Small Mammals Distribution and Composition in the Agumatsa Range, Volta Region, Ghana

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Abstract

The diversity and abundance of flora and fauna are declining alarmingly. Loss of original habitat has been documented as the most prevalent cause of species extinction globally. We assessed the present status of the small mammal species in the Agumatsa range, specifically in the Gbledi Gborgame, Gbledi Chebi, Fodome Ahor, and Wli Afegame settlements, which are located at the foot of the Agumatsa Range with similar habitat structure and complexity. Fifteen Sherman live collapsible traps (8 x 9 x 23 cm) were placed in 15-meter transects (n=60) separated 10 meters apart in the four communities and monitored for six months in 2019 and 2020. Traps were activated for five consecutive nights at each site for every sample session, making 14,400 trap nights of sampling. All traps were baited with peanut butter mixed with cornbread and set at ground level at the sampling sites. Seven hundred eighty-seven individual species were recorded, with an overall trap success rate of 5.5%. Species and frequencies recorded in the entire survey were *Praomys tullbergi* (238), *Mastomys erythroleucus* (200), *lemniscomys striatus* (139), *Crocidura crossei* (92), *Mus musculus* (75), *Tatera kempi* (21), *Dasymys incomtus* (14) and *Oenomys ornatus* (8). Specifically, 279 individual species were recorded in the rainy season, and 264 and 246 individuals were recorded in the dry and minor rainy seasons, respectively. The Gbledi Gborgame community had the most individual species (n=237). *Praomys tullbergi* (n=87) was the most numerous species during the dry season, whereas *Mastomys erythroleculus* (n=69) was the most abundant during the minor wet season. *Praomys tullbergi* was detected at all altitudes where the traps were deployed. *Dasymys incomtus* and *Oenomys ornatus* were species discovered in the Fodome Ahor community only, whereas *Lemniscomy straitus* was the only species not discovered in Gbledi Gborgame. The results of this study indicate that the forest along the Agumatsa range is under pressure from increased demand for natural products, thereby reducing the size and quality of small mammal habitats. The fast rate of deforestation of the Agumatsa range urgently requires an update of current records on the status of the different small mammal communities.

Keywords: Small Mammals, Agumatsa range, *Praomys tullbergi*, *Dasymys incomtus*, *Oenomys ornatus*

Introduction

Small mammals play critical roles in forest ecosystems and contribute to the biological and functional diversity of many ecosystems (Decher et al., 2021, Ofori et al., 2018, Nicolas et al., 2010) as consumers (Ofori et al., 2015), predators and dispersers of seeds, burrowers and as prey for carnivores and raptors (Adjapong et al. 2022, Ofori et al., 2022, Osman et al., 2022). Changes in habitat structure and complexity are associated with small mammal community structure changes and species richness (Avenant, 2011; Owusu et al., 2005). An ecological disturbance of the habitat of small mammals is often associated

with a decrease in small mammals' diversity. Therefore, the biodiversity of small mammals can be used as an indicator of disturbance in an ecosystem (Decher et al.; 2000).

Agumatsa range is located in the Hohoe District, Southeast of Hohoe in Ghana. It is part of the Akwapim – Togo Range, which is aligned North –East to South –West between the Volta River and the International border with Togo (Afenyo, 2018; Owusu et al., 2005; Ntiamoa-Baidu et al., 2001). The sites are currently not protected due to the exit of the Ghana Wildlife Society and the collapse of the Community Resource Management Area (CREMA) committee at the various sites. This distinctive vegetation has a high susceptibility to fire, placing the area on the national priority list of forest sites needing protection (Decker et al., 2021). The forest was declared and gazetted as a community nature reserve. Still, the local communities use the forest for hunting and collection of forest products, including *Thaumatococcus daniellii*, a species of Marantaceae exported for the extraction of the sweetener thaumatin, the leaves of which are used locally as a food wrapper (Owusu et al., 2005). The vegetation has shrunk, reducing the habitat qualities for small mammals, and information on the status of the different small mammal communities needs updating (Decker et al., 2021). Therefore, the objectives of the research were to examine the current status of small mammals' composition and distribution along the Agumatsa range. It was hypothesized that with similar habitat structure and complexity, there would be no variation in small mammal composition, sex ratio, abundance, and diversity.

Materials and Method

The study was conducted along four communities on the Agumasta range, Wli Afegame (7°09'18.69" 0°28'22.94"), Fodome Ahor (7°06'33.44" 0°27'11.04"), Gbledi Chebi (7°07'20.69" 0°19'24.35") and Gbledi Gborgame (7°11'01.86" 0°19'57.86"). Wli Afegame is about 5 kilometers from Fodome Ahor. From Fodome Ahor to Gbledi Chebi is about 4 kilometers and from Gbledi Chebi to Gbledi Gborgame is about 3 kilometers. The site includes that part of the mountain range, which falls within the Gbledi Gborgame, Gbledi Chebi, Fodome Ahor, and Wli (Owusu et al., 2005). The reserve is estimated to cover c. 2,000 ha. (Key Biodiversity Areas factsheet (KBA), 2022). The Agumatsa range lies within the dry – Deciduous Forest zone but includes a well-developed Guinea Savanna. The western slopes of the hills support semi–deciduous forests, part of which is disturbed, but savanna the wooded savanna dominates the more vertical eastern sides. Derived savanna grassland occurs in low–lying areas between settlements and on the lower slopes of the hill, but the presence of scattered, remnant forest trees, for instance, *Cola gigantean*, *Albizia adianthifolia*, *Morus mesozygia*, and *Antiaris toxicaria*, indicates that the area once supported semi–deciduous forest (KBA, 2022; GWS 2008).

Live trapping of small mammals

Sherman collapsible live traps were used to capture small mammals at the study site. The survey was conducted in 2019 (January, February, May, June, August, and September) and in 2020 (May, June, August, September, November, and December). Traps were baited with corn dough mixed with peanut butter and placed along transects established in each habitat for five consecutive nights. Trap lines consisted of 15 Sherman trap spaces about 10 meters apart. Overall, there was a total of 14,400 trap nights. Captured individuals were identified on the spot, sex determined, weighed, marked, and released at the point of capture. Small mammal trapping and handling complied with recommended guidelines and standard methods for mammal fieldwork (Sikes et al., 2011), and taxonomy was by the procedure of Wilson and Reeder (2005).

Data analysis

Species richness was calculated as the number of individual species captured in a particular habitat. The relative abundance of individual

species was computed as the ratio of the number of specific species to the total number of all individuals captured in a habitat. Trap success was calculated as the ratio of the number of individuals captured to the total trap nights in a habitat multiplied by 100%. Analyses were performed using R statistical software v 4.0, and significance was set at $p < 0.05$.

Results

A total of 787 individual species (640 individuals, 77 juveniles, and 70 pregnant females) were captured during the sampling period with 14 400 trap nights and an overall trap success of 5.5%. The female-to-male ratio was 389 to 397 (p-value = 0.0065). Species captured comprised of *Praomys tullbergi* (239), *Mastomys erythroleucus* (200), *lemniscomys striatus* (139), *Crocidura crossei* (92), *Mus musculus* (75), *Tatera kempi* (21), *Dasymys incomtus* (14) and *Oenomys ornatus* (8).

Species diversity

Species diversity of small mammals expressed by Simpson's index of dominance (D) and Shannon–Wiener index of diversity (H') is presented in Table 1.

Dominance measures the relative abundance of different species in a community. A lower dominance value suggests that the community is more evenly distributed, while a higher value indicates that a few species dominate the community. In this case, all the communities have relatively low dominance values, which suggests a more even distribution of species. Simpson's Diversity Index quantifies the probability that two individuals randomly selected from the community belong to the same species. Higher values indicate lower diversity, so these communities have relatively high diversity as the values are close to 1

Shannon's Diversity Index measures the uncertainty in predicting the species of a randomly selected individual from the community. Higher values indicate higher diversity. Fodome Ahor has the highest Shannon diversity index, suggesting the highest species diversity among the communities. Evenness measures how evenly the individuals are distributed among the different species in a community. A value of 1 represents perfect evenness, and lower values suggest uneven distribution. Chebi and Gbledi Gborgame have high evenness, indicating that the species are relatively evenly distributed within these communities. Fodome Ahor appears to have the highest species diversity among the communities, while Chebi and Gbledi Gborgame have more even species distributions. The ratio of male to female population was 1:1 hence there was no significant change (t=-9.737, df = 3.23, p-value = 0.0016) at 95% confidence interval.

Seasonal influence on species distribution

In the dry season (January and February in 2019; November and December in 2020), the total number of individual species captured was 262 individuals. A total of 246 individual species were captured in the minor rainy season (August & September 2019 and 2020), and a total of 279 individual species were

TABLE 1
Small mammal species richness (S), Simpson's index of dominance (D), and Shannon–Wiener index of diversity (H') in each community

Community	Number of Species	Number of Individual	Simpson's index of Dominance	Simpson diversity index	Shannon Wiener index	Evenness	Shapiro-Wilk test	p-value
Gbledi Chebi	5	213	0.22	0.78	1.54	0.93	0.83	0.05
Fodome Ahor	7	146	0.23	0.77	1.64	0.74	0.90	0.20
Gbledi Gborgame	4	238	0.29	0.71	1.31	0.93	0.80	0.03
Wli Afegame	6	190	0.21	0.79	1.62	0.84	0.85	0.10

TABLE 2
Relative abundance, trap success, and composition of small mammal species recorded during the study period

Small mammal species	Community Name				Total number of individuals	Relative abundance	Trap success(%)
	Gbledi Gborgame	Gbledi Chebi	Fodome Ahor	Wli Afegame			
Crocidura crossei	42	42	3	5	92	0.12	0.63
Dasymys incomtus	0	0	14	0	14	0.02	0.01
Lemniscomys striatus	0	57	37	45	139	0.18	1.11
Mastomys erythroleucus	77	46	29	48	200	0.25	1.40
Mus musculus	32	15	7	21	75	0.11	0.52
Oenomys ornatus	0	0	8	0	8	0.01	0.05
Praomys tullbergi	87	53	48	50	238	0.30	1.70
Tatera kempi	0	0	0	21	21	0.03	0.14
Totals	238	213	146	190	787	1.00	5.5

captured in the major rainy season (May & June in 2019 and 2020). Gbledi Gborgame community recorded the most individual species in all the seasons (Fig 2), followed by the Gbledi Chebi community, Wli community, and Fodome Ahor in that order during the study period.

Seasonal distribution of species at the various communities

The Gbledi Gborgame community recorded the highest (239 individuals) number of individual species captured during the study period (Dry season – 113, minor rainy season – 36, and rainy season – 90). The Gbledi Chebi community recorded the second highest number (213 individual species) for the duration of the study (Dry Season – 116, minor season – 22, and rainy season – 75) whereas the Wli community also recorded a total of 190 individual species (dry season – 109, minor season – 23, and rainy season 58) followed by the Fodome Ahor community (146 individuals) for the period of the study with 72, 18, and 56 individuals for the dry, minor, and rainy seasons respectively. During the dry season, *Praomys tullbergi* was the most captured individual species, with an abundance of 87 captures (Fig. 5). *Mastomys erythroleculus* was the second most abundant

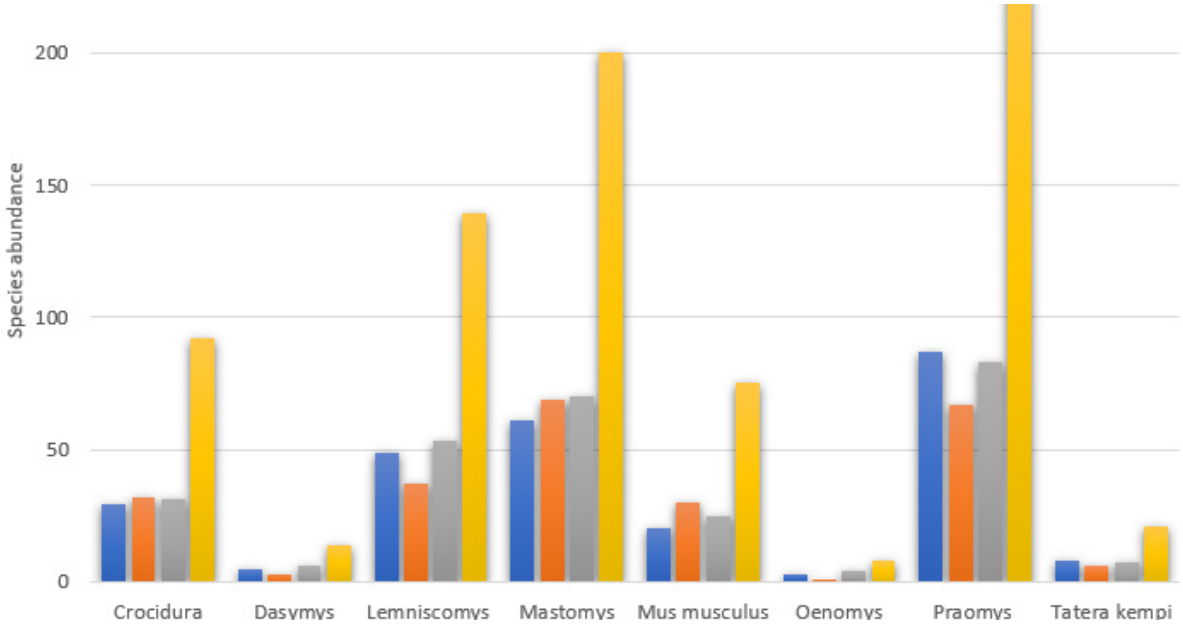

Fig. 2 Seasonal distribution of species captured at the sites

individual species, with 61 captures. The *Leminscomys striatus*, *Crocidura crossei*, and *Mus musculus* had an abundance of 49, 29, and 20 individual capture respectively. *Tatera kempi*, *Dasymys incomtus*, and *Oenomys ornatus* recorded the least individual capture of 8, 5, and 3, respectively. For the minor rainy season, *Mastomys erythroleculus* recorded the most individual species of 69 while *Praomys tullbergi* recorded 67 and *Leminscomys striatus* recorded 37 individuals. *Crocidura crossei*, *Mus musculus*, and *Tatera kempi* recorded 32, 30, and 6 individual captures respectively. The *Dasymys incomtus* and *Oenomys ornatus* were the least captured of 3 and 1 individual species, respectively. For the major rainy season, *Proamys tullbergi* recorded 83 individuals, *Mastomys erythroleculus* recorded 70 individuals, *Lemniscomys straitus* recorded 53, and *Crocidura crossei* recorded 31 individuals. The remaining species, *Mus musculus*, *Tatera kempi*, *Dasymys incomtus*, and *Oenomys ornatus*, recorded 25, 7, 6, and 4 individuals, respectively.

Species distribution and altitudes

Between the range of 211 to 244 masl, more (56 individuals) *Praomys tullbergi* were captured, followed by *Lemniscomys striatus* with 44 individuals and *Mastomys erythroleucus* with 31 individuals. *Mus musculus* and *Oenomys ornatus* had eight individuals each, and *Crocidura crossei* and *Tatera kempi* were the least of species captured on this range of altitude 3 & 4, respectively. All 14 species of *Dasymys incomtus* were caught in this range, 211 to 244 masl of altitude. Between the altitudinal range from 245 masl to 253 masl, *Mastomys erythroleucus*, *Praomys tullbergi*, & *Lemniscomys striatus* were the most captured individual species with 40, 38 & 36 on the range, respectively. There was no capture for *Crocidura crossei*, *Dasymys incomtus*, and *Oenomys ornatus*; however, both *Mus musculus* and *Tatera kempi* had 17 individual species captured on this scale. More individual species were captured at altitudes 262 masl to 284 masl in this order: *Praomys tullbergi* (139), *Mastomys erythroleucus* (126), *Crocidura crossei* (85), *Lemniscomys striatus* (59), and *Mus musculus* (48). There was no capture for *Dasymys incomtus*, *Oenomys ornatus*, and *Tatera kempi.*

Discussion

Small mammal species composition and distribution were assessed in the Agumatsa range. The study sites were four communities at the feet of the Agumatsa range Gbledi Gborgame, Gbledi Chebi, Fodome Ahor, and Wli Afegame. The aim was to update the records of species lists along these communities and to document which species is more dominant and widespread on the range. Findings from this research suggest that the forest along the Agumatsa range is under pressure from increased demand for natural products. This has made the vegetation shrink in size thus reducing the habitat qualities for small mammals. As the resultant changes are happening very fast, information on the status of the different small mammal communities needs updating. One of the significant challenges for an ecologist is to be able to forecast what the consequences will be for the stability and persistence of species inhabiting the ecosystem. Due to the interdependence among species in ecological networks, the loss of one species or even a change in the abundance of one species can cause a dramatic change or trigger a cascade of secondary extinction (Saavedra et al., 2011; Fowler 2010 & Dunne et al., 2002). According to Blaum et al., (2007), the abundance and distribution of small mammals vary spatiotemporally due to environmental variations such as biotic and abiotic factors. The study revealed significant changes in small mammal composition, distribution, and abundance over the study period, and this may account for changes in the vegetation cover over the past 30 years. A baseline survey of the study area on Mount Afadjato by Attuquayefio et al., (2005) recorded 15 individuals of three species: Eight individuals of *Praomys tullbergi*, six individuals of *Mus*

sp, and one individual of *Hylomyscus stella* in 250 trap nights with trap success and relative abundance being 6% and six respectively. Ofori et al., (2014) recorded 82 individual small mammals belonging to two orders (Rodentia and Insectivora), *Praomys tullbergi* and Crocidura crossei, in 3,360 trap nights. Yet another research in the study area by Boahen et al., (2021) recorded 210 individual species comprising *Praomys tullbergi*, *Mastomys erythrolecucus*, *Mus minutoides*, and *Myomys* sp over 2,208 trap nights and 9.5% trap success. This study recorded 787 individual species comprising eight species; *Crocidura crossei*, *Dasymys incomtus*, *Lemniscomys sriatus*, *Mus musculus*, *Mastomys erythroleculus*, *Oenomys ornatus*, *Praomys tullbergi*, *Tatera kempi* with a trap success of 5.5%. With the exception of *Dasymys incomtus* and *Oenomys ornatus*, which were only captured at Fodome Ahor because of the wetter grassy habitat and the presence of the Nubui river and that of *Tatera kempi* only captured at Wli, the rest of the species were evenly distributed in the other communities. However, *Lemniscomys striatus*, a grassland species, was not captured at the Gbledi Gborgame community, and even previous records suggest that there was no abundant grass cover. Gbledi Chebi, however, had the most abundant individuals of *Lemniscomys striatus* due to abundant grass cover and much felling of trees, as well as the creation of new agricultural fields. The mono dominance of *Praomys tullbergi* during the study period could have some conservation implications by largely improvising the diversity of the specialist species. The loss of some species and overabundance of others could have a potentially negative impact on a wide range of ecological processes because of the diverse ecological roles played by different small mammal species in the forest ecosystem (Attuquayefio et al., 2017; Ofori et al., 2013). During one-on-one interaction with opinion leaders in the community, some attested to the use of chemicals in cultivating their lands, which might have influenced small mammals' distribution. Again, the breakdown of the Community Resource Management Committee in each of the study communities has paved the way for hunters and tree loggers to hunt for bush meat and alter the habitat of small mammals. Previous work carried out by Decher and colleagues in 1999 had 426 trap nights with a total of 108 individual species comprising *Praomys* sp, *Malacomys edwardsi* (Edward's swamp rat), *Dephomys defua* (Defua mouse), *Hylomyscus alleni* (Allen's wood mouse), *Lemniscomys striatus* (striped grass mouse), *Graphiurus nagtglasii* (African Dormouse), *Mus musculoides* (pygmy mouse), *Tatera kempi* (Kemp's savanna gerbil), *Anomalurus beecroftii* (Beecroft's scaly tailed flying squirrel), *Paraxerus poensis* (Green bush squirrel), *Xerus erythropus* (striped ground squirrel)), *Crocidura cf. douceti* (Doucet"s musk shrew), *Crocidura foxi* (Fox's musk shrew), and *Galago* sp.(bush baby). While this study did not capture any squirrels as a result of the traps used, forest specialist species such as *Malacomys edwardsi* and *Hylomyscus alleni* were not recorded in this study, and this could be due to the frequent fire outbreaks during the dry seasons. *Dephomys defua* and *Graphiurus nagtglasii* were also not captured in this research. However, *Lemniscomys straitus*, *Mus musculoides*, *Tatera kempi*, and *Crocidura* sp were recorded in this research.

Conclusion

Most of the local human population depends on forests for their livelihoods, which is not only peculiar to the four communities at the feet of the Agumatsa range. Hence an urgent need to conserve the remaining wildlife, especially small mammals, without delay on this side of the range. It is evident from this research that *Oenomy ornatus* and *Dasymys incomtus* were recorded in Fodome Ahor only for the first time, and all efforts need to be in place to increase its population as their diversity and abundance were very low.

References

Adjapong, A. O., Oppong, S. K., Nsor, C. A., Boakye, E. A., Ashiagbor, G., Seidu, I.

& Danquah, E. (2022). Agri-driven habitat modification and small mammal species assemblage nexus in the Atewa Range and Bimpong Forest Reserves, Ghana. *Trees, Forests and People*,**10**:100335.

Adjei, R., Boakye, G. & Adu, S. (2001). Organisational Profile: Ghana Wildlife Society. *Marine Turtle Newsletter*,**93**:11-12.

Afenyo, E. A. (2018). *Residents' experiences with tourism as a livelihood strategy in Wli*, Ghana Doctoral dissertation, University of Cape Coast. Unpublished.

Attuquayefio, D. K., Owusu, E. H., & Ofori, B. Y. (2017). Impact of mining and forest regeneration on small mammal biodiversity in the Western Region of Ghana. *Environmental monitoring and assessment*, **189**:1-9.

Avenant, N. L. (2000). Small mammal community characteristics as indicators of ecological disturbance in the Willem Pretorius Nature Reserve, Free State, South Africa. *South African Journal of Wildlife Research-24-month delayed open access*, **30(1)**:26-33.

Bakarr, M., Bailey, B., Byler, D., Ham, R., Olivieri, S. & Omland, M. (2001). From the Forest to the Sea: Biodiversity Connections from Guinea to Togo. Conservation International, Washington, DC. 78 pp.

Blaum, N., Rossmanith, E. & Jeltsch, F. (2007). Land use affects rodent communities in Kalahari savannah rangelands. *African Journal of Ecology*, **45(2)**:189-195.

Boahen, F. A. (2021). Altitudinal variation in small mammal distribution on Mountain Afadjato. *Science and Development Journal*, **4(2)**:1-10.

Decher, J. & Bahian, L. K. (1999). Diversity and structure of terrestrial small mammal communities in different vegetation types on the Accra Plains of Ghana. *Journal of Zoology*, **247(3)**:395-408.

Decher, J., Kilpatrick, C. W. & Bahian, K. L. (2001). Small mammal zoogeography and diversity in West African forest remnants. *Progress report, Ghana. Wildlife Division*.

Decher, J., Norris, R. W., Abedi-Lartey, M., Oppong, J., Hutterer, R., Weinbrenner, M., ... & Kilpatrick, C. W. (2021). A survey of small mammals in the Volta Region of Ghana with comments on zoogeography and conservation. *Zoosystema*,**43(14)**:253-281.

Dunne, J. A., Williams, R. J., & Martinez, N. D. (2002). Network structure and biodiversity loss in food webs: robustness increases with connectance. *Ecology Letters*, **5(4)**:558-567.

Fowler, J. H. & Christakis, N. A. (2010). Cooperative behaviour cascades in human social networks. *Proceedings of the National Academy of Sciences*, **107(12)**:5334-

Hughes, J. J., Ward, D. & Perrin, M. R. (1994). Predation risk and competition affect habitat selection and activity of Namib Desert gerbils. *Ecology*, **75(5)**:1397-1405.

Kerley, G. I. (1992). Ecological correlates of small mammal community structure in the semi-arid Karoo, *South Africa. Journal of Zoology*, **227(1)**, 17-27.

Kotler, B. P. (1984). Risk of predation and the structure of desert rodent communities. *Ecology*, **65(3)**:89-701.

Nicolas, D., Lobry, J., Le Pape, O. & Boët, P. (2010). Functional diversity in European estuaries: relating the composition of fish assemblages to the abiotic environment. *Estuarine, Coastal and Shelf Science*, **88(3)**:329-338.

Ntiamoa-Baidu, Y. A. A., Owusu, E. H., Daramani, D. T. & Nuoh, A. A. (2001). Ghana. Important Bird Areas in Africa and Associated Islands Priority sites for conservation. (L.D.C. Fishpool and M.I. Evans, ed.), pp.367-389. Newbury and Cambridge, UK: Pisces Publications and Birdlife International (Birdlife conservation series No. 11).

Ofori, B. Y., Garshong, R. A., Gbogbo, F., Owusu, E. H. & Attuquayefio, D. K. (2018). The urban green area, provides refuge for native small mammal biodiversity in a rapidly expanding city in Ghana. *Environmental Monitoring and Assessment*, **190**:1-11.

Ofori, B. Y., Stow, A. J., Baumgartner, J. B. & Beaumont, L. J. (2017). Influence of adaptive capacity on the outcome of climate

change vulnerability assessment. *Scientific reports*, **7(1)** 12979.

Olson, R. A. & Brewer, M. J. (2003). Small mammal populations occurring in a diversified winter wheat cropping system. *Agriculture, ecosystems & environment*, **95(1)**:311-319.

Osman, A., Mariwah, S., Yawson, D. O. & Atampugre, G. (2022). Changing land cover and small mammal habitats: Implications for landscape ecological integrity. *Environmental Challenges*,**7**:100514.

Saavedra, S., Stouffer, D. B., Uzzi, B. & Bascompte, J. (2011). Strong contributors to network persistence are the most vulnerable to extinction. *Nature*, **478(7368)**:233-235.

Seamon, J. O. & Adler, G. H. (1996). Population performance of generalist and specialist rodents along habitat gradients. *Canadian Journal of Zoology*, **74(6)**:1130-1139.

Sikes, R. S. & Gannon, W. L. (2011). Guidelines of the American Society of Mammalogists for using wild mammals in research. *Journal of Mammalogy*, **92(1)**:235-253.

Wilson, D. E. & Reeder, D. M. (Eds.). (2005). *Mammal species of the world: a taxonomic and geographic reference* (Vol. 1). John Hopkins University Press, Baltimore