HHS Public Access

Author manuscript

Mammalia. Author manuscript; available in PMC 2024 July 26.

Published in final edited form as:

Mammalia. 2022 July 13; 86(6): 562–569. doi:10.1515/mammalia-2021-0197.

Activity patterns and burrowing ecology of the giant pouched rat (*Cricetomys emini*) in Tshuapa Province, D. R. Congo

Lem's N. Kalemba,
Department of Biology, Faculty of Science, University of Kinshasa, P. O. Box 218 Kinshasa 11, Kinshasa, Democratic Republic of the Congo

Clint N. Morgan,
Poxvirus and Rabies Branch, United States Centers for Disease Control and Prevention, 1600 Clifton Rd, NE 30333, GA, Atlanta, USA

Yoshinori J. Nakazawa,
Poxvirus and Rabies Branch, United States Centers for Disease Control and Prevention, 1600 Clifton Rd, NE 30333, GA, Atlanta, USA

Matthew R. Mauldin,
Poxvirus and Rabies Branch, United States Centers for Disease Control and Prevention, 1600 Clifton Rd, NE 30333, GA, Atlanta, USA

Jean M. Malekani,
Department of Biology, Faculty of Science, University of Kinshasa, P. O. Box 218 Kinshasa 11, Kinshasa, Democratic Republic of the Congo

Jeffrey B. Doty[*]
Poxvirus and Rabies Branch, United States Centers for Disease Control and Prevention, Atlanta, 1600 Clifton Rd, NE 30333, GA, USA

Abstract

Rodents of the genus *Cricetomys* have been reported to be nocturnal with a bimodal activity pattern and to frequently change burrows. However, no studies to date have examined these ecological aspects with the use of radio-telemetry. Five *C. emini* were captured and radio-collared to study their activity patterns and burrowing ecology from 9 March to 15 April 2016. Nocturnal

---

[*]**Corresponding author: Jeffrey B. Doty,** Poxvirus and Rabies Branch, United States Centers for Disease Control and Prevention, Atlanta, 1600 Clifton Rd, NE 30333, GA, USA, uwb7@cdc.gov.

Author contributions: Lem's N. Kalemba assisted with study design, executed the experiments, and wrote the manuscript. Clint N. Morgan conducted spatial analyses and contributed to writing the manuscript. Yoshinori J. Nakazawa assisted with analyses and making revisions to the manuscript. Matthew R. Mauldin assisted with study design and making revisions to the manuscript. Jean M. Malekani, and Jeffrey B. Doty designed the study, obtained funding, assisted with conducting analyses, and contributed to writing and revising the manuscript.

Conflict of interest statement: The authors declare that they have no conflicts of interest regarding this article.

Research ethics: We followed the American Society of Mammologists guidelines for trapping, anesthetizing, and handling animals (Sikes et al. 2016) under CDC approved IACUC protocol 2660GALMULX. Animal handling procedures were conducted in accordance with all applicable national and local laws.

activity ranged between the hours of 18:00 and 05:00 with a probable reduction of activities between 20:00–23:00 and around 04:00 with diurnal activity between 06:00 and 17:00 h with a reduction of activity between 11:00 and 14:00. While the present study does confirm nocturnal activity and a bimodal pattern, this study also suggests greater diurnal activity as compared to previous studies. Additionally, data presented here also suggest that *C. emini* may not change burrows as frequently as previously reported.

Keywords

activity patterns; burrowing ecology; *Cricetomys emini* ; D.R. Congo; giant pouched rats

1 Introduction

Giant-pouched rats of the genus *Cricetomys* are native to much of Sub-Saharan Africa, ranging from far West Africa and across the Congo Basin to the Indian Ocean (Kingdon 2015; Rosevear 1969). These rodents have been documented to be associated with a variety of zoonotic diseases such as leptospirosis, bartonellosis, trypanosomiasis, capillariasis and monkeypox (Centers for Disease Control and Prevention 2003; Gretillat et al. 1981; Herder et al. 2002; Hutin et al. 2001; Machang'u et al. 2004; Malekani et al. 1994). Monkeypox (MPX) is of particular concern in this region as the vast majority of MPX cases are reported from the Democratic Republic of the Congo (DRC) where there is an estimated infection rate of 5.53 cases per 10,000 people (Rimoin et al. 2010). MPX is endemic in the Tshuapa Province of DRC where an average of 661 suspected human cases were reported each year from 2011 to 2014 (Osadebe et al. 2017). Anti-orthopoxvirus antibodies have been found in samples collected from giant-pouched rats and other small mammals in this province and elsewhere in central Africa (Doty et al. 2017; Doshi et al. 2019), indicating some animals examined in these studies had possible exposure to *Monkeypox virus* (MPXV) or another *Orthopoxvirus* (OPXV). Additionally, giant-pouched rats are commonly hunted for meat and therefore pose a risk to human health in Tshuapa Province.

The taxonomy of this genus varies within the literature, either two (Van der Straeten and Peterhans 2008; Van der Straeten et al. 2008), four (Carleton and Musser 2005) or five species (Kingdon 2015) are currently recognized. The two species arrangement includes *C. emini* and *Cricetomys gambianus*, whereas others concur *Cricetomys kivuensis* and *Cricetomys ansorgei* are sufficiently divergent from *C. emini* and *C. gambianus*, respectively, to warrant species-level recognition. Recent molecular data has indicated both arrangements likely underestimate the true diversity within the genus (Olayemi et al. 2012), but further research is needed to appropriately connect taxonomy (subspecies and species), linked to morphologically identified type-specimens stored in natural history museums, to the recently identified genetic lineages. Clearly, additional research into the genetic variation within this group is warranted. Animals captured for this study were from the area south of the Congo River, as were animals sampled from lineage sp2 as described by Olayemi et al. (2012); however, because this area is within the geographic range of *C. emini* as currently recognized, animals are referred to as *C. emini*. Furthermore, captured specimens displayed a slender shape with a short, grey and soft fur coat, as which is indicative of the species *C. emini* (Olayemi et al. 2012).

Giant-pouched rats are primarily terrestrial and use underground burrows (Malekani 1990). Previous reports indicate burrows of *C. emini* can be found in dense forest as well as in open areas such as farmlands, fallow fields, and near abandoned houses in forest villages (Malekani 1987). Most burrows have been observed in elevated places (mounds, deserted termitaries or beneath large trees), with at least two entrances, of which one is primarily used (Malekani 1987, 1990). The second entrance is typically closed by ground cover or located inside a hollow making it difficult to locate. As a result, in some cases the burrow may seem to have only one entrance (Malekani 1990). Additional evidence suggests one individual occupies one burrow at a time; females with juveniles have been observed to occupy one burrow for several months (Malekani 1987). Rosevear (1969) reported that these animals change burrows frequently and that old burrows are left vacant. A recent study suggests that *Cricetomys* rodents utilize multiple borrows within the core areas of their home range, which may aid escaping predators (Yadok et al. 2019).

In general, *Cricetomys* rodents are considered to be solitary and nocturnal; with two peaks of activity (bimodal activity pattern), generally within the limits of dusk until dawn, with a reduction/cessation of activity during the few hours following midnight (Ewer 1967; Majer 1973; Rosevear 1969; Yadok et al. 2019). Some studies have additionally observed limited diurnal activity of *Cricetomys spp*. (Ewer 1967; Majer 1973; Rosevear 1969; Yadok et al. 2019). No study to date has addressed activity patterns of *C. emini* using radio-telemetry. Previous studies relating to the activity patterns of these rodents were either conducted in captivity (ex-situ) or focused on either nocturnal or diurnal activity only but not both. The use of radio transmitters allowed us to assess the behavior of these animals during the entire 24 h cycle. The purpose of this study was to gain a better understanding of burrow site selection and the temporal activity patterns of *C. emini* in the equatorial forest of DRC.

2 Materials and methods

2.1 Study area

This study was conducted approximately 7 km southeast of Boende, Tshuapa Province, DRC. The study site included agricultural fields, fragmented primary and secondary forests, as well as several creeks. These creeks provide a valuable resource for wild animals, domestic animals, and local residents (drinking, washing clothes, fishing, and bathing). Tshuapa Province is covered by ombrophilous forest in a tropical climate with limo-argillaceous sands and sandy-silty soils, with areas of seasonally inundated swampland (Ministère du Plan, D.R. Congo, 2005). Daily temperatures in this area range between 20 °C and 30 °C. The dry season is very limited with approximately 114 days with rain per year, averaging over 150 mm of precipitation per month and 1800 mm per year (Ministère du Plan, D.R. Congo, 2005).

2.2 Capture and telemetry

We captured and collected data on *Cricetomys emini* from 9 March to 15 April 2016. We followed the American Society of Mammalogists (ASM) guidelines for trapping, anesthetizing, and handling animals (Sikes and The Animal Care and Use Committee of the American Society of Mammalogists 2016) under CDC approved IACUC protocol 2660GALMULX. We captured specimens of *Cricetomys* by using 2 sizes of Tomahawk live traps (Tomahawk Live Trap Co., Tomahawk, Wisconsin; 66 × 23 × 23 cm, and 81 × 25 × 30 cm) baited with palm nuts and cassava root. We set 10 Tomahawk live traps (5 of each size) near suspected giant-pouched rat burrows in both primary and secondary forest during a 5 day period at the beginning of this study.

Captured animals were anesthetized with ketamine hydrochloride (10 mg/kg) prior to being measured, weighed, and fitted with a 13 g telemetry collar (transmitter dimensions: 14 × 14 × 16 mm) that featured an activity monitor and mortality sensor with an expected battery life of 345 days (Advanced Telemetry Systems, Isanti, Minnesota). The activity and mortality signal sequences produced by the radio-transmitter are impacted by the duration that no movement is detected (N = Normal, active movement detected, S = Sleep, no movement for >1 min and D = Dead, no movement for >16 h). Prior to animals being released at the site of capture, the sex and age (juvenile or adult) was recorded for each animal.

2.3 Activity patterns

Activity patterns were assessed by three kinds of signal sequences provided by the radio-transmitter as described above. Data were collected during nocturnal (18:00 – 06:00 h) and diurnal hours (07:00 – 17:00 h). To confirm activity, we reviewed the signals emitted by the telemetry transmitter for 15 min, occasionally rechecking signals, each >1 min apart (Garshelis et al. 1982). Average hours of activity, minimum and maximum periods, as well as the standard deviation, were used to characterize the patterns of *C. emini* activity.

2.4 Burrow characteristics and use patterns

Burrow sites were located via homing, and location coordinates were recorded with a handheld global positioning system (GPS) unit (Garmin, Olathe, Kansas). Burrow sites for each animal were visited once a week for 5 weeks. Total number and the maximum diameter of entrances were recorded for all observed burrows. To distinguish burrows or to recognize entrances belonging to the same burrow, we took into account that inhabited burrows have at least one of the entrances very clean and well-marked by frequent passage of the animal, additionally, emergency entrances were often located in the opposite direction of the main entrance.

Plots for burrow habitat analysis consisted of a 20 m-diameter circle around each burrow. Number of small (<10 cm diameter at breast height), and large (>10 cm diameter at breast height) trees were recorded for each plot. This was used to assess the relative human disturbance of the areas where these burrows were located, i.e., in primary versus secondary forests or agricultural areas. We compared the tree composition (small vs large trees) at each burrow via Wilcoxon rank sum test conducted in the statistical software R (version 3.4.3). A p-value of <0.05 was considered significant for this analysis.

2.5 Spatial analysis

The burrow sites were analyzed spatially in ArcGIS for proximity to developed areas (man-made structures, roads, pathways), and evaluation of spatial movements and distribution. Distances between burrow sites and man-made structures or paths were calculated as Euclidean distance using ArcGIS. Due to the paucity of spatial information on *C. emini*, den sites were spatially overlaid in ArcGIS with the documented home range of the congeneric *C. gambianus*, 4.95 ha (range = 2.23–11.10 ha) to serve as a proxy (Skinner and Chimimba 2005). This provides some insights into the dispersal and interaction potential between individual *Cricetomys*, as well as interactions with human activity and development. Structures, boundaries, and roadway data were sourced from OpenStreetMap contributors (https://www.openstreetmap.org). Specific imagery in Figure 1 was sourced from Maxar Technologies Inc., published in ESRI World Imagery basemap, accessed using ArcGIS software version 10.5 (ESRI, Redlands, California).

3 Results

We captured and telemetry collared 5 giant-pouched rats (2 males and 3 females). Based on their weight and reproductive status, 1 animal was determined to be a juvenile and 4 were adults. During examination of reproductive conditions, one (animal 3) of the three females was pregnant and the other two females had evidence of past reproductive events (i.e., enlarged nipples). One of the two males was reproductively active, whereas the other was a juvenile (410 g). The weights of the adult animals ranged from 750 – 900 g with the pregnant female being the largest (Table 1).

3.1 Activity patterns

For each hour of the 24 h cycle, data were collected 5 times per animal during the study period allowing for sufficient time between data points to be considered as independent readings. Animal 1 was captured by local hunters who returned the radio-collar of the animal two days after its disappearance. Therefore, Animal 1 was only observed for 3 full cycles prior to its removal from the study. Animal 1, a female, was observed to be the most active animal, averaging 1.67 h of inactivity with a maximum observed inactive period of 2 h while her normal activity averaged 22.33 h with a maximum period of 23 h of observed activity (Table 1). Animal 3, the pregnant female, was found to be the least active animal; average duration of inactivity was 5 h with a maximum period of 8 h, and normal activity duration averaged 19 h with a maximum period of 21 active hours (Table 1). The observed average inactivity period for all animals was 3.01 h and average normal activity period was 20.86 h.

Nocturnal activity appeared to range between the hours of 18:00 and 05:00 with a probable cessation or reduction of activity between 20:00–23:00 and around 04:00. Diurnal activity ranged between 06:00 and 17:00 h with a probable cessation of activity between 11:00 and 14:00 (Figure 2, Figure 3).

3.2 Burrow characteristics and use patterns

We identified a total of 10 burrow sites during this study; animals 1, 2, and 4 each used one burrow (Figure 1). Animal 3 changed burrows once and stayed in the new location for the remaining period, while animal 5 (adult, female) changed burrows frequently. Mean maximum diameter of burrow entrances was 11 cm ($n = 27$). The average number of entrances per burrow was 2.7 with a range of 1–5 entrances.

Results of Wilcoxon ranked sum test indicate that the number of small trees around burrows (DBH <10 cm; $s = 0.03$) is significantly higher than large trees. Furthermore, of the 10 burrow sites observed, 8 (80%) were located within or on the edge of mixed agricultural areas (cassava and palm) and one burrow was located in a primary forest fragment and another in secondary forest.

3.3 Spatial analysis

Burrow sites were within 1.3–3 km southeast of the edge of Boende, in a mixed habitat dominated by secondary forest growth fragmented by agricultural land with palm trees and bamboo clustered throughout. All burrows were within 1 km of man-made structures (distance range of 443–922 m), mostly built along pathways. The average distance from burrow to path was 123 m (range of 42–250 m; Figure 1), this average distance is well within the maximum distance that we observed an individual *C. emini* travel between burrows (Animal 5; 164.8 m) during the study period. The farthest distance traveled to another burrow site between time points (13 day period) was 82.5 m (Animal 5). Burrow movement events were observed in 2 of the 5 animals, with Animal 5 changing its burrow 5 times during the observation period. A conservative estimate of Animal 5’s home range calculated from the den sites via the minimum convex polygon (MCP) approach was 5527 m^2. Den site movement was also observed from Animal 4, which traveled 50.2 m from a burrow within a patch of primary forest with abundant cover, to a burrow located within a cassava farm with minimal cover. Using the home range of *C. gambianus* reported by Skinner and Chimimba (2005) as a proxy for potential home range of *C. emini*, there were no spatial overlaps observed between individuals.

4 Discussion

Only 5 telemetry collars were available for this study, therefore the sample size was limited to 5 animals. In addition to the small sample size, the short observation period of 37 days limits the conclusions that can be made from this data. Despite these constraints, this work provides new information as the only study to address activity patterns or burrow sites of *Cricetomys* rodents using radio telemetry (Ewer 1967; Majer 1973; Rosevear 1969; Yadok et al. 2019). The data presented here suggest that *C. emini* spends more time being active (maximum period of 20.86 h) than inactive (maximum period of 3.01 h). This suggests a different pattern than what was reported in *C. gambianus* (maximum activity period of 5.7 h) by Ewer (1967). These differences may be due to the fact that Ewer (1967) studied a captive animal colony in an unnatural setting. In the present study, Animal 3 was observed to have the most hours of inactivity (maximum period of 8 h) compared to the other animals (Table 1); this could potentially be due to pregnancy.

C. emini appears to have a bimodal activity pattern, active during multiple periods of the day and night. Nocturnal activity ranged between the hours of 18:00 and 05:00 with a probable reduction of activity between 20:00–23:00 and around 04:00 (Figure 2). This nocturnal activity is similar to that observed for *C. gambianus* by Ewer (1967) and for *C. emini* by Majer (1973), but differs from *Cricetomys* sp. as reported by Yadok et al. (2019) who described a bimodal activity pattern during nocturnal hours only. Yadok et al. (2019) suggests that this bimodal pattern may be due to the fact that these animals have a temporal strategy to avoid predators and reduce competition. We also found that diurnal activity for *C. emini* ranged between 06:00 and 17:00 h with a probable cessation of activity between 11:00 and 14:00 h (Figure 2). Rosevear (1969) states that *Cricetomys* is primarily nocturnal but has occasionally been seen hunting for food in the daytime. In the present study, *Cricetomys* were observed to be active during the day inside their burrows.

Rosevear (1969) reports that *Cricetomys* change burrows frequently, leaving the old burrow vacant and Yadok et al. (2019) suggests that *Cricetomys* rodents utilize multiple borrows within the core areas of their home range, which may be useful in aiding escape from predators. The present study suggests that *C. emini* may change burrows less frequently than previously reported, since only one among 5 animals (Animal 5) was found to regularly move between burrows (Figure 1). A giant pouched rat can only use one burrow at a time and unoccupied burrows may therefore be available for use by other individuals.

Burrows of this species have been commonly reported in dense forest habitats, in farmlands, near deserted houses in forest villages, and near riparian areas (Genest-Villard 1967; Malekani 1990; Misonne 1971; Yadok et al. 2019). De Balsac and Lamotte (1958) report this species is particularly fond of oil palm fruits. Burrow habitats observed in this study support these previous findings, as most burrow sites for *C. emini* were located in disturbed sites such as mixed agricultural areas, including cassava and palm farms with few old growth trees.

Given the low sample size and high burrow fidelity observed in this study, the home range estimate of 5,527 m^2 we generated is limited and core use areas cannot be identified. This estimate is based solely on burrow sites and therefore would underestimate the actual home range of the animal as data on the movements of *C. emini* while active were not collected. This serves as the first *C. emini* den selection and movement study to provide a home range estimate. However, it is likely that the home range is more similar to that documented for *C. gambianus*, given the similarity between the habitat usage and activity patterns of these congeners (Majer 1973). There was no observed overlap between home range buffered den sites (Figure 2). This is likely due to our low sample size, as we cannot assume that every animal in the area was captured and therefore overlap between undetected animals may have occurred. Another possibility is home range estimation error due to the methods described here, but is worth noting that this could be the result of territoriality between individuals, as both male and female *Cricetomys* are known to be territorial (Ajayi et al. 1978).

In the present study, we observed *C. emini* burrows with entrances between 6 and 15 cm in diameter and the mean maximum diameter of burrow entrances was 11 cm ($n = 27$). This is similar to burrows reported by Ajayi (1977) who observed entrances between 4.5 and 15 cm in diameter for *C. gambianus* in a savanna area. Additionally, Ajayi (1977) reported that *C. gambianus* are known to have a maximum of four burrow exits in the savanna and human modified landscapes. We observed that the average number of entrances per burrow was 2.7 with a range of 1–5 entrances for *C. emini*. The number of burrow exits may be higher for *C. emini* in Thsuapa because the risk of predation may be higher due to human activities.

There are multiple paths and roads that connect Boende with surrounding villages and farms. The five *C. emini* individuals observed during this study were, on average, 123 m away from these paths, which were routinely used by human traffic (Figure 1). Given that we observed den site movements of up to 164.8 m during the study period, co-occurrence with humans and human activity is evident. This is concerning as giant pouched rats are a potential reservoir of MPXV (Doty et al. 2017; Drake 2005; Hutin et al. 2001) and other zoonotic pathogens. Additionally, the activity patterns observed here suggest a higher degree of diurnal activity than previously described for *Cricetomys* species (Ewer 1967; Majer 1973; Rosevear 1969; Yadok et al. 2019). It is possible that this result was impacted by our short observation period or our limited sample size, however, one explanation may be a lack of resources in the area, as Rosevear (1969) states that *Cricetomys* can be seen foraging for food in the daytime. Another explanation may be an increase in predator avoidance behavior caused by human disturbance. Hunters reportedly dig into burrows to catch these animals as a source of protein (Ajayi 1977; Assogbadjo et al. 2005; Kingdon 1997), and the proximity of the observed burrows to human activity means these animals are relatively convenient to be captured. In fact, one animal (Animal 1) observed in this study was captured by local hunters who returned the radio-collar to the authors during the study period and reported consuming the animal.

Acknowledgments:

We thank Centers for Disease Control and Prevention, Atlanta, GA 30333, USA for the assistance and financial support for this study. We also thank the Tshuapa Monkeypox Office, which provided logistical assistance for the field work. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Research funding:

Funding for this work was provided by the Poxvirus and Rabies Branch at the US Centers for Disease Control and Prevention.

References

Ajayi SS (1977). Field observations on the African giant rat, *Cricetomys gambianus* waterhouse, in Southern Nigeria. East Afr. Wildl. J 15: 191–198.

Ajayi SS, Tewe OO, and Faturoti EO (1978). Behavioural changes in the African giant rat (*Cricetomys gambianus* waterhouse) under domestication. Afr. J. Ecol 16: 137–143.

Assogbadjo AE, Codjia JTC, Sinsin B, Ekue MRM, and Mensah GA (2005). Importance of rodents as a human food source in Benin. Belg. J. Zool 135: 11–115.

Carleton MD and Musser GG (2005). Order rodentia. In: Wilson DE and Reeder M (Eds.), Mammal species of the world. A taxonomic and geographic reference, 3rd ed. Johns Hopkins University Press, Baltimore, Maryland, pp. 745–752.

Centers for Disease Control and Prevention (2003). Multistate outbreak of monkeypox-Illinois, Indiana, Kansas, Missouri, Ohio, and Wisconsin. MMWR (Morb. Mortal. Wkly. Rep.) 52: 642–644. [PubMed: 12855947]

De Balsac H and Lamotte M (1958). La réserve naturelle intégrale du Mont-Nimba, 15, Mammifères (Muscardinidés et Muridés). Mémoire Institut Français Afrique Noire 53, Dakar, Senegal.

Doshi RH, Guagliardo SA, Doty JB, Dzabatou-Babeaux A, Matheny A, Ndakala N, Kanjingankolo T, Kitembo L, Malekani JM, Kalemba L, et al. (2019). Epidemiologic and ecologic investigations of monkeypox in likouala department, republic of the Congo, 2017. Emerg. Infect. Dis 25: 288–296.

Doty JB, Malekani JM, Kalemba LN, Stanley WT, Monroe BP, Nakazawa Y, Mauldin MR, Bakambana TL, Liyandja TLD, Braden Z, et al. (2017). Assessing monkeypox virus prevalence in small mammals at the human–animal interface in the democratic republic of the Congo. Viruses 9: 283. [PubMed: 28972544]

Drake JM (2005). Risk analysis for invasive species and emerging infectious diseases: concepts and applications. Am. Midl. Nat 153: 4–19.

Ewer RF (1967). The behavior of the African giant rat, *Cricetomys gambianus* waterhouse. Z. Tierpsychol 24: 6–79. [PubMed: 5627212]

Garshelis DL, Quigley HB, Villarrubia CR, and Pelton MR (1982). Assessment of telemetric motion sensors for studies of activity. Can. J. Zool 60: 1800–1805.

Genest-Villard H (1967). Revision du genre *Cricetomys* (rongeurs, cricetidae). Mammalia 31: 390–455.

Gretillat S, Mattei X, and Marchand B (1981). A new rickettsiale of gambia rats (*Cricetomys gambianus*) in Senegal: *Grahamella kaniae* n. sp. (Bartonellacae). Rev. Élev. méd. Vét. Pays Trop 34: 383–389. [PubMed: 7346907]

Herder S, Simo G, Nkinin S, and Njiokou F (2002). Identification of trypanosomes in wild animals from southern Cameroon using the polymerase chain reaction (PCR). Parasite 9: 345–349. [PubMed: 12514949]

Hutin Y, Williams RJ, Malfait P, Pebody R, Loparev VN, Ropp SL, Rodriguez M, Knight JC, Tshioko FK, Khan AS, et al. (2001). Outbreak of human monkeypox, democratic republic of Congo, 1996–1997. Emerg. Infect. Dis 7: 434–438. [PubMed: 11384521]

Kingdon J (1997). The Kingdon field guide to African mammals. Academic Press, London.

Kingdon J (2015). The Kingdon field guide to African mammals, 2nd ed. Princeton and Oxford: Princeton University Press.

Machang'u RS, Mgode GF, Assenga J, Mhamphi G, Weetjens B, Cox C, Verhagen R, Sondij S, Goris MG, and Hartskeerl RA (2004). Serological and molecular characterization of leptospira serovar Kenya from captive African giant pouched rats (*Cricetomys gambianus*) from Morogoro, Tanzania. FEMS Immunol. Med. Microbiol 41: 117–121. [PubMed: 15145455]

Majer JD (1973). Observations on the activity pattern of the forest giant rat *Cricetomys emini* (Mammalia: cricetidae). Mammalia 37: 390–393.

Malekani JM (1987). Techniques de capture et observations écoéthologiques sur le rat de Gambie, *Cricetomys*, dans la forêt équatoriale du Zaïre. Tropicultura 5: 160–164.

Malekani JM (1990). Studies on Hepatic capillariasis and on the genus Meggittina (Cestoda) of Cricetomys spp.; – some of the edible rodents of Zaire, M.S. thesis. Antwerp, Belgium, Prince Leopold Institute of Tropical Medicine.

Malekani JM, Kumar V, and Pandey VS (1994). *Hepatic capillariasis* in edible *Cricetomys spp.* (Rodentia: cricetidae) in Zaire and its possible health implications. Ann. Trop. Med. Parasitol 88: 569–572. [PubMed: 7979648]

Ministère du Plan (RD CONGO) (2005). Monographie de la Province de l'Equateur. Comité Provincialde la Stratégie de Réduction de la Pauvreté CP-SRP/Equateur. Le Musée royal de l'Afrique centrale (MRAC), Tervuren, Belgium.

Misonne X (1971). Order rodentia. In: Meester J and Setzer HW (Eds.), The mammals of Africa: an identification manual, Vol. 6. Washington, D.C. Part, Smithsonian Institution Press, pp. 1–39.

Olayemi A, Nicholas V, Hulselmans J, Missoup AD, Fichet-Calvet E, Amundala D, Dudu A, Dierckx T, Wendelen W, Leirs H, et al. (2012). Taxonomy of the African giant pouched rats (Nesomyidae: *Cricetomys*): molecular and craniometric evidence support n unexpected high species diversity. Zool. J. Linn. Soc 165: 700–719.

Osadebe L, Christine MH, Shongo RL, Kabamba J, Nguete B, Malekani JM, Pukuta E, Karhemere S, Muyembe JJ, Okitolonda EW, et al. (2017). Enhancing case definitions for surveillance of human monkeypox in the Democratic Republic of Congo. PLoS Neglected Trop. Dis 11: e0005857.

Rimoin AW, Mulembakani PM, Johnston SC, Lloyd Smith JO, Kisalu NK, Kinkela TL, Blumberg S, Thomassen HA, Pike BL, Fair JN, et al. (2010). Major increase in human monkeypox incidence 30 years after smallpox vaccination campaigns cease in the democratic republic of Congo. Proc. Natl. Acad. Sci. USA 107: 16262–16267. [PubMed: 20805472]

Rosevear DR (1969). The rodents of West Africa. British Museum of Natural History, London, UK.

Sikes RS and The Animal Care and Use Committee of the American Society of Mammalogists (2016). 2016 Guidelines of the American society of mammalogists for the use of wild mammals in research and education. J. Mammal 97: 663–688. [PubMed: 29692469]

Skinner JD and Chimimba CT (2005). The Mammals of the Southern African subregion. Cambridge University Press, Cambridge.

Van Der Straeten E, Kerbis PJ, Howell K, and Oguge N (2008). Cricetomys gambianus. In: IUCN 2015. The IUCN red List of threatened species, Version 2015.3, Available at: <http://www.iucnredlist.org> (Accessed 10 November 2016).

Yadok BG, Pech R, and Chapman H (2019). Perception of predation risk by African giant pouched rats (Cricetomys sp. nov) is higher in forest-edge microhabitats. Behav. Process 168: 103953.

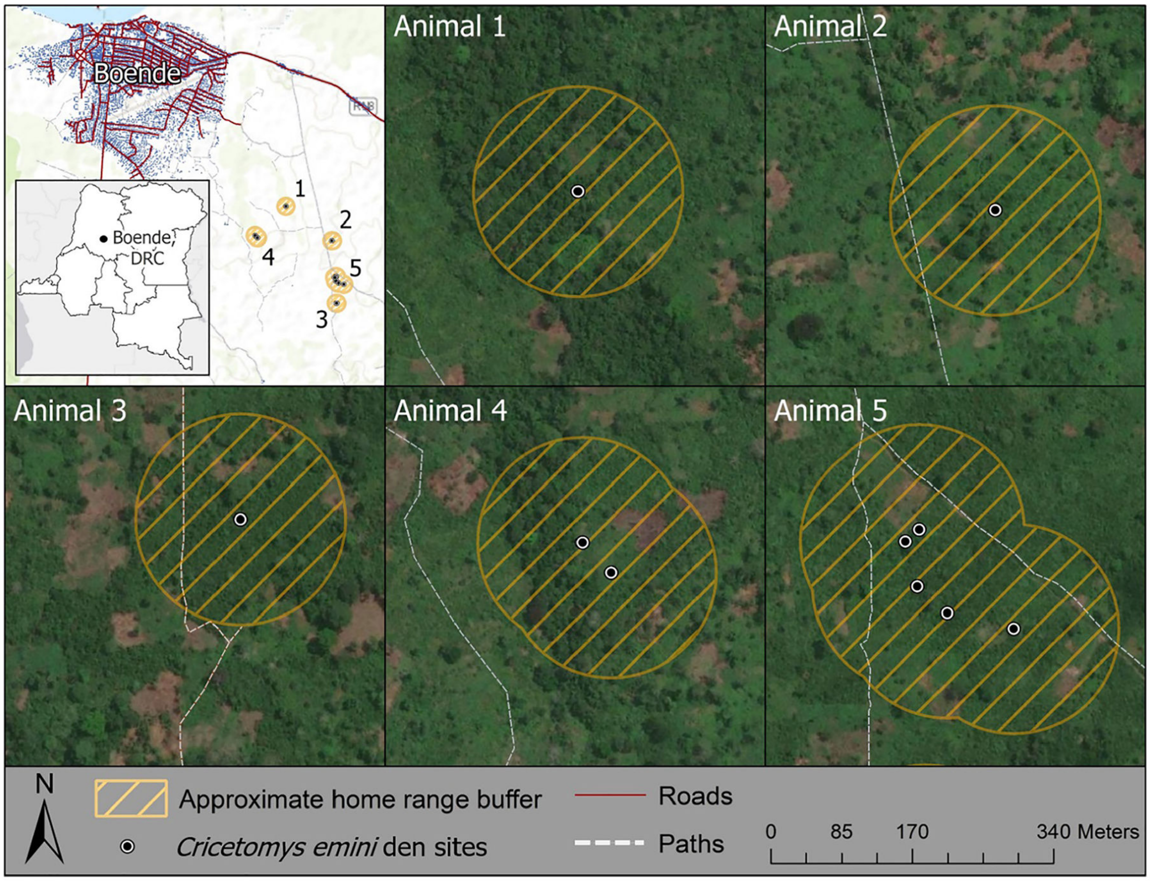

Figure 1:

Satellite imagery and location of the den sites of *Cricetomys emini* that were identified in tshuapa province, DR Congo, 2016. The den sites are buffered by a circular crosshatched area approximately equivalent to the home range of the congeneric *C. gambianus* reported by Skinner and Chimimba (2005).

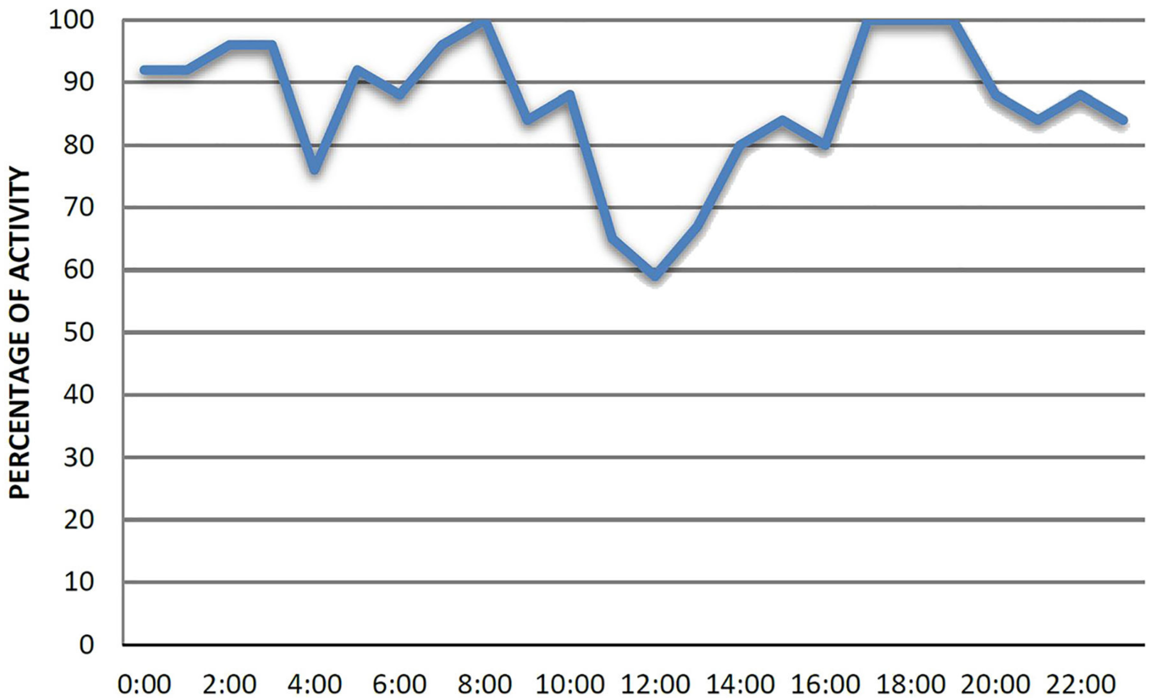

Figure 2:
Percentage of active observations recorded for each 1 h period for five (5) *Cricetomys emini* in tshuapa province, DR Congo, 2016.

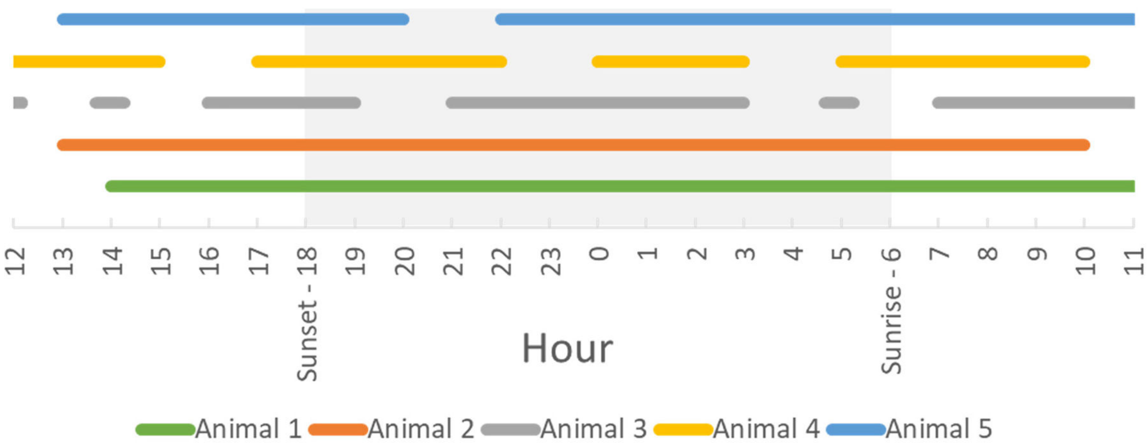

Figure 3:
Most frequently observed daily activity of individual *Cricetomys emini* in tshuapa province, DR Congo, 2016. The most common (modal value) activity parameter (active or inactive) recorded for each 1 h period is graphed. Breaks in the animal-specific lines denote periods where inactivity was the most common parameter of the individual among all observations.

Table 1:

Parameters characterizing the frequency of activity for 5 *Cricetomys emini*, DR Congo, 2016.

AN	Age	Weight (g)	Sex	ON	$\overline{x}S$ (h)	$\overline{x}N$ (h)	SDS	SDN	MinS (h)	MaxS (h)	MinN (h)	MaxN (h)
1	A.	750	F	$N = 3$	1.67	22.33	0.58	0.58	1	2	22	23
2	J.	410	M	$N = 5$	1.6	22.4	0.89	0.89	1	3	21	23
3	A.	900	F	$N = 5$	5	19	2.74	2.74	3	8	16	21
4	A.	850	M	$N = 5$	4.4	19.6	2.41	2.41	1	7	17	23
5	A.	770	F	$N = 5$	2.4	21.6	1.14	1.14	1	4	20	23

AN, animal number. Age: A., adult, J., juvenile. ON, 24 h cycle observations. $\overline{x}S$, mean period of inactivity (sleep). $\overline{x}N$, ean period of activity (normal). SDS, standard deviation of sleeping period; SDN, standard deviation of normal period; MinS, minimum period of sleeping; MaxS, maximum period of sleeping; MinN, minimum period of activity; MaxN, maximum period of activity.