Effect of Habitat Change through Infrastructural Development on Small Mammal Diversity and Abundance on the Legon Campus of the University of Ghana

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Abstract

The study investigated the effect of real estate development on small mammal diversity and abundance in order to inform town planners during their decision-making process. Small mammals were used because they are relatively easy to survey and serve as bio-indicators that provide knowledge on the state of health of the habitat in which they inhabit. The University of Ghana Campus, Legon (UGCL) was divided into two sites: built-up area and the botanical garden, which is less developed. The small mammals were live-trapped using Sherman traps in May 2009 for seven nights by means of transect in the two study sites, using a mixture of peanut butter and corn meal as the preferred bait. The 350 trap-nights yielded 68 captures of five species of small mammals. They were (i) Pygmy mouse (*Mus musculoides*), (ii) Unstriped grass rat (*Arvicanthis niloticus*), (iii) Tullberg's soft-furred rat (*Praomys tullbergi*), (iv) African giant shrew (*Crocidura olivieri*) and (v) White-bellied hedgehog (*Atelerix albiventris*). Small mammal diversity and abundance were similar between the two sites. This may be due to the comparatively large size and the presence of green areas in the built-up area. The preference of *C. olivieri* for human-interfered habitats may be used to monitor further habitat modification through real estate development in UGCL.

Introduction

The most important and undoubtedly the number one modern-day cause of species diversity decline are habitat alteration and destruction (Linzey, 2001). Habitat alteration and destruction have largely been attributed to neglect and unsustainable human activities such as estate development (Wuver & Attuquayefio, 2006), increased mining activities (McCullough *et al*., 2007), agriculture (Jeffrey, 1977; Marini *et al*., 2009, Ribeiro *et al*., 2009), logging (Wells *et al*., 2007), urbanization and increasing human population (Bakarr *et al*., 2001; Pauchard *et al*., 2006).

To forestall serious consequences relating to habitat destruction, Environmental Impact Assessments (EIAs) are carried out before the implementation of major developmental projects such as large-scale mining. However, the periodic monitoring of the impact of these projects on the environment after their implementation is often not given the necessary attention. Also in many cases, the conduction of EIAs is not focused on real estate developmental projects, but rather those that are deemed more environmentally destructive, like large-scale mining.

Ghana has six public universities, all of which are witnessing increasing student populations in recent times. The University of Ghana, the oldest and largest among them, has seen an over 100% increase in student population in the past 10 years to a current

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student population of 29,754 because enrolment over the years has always exceeded the output (Fig. 1). These increments prompted a corresponding increase in student housing facilities, administrative offices, and lecture theatres to cater for accommodation and office space needs of the growing university community. The increase in infrastructure has resulted in the clearance of large tracts of lands at the expense of many terrestrial fauna. It is, therefore, important that faunal species abundance and diversity in isolated patches of vegetation enclosed within real estates be compared with relatively undisturbed habitats of similar ecological status to help detect the trends in faunal change.

One group of organisms that provide insight to environmental health and faunal diversity is small mammals (Class: Mammalia; Orders – (i) Chiroptera – bats, (ii) Rodentia – rodents, (iii) Soricomorpha – shrews and (iv) Erinaceomorpha – hedgehogs). Small mammal communities are relatively easy to survey, and because they serve as food sources for many other organisms such as owls, changes in their diversity and populations can easily be used to deduce trends in other faunal communities.

Most studies on the impact of land-use on small mammals are, however, carried out in protected areas (Attuquayefio & Ryan, 2006), agroforests (Fitzgibbon, 1997) or farmlands (Barnett *et al*., 2000). Thus, available data interlinking real estate development and small mammal communities, necessary in town planning decision-making, is largely limited.

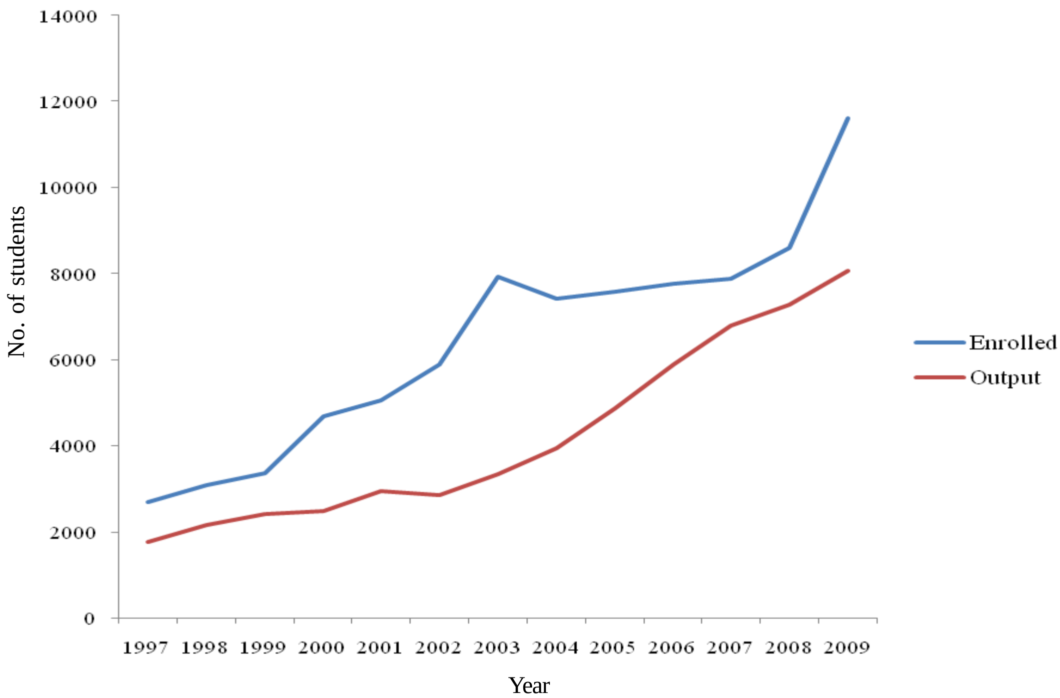

Fig. 1. Trends in student enrolment and number graduating (output) over a 13-year period

The University of Ghana Campus, Legon (UGCL) has a built-up area in which the increasing infrastructural development has been centred contrary to the nearby botanical garden. Though the University of Ghana is equally surrounded by settlement in a large spatial scale and can best be described as an island in the sea of urbanization, the botanical garden has seen minimal infrastructural development and could serve as important refugia for many species of animals. The state of health of the environment is determined by the kind of species living in it and the absence of certain key species that would have otherwise been expected to exist within the habitat. The paper compares the diversity and abundance of the small mammals of UGCL to that of the adjoining botanical garden in order to determine the effect of infrastructural development on the diversity and abundance of small mammals.

Materials and methods

Study area

The Legon Campus of University of Ghana (5^0 36' N, 0^0 10' W) is located in Accra, which has an estimated population of 3,963,264 in 2011. Originating from rural-urban drift, increasing developmental activities and rapid expansion of the city of Accra has resulted in the destruction of many faunal habitats within the Accra Plains. According to Grimes (2006), the suburbs of Accra began to spread northwards in the 1970s and the northern ward limit was about 5 km south of Legon. Also, about 1 km north and northeast of Legon in the 1970s was the village of Madina and Kwabenya. Grimes (2006), however, described Legon in the face of the expansion of Accra as "an island in a sea of urbanization" in which Madina and Kwabenya had been swallowed up.

The Legon Campus has an area of about 13 km^2, with a climate characterized by a pronounced gradient of mean annual rainfall ranging from 733 mm to 1,118 mm and an altitude of between 91 m and 122 m (Decher & Bahian, 1999). The vegetation is generally coastal scrub and thicket but with an anthropic landscape (farm regrowth, football pitches, built-up areas, etc.).

The built-up area of Legon Campus has hostels and halls of residence, lecture theatres, departmental blocks, staff bungalows, lawns and major roads, with low growing grassland. Avenue trees such as *Khaya senegalensis*, *Erythrophleum* sp. and *Millettia thonningii* line the major roads. On the contrary, the university botanical garden, with little infrastructural development, covers an area of about 0.25 km^2 and supports scientific research. It also has facilities for picnics. The vegetation consists of a mosaic of forest type vegetation, patch of the original thicket vegetation, woodland (mainly neem trees, *Azadirachta indica*) and grassland composed mainly of *Heteropogon contortus*, *Sporobolus pyramidalis*, elephant grass (*Pennistum purpureum*) and 'Acheampong' weed (*Chromolaena odorata*).

Site selection

The vegetation type in the built-up area was basically similar, comprising of grassland with few interspersed trees at certain locations, hence, the study sites in the built-up area were randomly selected. The botanical garden, however, had four distinct vegetation types: thicket, forest, grassland and woodland. Transect lines were, therefore, established to cut across the different vegetation types taking their relative sizes into consideration (Fig. 2).

Live-trapping of small mammals

Small mammals were captured using Sherman collapsible traps (23 cm × 9 cm × 7.5 cm) for seven consecutive days in May 2009. Twenty-five traps were separately used for the study in the built-up area and botanical garden, giving a total of 175 trap-nights per area. The traps were baited with a mixture of peanut butter and corn meal and placed at 10-m intervals along transect lines. Traps were set, rebaited and replaced at sunset around 16:00 h GMT and inspected around 06:00 h GMT the next morning throughout the study period. Trap stations were relocated each day.

The captured small mammals were sedated using chloroform then identified, sexed (using the ano-genital distance, which is longer in males), weighed and examined for reproductive condition (abdominal or scrotal testes in males and enlarged nipples, perforate vaginas and pregnancy in females). Lactating females had bare areas around the mammae, indicating suckling from the young. Pregnancy was determined by weight and feeling of foetus with fingers. Reproductive males exhibited prominent scrotal testes. Field handling techniques followed Davies & Howell (2004).

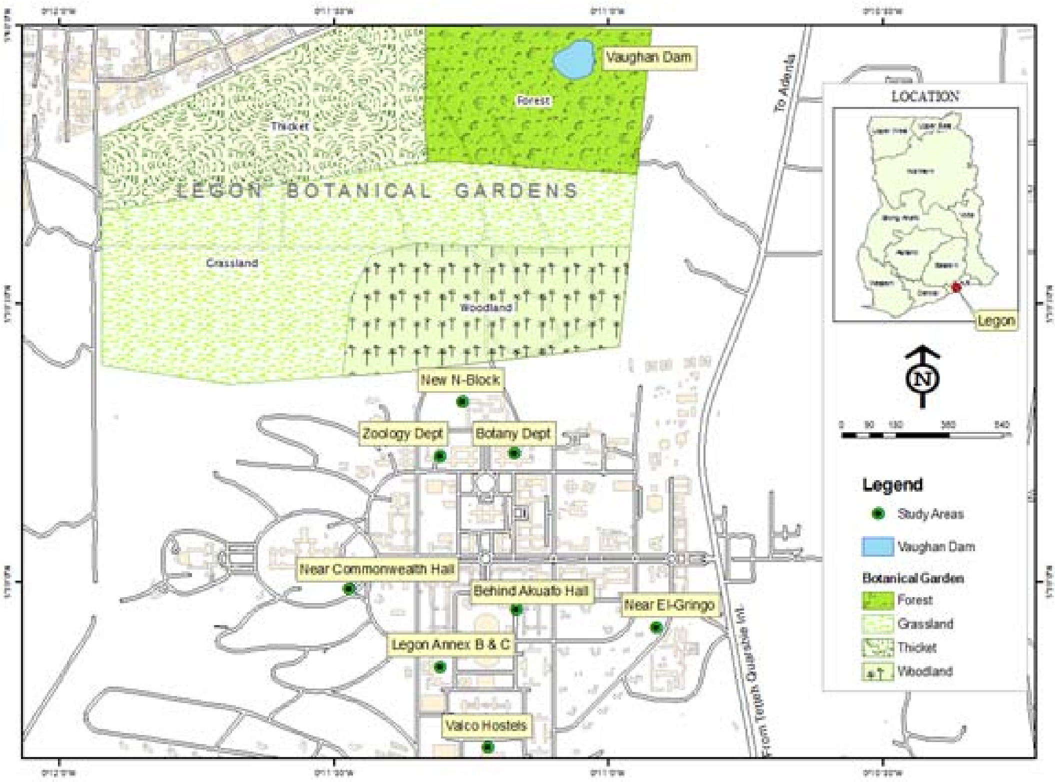

Fig. 2. Distribution of transects in the built-up area and botanical garden

The identification of small mammals was aided by taking the following standard measurements: (i) Total body and tail length (TOTL), (ii) Tail length (TL), (iii) Head and body length, i.e. TOTL – TL (HBL), (iv) Hind foot length (HFL), (v) Ear length (EL), (vi) Fresh body weight (WT). Unfamiliar species were confirmed using Kingdon (2004), Rosevear (1969), and Hutterer & Happold (1983).

Data analyses

The percent occurrence, relative abundance (RA), trapping success (TS) and the Shannon-Wiener index (H^I) were calculated, given that:

i) Percent Occurrence = (total number of a particular species/total number of small mammals caught in the area) × 100
ii) (RA) = (number of individuals of a particular species/total trap nights) × 100
iii) (TS) = (total number of individuals captured/total trap-nights) × 100, where one trap-night refers to one trap set for one night.
iv) $H^I = (\sum p_i \ln p_i)$, where p_i is the proportion of the total sample belonging to the i-th species. H^I is sometimes written in the form, exp H^I (e^{HI}), which is the effective number of species, where e = 2.178 (Jost, 2006). It measures the amount of uncertainty by predicting what species an individual would belong to when chosen at random from a sample (Magurran, 1991).

The PractiStat software (Ashcroft & Pereira, 2002) was used to provide the measure of dispersion (i.e. standard deviations) and test for significance, using Mann-Whitney U-test (2 tailed).

Results

Small mammal species composition within the two study areas

In all, 68 individuals of five species of small mammals belonging to three families were captured. They included (i) *Mus musculoides* (Pygmy mouse), (ii) *Praomys tullbergi* (Tullberg's soft-furred rat), (iii) *Arvicanthis niloticus* (Unstriped grass rat), (iv) *Atelerix albiventris* (White-bellied hedgehog) and (v) *Crocidura olivieri* (African giant/Olivier's shrew) (Table 1).

Forty-one individuals of three species (*M. musculoides*, *A. niloticus* and *C. olivieri*) captured in the built-up area as against 27 individuals of four species (*P. tullbergi*, *A. niloticus*, *A. albiventris* and *C. olivieri*) were captured in the botanical garden (Table 1). The number of individuals of small mammals captured for each site was, however, not significantly different ($U = 35.000$; $U_{critical\ (7,7;\ 0.05)} = 41.000$; $P > 0.05$). Average trapping success for the survey was 19.4%, narrowing down to 23.4% and 15.4% for the built-up area and botanical garden, respectively (Table 1).

C. olivieri was the commonest and most abundant small mammal species in both the botanical garden and the built-up area. The single specimens of *A. albiventris* and *P. tullbergi* occurred only in the botanical garden (the thicket and forest zones, respectively) whereas *M. musculoides* was recorded only in the built-up area (Table 1).

Relative abundance and diversity of the small mammal species

The relative abundance of the most abundant species at each site, *C. olivieri*, and the diversity values between the two sites were not significantly different ($U = 34.000$;

TABLE 1

Capture data of the small mammals trapped during the study period (% occurrence values in bracket and same variable indicate no significant difference between the two sites)

Order	*Family*	*Species*	*Number of individuals captured*		
			Built-up area	*Botanical garden*	*Total*
Soricomorpha	Soricidae	*Crocidura olivieri*	34 (82.9)	23 (85.2)	57 (83.8)
Erinaceomorpha	Erinaceidae	*Atelerix albiventris*	0 (0.0)	1 (3.7)	1 (1.5)
Rodentia	Muridae	*Arvicanthis niloticus*	4 (9.8)	2 (7.4)	6 (8.8)
		Mus musculoides	3 (7.3)	0 (0.0)	3 (4.4)
		Praomys tullbergi	0 (0.0)	1 (3.7)	1 (1.5)
Total number of individuals			41a	27a	68
Number of trap-nights			175	175	350
Trapping success (%)			23.4	15.4	19.4

$U_{critical\ (7,7;\ 0.05)}$ = 41.000; $P > 0.05$ and U = 14.000; $U_{critical\ (5,5;\ 0.05)}$ = 23.000; $P > 0.05$ respectively) (Table 2).

Reproductive characteristics of the small mammal community on the University of Ghana Legon Campus

Reproductive features were determined for only the adult small mammal species because they exhibited well-developed and visible reproductive characteristics. With the exception of *A. albiventris* and *P. tullbergi*, all of the other species of small mammals showed some evidence of reproductive activity. All the male *M. musculoides* and *A. niloticus* showed prominent scrotal testes while the only female *A. niloticus* exhibited signs of lactation (Table 3).

Discussion

The Accra Plains is a vast area of land of which the University of Ghana forms a small percentage. Studies done by Decher & Bahian (1999) in conservation sites within the Accra Plains revealed 13 species of small mammal (four soricomorphs – shrews, and

TABLE 2

Relative abundance and diversity values of small mammals in the two sites during the study period (same variable indicate no significant difference between the two sites)

Species	*Relative Abundance*	
	Built-up area	*Botanical garden*
Crocidura olivieri	19.4 ± 9.1a	13.1 ± 7.6a
Atelerix albiventris	0.0 ± 0.0	0.6 ± 1.5
Arvicanthis niloticus	2.3 ± 3.1	1.1 ± 2.0
Mus musculoides	1.7 ± 3.1	0.0 ± 0.0
Praomys tullbergi	0.0 ± 0.0	0.6 ± 1.5
Diversity measure		
Shannon-Wiener, H^I	0.5736 ± 0.1078a	0.5735 ± 0.0704a
exp H^I	1.1267 ± 0.1197a	1.1237 ± 0.0771a

TABLE 3
Reproductive characteristics of the adult small mammals captured during the study period

Species	*Total*	*Male* *Scrotal testes (%)*	*Total*	*Femal* *Percentage pregnant*	*Percentage Lactating*
C. olivieri	38	0.0	16	0.0	43.8
A. albiventris	1	0.0	0	0.0	0.0
A. niloticus	5	100.0	1	0.0	100.0
M. musculoides	3	100.0	0	0.0	0.0
P. tullbergi	1	0.0	0	0.0	0.0

nine murids). Comparing the results of the two studies, only *P. tullbergi* was common to both sites. This study added two new species of insectivores (*C. olivieri* and *A. albiventris*) and one murid, *A. niloticus* to the existing species list of the Accra Plains (Decher & Bahian, 1999), bringing the species list of small mammals of the Accra Plains to 16.

The white-bellied hedgehog, also called four-toed hedgehog (*A. albiventris*) is unusually encountered in small mammal surveys due to their very low trappability in Sherman traps, suggesting reasons for the need to conserve and protect the botanical garden. This species usually inhabit relatively open, dry and seasonal habitats with sparse or patchy grass cover (Kingdon, 2004), confirming the occurrence of *A. albiventris* in the thicket-grassland boundary of the botanical garden where it was captured.

A. niloticus occurs in grassland and secondary thicket vegetations but has a marked preference for farmlands (Rosevear, 1969), signifying its preference for habitats that are degraded with ample food resources. All but one of the *A. niloticus* in this study were trapped in areas which had some amount of refuse. The trapping of more *A. niloticus* in the built-up area than the botanical garden confirms that the built-up area is more degraded in terms of human interference than the botanical garden. The unstriped grass rats of the botanical garden were both caught at the peripheries of the thicket zone.

M. musculoides occurs in any kind of habitat – grassland, farms in forests and towns, and around buildings. It occurs in habitats with low canopy cover (Rosevear, 1969). All the *M. musculoides* in this study were caught near buildings, specifically around the halls of residence.

P. tullbergi is a forest species but also inhabit, farmlands, plantations, homes and gardens (Rosevear, 1969). It has a more generalized habitat and dietary requirements than other true forest species (Barnett *et al*., 2000). The only *P. tullbergi* in this study was caught in the planned forest zone of the botanical garden. *P. tullbergi* can occur in buildings where it can obtain food but in-house trapping was not included in this study, suggesting their preclusion from the built-up area. This makes the forest zone of the botanical garden an important site for the conservation of *P. tullbergi*.

The relatively higher numbers of *C. olivieri* in comparison to the other small mammal species may be due to its occurrence in all kinds of natural habitats and in human settlements. It, however, rarely occurs in rainforests and natural savanna, suggesting that they are common in human interfered habitats such as the University of Ghana Campus, Legon. Owing to their preference for man-made habitats, it is probable that their numbers and range increase with increasing man-made habitats (Hutterer & Happold, 1983). This may have resulted in the higher number of individuals of *C. olivieri* in the built-up area than the botanical garden. Significant alterations in abundance of *C. olivieri* in both sites during future studies may, therefore, indicate increment in infrastructural development or any such human settlement in the study area.

Generally, the occurrence of small mammals decreases with increasing levels of development (Gbogbo *et al*., 2006). This is because, in putting up buildings, vegetation and associated fauna are eliminated along with food and shelter needed by the small mammals for growth and survival (Anderson, 1991). The botanical garden had fragments of different vegetation types compared to the built-up area that had only grassland vegetation. There was, therefore, the expectation that diversity of small mammals would be higher in the garden than the built-up area. The study, however, showed no significant difference between the abundance and diversity of small mammals in the built-up area and the botanical garden.

Most of the buildings in the built-up area are well spaced, with low growing grasses (some few areas around the staff bungalows had tall grasses), and this could be providing enough hiding, breeding and foraging habitats for the small mammals, especially *C. olivieri*, which was mostly caught in the grassland vegetation. The difference in size of the two habitats might have also accounted for the insignificant difference in abundance. Thus, although the built-up area had faced much habitat destruction, its large size, coupled with patches of vegetation, might have compensated for the loss of habitat. This means that it is essential for town planners to designate green areas in their building plans to serve as critical habitats for local wildlife species.

Conclusion

Contrary to the expectation that real estate development would have a negative impact on the diversity and abundance of small mammal species, comparative data on small mammals in a built-up area and the botanical garden of the University of Ghana Campus, Legon showed no significant differences. *C. olivieri* was the most common species in both study sites and alterations in its abundance in the future may be used to indicate man-made changes such as infrastructural development on the Legon campus of the University of Ghana.

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