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Status and challenges for conservation of small mammals assemblages of Ghana

Benjamin Y. Ofori*, Daniel K. Attuquayefio, Gbogbo Francis

Department of Animal Biology and Conservation Science, University of Ghana, Legon-Accra, Ghana

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Abstract

Our knowledge of the distribution, composition and status of small mammal assemblages of Ghana is scanty. To date, an up-to-date checklist of small mammals of the country is non-existent, despite being vital zoogeographical and conservation tool. Here, we review available literature to compile a preliminary checklist of Ghana's small mammals, highlight key knowledge gaps and challenges for conservation and identify future research priorities. Forty-nine species comprising 34 rodents (Rodentia) (excluding squirrels and cane rats), 14 shrews (Soricomorpha) and one hedgehog (Erinaceomorpha) have been recorded in Ghana since 1975. Rodents and shrews showed widespread distribution across southern Ghana where most published studies have been concentrated. The rodent *Praomys tullbergi* and the shrew *Crocidura olivieri* were most commonly-reported. All small mammals were listed as Least Concern except *Crocidura buettikoferi* and *Crocidura grandiceps*, which are Near Threatened. *Malacomys edwardsi* and *Hybomys trivirgattus* are forest-obligates and Upper Guinean endemics of conservation importance. There is an urgent need for basic biological surveys throughout the country, particularly in the northern regions where no small mammal studies has been published. Long-term monitoring of forest obligate like *Hylomyscus* sp., *Hybomys* sp., *Malacomys* sp., *Crocidura muricaudata* and *C. grandiceps* could reveal the impacts of environmental changes including habitat loss and degradation, and climate change on Ghana's small mammals.

***Corresponding Author:** Benjamin Y. Ofori ✉ byofori@yahoo.com

Introduction

Small mammals (rodents, shrews and hedgehogs < 2 kg) form the majority of mammalian fauna and are an important component of most natural and semi-natural ecosystems (Addisu and Bekele, 2013). They influence the structure and composition of ecosystems by feeding on seeds, seedlings, fungal spores and insects and by serving as food for many medium-sized mammalian predators, raptors and snakes (Angelici and Luiselli, 2005; Makundi et at., 2009). Their abundance and composition, in turn, are influenced by habitat structure and productivity (Avenant, 2011). The high reproductive rates, rapid turn-over and sensitive of small mammals to environmental changes make them good bioindicators of habitat quality, or environmental disturbance (Malcom and Ray, 2000; Sullivan and Sullivan, 2001). Small mammals are also major pests of agriculture, causing substantial damage to crops and stored farm produce (Singleton *et al*., 2003).

The ecological and economic importance of small mammals merit their conservation and management. To do this effectively requires that we understand their spatial and temporal distribution and population dynamics, and how these are impacted by changing environments. This notwithstanding, our knowledge of the abundance, composition, distribution and status of small mammals of Ghana is scanty. To date, an up-to-date checklist of the small mammal assemblages of the country is non-existent (Ofori *et al*., 2014). We also have incomplete knowledge of how these mammals are responding to habitat loss and degradation, climate change and other environmental stressors. There is therefore an urgent need for inventories and monitoring, particularly in previously unsurveyed areas and areas experiencing unprecedented rates of habitat loss and degradation in order to bridge this knowledge gap (Attuquayefio and Ryan, 2006; Decher and Bahian, 1999).

Although there have been previous accounts of mammalian systematics in Ghana, these are well out-of-date (e.g., Booth, 1959). The most recent comprehensive study of small mammals of southern Ghana was by Decher and Bahian (1999), who studied the diversity and structure of these mammal communities in different vegetation types of the Accra Plains of Ghana. Their checklist of small mammals of the Accra Plains has recently been updated by Ofori *et al.* (2014) and Garshong *et al.* (2013a). More recently, there have been studies conducted in wetlands, forest reserves and sacred groves, and in areas under no form of protection, including farmbush, plantations and human-modified landscapes to help build the badly-needed checklist of the small mammals of Ghana (e.g., Ofori *et al*., 2013a,b, 2014; Garshong *et al*., 2013a,b; Holbech,2013; Oduro and Anti, 2010; Attuquayefio, 2008). However, the findings of these studies are widely scattered in various journals. As far as we are aware, no study provides complete information on the distribution, composition, population trends and conservation status of small mammals of Ghana.

Here, we review available literature to (i) compile a preliminary checklist of small mammals reported from Ghana, (ii) highlight knowledge gaps and challenges for conservation and (iii) identify priority areas for future research. We hope that this review will provide context for, and stimulate collaborative research to enhance our knowledge of the status of, and threats to small mammal biodiversity in Ghana.

Materials and methods

Literature review

We drew on published peer-reviewed papers and scientific reports from field-based studies of small mammals in Ghana, excluding taxonomic reviews that made cursory mentions of the Ghana fauna. Works reviewed included Cole (1975), Jeffrey (1977), Yeboah (1984, 1998), Decher and Bahian (1999), Ryan and Attuquayefio (2000), Decher and Abedi-Lartey (2002), Attuquayefio and Wuver (2003), Attuquayefio *et al.* (2005), Decher *et al.* (2005), Vordzogbe *et al.* (2005), Attuquayefio and Ryan (2006), Weber and Fahr (2007), Barriere *et al.*

(2008), Attuquayefio (2008), Oduro and Anti (2010), Garshong *et al.* (2013a,b), Holbech (2013), and Ofori *et al.* (2013a,b, 2014).

These papers were identified by systematically reviewing small mammal literature using the ISI Web of Science, Scopus and Google Scholar data-bases in November 2014. We used key phrases such as "small mammals of Ghana", "Rodents of Ghana", "shrews of Ghana", "mammalian fuana of Ghana", "ecology of rodents of Ghana", "ecology of small mammals of Ghana", "abundance, diversity and distribution of smalls/rodents/shrews, Ghana". We also followed up on relevant papers cited by the retrieved papers. The paper selected stated explicitly the areas, regions or localities within which the studies were conducted, the small mammal trapping and identification protocols, and the purpose and duration of the studies.

Results

Forty-nine small mammal species comprising 34 rodents (Rodentia) (excluding squirrels and cane rats), 14 shrews (Soricomorpha) and one hedgehog (Erinaceomorpha) have been recorded in Ghana between 1975 and 2014 (Table 1). Small mammals showed widespread distribution across southern Ghana where most (95%) of published studies were concentrated. Tullberg's soft-furred mouse (*Praomys tullbergi*) and Olivier's shrew (*Crocidura olivieri*) were the most commonly-reported rodent and shrew respectively. The small mammals could be grouped into four broad categories as (i) forest specialists, (ii) open forest/shrubland species, (iii) grassland species and (iv) generalist species that tolerate habitat modifications (Table 1). *Praomys tullbergi* dominated forested areas, while Multimammate mice (*Mastomys* sp.) were the dominant species in grasslands and farmlands/farmbushes.

Table 1a. Checklist, habitat association and conservation status (IUCN red list of threatened species) of rodents (excluding squirrels and cane rats) reported from Ghana from 1975 to 2014.

Species (Code)	Synonym	Common name	Habitat association	Conser-vation Status
Order Rodentia				
Arvicanthis niloticus solatus (1)	None	African grass rat	S	LC
Cricetomys emii (2)	*C. kivuensis*	Emin's pouched rat	F	LC
Cricetomys gambianus (3)	*C. ansorgei*	Gambian pouched rat	F, W, P, fb, hd	LC
*Dasymys incomtus**(4)	*D. alleni*	African marsh rat	F,S,Ag	LC
Dephomys defua (5)	None	Defua rat	F, Ts	LC
Grammomys rutilans (6)	*Thamnomys rutilans*	Shining thicket rat	F, MS, P	LC
Graphiurus hueti (7)	None	Huet's dormouse	F, MS, P, W	LC
Graphiurus lorraineus (8)	None	Lorrain dormouse	F, MS, P, W	LC
*Graphiurus murinus** (9)	None	Woodland dormouse	F, MS, P, W	LC
Graphiurus nagtglasii (10)	None	Nagtglas' African dormouse	F, WS	LC
Hybomys trivirgatus (11)	None	Temminck's striped mouse	F	LC
Hybomys univittatus (12)	None	Peter's striped mouse	F	LC
Hylomyscus alleni (13)	None	Allen's wood mouse	F	LC
Hylomyscus stella (14)	None	Stella wood mouse	F	LC
Lemnyscomys barbarus (15)	*L. zebra*	Barbary striped grass mouse	S, Fc, Gop	LC
Lemnyscomys striatus (16)	*L. ardens*	Typical striped grass mouse	S, Fc, Gop	LC
*Lophuromys flavopunctatus**(17)	None	Yellow-spotted brush-furred rat	FO, MS	LC

Species (Code)	Synonym	Common name	Habitat association	Conservation Status
Lophuromys sikapusi (18)	None	Rusty-bellied brush-furred	FO, MS	LC
Malacomys cansdalei (19)	None	Cansdale's swamp rat	F	LC
Malacomys edwardsi (20)	None	Edward's swamp rat	F, Sh, Ts	LC
Malacomys longipes (21)	None	Big-eared swamp rat	F,Ts	LC
Mastomys erythroleucus (22)	None	Guinea multimammate mouse	S, Fb, Sh, Fc, Fe, Ag	LC
Mastomys natalensis (23)	*Mastomys hildebrandtii*	Natal's multimammate rat	S, Fb, Sh, Fc, Fe, Ag	LC
Mus haussa (24)	None	Huausa mouse	S, Fb, Sh	LC
Mus minutoides (25)	*Mus kasaicus*	African pigmy mouse	S, Fb, Sh	LC
Mus musculoides (26)	*Mus kasaicus*	Temminck's mouse	Generalist	LC
Mus musculus (27)	*M. domestica*	House mouse	Generalist	LC
Myomys daltoni (28)	*Praomys daltoni*	Dalton's mouse	Generalist	LC
Oenomys ornatus (29)	None	Ghana rufous-nosed rat	MS, Ag	
Praomys tullbergi (30)	None	Tullberg's soft-furred mouse	F	LC
Steatomys caurinus (31)	None	Northwestern fat mouse	S, Fb	LC
Steatomys cuppedius (32)	None	Dainty fat mouse	S, Sh	LC
Tatera kempi (33)	None	Kemp's savanna gerbil	S, Sh, Ag, WS	LC
Uranomys ruddi (34)	None	Rudd's brush-furred rat	S, Fb, Sc, Gop	LC

Table 1b. Checklist, habitat association and conservation status (IUCN red list of threatened species) of shrews and hedgehog reported from Ghana from 1975 to 2014.

Species (Code)	Synonym	Common name	Habitat association	Conservation Status
Order Soricomorpha				
*Crocidura bottegi**(35)	None	Bottego's shrew	F, Gop, S	LC
Crocidura buettikoferi (36)	None	Buettikofer's shrew	F	NT
Crocidura crossei (37)	*C. ingoldbyi*	Crosse's shrew	F, S	LC
Crocidura douceti (38)	None	Doucet's musk shrew	F	DD
Crocidura foxi (39)	None	Fox's shrew	Fe, S	LC
Crocidura fuscomurina (40)	None	Bicolored musk shrew	S	LC
Crocidura grandiceps (41)	None	Large-headed shrew	F	NT
Crocidura jouvenetae (42)	*C. ebriensis*	Jouvenet's shrew	F	LC
Crocidura lamottei (43)	None	Lamottte's shrew	S	LC
Crocidura muricaudata (44)	None	Mouse-tailed shrew	F	LC
Crocidura nigeriae (45)	*C. poensis nigeriae*	Nigeria shrew	F, Gop, S	LC
Crocidura obscurior (46)	None	West African pygmy shrew	F	LC

Species (Code)	Synonym	Common name	Habitat association	Conser-vation Status
Crocidura olivieri (47)	formally *C. flavescence*	Olivier's shrew	generalist	LC
Crocidura poensis (48)	None	Fraser's musk shrew	F, S, Fb	LC
Order Erinaceomorpha				
Atelerix albiventris (49)	None	Four-toed hedgehog	S, Sh, WS	LC

Habitat Association:

F = forest, P = plantations, S = savanna, MS = moist savanna, W = woodland, WS= woodland savanna, Ag = agricultural land, Fb = farmbush, Fc = forest clearings, Fe = forest edge, Fo = forest openings, Gop = grassland in open forests, Hd = human dominated landscapes, Sc = scrubland, Sh = shrubland, Ts = tropical swamps

Conservation Status (IUCN Red List of Threatened Species 2010):

NT = Near Threatened, LC = Least Concern

*species might have been wrongly identified; *M. minutoides* and *G. murinus* are believed to be endemic to Southern Africa, *D. incomtus* occurs in Central, East and Southern Africa, whereas West African record of *C. bottegi* might be *C. obscurior* and *C. eburnean*. However, until the controversies shrouding these species are firmly resolved, we give the authors the benefit of doubt and treat these species as being present in Ghana.

Buettikofer's shrew (*Crocidura buettikoferi*) and large-headed shrew (*Crocidura grandiceps* Hutterer 1983) are listed as Near Threatened (IUCN, 2010), while the rest are listed as Least Concern because they are presumed unlikely to be fast declining due to their large population sizes and wide distribution. *Malacomys edwardsi* and *Hybomys trivirgattus* are Upper Guinean endemics. These species together with Malacomys longepes, *Hybomys univittatus* and *Hylomyscus* sp., and the shrews *Crocidura muricaudata*, *C. grandiceps*, *C. douceti*, *C. buettikoferi* and *C. jouvenetae* are forest obligates that are of conservation importance. In general, the single largest threat to Ghana's small mammals is habitat loss, fragmentation and degradation resulting from agriculture expansion, urbanization, mining, logging, and tree and palm plantations (Hawthorne and Abu-Juam, 1995; Holbech, 2013; Poorter *et al.*, 2014). Other threats such as direct persecution, invasive species, pollution, disease and climate change are evident, but these threats have been poorly studied.

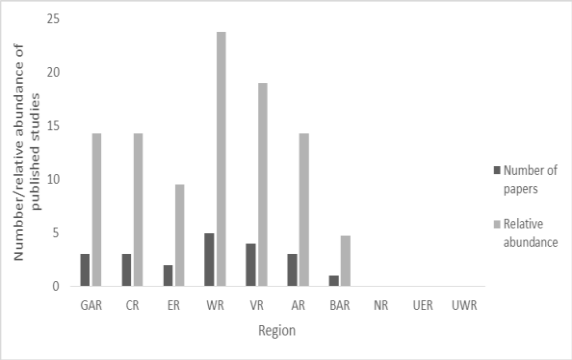

Fig. 1. Number and relative abundance of published studies on small mammals of Ghana between 1975 and 2014 per Region. Relative abundance of studies was estimated as the ratio of number of published studies in a Region to the total number of published studies Ghana multiplied by100%.

Ninety-five percent (20 of 21) of the studies were conducted within the six regions forming the southern zone of the country and the rest in the mid-zone. No small mammal study has as yet been published from the three northern regions of the country (Northern, Upper East and Upper West) (Fig. 1). The studies were conducted in nationally-protected areas, sacred groves and unmanaged sites

including farmlands, forest plantations and built-up areas, and were largely inventories for ecological and conservation purposes. Eight trap types were used, notably Sherman, Tomahawk, National, Victor Rat, Museum Special, Metal Base and Wooden Base Breakback and Pitfall traps). Fifty-two percent of the studies used Sherman live traps only, while the rest combined two or more different traps.

Duration of study varied between a week for inventories and eight months for extended ecological studies. Traps were set for two to 13 consecutive nights, but for most inventories traps were set for three consecutive nights per trapping session. Most (71.4%) studies were conducted either during the wet or dry seasons. The few studies (six of 21) that extended across both the wet and dry seasons were mostly ecological. Small mammals were identified using mostly morphometry following Rosevear (1969), Meester and Setzer (1971), Hutterrer and Happold (1983), Happold (1987), Kingdon (1997). Small mammal systematics normally followed Wilson and Reeder (1993).

Table 2. Regional/geographical distribution of small mammals reported from Ghana.

Region	Locality	Coordinate	Study	Species	Reference
Western Region	Ankasa	05º 23'N 02º 28'W	E	11,14,20,21,30,	Cole (1975)
	Fure River FR	05º 25'N 02º 20'W	E	5,11,20,21,30,	Cole (1975)
	Pra Suhien	05º 21'N 01º 23'W	E	20,21	Cole (1975)
	Sefwi Wiaso	06º 10,N 02º 30'W	E, I	5,6,7,9,11,14,16,17, 18, 20,26,23, 27,28,30	Jeffrey (1977), Vordzogbe *et al.* (2005)
	Draw River FR	05º 12'N 02º 24'W	I	2,5,11,13,18,19,30,36, 39,46	Decher *et al.* (2005)
	Boin-Tano FR	05º 32'N 02º 37'W	I	2,5,6,111318,20,30, 37,44,46	Decher *et al.* (2005)
	Krokosua Hills FR	06º 37'N 02º 51'W	I	10,13,20,30,37,46,47	Decher *et al.* (2005)
	Ankasa CA	05º 15'N 02º 35'W	C, E, I	2,13,16,18,20,23,26, 30,47,48	Holbech (2013)
	Bia CA	06º 30'N 03º 05'W	C, E, I	2,13,18,20,25,30,47,48	Holbech (2013)
Greater Accra Region	Shai Hills RR	05º 57'N 00º 04'E	C, I	8,16,30,33,34	Decher and Bahian (1999)
	Kpong	06º 08'N 00º 04E	C, I	8,16,22,23,30,37	Decher and Bahian (1999)
	Pinkwae Forest SC	05º 45'N 00º 08'W	C, I	26,30,37,43,	Decher and Bahian (1999)
	Adumanya SG	05º 54'N 00º 07'W	C, I	13,25,30,36,48	Decher and Bahian (1999)
	University of Ghana BG	05º 39'N 00º 11'E	C, E, I	1,22,28,30,39,47,49	Garshong and Attuquayefio (2013), Ofori *et al.* (2014)
Central Region	Kakum NP	05º 05'N 01º 07'W	C, E, I	6,11,12,13,14,15, 20,21,28,30,31,47	18,Yeboah (1998)
	Muni-Pomadze	05º 19'N 00º 37'W	C, E, I	3,13,15,16,22,33,	Ryan and Attuquayefio

Region	Locality	Coordinate	Study	Species	Reference
	RS			34, 37	(2000), Attuquayefio and Wuver (2003)
Volta Region	Kalakpa RR	06º 18'N 00º 17'E	E, I	26,30,33	Decher and Abedi-Lartey (2002)
	Wli	07º 06'N 00º 37'E	E, I	10,16,26,30,	
	Apesokubi	07º 37'N 00º 24'E	E, I	5,10,13,16,20,30, 38,39	
	Keta RS	06º 03'N 00º 53'E	E, I	3,33,35,47	Attuquayefio *et al.* (2005), Attuquayefio and Ryan (2006)
	Mount Afadjato	06º 45'N 00º 15'E	E	30,47	Ofori *et al.* (2013)
Eastern Region	Atewa FR	06º 12'N 0º 34'W	I	20,30,41	Weber and Fahr (2007)
	Ajenjua Bepo FR	06º 22' N 01º 01W	I	20,26,30,36,37,42,44, 46,47	Barriere *et al.* (2009)
	Mamang River FR	06º 15'N 01º 02' W	I	16,20,22,26,30,36,42, 44,46,47	Barriere *et al.* (2009)
Ashanti Region	KNUST BG	00º 40'N 01º 34'W	I	16,18,23,30	Oduro and Anti (2010)
	Owabi WS	06º 45'N 01º 43'W	E	11,18,20,30,36	Garshong *et al.* (2013)
	Gyeni River FR	06º 30'N 01º 55'W	E, I	13,18,26,30,34,47	Ofori *et al.* (2013)
	Gyemera FR	06º 36'N 01º 55'W	E, I	16,18,20,23,25,30,34, 43,47	Ofori *et al.* (2013)
	Okyem Kwaye SG	06º 34'N 01º 53'W	E, I	18,25,28,47	Ofori *et al.* (2013)
	Prako Kwaye SG	06º 33'N 01º 53'W	E, I	10,18,20,25,30,41,47	Ofori *et al.* (2013)
	Amansie West	06º 32'N 01º 57'W	E, I	5,13,16,18,23,25,28, 30,34	Ofori *et al.* (2013)
Brong-Ahafo Region	TainI FR	07º 25'N 02º 14'W	C, E, I	5,22,30	Attuquayefio (2008)
	Tain II FR	07º 35'N 03º 50'W	C, E, I	4,5,12,13,22,27,30	Attuquayefio (2008)
	Yaya FR	07º 27'N 02º 08'W	C, E, I	27,17,29,	Attuquayefio (2008)
	Nsemere FR	07º 32'N 020 12'W	C, E, I	4,22,27	Attuquayefio (2008)
	Sawsaw FRR	07º 36'N 02º 10'W	C, E, I	4,22,17,27,30	Attuquayefio (2008)

Locality: BG = botanical garden, CA = conservation area, FR = forest reserve, SG= sacred grove, RR = resource reserve, SNR = strict nature reserve, WS = wildlife sanctuary.

Study type: C = conservational, E = ecological, I = inventory.

Discussion

Even though our review identified 49 small mammal species reported from Ghana since 1975, we believe that the current species list markedly underestimates the actual number of species resident in Ghana. This is largely because of difficulties in correct identification of rodents and shrews, particularly sibling ones (Nicolas *et al.*, 2005). Although correct systematics and taxonomy are vital for evaluating conservation status and priorities, the systematics and taxonomy of many rodents and shrews are shrouded in controversy (Nicolas *et al.*, 2010). Most of Ghana's small mammals form problematic species complexes that are difficult to identify using external

morphology. For instance, *P. tullbergi* is believed to be a complex of about eight species (Ofori *et al*., 2013b), while the genera *Mus, Mastomys, Malacomys* and *Hylomyscus* have sibling species with low levels of morphological differentiations. Correct identification of such species required the use of cranio-dental characters and/or molecular genetic analysis. The use of external morphological characteristics only to identify the species in most of the reviewed studies might have misidentified, misrepresented and underestimated small mammal species richness in the country.

Furthermore, rare species are very difficult to encounter, and are more likely to be captured in extended trapping periods using combination of different traps. For instance, pitfall traps are less efficient for capturing relatively large-weight rodents, but are very efficient for capturing shrews and small-weight rodents that are often missed by Sherman, Tomahawk and Snap (Breakback) traps. Sherman and snap traps have been shown to have complementary qualities for capturing rodents (Nicolas and Colyn, 2006). The use of Sherman traps only for short trapping sessions in most of the reviewed studies might have left many rare species unaccounted for.

Large parts of the country, especially the middle and three northern regions remain largely unexplored. These areas could be harbouring many undiscovered species, requiring a considerable amount of basic biological surveys. Even for the southern part of the country where most of the published studies have been conducted, the number of studies per Region (Fig. 1) is grossly inadequate. More extensive studies in each of the six regions in the southern part of the country could record many new species. For instance, Decher and Bahian recorded 13 species from six different sites in their study of small mammals of the Accra Plains of Ghana. More extensive studies in the University of Ghana Botanical garden alone added two new species (Ofori *et al*., 2014; Garshong *et al*., 2013b).

The positioning of traps, particularly in forest ecosystems have strong impacts on captured species. Most forest-dependent rodents are arboreal, living in tree branches and hollows. Placing traps on the ground in forests therefore might have biased captures toward ground-dwelling species such as *P. tullbergi*, underestimating small mammal species richness and abundance reported from forest localities. Most of the studies reviewed employed line-transects of trap arrays which reduce the actual areas sampled, which in turn, influence the number of individuals that encounter traps. Sampling in grids and trap-replacement are believed to provide wider coverage, and hence are recommended if one aims at obtaining complete species inventories.

Our results showed that considerable amount of basic biological surveys are still needed throughout the country, in particular the middle and three northern regions, which could be harbouring many undiscovered species. Lack of long-term monitoring and applied research to characterize threats to small mammals and to develop strategies to reduce their impacts remains a major conservation challenge. As yet, we are not aware of any existing long-term small mammal assessment and monitoring programme in the country. Reflecting the general widespread of data-deficient species in the country it is fair to conclude that we know virtually nothing about species-specific threats and how species are responding to these threats.

Research priorities for the future should focus on assessments of areas where there has been limited or no studies. Monitoring areas with known species abundance and composition can enable comprehensive assessment of the threats to, and impacts of environmental changes on small mammals and more importantly how they respond to these changes. Such accurate information is needed to formulate effective conservation strategies. Forest obligates such as *Hylomyscus* sp., *Hybomys* sp., *Malacomys* sp., *Crocidura muricaudata* and *C. grandiceps* are good candidates for such monitoring

programmes. Future studies could benefit from molecular and cranio-dental identification of species, and extended trap nights and trapping sessions using appropriate trap combinations and positions.

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