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Anthropogenic habitats influence rodent diversity in the diet of Barn Owls (*Tyto alba*): Insights for possible biological control of commensal rodents

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1 | INTRODUCTION

The mosaic of land use types in Africa's agricultural savannah can harbour a diversity of rodents (Ogada & Kibuthu, 2009; Taylor et al., 2012), which move between fields and homesteads in response to food availability (Monadjem et al., 2011). Rodents therefore considered a major pest in agricultural fields, and their control is advocated to ensure a sustainable food supply (Constant et al., 2020). With at least 77 rodent species regarded as pests on the African continent (Monadjem et al., 2015) and threatening food security (Swanepoel et al., 2017), it is apparent that Africa should proactively deal with the problem.

The complex biology and behaviour of rodents make it difficult for integrated pest management to fully be implemented as ecologically based management strategies require adequate information at species and habitat levels (Jacob et al., 2010). This often leads to the management of rodents still being based on the use of chemicals, often leading to secondary poisoning (Jacob et al., 2010), even though it is often done with an array of other methods (Witmer, 2019). Control methods reducing survival and reproduction have long-term effects on populations when applied consistently. Such methods maintain rodent populations below levels that could cause significant economic loss and are best for managing overabundant rodent populations on agricultural land (Chr et al., 2001).

The Barn Owl's ability to switch prey has promoted its use in rodent population control (Browning et al., 2016). In this study, we sought to understand the possible impact of Barn Owl predation on

rodent populations, by investigating owl diet composition in the agricultural areas and nearby protected areas. Because the use of owls as a rodent control method aims at reducing rodent pests, we present our results emphasising the contribution of commensal rodents to the Barn Owl diet. Further, we were interested in because pest rodent control by owls, through adequate nest box positioning, is largely restricted to the breeding season. As a preliminary assessment, we compared the species diversity found in pellets with that from trapping data. We expected that seasonality, land use and the level of human presence in a landscape would influence the number of rodents in the diet of the Barn Owl (Langton et al., 2001; Panti-May et al., 2012), the proportion of commensal species and the relative age classes abundance in the diet. We hypothesised that the mass of rodent would also influence its catchability (Brown et al., 1988).

2 | MATERIALS AND METHODS

2.1 | Study area

The study was conducted in Hwange District (Zimbabwe), in Hwange National Park (HNP, covering 14,651 km²), centred on 19°00'S, 26°30'E (Tarakini et al., 2018), Sikumi Forest Area (SFA, covering 544 km²) and a communal area (Ward 15), bordering the park (Figure 1). HNP and Sikumi Forest are protected by the Parks and Wildlife Act and the Forest Act. The average annual rainfall is

708mm and the temperature averages 24°C in winter and 32°C in summer (Mukwashi et al., 2012). The area is characterised by poorly drained Kalahari sands (Childes & Mundy, 2001) with vegetation of grasslands, bushed grasslands, bushland and bushed woodland. People in these communal areas rely on subsistence farming (Guerbois et al., 2013) and the economy in the area is dependent on tourism (Guerbois & Fritz, 2017).

2.2 | Data collection

Twenty-seven owl boxes and 60 Sherman traps were used to collect data. A questionnaire administered through stratified random sampling was used to determine the homesteads that were willing to have nest boxes in their cropping fields. Sherman traps were placed on straight lines and parallel, with distances of 10 and 50m, respectively. Food attractants (peanut butter and roasted peanuts) were used as bait. The traps were mounted on three 90×50m plots in each land use and deployed and monitored three consecutive nights in each of the study seasons, that is, early-wet, late-wet, early-dry and late-dry seasons over 2 years. The contents of the pellets were identified with the assistance of the Natural History Museum. The research tools received ethics clearance from the NUST Faculty of

Higher Degrees Committee, the District Administrator and the traditional leadership.

2.3 | Data analysis

A Shannon–Weiner index was used to compare the diversity of data from pellets with the data from the traps. A Spearman's correlation test was used to assess whether pellets and traps gave a similar picture of the abundance in the area. Only pellet data were used for the rest of the analyses as trapping success was low. A Generalised Linear Model (GLM) was used to determine the influence of the mass of a species on its catchability. Species body mass was species drawn from the literature on rodents in the region. As more pellets were collected in the protected area and as there was large heterogeneity in collected pellet numbers between sites, we created a corrected abundance index of rodent species in the diet. At a given nest site, we scaled the number of individuals of each rodent species by the log₁₀ of the total, an index of collection success. The corrected values were used for the rest of the analyses.

A GLM was used to determine the influence of season (breeding/nonbreeding), rainfall and land use on the likelihood of including commensal rodents in the diet of owls. We applied a backward

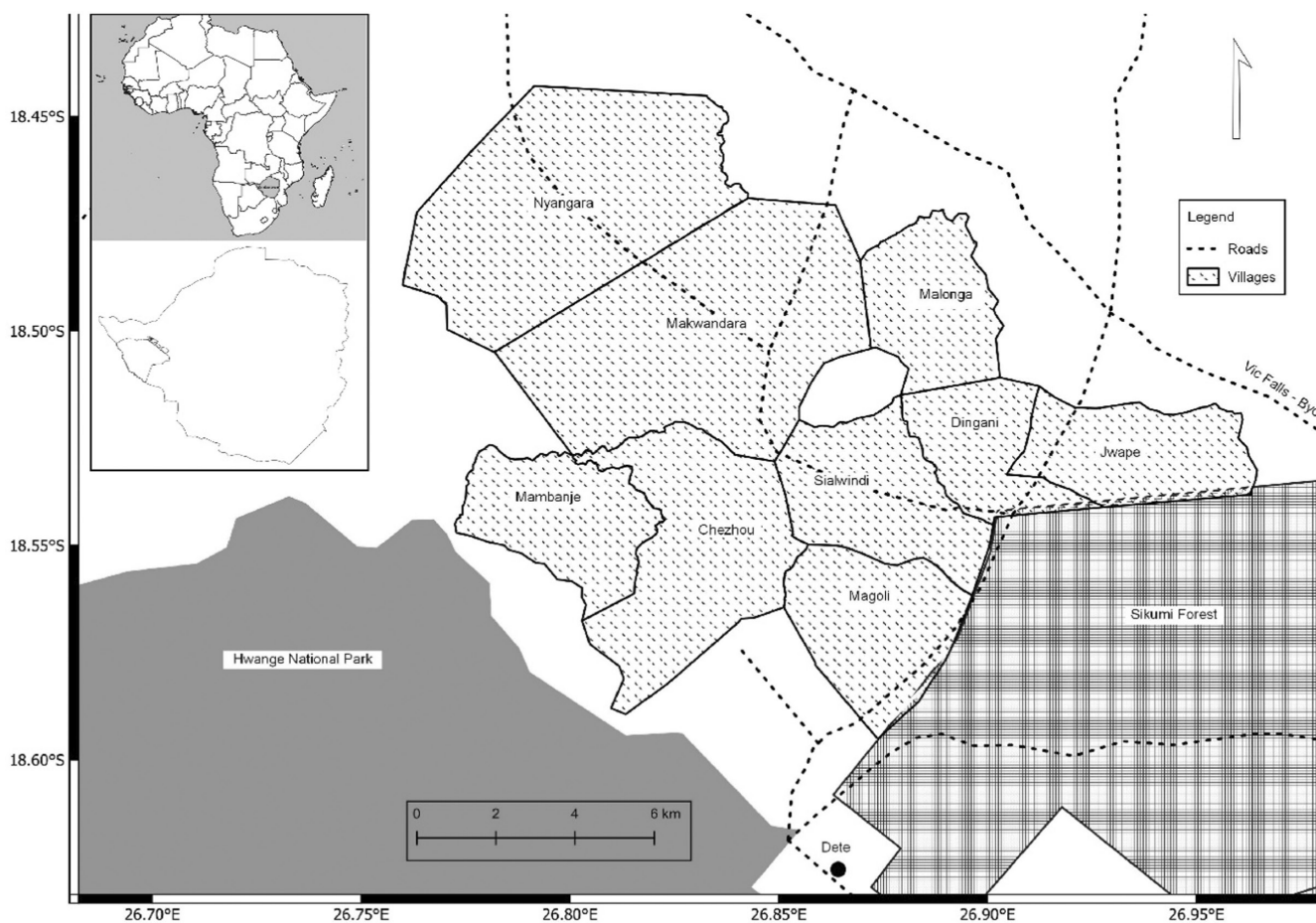


FIGURE 1 The study area with protected areas and communal land

procedure to define the most parsimonious model. Rainfall was never significant, hence was removed from the final predictive model. Because there were some human infrastructures inside the protected area, some of which had nesting owls, we also created another variable that described whether owls were near anthropogenic resources (disturbed/wild) irrespective of the land use type. A similar GLM was run to determine the influence of season and the level of human presence (disturbance) on the likelihood of finding commensal rodent species in the diet of owls. We then ran the retained predictive model (Prediction = exponential (model)/1 + exponential (model)) to display the probability of finding a commensal rodent in the diet in different land uses and in different levels of human presence, both coupled with the season.

A GLM was used to assess the factors influencing the age of commensal rodents in the diet, as the effect of predation on age structure may ultimately impact the rodent population dynamics. The explanatory variables used were season and land use for one analysis and season and level of human presence for another. A similar predictive model was run to predict the probability of finding an adult commensal in the diet in different land uses and in different levels of human presence, both coupled with the season. All statistical analyses were performed in the R statistical software.

3 | RESULTS AND DISCUSSION

The occupation rate of the boxes was 62.96%. Seven of the occupied boxes were in the protected area and 10 were in the communal area. Some of the boxes were abandoned early hence they were not included in the diet analysis. Thus, 11 boxes were used for analysis, six in the protected area and five in the communal area. A total of 1587 rodents and 116 shrews were identified from the pellets. Ten species were identified from the protected area and seven from the communal area (Table 1). The number and diversity of rodents in pellets is the first cue that owls could effectively be rodent regulating

agents (Johnson & St George, 2020). The high diversity and abundance of rodents in the protected area differs from other studies, which found them to be higher outside protected areas (Caro, 2001; Konečný et al., 2010). This may be due to the poor vegetation cover in the study area (Hoffmann & Zeller, 2005). Other remains found were a bat and insects of the following orders: Coleoptera, Hymenoptera and Orthoptera.

The level of diversity of rodents and shrews was the same in pellets and live traps ($H = 1.6$), although the traps had a better evenness of rodent species (0.89) than the pellets (0.71). The relative species abundance was similar between the two methods: Spearman's correlation coefficient ($r_s = 0.7$). The diversity of rodent species in the owl diet per nest box was dependent on the sampling effort (number of pellets) with an increase in diversity being positively related to sample size ($F_{1,28} = 22.069$ $p < 0.001$, $r_s = 0.018 \pm 0.004$). There was no mass effect on the relative abundance of different rodent species in the diet ($t = -0.771$, $p = 0.4631$, $df = 8$, $r_s = -1.145$, $SE = 1.486$), but the most abundant seemed to be in the middle range (65–72 g) of body weights. This suggests that abundance was more important than size in prey selection (Charter et al., 2007). It has also been suggested that owls prefer smaller rodents to heavier ones (Trejo & Guthmann, 2003), probably because smaller species spend more time exploring and foraging, hence being more exposed (Best et al., 2020).

The probability of finding a commensal in the diet over the whole study site was 0.681. This probability increases with an increase in sample size (z value = 5.240, $p < 0.001$, $df = 26$, $r_s = 0.004$, $SE = 0.001$), suggesting a frequency-dependent selection of commensals, at the nest scale. It was also higher in the breeding season (>0.35) in the communal area (Estimate = -1.630 , $p < 0.001$, $SE = 0.170$) and although lower in the protected area, there was no difference in the breeding and nonbreeding season (Estimate = -0.101 , $p = 0.103$, $SE = 0.143$) (Figure 2). Disturbed areas had a higher proportion of commensals than the wild areas (Estimate = -1.393 , $p < 0.001$, $SE = 0.158$). The nonbreeding season

TABLE 1 Numbers of rodents and shrews found in pellets and caught in traps

Species		Output from pellets		
Scientific name	English name	Protected area	Communal area	Traps
<i>Aethomys chrysophilus</i>	Red rock rat	234	29	6
<i>Micaelamys namaquensis</i> ^a	Namaqua rock rat	13	24	5
<i>Crocidura hirta</i> ^a	Lesser red musk shrew	76	40	
<i>Fukomys damarensis</i>	Damara mole rat	1	0	
<i>Dasymys incomtus</i>	African marsh rat	4	0	
<i>Mastomys natalensis</i> ^a	Natal multimammate mouse	216	77	9
<i>Saccostomus campestris</i>	South African pouched mouse	109	24	6
<i>Steatomys pratensis</i>	Fat mouse	124	18	2
<i>Gerbilliscus leucogaster</i> ^a	Bushveld gerbil	642	70	16
<i>Rattus rattus</i> ^a	House rat	2	0	
Total		1421	282	44

^aCommensal.

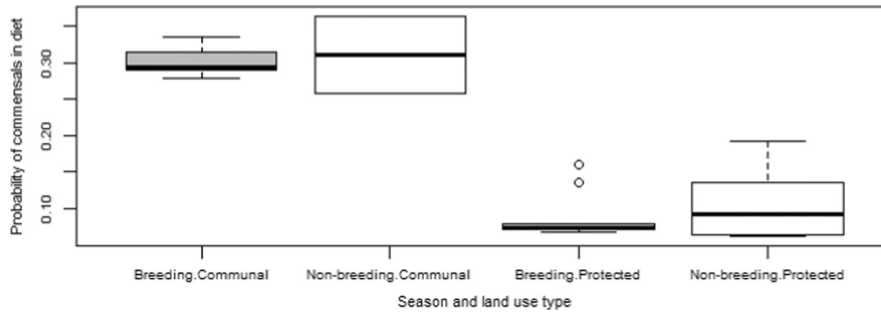


FIGURE 2 The effect of land use (communal vs. protected area) and breeding season (breeding vs. nonbreeding) on proportions of commensal rodents

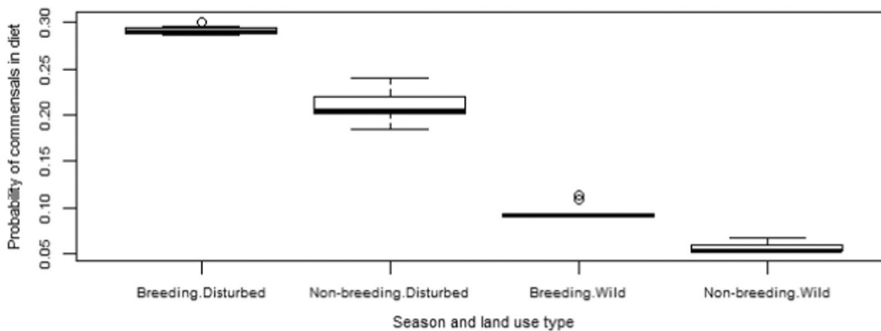


FIGURE 3 The influence of human presence on proportions of commensal rodents in the Barn Owl diet

in the disturbed area had fewer commensals than the same season in the wild area (Estimate = -0.573 , $p = 0.001$, SE = 0.170) (Figure 3).

The age of the rodents caught was influenced by the season of capture, with fewer adults caught in the nonbreeding season of Barn Owls (Estimate = -0.307 , $p = 0.023$, SE = 0.139). The wild area had fewer adult commensals than the disturbed area in both the breeding and nonbreeding season (Estimate = -0.016 , $p < 0.001$, SE = 0.170), showing the effect of land use on rodent populations (Stenkewitz et al., 2010). This is contrary to the observation that protected areas could provide a safer environment, increasing survival chances for rodents (Botha & Komen, 2006).

The opportunistic feeding habits of Barn Owls (Avery et al., 2005), make them ideal for pest control in years of rodent outbreaks although the key aspect is the ability to impact commensal species (Bonwitt et al., 2017). It seems to be the case in our study area as our results suggest that Barn Owls incorporate a large amount of commensals, in the communal area, as well as in human-disturbed areas inside the protected area. Our study thus shows that Barn Owls, if restored to adequate densities, could significantly impact rodents in communal areas and may reduce damage caused by commensal species.

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CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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