Hindawi Publishing Corporation
Psyche
Volume 2012, Article ID 437589, 6 pages
doi:10.1155/2012/437589

Research Article

Dung Beetles (Coleoptera: Scarabaeinae) Attracted to *Lagothrix lagotricha* (Humboldt) and *Alouatta seniculus* (Linnaeus) (Primates: Atelidae) Dung in a Colombian Amazon Forest

Jorge Ari Noriega

Laboratorio de Zoología y Ecología Acuática (LAZOEA), Universidad de Los Andes, Bogota, Colombia

Correspondence should be addressed to Jorge Ari Noriega, jnorieg@hotmail.com

Received 5 October 2011; Accepted 20 December 2011

Academic Editor: D. Bruce Conn

Dung beetles are among the most important insects in the Neotropics. Some species use a wide range of food sources, whereas other species are highly specialized. This study compares the use of two-primate excrement by an assemblage of dung beetles in a tropical forest in Colombia. Dung of *Lagothrix lagotricha* and *Alouatta seniculus* was used to attract beetles. A total of 32 species (47.7% of the species recorded for the area) were found on the two types of excrement studied, demonstrating that primate excrement is an important resource. The niche overlap between both feces is 27.03%, which indicates a high degree of resource specialization. Although these two primate species are found in the same areas, their diets vary greatly to permit a high degree of differentiation in beetle species. A study that includes dung of others primates would create a more complete panorama of resource overlap in the assemblage.

1. Introduction

Dung beetles are among the most important insect assemblages in the Neotropics, due to their important role in nutrient recycling, seed dispersal, and helminthes control, as they use omnivorous and herbivorous mammals dung as their food resource [1, 2].

Some species of dung beetles can use a wide range of food sources, from carrion to dung or more specific resources such as mushrooms, fruits, diplopods, decomposing vegetation, detritus, and eggs [1, 3–10]. Other species are highly specialized, using certain mammal dung [4, 11–15] or a more specific resource like primate dung of *Alouatta* spp. [3, 16–24] as well as *Lagothrix* spp. [25, 26].

Although, diverse aspects of the natural history and ecology of dung beetles have been widely studied [2, 27–30], little is known about their specialized use of some resources, especially primate dung. For this reason, this paper presents a study comparing the use of two primate excrement types by an assemblage of dung beetles in a tropical forest in Colombian Amazon region. Up to the present, no study has compared the preferences between two different primates excrement in the same locality.

2. Materials and Methods

2.1. Study Area. This study was carried out at the Center for Ecological Research of the Macarena (CIEM), located at 2° 40′ N and 74° 10′ W at an altitude of 350 m. The area is in a lowland tropical wet forest, located on the right bank of the Duda River, at the eastern border of Tinigua National Natural Park (Meta Department, Colombia). The predominant vegetation is mature forest [31] with a single rain cycle (dry period between December and March). The annual precipitation average is 2400 mm, with the least rainfall recorded in January (0 mm) and the greatest amounts in May–July (530 mm) [32].

The study was conducted in the primary habitat of the area, mature land forest, characterized by a continual tree canopy with a height of 25 to 30 m and emergent trees that

reach up to 35 m [33]. Seven species of primates coexist in the area and of these, *Lagothrix lagotricha* (Humboldt, 1812) (Woolly Monkeys) and *Alouatta seniculus* (Linnaeus, 1766) (Red Howler Monkeys) are the most abundant [34].

2.2. Field Sampling

2.2.1. Lagothrix lagotricha Dung (see [25]). From january to July 1997 (including part of dry and rainy season), a group of woolly monkeys was followed for 60 h each month, and dung from a single focal individual was collected during the day. Dung beetles attracted to the dung were collected in plastic bags with the monkeys dung sample ($n = 520$). Dung was collected between 5 minutes after defecation. Additionally, five pitfall traps on soil surface were used during 72 hours in mature forest (replaced the dung daily), in order to complement the sample for nocturnal and delayed visitors.

2.2.2. Alouatta seniculus Dung. During January 1998 (dry season), a group of howler monkeys was followed and in the morning, when the monkeys defecated all the species attracted to the dung for 10 minutes were collected. Afterwards, the largest possible quantity of dung was collected in a hermetic container. The collected excrement was placed the same day in 25 mL cups along a 300 m transect in 10 pitfall traps. The traps were placed 30 m apart for a period of 24 hours. This methodology was carried out on three occasions with two days between each sampling effort.

The specimens collected were preserved in a 70% alcohol and taken to the Museum of Natural History at the University of Los Andes (ANDES-E), where they were deposited. They were identified to species level using keys, in comparison with the other specimens and the assistance of specialists.

2.3. Data Analysis. Percentage overlap between the dung types was determined using the Jaccard similarity analysis by PAST software. In addition, to compare the composition of species recorded on the two types of dung, an analysis was carried out using the Levin's breadth of niche index with the standardization proposed by Hurlbert [35]. The MacArthur and Levin's index of niche overlap was calculated with the modification proposed by Pianka [36], using the species as resources and the types of dung as the species [37].

3. Results

A total of 32 species were found on the two types of excrement studied, seven of those found on *L. lagotricha* were only identifiable to the genus level and thus appear as morph species in Table 1. It is probable that these morph species are contained in the species already identified for *A. seniculus*, but the material obtained for the two excrement types could not be compared. The analysis comparing the two excrements was thus conducted for two possible extreme scenarios: (a) where the seven morph species not identified by *L. lagotricha* are contained within the species identified for *A. seniculus* and (b) where these species are not contained and are different species.

The species found on the primate dung sample account for 47.7% of the 67 total species recorded for the area [15], demonstrating that the excrement of both primate species is without doubt an important resource in the area. 18 species were found on the excrement of *L. lagotricha*, of which seven were exclusive to this type of excrement (or 13 given scenario (a)). Likewise, 19 species were found on the excrement of *A. seniculus* of which 14 are exclusive (or 8 in scenario (a)). Five species were recorded on both types of excrement (11 in scenario (a)).

The similarity between both dung types is higher in scenario (a) (Jaccard's mean value = 42.5%, SD = 9.04%) than in scenario (b) (Jaccard's mean value = 18.5%, SD = 6.85%). In addition, the structure of the assemblage in each scenario fluctuates in the species in common related with the dung type they use (Figure 1). The Levin's niche breadth index does not present significant differences between both species (*L. lagotricha* = 0.016, *A. seniculus* = 0.017, mean value $IL = 1.958$). The niche overlap index presented a mean value of 0.2703 (72.97%), with no significant differences between both species (*L. lagotricha* over *A. seniculus* = 0.277, *A. seniculus* over *L. lagotricha* = 0.2631), while the Renkonen overlap percentage was 15%.

In addition, it is interesting to note that on both dung types, it is possible to found rolling species (telecoprids) and tunnelers (paracoprids), while the dwellers (endocoprids) were only collected on the dung of *A. seniculus* (Figure 2).

4. Discussion

Estrada et al. [14] registered an overlap greater than 80% for the dung beetles assemblage on the excrement of *A. seniculus* and *Nasua narica* (L., 1776), presenting a high number of common species with some variations in abundance, as a few were recorded exclusively on a single bait. In this study, the relation found between the overlap percentages in the two excrements was the opposite, a range between 15.6% (scenario (b), $n = 5$ spp.) and 34.3% (scenario (a), $n = 11$ spp.), which indicates that, for this locality, few species are generally associated with both types of dung.

These results indicate that there is a high degree of food resource specialization, despite both excrements coming from primates, there are sufficient differences in diet, microhabitat, and behavior of each species to permit a degree of differentiation between the species that make use of each dung [38–42].

Although these two species are found in the same areas, their diets vary greatly, as *L. lagotricha* consumes insects, fruits, and leaves, while the diet of *A. seniculus* is primarily foliage [25], and these differences affect the consistency, nutritional composition and smell of their respective excrements. Additionally, these species use different forest strata, produce excrement at different places, and times and the mobility and number of individuals per group are different [41]. It is probable that the use of different forest strata [41] affects the spatial disposition of the dung and distribution of the species that use these food resources. In addition, it is possible that seasonal difference in diet proportion affects the number of shared species between primates dung because

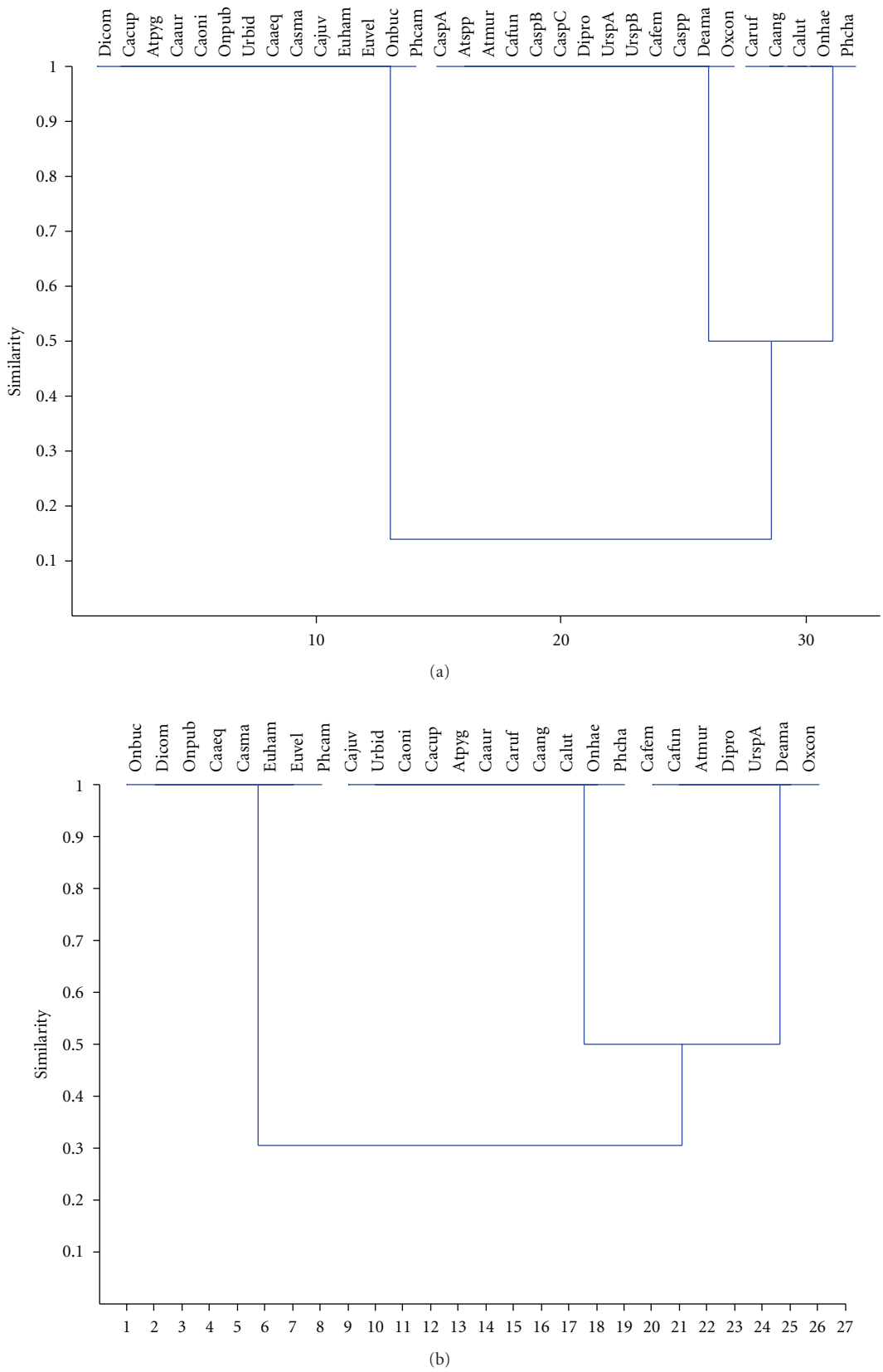

Figure 1: Dendrogram cluster analysis of similarity (Jaccard's index) among species and the dung type they use in scenarios (a) and (b), CIEM-Meta, Colombia.

Table 1: List of the species associated with each of the primate's dung, with their relocation habits (T: tunneler, R: roller, and D: dweller), in the CIEM station, Meta, Colombia.

Tribe	Species	rh	*L. lagotricha*	*A. seniculus*
Ateuchini	*Ateuchus murrayi* (Harold, 1868)	T	X	—
	Ateuchus pygidialis (Balthasar, 1939)	T	—	X
	Ateuchus sp.	T	X	—
Coprini	*Canthidium aurifex* (Bates, 1887)	T	—	X
	Canthidium cupreum (Blanchard, 1843)	T	—	X
	Canthidium funebre (Balthasar, 1939)	T	X	—
	Canthidium onitoides (Perty, 1830)	T	—	X
	Canthidium ruficolle (Germar, 1824)	T	X	X
	Canthidium sp. A	T	X	—
	Canthidium sp. B	T	X	—
	Canthidium sp. C	T	X	—
	Dichotomius compressicollis (Luederwaldt, 1929)	T	—	X
	Dichotomius problematicus (Luederwaldt, 1922)	T	X	—
	Ontherus pubens (Genier, 1996)	T	—	X
Coptodactylini	*Uroxys bidentis* (Howden and Young, 1981)	T	—	X
	Uroxys sp. A	T	X	—
	Uroxys sp. B	T	X	—
Deltochilini	*Canthon aequinoctialis* (Harold, 1868)	R	—	X
	Canthon angustatus (Harold, 1867)	R	X	X
	Canthon femoralis (Chevrolat, 1834)	R	X	—
	Canthon fulgidus (Redtenbacher, 1867)	R	—	X
	Canthon juvencus (Harold, 1868)	R	—	X
	Canthon luteicollis (Erichson, 1847)	R	X	X
	Canthon sp.	R	X	—
	Deltochilum amazonicum (Bates, 1887)	R	X	—
Oniticellini	*Eurysternus hamaticollis* (Balthasar, 1939)	D	—	X
	Eurysternus velutinus (Bates, 1887)	D	—	X
Onthophagini	*Onthophagus buculus* (Mannerheim, 1829)	T	—	X
	Onthophagus haematopus (Harold, 1875)	T	X	X
Phanaeini	*Oxysternon conspicillatum* (Weber, 1801)	T	X	—
	Phanaeus cambeforti (Arnaud, 1982)	T	—	X
	Phanaeus chalcomelas (Perty, 1830)	T	X	X

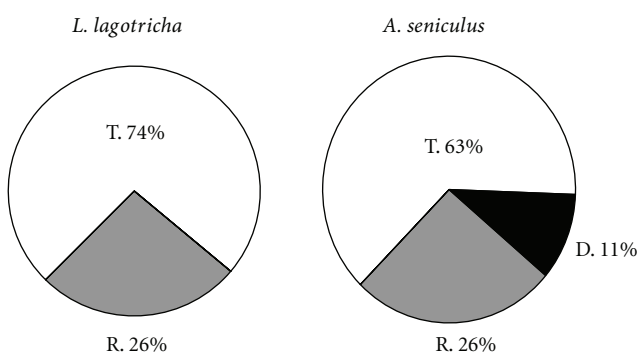

Figure 2: Richness of the three relocating guilds (R: rollers, T: tunnelers, D: dwellers) in the two dung types (*L. lagotricha* and *A. seniculus*) in the area, CIEM-Meta, Colombia.

the diet of these species is more similar in the rain season, but at dry time it is very different (P. Stevenson pers. comm.).

The rolling species can use the dung that remains on leaves, while tunnelers and dwellers do not, but even so the dominant group on both excrement types is the tunnelers. It is interesting to note that many of the species recorded on the two excrements were frequently found perching in the study area (Noriega, unpublished data). The amount of dung that remains on leaves is very small compared to what reaches the ground, but some of the species that utilize the dung that remains on leaves did not fall into the traps were placed at ground level [43].

A study that includes other possible resources, such as the dung of others primates species in the area and that of other mammals, would create a more complete panorama of

resource overlap in the beetle assemblage, clarifying which species have generalist habits and which really are specialists, allowing to approach the quantification of the interspecific competition for this locality.

Acknowledgments

The author would like to thank Carlos Arturo Mejia, Ramiro Montealegre, Juan Cristobal Calle, and Alejandra Vega for their help during the fieldwork; Emilio Realpe for the support during the laboratory work; Fernando Vaz-de-Mello for taxonomic support; Carolina Rudas and Pablo Stevenson for valuable information; Castor Guisande and Daniel Monroy for statistic collaboration; Pablo Stevenson, K. Isawa, Julio Louzada, Ricardo Botero, Carolina Vizcaíno, and Nora Martínez for helpful comments, and suggestions which improved the paper; To David Morris for kindly checking the English versión; two anonymous reviewers for the critical reading of this paper.

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