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COMMUNICATION

University campuses can contribute to wildlife conservation in urbanizing regions: a case study from Nigeria

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Abstract: Globally, colleges and universities are increasingly mandating sustainability and environmental protection into their practices. To date, such institutions have focused their efforts on recycling and energy-use reduction and less on the management and conservation of wildlife and wildlife habitats. However, in an increasingly urbanizing world, well-managed campuses can provide habitat and even refuge for wildlife species. On the campus of a sustainability-minded university in Nigeria, we used camera traps to determine the presence of wildlife and used occupancy modeling to evaluate factors that influenced the detectability and habitat use of two mammals for which we had sufficient detections: White-tailed Mongoose *Ichneumia albicauda* and Gambian Rat *Cricetomys gambianus*. Our intent was to gather baseline data on campus wildlife to inform future research and make recommendations for maintaining wildlife populations. We detected wildlife primarily within less-disturbed areas that contained a designated nature area, and the presence of a nature area was the key predictor variable influencing habitat use. No measured variables influenced detectability. This study supports other research that highlights the importance of undisturbed or minimally disturbed natural habitats on university campuses for wildlife, especially in increasingly built-up and developed regions. We recommend that institutions of higher education devote greater resources to making campuses wildlife-friendly and increase opportunities for students to engage in campus-based wildlife research and conservation and other sustainability-related programs.

Keywords: Camera trap, *Cricetomys gambianus*, detectability, habitat use, *Ichneumia albicauda*, occupancy modeling, sustainability, wildlife management.

Hausa abstract: A duk fadin duniya, kwalejoji da jami'o'i suna kara ba da umarnin dorewa da kiyaye muhalli cikin ayyukansu. Har ya zuwa yau, irin wadannan cibiyoyin sun mayar da hankalinsu kan sake sarrafawa da rage amfani da makamashi sun kuma rage kulawa da kiyaye namun daji da muhalli. Sai dai kuma, duk da yawan karuwar birane, harabar jami'a mai kyakkyawan tsari na iya samar da mazauni har ma da mafaka ga nau'ukan namun daji. A wata harabar jami'a mai dorewa a Nijeriya, mun yi amfani da tarko na kyamara don ƙaddara kasancewar halittu da amfani da tallan zama don kimanta abubuwan da suka shafi tasirin ganowa da amfani da mazaunin dabbobi masu shayarwa guda biyu waɗanda muke da cikakkun bincike game da su: White-tailed Mongoose *Ichneumia albicauda* da Gambian Rat *Cricetomys gambianus*. Manufarmu ita ce tattara bayanan asali kan namun daji na harabar don sanar da bincike na gaba da ba da shawarwari don kiyaye yawan namun daji. Mun gano dabbobin daji da farko a cikin yankunan da ba hayaniya wanda ya kunshi yanki na musamman, kuma kasancewar wani yanki shine maɓallin canjin tasiri mai amfani da wurin zama. Babu wani canji da aka auna wanda yayi tasiri akan ganowa. Wannan binciken yana karfafa wasu binciken da ke nuna mahimmancin rashin hayaniya a wuraren zama na rayuwa a makarantun jami'a don rayuwar namun daji, musamman a wuraren da ke da ingantattun gine-gine da yankuna masu tasowa. Muna ba da shawarar cewa cibiyoyin ilimi mafi girma su ba da kaso mai tsoka don samar da cibiyoyin karatun abokantaka na namun daji tare da habaka dama ga ɗalibai don shiga cikin bincike da kiyaye namun daji na cikin harabar makarantar da sauran shirye-shiryen da suka dace.

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INTRODUCTION

Institutions of higher education are increasingly integrating sustainability and environmental protection into their missions and practices (van Weenen 2000; Calder & Clugston 2003). This movement has led to several partnership platforms, such as the U.S.-based Association for the Advancement of Sustainability in Higher Education and United Nations Environment Program's Mainstreaming Environment and Sustainability in African Universities Partnership. Although some universities have given biodiversity conservation elevated importance (e.g., Kyushu University in Japan, Normile 2004), to date campus sustainability efforts have largely emphasized recycling programs and energy use (Bocsi et al. 2018). Management and conservation of wildlife and wildlife habitats have received comparatively limited attention. For institutions that do engage in wildlife habitat management, they generally favor certain practices, notably planting native species and using sustainable practices for lawn maintenance and landscaping, over providing food, water, and cover for wildlife (Bocsi et al. 2018).

Where campuses occur in crowded, urban landscapes or landscapes affected by habitat degradation and deforestation, natural campus sites may provide refuge for wildlife, including rare and endangered species (Ramli 2004; Aneesh et al. 2013). For institutions that devote resources to wildlife management, they may, at times by necessity, focus resources on the most visible, common species or shift resources to managing "problem" domestic animals. Such situations might include managing abundant wildlife species that threaten people on campus (Hubbard & Nielsen 2009) or managing increasing populations of feral cats (Tennent et al. 2009; Dombrosky & Wolverton 2014). As a result, campus authorities may overlook rare or cryptic species.

We investigated the status of wildlife on the campus of a sustainability-minded university in Nigeria. We determined the presence of mammals using cameras and assessed how anthropogenic and natural factors influenced detectability and habitat use of these species using occupancy modeling. At the time of our study, the university's sustainability programs focused on waste management, recycling, and water and energy conservation. Although the university informally set aside two plots of land as nature areas in 2013 and 2015, there have been no dedicated efforts to manage these sites for wildlife; for example, authorities regularly clear grasses in these areas to make the campus more attractive to visitors and reduce the risk of fire. The surrounding region has no official protected areas designated for biodiversity conservation. Because the university prohibits hunting and trapping, the campus may provide wildlife with respite from anthropogenic pressures in the region. The objectives of this work were to gather baseline data on campus wildlife to inform future research and recommend to university authorities best practices for maintaining wildlife populations.

METHODS

We conducted this study in the dry season (January–March 2018) on the American University of Nigeria (AUN) campus in Yola, Adamawa State, in northeastern Nigeria (Image 1). AUN was constructed in 2003 on ~110ha of land previously disturbed by livestock grazing, farming, and construction (Dariye 2016). Over time, grazing and farming were restricted. Regional habitat comprises woodland-savanna-grassland mosaic. Campus grounds are relatively open with sparse tree cover and abundant grasses, particularly Gamba Grass *Andropogon gayanus*. A 3m-high wall demarcates the campus perimeter. This wall does not restrict wildlife movement, however. Three open areas along the wall serve as an entrance for vehicles and a few parts of the wall are degraded, creating gaps through which wildlife could pass. Outside the university are mainly residential areas, farmland, and farm-savanna mosaic; however, local development is increasing.

We divided the campus into four study zones representing undeveloped sites: North Nature Zone (20ha, about half of which encompassed one of the two nature areas), South Nature Zone (16.5ha, nearly all of which encompassed the other nature area), Southwest Zone (4ha), and Northwest Zone (14ha). Although the university designated two nature areas on campus, they were informally delimited and not strictly protected. Each study zone varied by amount of vegetative cover and distance from built structures, with the nature-area zones having greater tree and shrub densities, commonly of *Azadirachta indica* and *Guiera senegalensis*. South Nature Zone had the highest species richness and diversity of woody plants (Dariye 2016).

Using a 150m-x-150m-grid overlay of the campus, we systematically placed two cameras (Bushnell Trophy HD Aggressor) at 150m intervals along the grid within each zone; we selected these intervals to ensure widespread coverage of each study zone and the campus. We used portable camera mounts set at a height of 30cm. Our sampling effort was proportional, based on size of the study zone: North Nature Zone: 37% (10 sampling points),

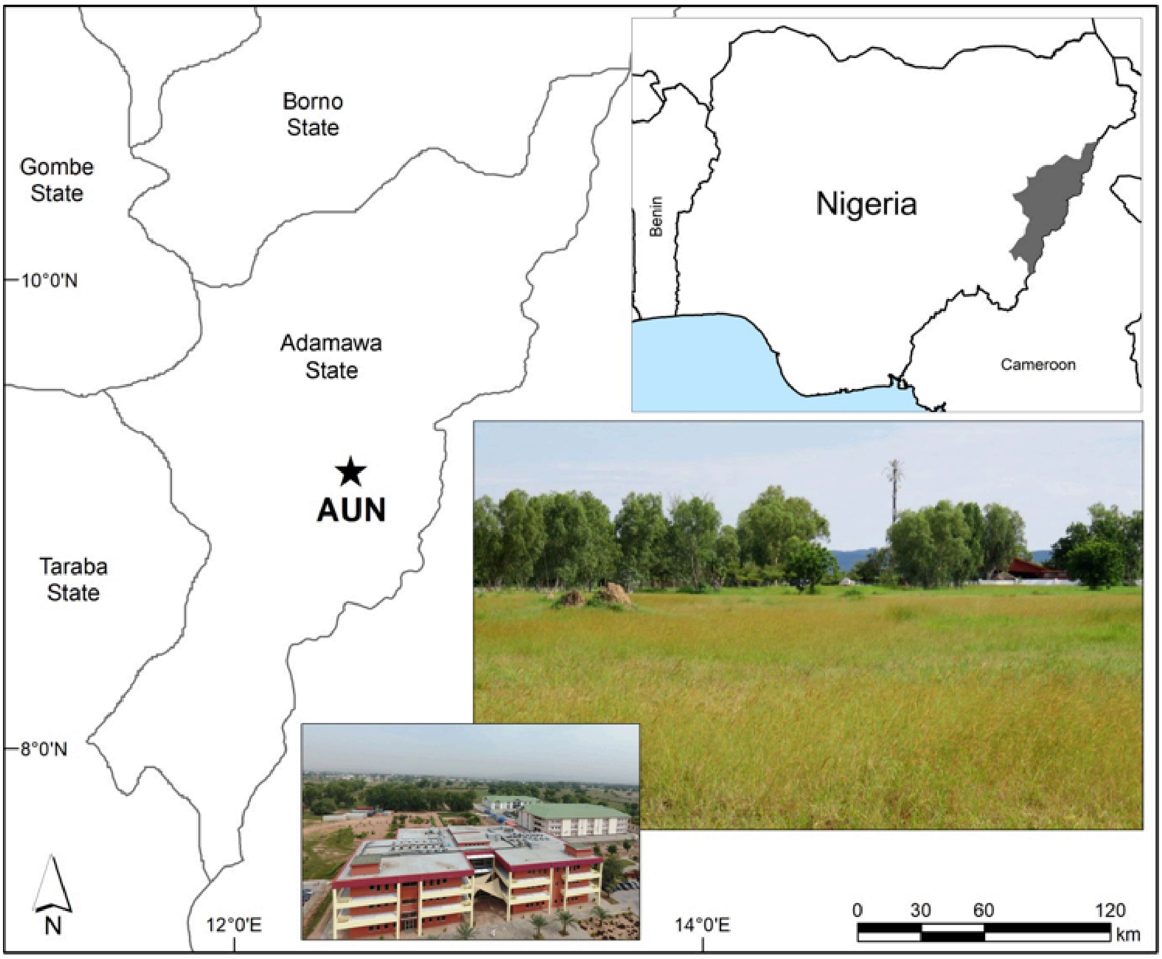

Image 1. Location of the American University of Nigeria (AUN) campus in Adamawa State, northeastern Nigeria, and photos of a nature area and aerial view of campus.

South Nature Zone: 30% (8 points), Southwest Zone: 7% (3 points), and Northwest Zone: 26% (8 points). Total number of sampling points was 29. During the study, we placed the two cameras at different sampling points and surveyed each sampling point for three nights.

Using Program PRESENCE (Hines 2006), we fitted a series of single-season occupancy models to the data. Number of cameras deployed per site represented spatially replicated surveys. We modeled the presence of each species to evaluate the influence of two site (habitat) covariates: presence of livestock and presence of a nature area. We included three sampling (survey-specific) covariates: detection of domestic cats (potential predators), whether the camera was physically under tree cover, and distance (in meters) to the nearest food/waste bin (standardized using a z-transformation).

Occupancy estimates rely on study designs that do not violate the basic assumptions of occupancy modeling, of which one is closure. We could not ensure that closure was met in this study, so we interpreted occupancy (ψ) as the proportion of sites used, instead of occupied, by a species (MacKenzie et al. 2006). The models, thus, estimated habitat use (ψ) and detection probabilities (p).

We initially held habitat use constant and modeled detection probabilities considering sampling covariates; we then held detection probabilities constant and modeled habitat use considering site-specific covariates. We used Akaike's information criterion (AIC) adjusted for small sample size (AIC_c) to calculate model weights. Starting with a null model [$\psi(.),p(.)$], we used a forward-selection approach (Baker et al. 2011). If a covariate did not reduce AIC_c compared to the null model, we removed that variable from the analysis. For each species, we initially conducted a goodness-of-fit test on the global model. Using 10,000 parametric bootstraps, we obtained a Pearson's chi-square statistic and estimated a variance inflation factor, $\hat{c}$. We then adjusted model ranks for overdispersion ($\hat{c} > 1$) using $QAIC_c$.

RESULTS

Cameras captured four wild mammals: White-tailed Mongoose *Ichneumia albicauda* (Image 2), Gambian Rat *Cricetomys gambianus* (Image 3), Banded Mongoose *Mungos mungo*, and Striped Ground Squirrel *Xerus erythropus*. None is a threatened species, and all are widely distributed in Africa. Cameras also captured feral cats and West African Dwarf goats. Of the mammals detected, we focused our analyses on the species for which we had sufficient data: White-tailed Mongoose and Gambian Rat. We detected White-tailed Mongoose only on the north side of campus and never in the same zone as Banded Mongoose; we detected Gambian Rat only in zones with nature areas. Cats occurred across all study zones and goats in just one zone (Table 1).

For both White-tailed Mongoose and Gambian Rat, no sampling covariates influenced detectability; all models with sampling covariates had a $\Delta QAIC_c > 5$, indicating little support for these models (Table 2). For White-tailed Mongoose, the best-supported models of habitat use included both site covariates: nature area and livestock (in this case, goats) (Table 2a). Each covariate had a slightly positive effect (nature area: $\beta = 0.215$, SE = 1.607; goats: $\beta = 25.952$, SE = not estimated). For Gambian Rat, the best-supported models also included nature area and livestock (Table 2b). Nature area had a positive effect on habitat use ($\beta = 29.199$, SE = not estimated), whereas presence of goats had a negative effect ($\beta = -27.327$, SE = not estimated).

Image 2. White-tailed Mongoose *Ichneumia albicauda*

Image 3. Gambian Rat *Cricetomys gambianus*

DISCUSSION

Given regional anthropogenic pressures, such as population growth, deforestation, and land degradation, we expected wildlife to use the AUN campus as university grounds provide some protection from exploitation. Most detections of wildlife in this study were within less-disturbed zones containing nature areas. That we did not detect wildlife in the Southwest Zone may be an artefact of sampling effort (i.e., smaller area) or because human disturbance around this area was common during our study. This research supports other studies that show that undisturbed or minimally disturbed natural habitats on campuses can support wildlife, providing refuge in urban or urbanizing regions (e.g., rare birds in Malaysia,

Table 1. Species detected in this study, zones where detected, and number of detections. A '+' denotes one detection, while '—' denotes no detection. Multiple '+' signs reflect the total number of detections for that zone.

Species	Northwest Zone	North Nature Zone	Southwest Zone	South Nature Zone
White-tailed Mongoose	+++	++	—	—
Gambian Rat	—	++	—	+++
Banded Mongoose	—	—	—	+
Striped Ground Squirrel	—	+	—	—
Domestic cat	+	+	+	+++
Dwarf goat	+	—	—	—

Table 2. Results of model selection for habitat use and detection probability using AIC corrected for sample size and overdispersion ($QAIC_c$). Best-supported models were those with lower $QAIC_c$ scores relative to the null model [$\psi(.),p(.)$] and model weights > 0.10.

a) White-tailed Mongoose

Model	$QAIC_c$	$\Delta QAIC_c$	Model weight	Likelihood	K[b]	-2* LogLikehood
ψ(nature area), p(.)	25.13	0.00	0.4997	1.0000	2	23.22
ψ(goats), p(.)	26.49	1.36	0.2531	0.5066	2	24.78
ψ(.),p(.)	27.35	2.22	0.1647	0.3296	2	25.76
ψ(.),p(distance-bins)	30.64	5.51	0.0318	0.0636	2	29.52
ψ(.),p(cats)	31.04	5.91	0.0260	0.0521	2	29.98
ψ(.),p(tree cover)	31.26	6.13	0.0233	0.0467	2	30.23
Global model[a]	36.83	11.70	0.0014	0.0029	5	24.92

b) Gambian Rat

Model	$QAIC_c$	$\Delta QAIC_c$	Model weight	Likelihood	K[b]	-2* LogLikehood
ψ(nature area),p(.)	24.88	0.00	0.4964	1.0000	2	23.22
ψ(goats),p(.)	26.23	1.35	0.2528	0.5092	2	24.78
ψ(.),p(.)	27.07	2.19	0.1661	0.3345	2	25.76
ψ(.),p(distance-bins)	30.33	5.45	0.0325	0.0655	2	29.52
ψ(.),p(cats)	30.72	5.84	0.0268	0.0539	2	29.98
ψ(.),p(tree cover)	30.94	6.06	0.0240	0.0483	2	30.23
Global model[c]	36.57	11.69	0.0014	0.0029	5	24.94

(.) Indicates that the parameter was held constant
[a] Used to estimate $\hat{c}$ using 10,000 parametric bootstraps ($\hat{c}$ = 1.1424)
[b] Number of model parameters
[c] Used to estimate $\hat{c}$ using 10,000 parametric bootstraps ($\hat{c}$ = 1.1565)

Ramli 2004; endemic and rare butterflies in India, Aneesh et al. 2013).

We were unsurprised that White-tailed Mongoose occurred in areas of the AUN campus disturbed by road traffic, lighting, and regular mowing activity. The species is known to tolerate anthropogenic pressures (Schuette et al. 2013). We most often captured White-tailed Mongoose in relatively open areas with abundant short and medium grasses, habitat preferred by this species (Waser 1980). Although the species also prefers open woodland and bush, within these habitats it forages in grassy areas where invertebrate prey may be abundant (Admasu et al. 2004). Although modeling revealed that the presence of goats positively influenced habitat use of White-tailed Mongoose, this relationship may not be meaningful; instead, it may relate to the habitat characteristics in the zone where we detected goats. Sheep and goats infrequently occur on campus, and we detected goats once, in the Northwest Zone. This zone is primarily open, grassy habitat, which is likely important foraging habitat for White-tailed Mongoose. Additionally, studies have shown that livestock activity negatively influences the detectability of White-tailed Mongoose (e.g., Ramesh & Downs 2015). That this species did not use the South Nature Zone may relate to the area's greater tree cover or the presence of Banded Mongoose, even though the two species have different activity regimens and sociality.

Cameras captured Gambian Rat only in nature-area zones. This was expected given the species prefers well-shaded areas and burrows inside deserted termite mounds and underneath tree roots (Ajayi 1977). Having a low tolerance to heat, Gambian Rat is physiologically adapted to burrowing habitats in cooler environments, such as under tree cover (Knight 1988). In this study, the presence of feral cats, potential predators of rats, did not affect the species' detectability.

Our findings should be considered in context of the limitations of this research. Only two cameras were available for this study, which restricted the number of trap nights and our ability to survey areas simultaneously across campus. In addition, we were unable to model habitat use for other captured species due to an insufficient number of detections.

Although limited in scope, this study provided insight into wildlife habitat use on the AUN campus. The importance of maintaining minimally disturbed nature areas is evident. We recommend that campus authorities clearly delineate the two nature areas, train facility workers on acceptable activities in these areas, and post clearly marked signboards along boundaries and walking trails. Presently, controlling feral cats does not seem important; however, the university should monitor the campus cat population to track potential changes over time. For White-tailed Mongoose, we recommend that authorities avoid completely cutting down grasses. For Gambian Rat, we recommend tree planting to provide additional cover and food sources, as well as the preservation of old termite mounds as potential burrows for this species. Given the use of pesticides across campus, we also recommend research to investigate potential impacts of pesticide spraying on insect abundance and water sources.

Finally, campus authorities should involve students more in campus-based wildlife research and other sustainability projects. This could include promoting and engaging conservation, wildlife, sustainability, or similar student associations in institutional-level sustainability research and planning. In addition, institutions that maintain natural habitats on their campuses provide convenient research sites for students. Campus projects allow for experiential learning in which students can contribute to practical wildlife research and management (McCleery et al. 2005). Furthermore, university sustainability programs that place greater emphasis on student involvement in environmental activities lead to physical campus improvements, such as tree planting, as well as affect students' sense of place and mental well-being (Krasny & Delia 2015).

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Author contribution: All authors designed the study; IS collected the data; IS and JC organized the data; LRB performed data analyses; IS and LRB drafted the manuscript; JC provided editorial inputs to the manuscript.

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