A study of edge effects and dung preference in dung beetles in Kibale Forest National Park

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Abstract

Dung beetles have been classified as keystone species and are often adversely affected by fragmentation. The African continent has a unique dung beetle fauna, thus making it an ideal area for the study of dung beetle ecology. This study used dung baited pitfall traps to examine edge effects and dung preference of dung beetles in Kibale Forest. Primate dung attracted significantly more individuals, species and total biomass compared to elephant dung. A weak edge effect was detected; beetles on primate dung appeared to be more negatively affected than those on elephant dung.

INTRODUCTION

Edge effects which arise due to habitat fragmentation have negative impacts on forest flora and fauna (Soulé 1986). Several studies have shown that dung beetles are adversely affected by fragmentation and microclimate changes (Klein, 1989, Nummelin & Hanski, 1989). Primack (1993) states that the microclimate at the edge of the fragment may be hotter and drier, which can have negative effects on the larval development of many beetle species. Klein (1989) noted that smaller forest fragments have fewer species of dung beetle, smaller individuals and smaller population sizes. The animals whose dung the beetles feed on are often negatively affected by fragmentation, thus also affecting dung beetle distribution (Klein, 1989).

Dung beetles have been classified as keystone species because they aid in decomposition, seed dispersal and control vertebrate parasites in the ecosystem in which they live (Klein, 1989; Primack, 1993). In sub-Saharan Africa, more than 2000 species of dung beetles of the subfamily *Scarabaeidae* can be found. African forest dung beetles can be roughly divided into two groups, those specialising on small droppings of primates, and those specialising on large droppings of herbivores such as elephants (Hanski & Cambefort, 1991). Many types of dung beetles are adapted to utilise one type of dung or another. Africa is unique amongst the tropics, as it possesses large dung beetle species which specialise on large herbivore dung. This makes Africa a particularly interesting area for a study of dung beetle ecology (Hanski & Cambefort, 1991).

Kibale Forest National Park has a rich and abundant mammal and dung beetle fauna (Nummelin & Hanski, 1989). Most mammal species occur throughout the whole forest, therefore resources for dung beetles are ubiquitously available in all forest types (Nummelin & Hanski, 1989).

This study aimed to determine if dung beetles in Kibale Forest were adversely affected by fragmentation. We also asked which types of dung beetle deal better with edge effects, those specialising on primate or herbivore dung. The edge and core habitats were characterised by measuring temperature and light intensity, two key microclimatic parameters. Another aim of this study was to examine which dung type attracted more species and to identify differences between dung type in species composition.

Materials and methods

Study area

The study was carried out in Kibale Forest National Park in Western Uganda. Kibale is a medium altitude moist evergreen forest with an average elevation of 1500m and the dominant forest tree is *Parinari excelsa* (Nummelin & Hanski, 1989; Nummelin, 1996). Within the National Park, the forest area covers about 50 km^2. There are two rainy seasons, one from late August to the beginning of December and one from early March to early May. The annual rainfall is approximately 1500 mm (Nummelin & Hanski, 1989).

Data collection

Baited pitfall traps were laid between 18^{th} and 22^{nd} September 2004. Trapping was conducted at five sites; each site consisted of an edge and core location. The edge locations were placed 2 meters from a logging road, the core locations were 100 to 150 meters from the road, and in a densely forested area. There was a minimum distance of 200 meters between each site in order to assure that the samples were independent.

The trap design was similar to that used by Klein (1989) during his study in central Amazonia, Brazil. A plastic cup (86 mm in diameter and 112 mm deep) was sunk into the ground, ensuring that its lip was continuous with the soil. A small plastic cup (51 mm in diameter and 25 mm deep) containing the dung was placed at the bottom of the trap. A live trap design was used therefore no killing or preserving agent was required. The completed traps were covered with an inverted weighing boat (150 mm x 150 mm) which was supported by four sticks driven into the ground. The trap was then camouflaged with leaves to avoid attracting vertebrates that might destroy the traps.

At each location, eight traps were set; four baited with elephant dung, four baited with primate dung. A paired design was used in the distribution of the traps, one elephant dung trap was placed beside one primate dung trap. The trap pairs were set in a square pattern with 10 meters between each pair (Figure 1). The placement of dung types between location A and B at each trap site was done at random. After every 24-hour period, the catch of the traps was collected, and the dung was replaced. Light intensity was measured at each location on a daily basis. Maximum and minimum temperatures were recorded at three edge and three core locations.

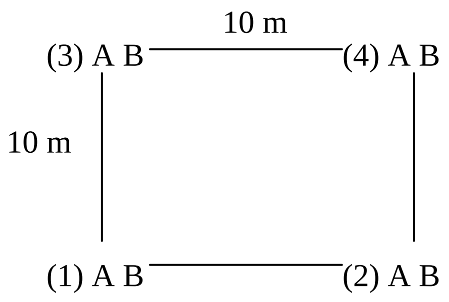

Fig. 1 Paired design of trap distribution at a location. A and B indicate different dung types and 1 to 4 indicate different trap sites.

The species were identified to morphospecies and given a descriptive name. The total biomass of all the individuals of each morphospecies per trap was determined. One individual of each species was preserved to allow comparison and for future identification to species level by an expert.

Data analysis

The Sørensen similarity index was calculated to determine the similarity in species composition between sites and dung types (equation 1).

Sørensen similarity index:

$C_s = 2 j / (a + b)$ (Eq. 1)

Where; **j**= the number of species present in both groups, **a=** the number of species in the first group and **b=** the number of species in the second group.

MINITAB 13 for windows was used to analyse the data. The data had a non-normal distribution even after log and square root transformations therefore non-parametric statistics were used. A Scheihner-Ray-Hare test, the non-parametric equivalent of a two-way ANOVA, was performed on the biomass, abundance and species composition. The average biomass per individual was calculated for both primate and elephant dung baited traps, and the frequency distribution of the average biomass per individual for each trap treatment was graphed. The data for the primate dung were normal; therefore an independent t-test was used to compare the biomass from edge and core sites. The data from the elephant dung were non-normally distributed therefore Mann-Whitney U tests were carried out to compare edge and core sites and both dung types.

Results

A total of 1073 individuals of 41 species of dung beetles were caught over the five nights of trapping (Appendix 1). Certain species were only caught in one trap treatment (Appendix 1; Figure 2). Twenty-five species were caught in primate dung traps only; six species were trapped exclusively at core traps and three species exclusively at edge traps. Only three species were caught exclusively in elephant dung traps, two of which were trapped only at the core and one at the edge. Six species were caught exclusively at the core, and seven species exclusively at the edge. The Sørensen similarity index (Table 1) shows that none of the trap treatments had particularly similar species compositions.

Table 1 Sørensen similarity index results

edge-core	0.400
elephant-primate	0.224
primate/edge-primate/core	0.400
elephant/edge-elephant/core	0.125
primate/edge-elephant/edge	0.132
primate/core-elephant/core	0.158

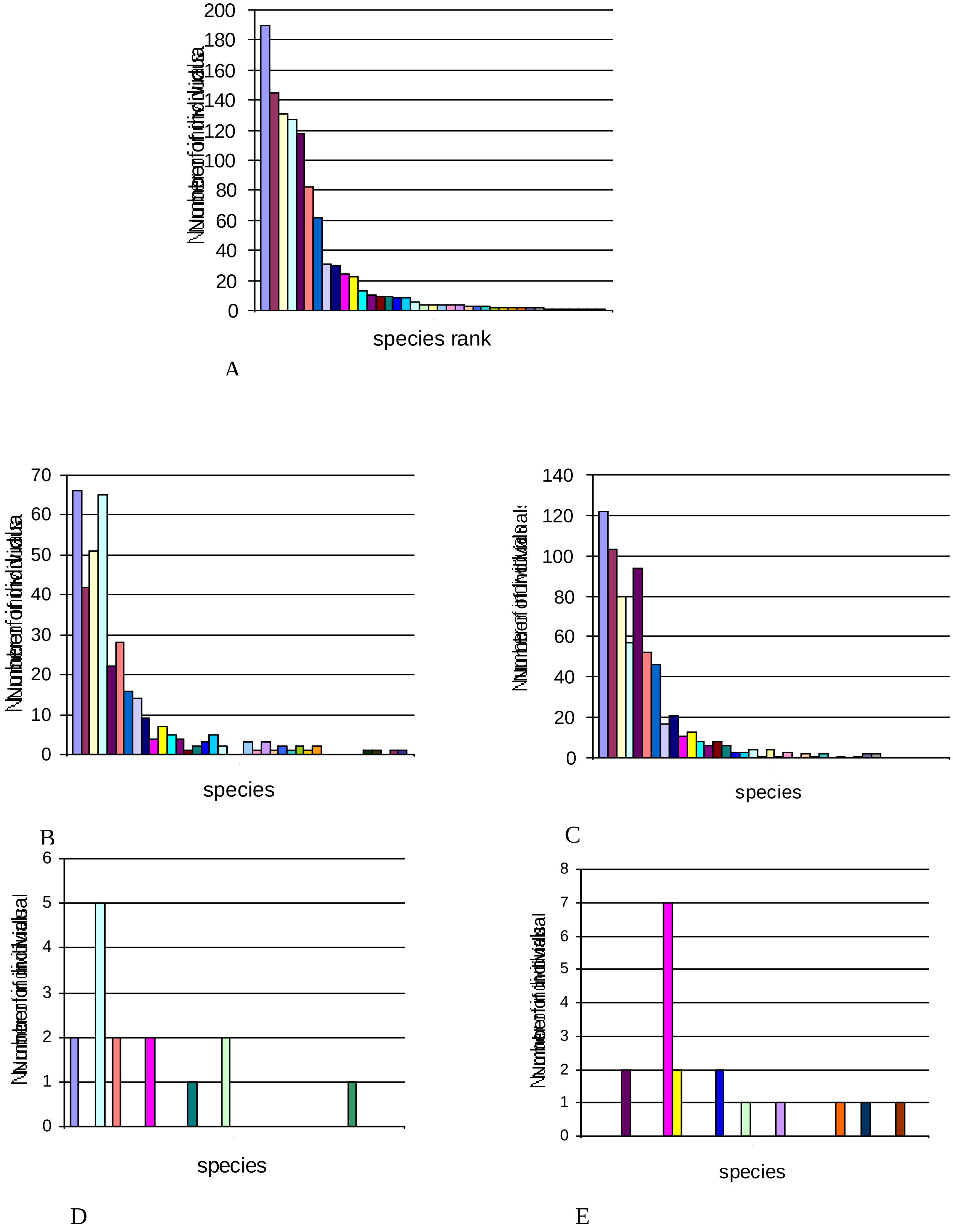

Fig. 2 Species rank abundance of the total catch (A). Species composition in primate dung at edge (B), and core sites (C) and in elephant dung at edge (D) and core sites (E). The same order of species is used for Figures 2 to 5, and was determined by the total species rank abundance curve. See Appendix 1 for species names.

Microclimate parameters

There was no significant difference in the microclimate parameters at the edge and core sites (Figures 3 and 4).

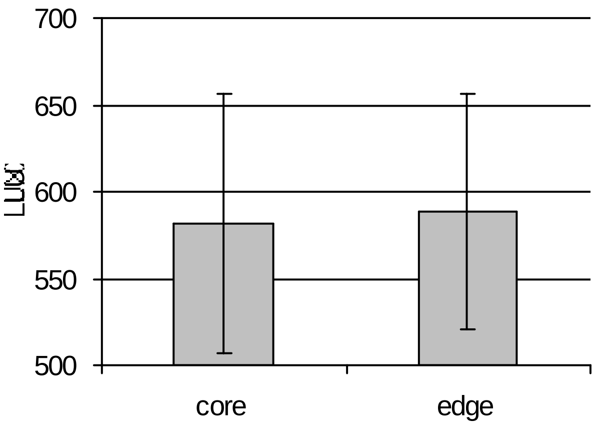

Fig. 3 Average light intensity at core and edge sites (± S.E)

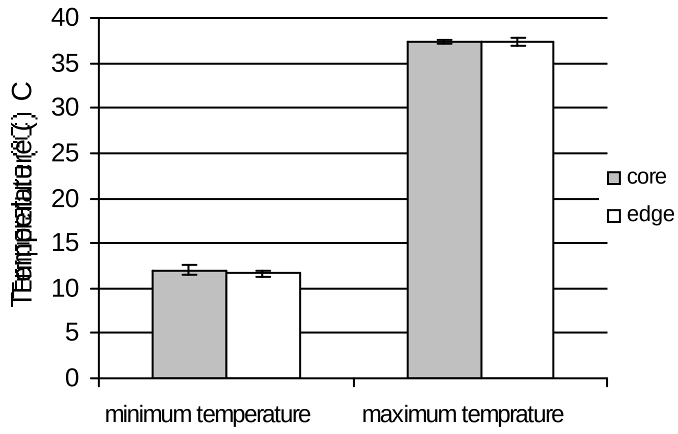

Fig. 4 Maximum and minimum temperatures at core and edge sites (± S.E).

Site and dung type differences

There were significantly more individuals (Figure 5), species (Figure 6) and biomass (Figure 7) found in the traps baited with primate as compared to elephant dung. There was no significant difference between these measurements for the edge and core for either dung type. However, there was a bigger difference between dung types for the number of individuals, number of species and biomass at the core than at the edge.

Table 2 Statistical results for the number of individuals per trap

Test	F-value	d.f.	p-value
Site	0.73	1	0.395
Dung type	142.9	1	<0.001
Site x dung type	6.41	1	<0.05

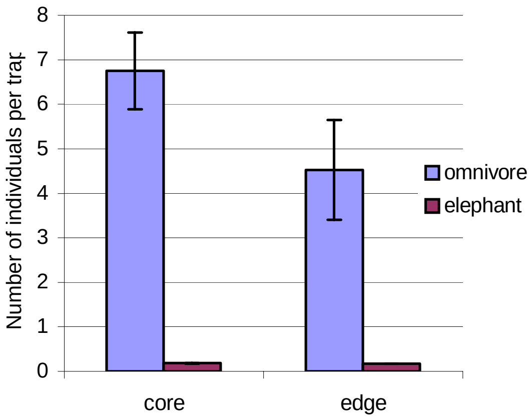

Fig 5 Average number of individuals per trap at core and edge sites for both dung types (±S.E).

Table 3 Statistical results for the number of species per trap

Test	F-value	d.f.	p-value
Site	0.22	1	0.638
Dung type	155.78	1	<0.001
Site x dung type	5.41	1	<0.05

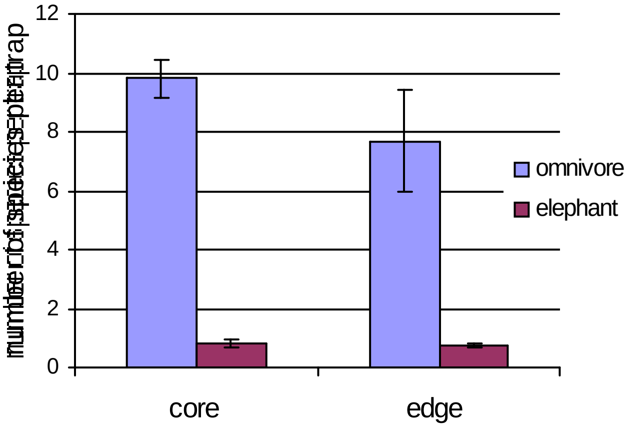

Fig. 6 Total species richness per trap at core and edge sites for both dung types (± S.E).

Table 4: Statistical results for the biomass per trap

Test	F-value	d.f.	p-value
Site	0.68	1	0.414
Dung type	138.48	1	<0.001
Site x dung type	6.64	1	<0.05

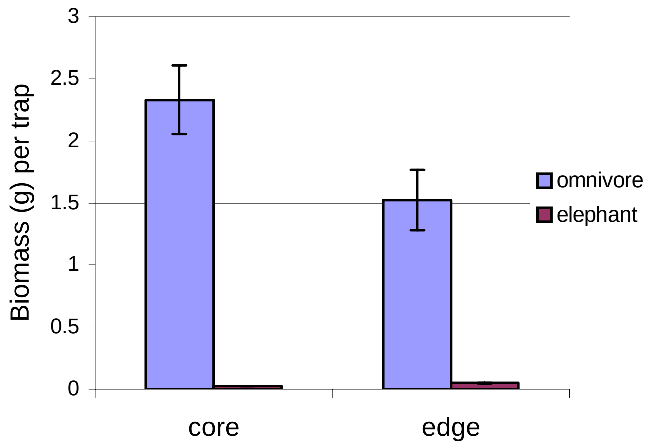

Fig. 7 Average biomass per trap at core and edge sites for both dung types (± S.E).

Biomass distribution

There was no difference in the average biomass per individual between edge and core traps for either dung type. The average biomass per individual in primate dung was significantly higher than in elephant dung at core sites (W = 237076.0, N = 675, 18, p<0.001; Figure 8).

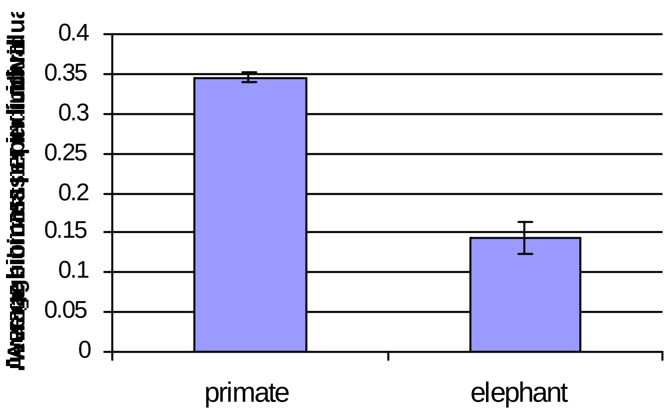

Fig. 8 Average biomass per individual at core sites (± S.E).

The frequency distribution of the average biomass per individual differed between trap treatments. In elephant dung baited traps at both core and edge, the biomass per individual was skewed with most beetles falling in the smallest size class (Figs. 9 & 10). While the average biomass per individual for the primate dung baited traps was more heterogeneous at core and edge sites, as larger individuals were better represented (Figs. 11 & 12). The range of the distribution was the same for both dung types. There was no apparent difference between core and edge sites for either dung type.

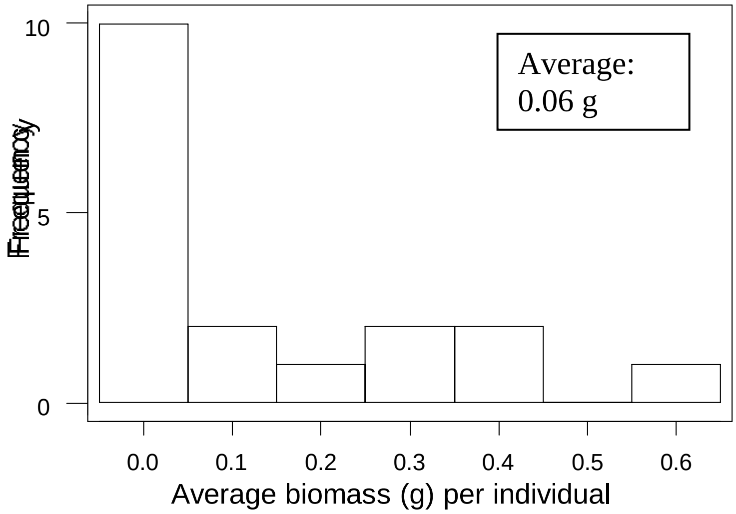

Fig. 9 Distribution of the average biomass per individual in elephant dung at core sites *.

Average
0.15g

Figure 11: Distribution of the average biomass per individual in primate dung at core sites*.

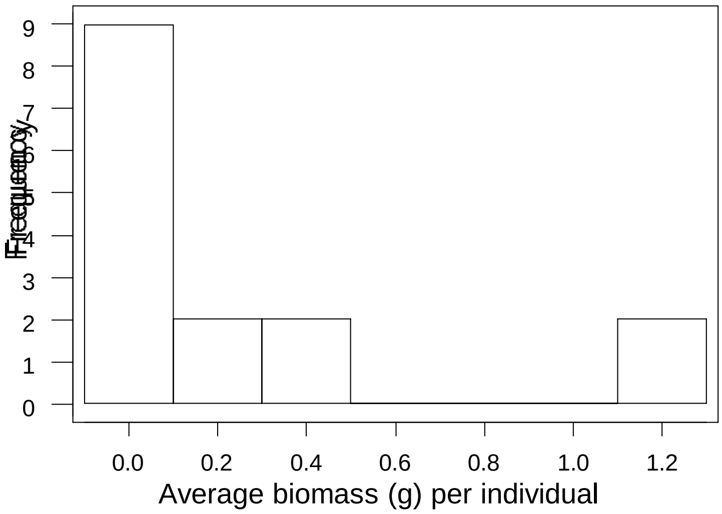

Fig. 10 Distribution of the average biomass per individual in elephant dung at edge sites *.

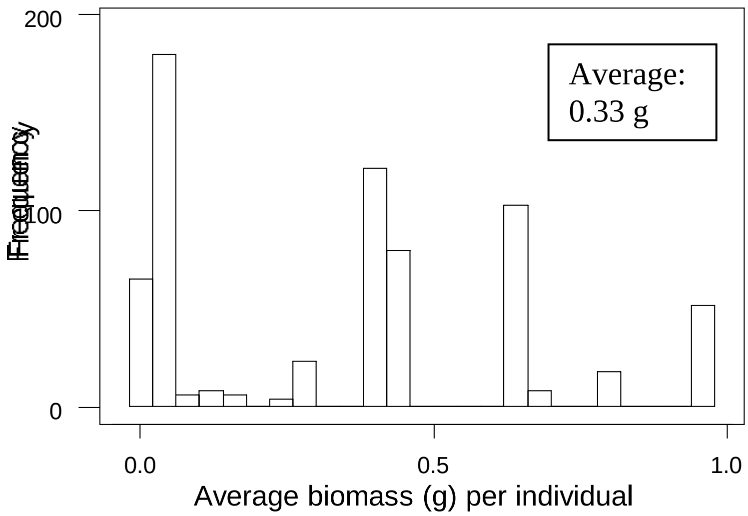

Fig. 11 Distribution of the average biomass per individual in primate dung at core sites*.

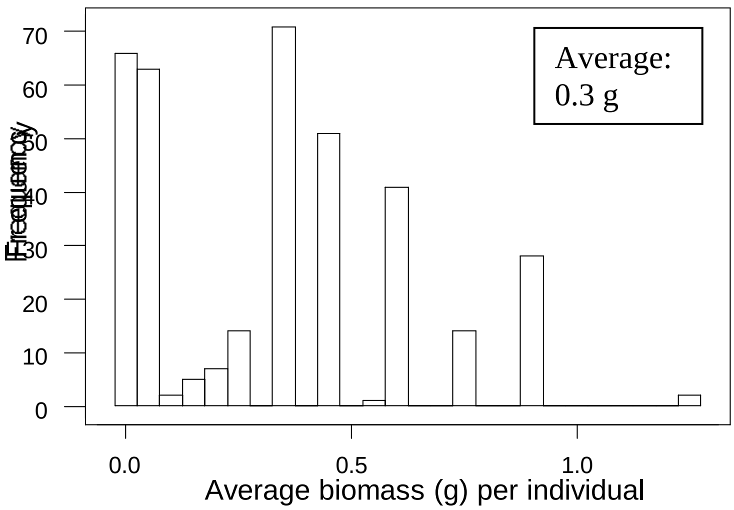

Figure 12: Distribution of the average biomass per individual in primate dung at edge sites*.
***On the x-axis scale the 0.0g bar includes all animals with biomass between 0.0g and 0.1 g**

DISCUSSION

Are dung beetles in Kibale forest affected by fragmentation?

For primate dung baited traps, the number of individuals and the total biomass were almost twice as high at the core as at the edge, but the differences were not significant. There was only a 40% similarity in species between edge and core, six species were found only at the core and seven only at the edge. Although the trend is weak, there may be some edge effect with fewer individuals and less biomass, but unique species found at the edge.

The number of individuals, number of species and biomass were greater at the core than the edge for primate dung baited traps; the opposite was true for the elephant dung baited traps. Thus at the edge there was less difference between the catch of the two dung types than at the core, this would suggest that there was some edge effect, although this effect was weak as it was not significant. Also the activity density for the primate dung baited traps was greater at the core than at the edge.

There was no significant difference in the microclimatic parameters at the edge and core sites. The edge effects that were observed were not due to the microclimatic parameters measured in this study. A more important parameter may be humidity, as at the edge, the microclimate may be drier causing the dung to dry out quicker thus making these sites less suitable habitats for dung beetles. It is also possible that dung beetles do not perceive Kibale Forest as fragmented or that the core sites should have been placed further away from the edge of the fragment.

Which dung type attracts more beetles?

The catch in the primate dung baited traps was significantly higher than in the elephant dung baited traps for both core and edge sites, whether biomass, number of individuals or number of species was considered. Also there were more species found only in the primate dung than only in the elephant dung and the average biomass per individual was greater in primate dung. This results are consistent with Nummelin and Hanski (1989) who noted that sixteen of the thirty species of dung beetles that they found in Kibale Forest were members of the genus Onthophagus, who tend to specialise exclusively on primate dung (Hanski and Cambefort 1991). A study in Taï National Park, Ivory Coast showed that ten times as much elephant dung as human dung was required to attract the same number of dung beetles (Hanski and Cambefort 1991). This may be because omnivore dung is more nutritious than megaherbivore dung therefore a smaller quantity is required to attract beetles. In future research, it may prove more informative to use a larger quantity of elephant dung as in this study none of the large species of beetle, which make the African Scarabaeidea fauna so interesting, were captured.

Which group of dung beetles are less sensitive to edge effects?

As edge effects in this study were weak when compared to dung preference trends, it is difficult to address this question. However, the number of individuals, number of species and biomass was less at the edge than at the core for the primate dung baited traps, whereas the opposite was true for the elephant. Beetles which occurred on primate dung did better at the core while beetles which occurred on elephant dung did better at the edge. It is possible that dung beetles which specialise on megaherbivore dung are evolutionarily better adapted to edge habitats as elephant would be more likely to occur there.

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Appendix 1: Trapping results from edge and core sites with primate and elephant dung baited traps.

Trap treatment Species	Primate edge	Elephant edge	Primate core	Elephant core	Total number of individuals per species
Black 17mm	66	2	122	0	190
Purple shiny	42	0	103	0	145
Rhino	51	0	80	0	131
Black long legged	65	5	57	0	127
Black 5 mm	22	0	94	2	118
Rough back 23 mm	28	2	52	0	82
Orange cheeked	16	0	46	0	62
red/black hairy carapace	14	0	17	0	31
Green	9	0	21	0	30
Brown ground	4	2	11	7	24
Scorpion mimic	7	0	13	2	22
Chestnut	5	0	8	0	13
Black 10 mm	4	0	6	0	10
Black shiny	1	0	8	0	9
red/green ground beetle	2	1	6	0	9
Black hairy legged	3	0	3	2	8
Red	5	0	3	0	8
Mini green	2	0	4	0	6
Large black ground	0	2	1	1	4
Long legged 10 mm	0	0	4	0	4
Rough long legged	3	0	1	0	4
Small shiny green	1	0	3	0	4
White spotted	3	0	0	1	4
Brown backed	1	0	2	0	3
Brown horned	2	0	1	0	3
Mini black	1	0	2	0	3
big brown shiny	2	0	0	0	2
Black head red carapace	1	0	1	0	2
red iridescent headed	2	0	0	0	2
Ridged backed	0	0	1	1	2
Rough black 10mm	0	0	2	0	2
Small black ground	0	0	2	0	2
Armoured black 5 mm	0	0	0	1	1
Brown 10 mm	0	1	0	0	1
Gold/green hairy	1	0	0	0	1
Large green	1	0	0	0	1
Long black 30 mm	0	0	0	1	1
m backed	1	0	0	0	1
Mini spiny back	1	0	0	0	1
Total nr of individuals	**366**	**15**	**674**	**18**	**1073**
Total nr of species	**31**	**7**	**29**	**9**	**41**
Total biomass (g)	**122.0**	**4.0**	**233.3**	**2.6**	**361.8**
Activity density (per 10 traps/night)	**45.8**	**1.9**	**67.4**	**1.8**	**53.65**