night (Table 1).

DISCUSSION

Although we found more beetles in traps baited with vegetarian feces, there was no statistical difference in the abundance of dung beetles visiting herbivorous and omnivorous dung. Either these beetles may not sense a difference in the nutritional value of feces, or the diets of the herbivores and omnivores were not different enough to elicit an overall response. Our predictions may also have been incorrect since the ball-rolling behavior of Scarabaeinae is facilitated by high fiber content (Kroenlein 1997), which was observed to be more common in the herbivore dung. Thus, there may be a trade-off between nutrient-rich omnivore and fibrous vegetarian dung. Since we used feces from FSP students, and each FSPer's diet is similar except for relatively small quantities of meat, beetles may not have been able to detect any difference. Future studies should use subjects with greater differences in diet to test beetle preferences.

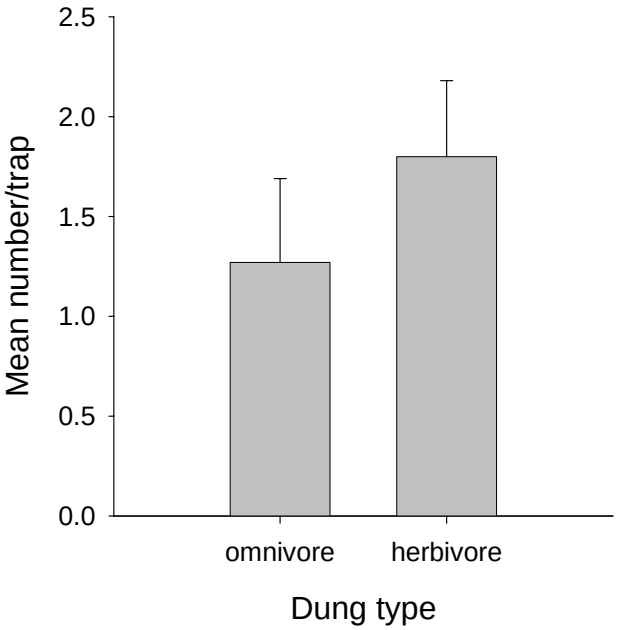

Figure 2. Mean number of beetles per trap (+ 1 SE) for omnivore and herbivore dung (n = 80 traps). There was no statistical difference between the two means (P = 0.18)

Dung can be deposited during day or night. Because small beetles are active during both time periods, they could exploit day- as well as night-deposited dung resources, thus limiting resources for those beetles that are active only at night. Medium and large dung beetles that forage only at night may only be able to utilize night-deposited dung resources. The use

of daytime foraging by small beetles may decrease their competition with the larger species, but increase their risk of predation by diurnally active predators. If large beetles foraged during the day, they would be more visible than smaller beetles, making them easier targets for visual predators. Therefore night foraging in the larger species may be a strategy to minimize predation risk, but their larger size may allow them to out-compete smaller beetles at night-deposited dung resources.

LITERATURE CITED

Alexander, K. M., M. L. Coleman and K. S. Nowak. 2002. Effects of habitat fragmentation and diel activity patterns on dung beetle communities. Dartmouth Studies in Tropical Ecology, p. 47-49.

Cook, S. P., K. K. Ingram, and M. B. Royer. 1993. Resource and habitat preference of dung beetles. Dartmouth Studies in Tropical Ecology, p. 84-86.

Forsyth, A., and K. Miyata. 1984. Tropical Nature. Macmillan Publishing Co: New York.

Kroenlein, K. R., and J. P. Zak. 1997. Abundances of two dung beetle subfamilies (Scarabaeinae and Aphodiinae) in forested vs. open tropical habitats. Dartmouth Studies in Tropical Ecology, p. 126-128.