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A Dung Beetle Assemblage in an Urban Park in Louisiana

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Abstract - We examined the dynamics of a dung beetle community over the course of a year in a forested urban park in Baton Rouge, LA. Dung beetle volume per trap-day and abundance peaked during March and the months of August through November, with species richness highest during March. The subfamily Aphodiinae dominated the community during the cold months, and Scarabaeinae dominated it during the warm months. The relationship of these patterns to local temperature and precipitation is discussed.

Introduction

Dung beetles (Scarabaeidae) are important contributors to decomposition processes in the southeastern United States. In natural environments, dung beetles utilize the excrement of large and small mammals and can subsist on carrion, rotting fruit, and other decaying organic matter if necessary (Gill 1991). However, most landscapes in the United States have been modified by people, thus altering local organism composition. Of particular interest to us are the dynamics of urban parks within large cities, a subject infrequently addressed by dung beetle research (Carpaneto et al. 2005, Wallace and Richardson 2005). Are sufficient food sources available to sustain populations of dung beetles? How do species richness and biomass compare with more pristine habitat? Previous studies (Carpaneto et al. 2005, Wallace and Richardson 2005) have demonstrated that dung beetles perform an important service by recycling dung from house pets in urban areas.

Our study documented the dynamics of a dung beetle community over one year in an urban bottomland hardwood forest park in Baton Rouge, LA. We provide monthly data on species' presence, abundance, biomass, and species richness. These data will be useful for future urban park studies or comparisons with more natural areas. Furthermore, we present volume-biomass equations for dung beetles found in bottomland/upland hardwood forests.

Methods

Scarab monitoring

Highland Road Observatory Park is a city park located in Baton Rouge, LA (30°20.698'N, 91°04.406'W). The park is a fragment of secondary forest

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of approximately 32.5 ha on the edge of the city. The forest, classified as bottomland hardwood, is prone to flooding after heavy rains, especially in the spring. Although the Park is isolated and small, the occasional *Odocoileus virginianus* (Boddaert) (white-tailed deer) is present, in addition to *Procyon lotor* Linnaeus (raccoon) and *Canis lupus familiaris* Linnaeus (dog). We collected dung beetles from November 2003 until October 2004. We used 8 to 10 pitfall traps, baited with dung of *Sus scrofa* L. (pig), spaced at least 20 m apart. Traps consisted of a 500-ml plastic cup, 88 mm in diameter by 121 mm in height, with a wooden or plastic covering suspended above the cup for rain protection. At least 50 g of pig dung was placed in a 150-ml cup and attached to the side of the "pitfall" cup. Traps were baited on the first day of a collecting period, and the contents collected 5 days later. We trapped once a month over the course of a year, with the exception of September 2004.

Beetle specimens, collected in the field, were frozen until they could be measured in the lab. Directly measuring biomass is difficult because dried specimens are extremely fragile. Therefore, we measured beetle volume, which is highly correlated with beetle biomass (Radtke and Williamson 2005). To measure volume, we inserted a number two insect pin into the elytra of the beetle and used the pin as a "handle" to completely submerge the beetle in a beaker of distilled water resting on top of an electronic balance. The change in weight on the balance corresponds to the beetle's volume (1g = 1 ml of water at sea level). This method has been used successfully to make comparisons, either directly of volume among samples or indirectly by first converting volume into biomass (Radtke and Williamson 2005, Radtke et al. 2006). We identified each species using the Louisiana State Arthropod Museum (LSAM) reference collection and keys (Arnett et al. 2002, Harpootlian 2001). Specimens were deposited in the LSAM, Baton Rouge, LA. Climatological data was taken from Louisiana Office of State Climatology monthly reports.

Temperate equations

We developed a biomass-volume equation (Radtke et al. 2006) for bottomland/upland hardwood forest scarabs using beetles collected from Highland Road Observatory Park (Louisiana) and Homochitto National Forest (Mississippi). Specimens were dried in a drying oven for at least 48 hours at 50 °C. We measured their biomass three separate times on a top-loading electronic balance (± 0.01 g) and then averaged the numbers. Equations were derived using untransformed and log-transformed data. We log-transformed the data because the variance in biomass and volume increased with larger beetles. We used proc reg in SAS for our analyses (SAS Institute 2001).

Results

Scarab monitoring

We captured a total of 699 beetles and 12 species during 525 trap-days (Table 1). *Onthophagus hecate hecate* (Panzer) dominated the collection

Table 1. Species abundance and percent volume (in parentheses) for each month, total abundance, and average size and SD by species for Highland Road Observatory, LA. "*" indicates the species with the largest proportion of volume for each month.

Species	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Oct.	Total abundance	Average volume (ml)
Aphodius bicolor	29 (0.2)	6 (0.6)	20 (4)	4 (0.3)	0	0	0	0	0	0	0	59	0.001 ± 0.000
A. nigritus	6 (0.1)	1 (0.1)	0	0	15 (0.1)	3 (0.1)	2 (0.04)	0	0	0	0	27	0.001 ± 0.000
A. rusicola	2 (0.02)	0	2 (0.4)	1 (0.1)	82 (0.3)	18 (0.8)	1 (0.02)	1 (0.03)	0	0	0	107	0.001 ± 0.000
Ateuchus histeroides Weber	0	0	0	0	3 (0.3)	1 (1)	0	0	0	0	0	4	0.029 ± 0.000
Canthon viridis (Beauvois)	0	0	0	0	1 (0.03)	0	0	0	0	0	0	1	0.010
Copris minutus	0	1 (8)	4 (86)*	3 (33)	2 (0.9)	0	3 (5)	0	0	0	11 (10)	24	0.120 ± 0.020
Deltochilum gibbosum gibbosum	1 (21)	0	0	0	0	1 (55)*	2 (76)*	0	0	0	0	4	2.060 ± 0.530
Dichotomius carolinus	2 (23)	0	0	0	10 (83)*	0	0	0	0	2 (66)*	4 (87)*	18	2.660 ± 0.550
Onthophagus gazella F.	0	0	0	0	1 (0.6)	0	0	0	0	0	0	1	0.170
O. hecate hecate	134 (54)*	20 (91)*	1 (11)	16 (66)*	77 (14)	21 (43)	22 (18)	55 (99)*	6 (100)*	62 (34)	6 (3)	420	0.050 ± 0.010
O. orpheus Panzer	5 (7)	0	0	0	0	0	0	0	0	0	1 (0.1)	6	0.030 ± 0.010
Pseudocanthon perplexus	0	1 (1)	0	0	23 (0.8)	0	1 (0.2)	3 (1)	0	0	0	28	0.010 ± 0.000

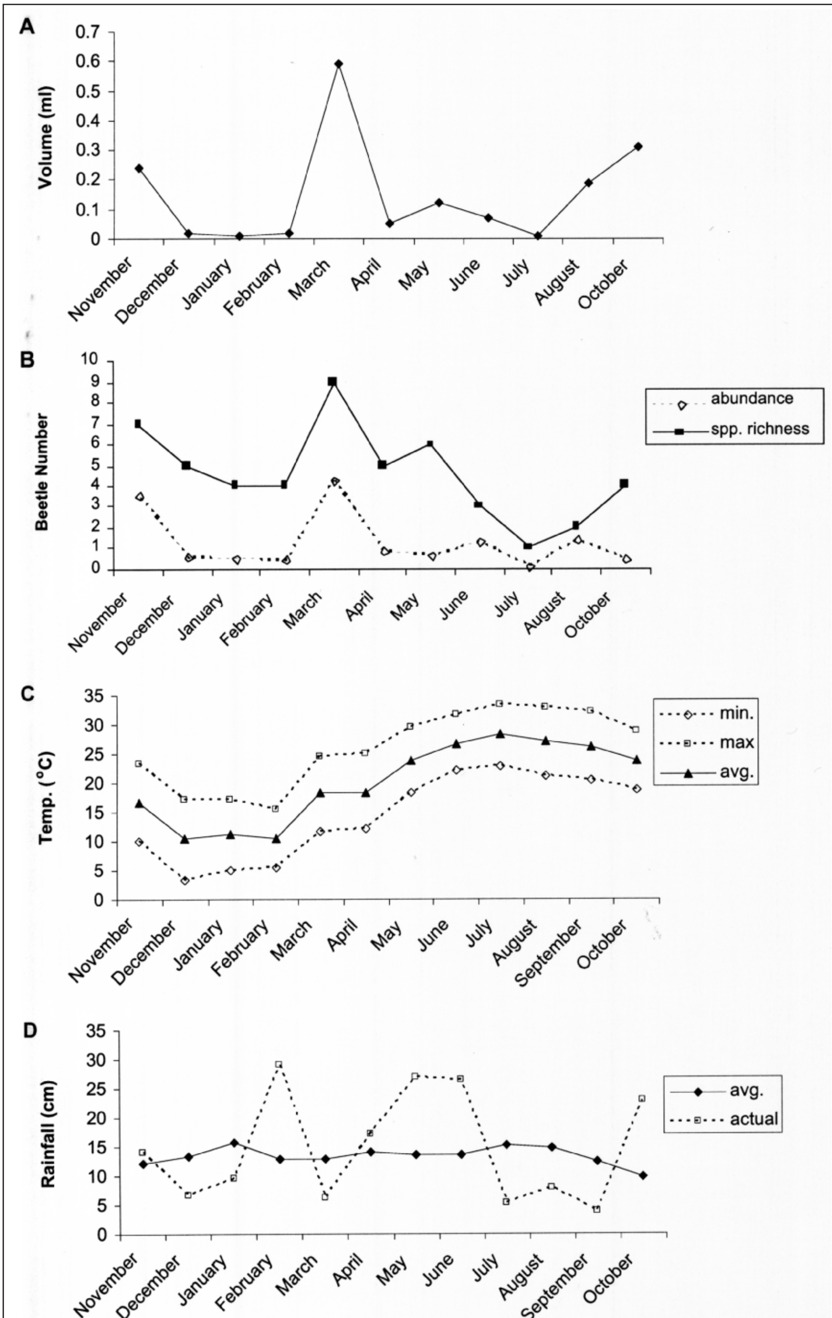

Figure 1. Dung beetle and abiotic dynamics of Highland Road Park (Baton Rouge, LA). A) Volume per trap-day, B) Abundance per trap-day and species richness; C) Minimum, maximum, and average temperatures for November 2003 through October 2004; and D) Monthly precipitation for 2003–2004 and the 30-year average.

with 420 individuals. The number of individuals of other species ranged from one to 107. The month of March yielded the highest volume per trap-day, abundance, and species richness. However, the months of August, October, and November were also high in beetle volume, but abundance did not strictly follow this pattern. Species richness generally mirrored the dynamics of beetle abundance (Figs. 1A and 1B).

Species composition and dominance changed throughout the year. In terms of actual numbers, *Aphodius bicolor* Say*, A. nigritus* F.*, A. rusicola* Melsheimer*,* and *Pseudocanthon perplexus* (LeConte) were high in abundance and dominated the scarab community from January through March (Figs. 2A and 2B). *Onthophagus hecate hecate* was present all year round, but was most dominant during the hottest months of the year, even though its abundance was sometimes quite low (Fig. 2C). We examined community dominance by looking at beetle volume and found that *O. hecate hecate* was dominant for five months, *Dichotomius carolinus* (L.) for three months, *Deltochilum gibbosum gibbosum* (F.) for two months, and *Copris minutus* (Drury) for one month (Table 1). All other species were generally more random in their presence in the community and did not show any discernable pattern; however, most species were present during the month of March.

Average monthly temperatures were coldest from December through February and warmest from June through September. In general, the abundance of *O. hecate hecate* mirrored the increases and decreases in temperature (Fig. 1C). During the study, monthly precipitation showed peaks in February, May through June, and October, although 30-year averages exhibited relatively constant monthly rainfall. With the exception of the summer months, total beetle volume seemed to shift up or down in a positive response to rainfall (Figs. 1A and 1D).

Temperate equations

For the biomass-volume regressions, we measured 201 beetles from 9 species in 5 genera. We constructed two highly significant equations ($P < 0.0001$) with untransformed data explaining 86% of the variation and log-transformed data explaining 95% of the variation (Table 2).

Discussion

Scarab monitoring

Over the course of a year, we found that dung beetle volume, abundance, and species richness changed by season. We investigated possible correlations of these changes with average monthly temperature and

Table 2. Regressions for temperate scarabs. Both equations are significant at the $P < 0.0001$ level and with one degree of freedom.

	Equation	R^2	*F*
Untransformed	$y = 0.19x + 0.007$	0.86	1180
Log-transformed	$y = 0.82x - 0.71$	0.95	3438

rainfall. Although evidence exists in the literature that dung beetle composition changes with abiotic factors and our study found support for

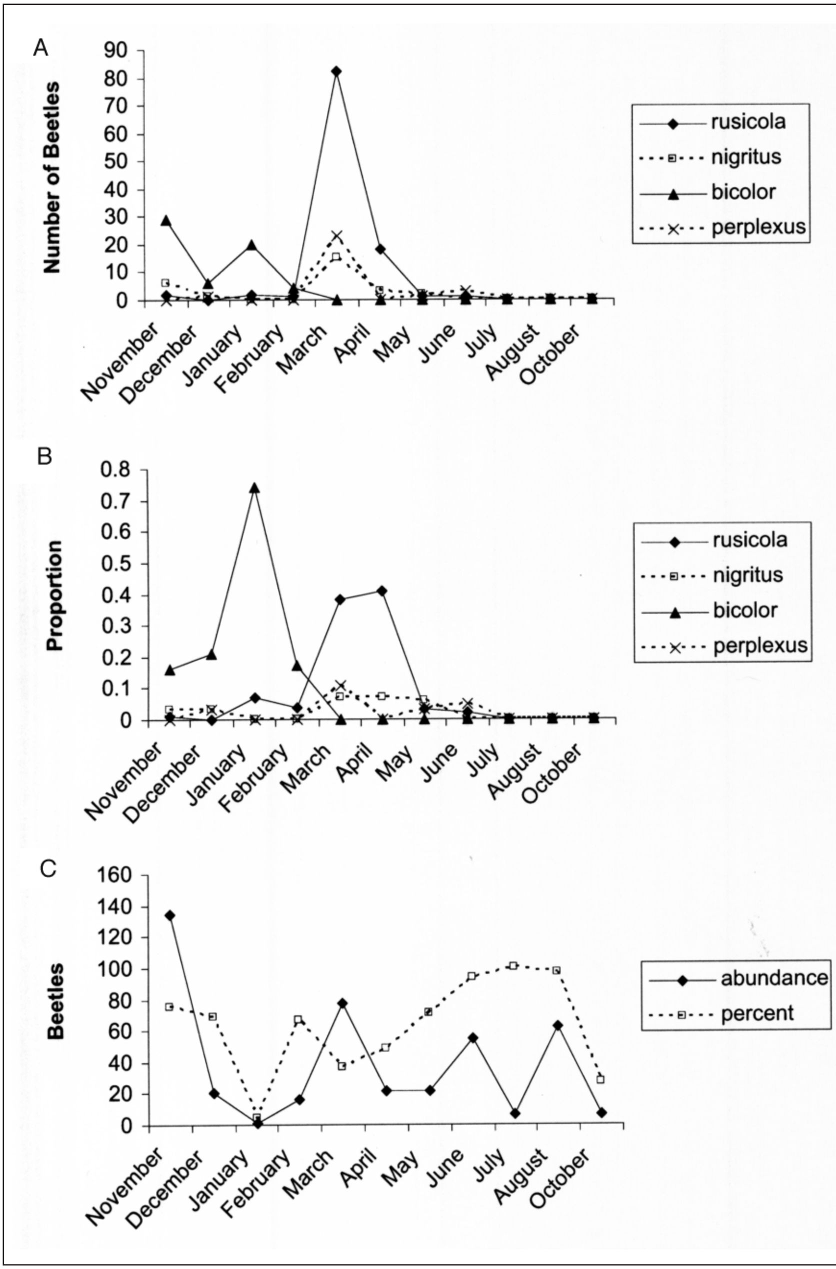

Figure 2. Dung beetle demographics at Highland Park (Baton Rouge, LA). A) Abundance, B) Dominance of small beetles, and C) Abundance and percent of the scarab community composition for *O. hecate hecate.*

some of these conclusions, we caution against any definitive conclusions based solely on this study. We collected data for 12 months, but temperature and precipitation can be highly variable from year to year necessitating the need for several more years of data. Furthermore, we cannot directly compare our study to others because those performed at similar latitudes in North America were not in bottomland hardwood forests (Howden and Scholtz 1986, Nealis 1977). With these caveats, we suggest the following patterns and explanations for the dung beetles collected at Highland Road Park.

Species composition varied by season, mostly by subfamily. Species of Aphodiinae were only present during the cold months and dominated the dung beetle community during January, whereas most species of Scarabaeinae were collected during the warmer months, mainly March through November. The aphodiine species tolerate cold conditions and dominate northern temperate climates, although they are equally species rich in the tropics. They are small, generally less than 13 mm in length, and reproduce directly in dung pats (Hanski and Cambefort 1991a). Scarabaeine species thrive in warm climates, and many diapause during cold and dry months. They are larger in size than members of Aphodiinae and either bury dung below the pat or roll it away for burial and subsequent nesting. Scarabaeines, because of their size and resource relocation strategies, easily out-compete the Aphodiinae for resources during seasons where both subfamilies are active (Finn and Gittings 2003, Hanski and Cambefort 1991a).

We observed two peak periods of dung beetle abundance and volume: March, and August through November. *Onthophagus hecate hecate* made up 36 to 97% of total individuals collected during the peak periods and dominated collections during the months of August (97%) and November (75%). *Aphodius rusicola* (38%) represented the highest proportion of beetles in March, and *C. minutus* (50%) was dominant in October. The degree of dominance by individual species varied between the March and fall collections. The fall months had lower absolute numbers of individuals (22–179), and during this time, members of a single species accounted for at least 50% of the collection. March had a much higher number of individuals (214), and two species, *A. rusicola* and *O. hecate hecate* (36%), shared dominance during this month.

Volume per trap-day peaks were largely the result of Scarabaeinae rather than Aphodiinae because of body-size differences. In particular, *D. carolinus* was the most influential volume contributor. As one of the largest species collected, having a few individuals in a monthly collection drastically increased the volume per trap-day. As functional efficiency of dung beetles may be related to their overall size (Larsen et al. 2005), early spring and fall may have the highest rates of dung degradation caused by the presence of *D. carolinus*. In temperate forests, these times of year correspond with an increase in food sources for mammals. Early spring offers an abundance of flowers and new leaf growth that is rich in nitrogen, phosphorus, and other nutrients (Nolet et al. 2005). Forage quality decreases during the summer, but food becomes abundant again in the fall as fruits and nuts reach maturity. Mammals depend on these times of elevated food availability; thus, their activity increases and reproductive events are timed accordingly (Côté and Festa-Bianchet 2001, Nolet et al. 2005). In addition to increasing the mammal dung supply, the presence of copious quantities of decaying flowers and fruit could directly supplement the dung beetle diet as well (Gill 1991).

Dung beetle abundance and volume per trap-day peaks may be explained in part by temperature and precipitation requirements. Dung beetles have the ability to diapause during seasons of the year that are unfavorable for survival. Factors that may induce this behavior are rainfall (too much or too little), temperature (too high or too low), resource availability, and interspecific competition (Hanski and Cambefort 1991b). The rainfall in February combined with the warm temperatures in March may have created optimal conditions for the already active aphodiine populations to expand and for the inactive scarabaeines to emerge from dormancy. The drop in scarabaeine populations in the summer may have been caused by higher than favorable temperatures as well as a reduction in mammal activity. Dung beetle abundance and volume peaked again in the fall as resources and environmental conditions once again became optimal for activity.

The presence of *O. hecate hecate* in every month of the collection period suggests it is a hardy species that tolerates a variety of temperature and moisture conditions. It is small, ranging in size from 0.021 to 0.066 ml, and the large numbers collected make it an important contributor to volume per trap-day, even in months when it was not the dominant contributor (Table 1). *Onthophagus hecate hecate* does not show a seasonal abundance pattern (Fig. 2C). Interspecific competition, possibly with some of the larger scarabaeines, may control population increases and declines during the warm months of the year; whereas biotic conditions may control the success of the species during the winter. Despite these fluctuations, *O. hecate hecate* clearly dominated the dung beetle community from May through August and then again in November and December (Fig. 2C).

Studies of urban dung beetle communities are important because they can indicate ecological changes in the local environment (Spector 2006). Carpaneto et al. (2005) documented changes in the dung beetle community of an urban park in Rome when dung resources changed from sheep dung to primarily dog dung. Species richness decreased from 19 to 9 species, whereas the abundance of dung beetles increased by seven fold. Wallace and Richardson's (2005) study of an urban dung beetle community in Austin, TX documents 9 species that heavily rely on dog dung as a resource. Demographic studies like this one and Wallace and Richardson's (2005) are important baseline studies for future comparisons. As humans are constantly modifying their surroundings, monitoring dung beetle communities can provide insight into the larger ecological changes that are occurring.

Temperate equations

Both the untransformed and log-transformed equations relating beetle biomass and volume were highly significant, as has been seen in Neotropical studies (Radtke and Williamson 2005, Radtke et al. 2006). The log-transformed equation explained the relationship better than the untransformed equation, probably because of the increased variance in measurement in large beetles. We recommend these equations be used in ecological studies or assessments, especially where field conditions may prevent access to drying ovens or other specialized equipment.

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