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ARTICLE

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Video of rusty-spotted genets consuming bats and other prey: Behaviors observed and eco-epidemiological considerations

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Abstract

Following the implementation of a camera trap-monitoring protocol of interactions between cave bats and wildlife in the Republic of Congo, we identified sustained rusty-spotted genet (*Genetta maculata*) activity in Boundou cave. This cave, consisting of a single chamber, is home to a colony of several species of insectivorous bats throughout the year. Between 2022 and 2023, we recorded four events of bat or rodent consumption, one hunting attempt on bats and three feeding behaviors on insects. We describe and discuss the various behaviors and briefly elaborate on the potential epidemiological implications of bat consumption. To the best of our knowledge, our videos are the first to depict the consumption of bats by rusty-spotted genets.

KEYWORDS
camera traps, cave, foraging behavior, *Genetta maculata*, predation, scavenger, trophic chain

INTRODUCTION

With more than 1470 known species (Simmons & Cirranello, 2023), bats (Chiroptera) are the mammalian order represented globally by the largest number of individuals (Greenspoon et al., 2023). They are present in a wide range of habitats and exhibit a great diversity in their foraging and refuge behaviors, providing numerous ecosystem services (Kunz, 2013). They are also an essential element in the food chain, serving as food for many

predators (Kasso & Balakrishnan, 2013), including humans (Mickleburgh et al., 2009). During their resting period or when they emerge from their roosts, bats are predated by snakes (Price, 2004; Ridley, 1898), birds from different families (Tanalgo et al., 2019), centipedes (Molinari et al., 2005), as well as wild and domestic mammals (Costa-Pinto, 2020; Mallick et al., 2021; Oedin et al., 2021; Scrimgeour et al., 2012).

The Viverridae (order Carnivora) is a family of medium-sized, feliform carnivorous mammals comprising at least 34 different species distributed across three continents (southern Europe, Africa and Asia), divided into 14 distinct genera including genets, civets, and binturongs (Do Linh San, 2022; Jennings & Veron, 2009). Mainly known as nocturnal and terrestrial and/or arboreal hunters, they have a varied diet ranging from small vertebrates and invertebrates to fruits, seeds, and other plant materials (Jennings & Veron, 2009; Kingdon & Hoffmann, 2013). In Africa, there are between 14 and 17 recognized species of genets (Gaubert, 2013; Gaubert et al., 2005), with possibly up to four species living in the Republic of Congo (see appendix ES1 in Do Linh San et al., 2013). The rusty-spotted genet or Central African large-spotted genet (*Genetta maculata*; note that the species epithet *maculata* is no longer valid according to the International Commission on Zoological Nomenclature, and thus should only be used as a provisional naming; ICZN, 2007) is present in a wide range of countries in Africa (Angelici et al., 2016), including the Republic of Congo, where it is likely one of the most common genet species. It is known to be mainly carnivorous (small mammals, insects, gastropods, fish, amphibians, small birds and eggs), but it can supplement its diet with fruits, seeds and berries (Angelici & Gaubert, 2013; Roux et al., 2016).

Some genet species are known to consume bats on a more or less regular basis as part of their diet, such as the Cape genet (*Genetta tigrina*) (Azzaroli & Simonetta, 1966) and the common genet (*Genetta genetta*) (Carvalho et al., 2016; Fuller et al., 1990; Mas et al., 2015; Riols & Nadal, 2018). Although bat remains have been found in genet feces or stomachs, their direct consumption has not been well documented and predation events have rarely been observed. To our knowledge, only two studies, both in South Africa, mention cases of predation by *G. maculata* on bats. Carpenter (1970) described a rusty-spotted genet repeatedly consuming bats (average of six individuals per night) and Rautenbach (1978) mentioned the presence of a bat in the food bowl of an individual captured for an inventory.

In Africa and Asia, Viverridae are hunted for food (Brookes et al., 2022; Gaubert et al., 2015; Gossé et al., 2022) and to create clothing from their skins, or are captured alive to serve as exotic pets (Angelici et al., 2016; Carvalho et al., 2016; Widdows et al., 2016). Scientists suspect that at least one of these practices may be behind the outbreak of a new form of severe viral pneumonia (SARS) in 2002 due to interaction with masked palm civet (*Paguma larvata*) (Shi & Hu, 2008; Wang & Eaton, 2007; Xu et al., 2004; Yu et al., 2003). These predatory species can indeed contribute to the transmission of viruses to humans as bridge hosts by coming into contact with reservoir species such as bats (Borremans et al., 2019; Caron et al., 2015, 2018).

Camera monitoring has become a widespread technique, notably to detect the presence and determine the occupancy of wildlife species in focal regions and habitats (Ahumada et al., 2013; Fleming et al., 2014; Kucera & Barrett, 2011). However, the use of video recording can also provide precious and possibly novel information about interspecies interactions, including the feeding behavior of some predators and the interactions with their prey (Currylow et al., 2022; Yin et al., 2023).

Here, following a camera-trap monitoring program of cave-dwelling bats in the Republic of Congo, we report and describe, to our knowledge, the first recorded visual observations of rusty-spotted genets consuming bats (active predation and potential scavenging inside and outside caves). We also present observations of rodent and insect consumption by genets. We describe and discuss the various behaviors in relation to the current state of knowledge on the feeding ecology of *Genetta* species and briefly elaborate on the potential impact of these feeding behaviors on pathogen circulation pathways.

STUDY AREA AND METHODS

In September 2021, in the framework of a EBOSURSY project investigating the nonhuman animal and human interface and the associated risks of viral emergence, we started a monitoring program with camera traps to study the interactions between bat colonies and wildlife at two separate cave sites in the Republic of Congo (Figure 1) Mont Belo cave (4.1669° S; 12.9239° E), located in the department of Niari has one main chamber and two secondary chambers. Around Mont Belo cave, the habitat consists mainly of food crops and grassy savannah. Boundou cave (3.8916° S; 12.5573° E), located in the department of Bouenza consists of a main chamber and a secondary chamber which is not easily accessible by people due to a very narrow passage close to the ground. The habitat around Boundou cave is dominated by grassy savannah with patches of secondary forest. There is little human presence near the cave, with the first village 5 km away. In both caves, the presence of at least five species of

FIGURE 1 Study site in the Republic of Congo with Mont Belo and Boundou caves located approximately 50 km from one another.

bats has been recorded using harp traps at different times of the year (*Miniopterus* sp., *Rhinolophus* sp., *Hipposideros* sp., and *Roussettus aegyptiacus*) (M. Labadie, personal observations, 2021–2023).

In total, nine Moultrie M50 cameras (Moultrie, Birmingham, USA) (five at Boundou cave and four at Mont Belo cave) were placed to cover the entrance of each cave. We also placed at least one camera inside the main chamber to observe the behavior of wildlife inside the caves housing the bat colonies. From October 2021 to March 2023, we recorded wildlife activities at each cave for an average of 18 days every month. Cameras were set to take a photo and a 30-s video after each trigger. Camera sensitivity was set to maximum and a delay of 5 min between two detections was selected.

The detection of genet presence in pictures was initially carried out using the Megadetector software (Beery et al., 2019; Fennell et al., 2022) and all the corresponding videos were viewed by only one of the authors (Morgane Labadie). Following this first viewing, recordings showing feeding behaviors were extracted and analyzed. The interpretation of genet behavior on the videos of interest was carried out independently by two observers including an expert in small carnivores (Morgane Labadie and Emmanuel Do Linh San).

Three species of genets have so far been reported in the Republic of Congo, namely the rusty-spotted genet, servaline genet (*Genetta servalina*) and king genet (*Genetta poensis*), while the presence of crested genet (*Genetta cristata*) is uncertain (see appendix ES1 in Do Linh San et al., 2013). Of these, only rusty-spotted and servaline genets were detected at the study site. Both species lack the presence of an erectile mid-dorsal crest and display a broad intraspecific variation in coat coloration and spot and tail ring patterns (E. Do Linh San, personal observation). However, the former can generally be visually differentiated from the latter by a combination of morphological features: the presence of a limited number of large dark or rusty blotches (of round or square shape) in the first two dorsal rows; legs that are generally pale in color; a lower number of pale rings on the tail; and the tail tip is dark and appears elongated (Gaubert et al., 2008). For videos with poor quality or that were very dark, we used the software Vegas Pro (Magix Software, Berlin, Germany) to increase quality and/or brightness.

RESULTS

In total, over a period of 2 years, in Boundou cave, we recorded 1053 genet detections (corresponding to 56% of mammal detections, excluding bats), with 634 inside the cave and 419 at the cave entry. The genets were the only mammals present that were caught by the cameras displaying predatory behavior in Boundou cave. In contrast, at Mont Belo cave, we detected the presence of genets only seven times outside the cave, and no genet was ever filmed in the cave. The species detected at Mont Belo has been identified as the servaline genet (recorded

by video moving outside the cave) and the species present at Boundou as the rusty-spotted genet.

Feeding behaviors of genets were observed in Boundou cave only. Inside that cave, we recorded two cases of predation on bats, two others where it was not possible to distinguish between bats and rodents (due to the poor quality of the video and the angle), one attempt of hunting behavior on bats and three feeding events on insects. Table 1 lists the corresponding video files and summarizes the behaviors observed. All these events took place at night between 03:00 am and 06:00 am.

The first video (Video S1) shows an adult genet with its back facing the camera, eating a relatively large prey that is light in color. The individual could potentially be eating a rodent or a bat (Video S1). The second video (Video S2) again shows a genet with its back facing the camera, actively searching around a rock and retrieving a prey with its mouth. The genet then turns toward the camera to eat the animal (most probably a bat, given the shape).

The unequivocal consumption of bats by rusty-spotted genets was observed during two different months (June and September 2022) inside Boundou cave (see Videos S3 and S4). Video S3 starts by showing an adult genet holding a bat (Figure 2) that appears dead in its mouth. It then puts the bat back on the ground for a few seconds, before taking it back into its mouth and turning its back to the camera to consume the bat (see Video S3). The second consumption event shows the genet initially walking (with its back facing the camera) and then finding a bat lying on the ground (see Video S4). The animal then moves 1–2 m away from the initial site to eat it (see Video S4).

Video S5 shows a hunting attempt on bats by a genet outside Boundou cave. The event takes place on 26 January 2021, at 06:03 am, the time when bats enter the cave to rest before sunrise. We observe a genet sitting on a rock at the cave's main entrance, right in the middle of one of the passageways used by the bats to enter or leave the cave (the cave entrance is in the right-hand frame of the video, Video S5). On several occasions, the genet seems to attempt to catch bats flying close to it (Video S5).

Active predation on insects also took place on three different occasions (Videos S6, S7 and S8). In Video S6, a genet is rummaging in the leaf litter outside Boundou cave when it suddenly catches a ground insect before consuming it. The individual then moves around, while continuing to sniff the leaf litter. In Video S7, the genet

TABLE 1 Summary of videos from this study, metadata, observed behaviors, and additional comments.

Video evidence	Video ID and location	Date and time	Behavior	Other comments
Video S1	4842—Inside Boundou Cave	4 June 2022 at 05:45 pm	Consumption of a bat or rodent	Ignore the date in the video, the camera had the wrong date.
Video S2	8270—Inside Boundou Cave	27 January 2023 at 03:44 am	Consumption of a bat or rodent	
Video S3	5058—Inside Boundou Cave	19 June 2022 at 05:26 am	Consumption of a bat	Not clear whether the bat was killed or found dead.
Video S4	6118—Inside Boundou Cave	7 September 2022 at 03:55 am	Consumption of a bat	Not clear whether the bat was killed or found dead.
Video S5	2845—Outside Boundou Cave	26 January 2021 at 06:03 am	Hunting behavior toward bats flying around the genet	The rock where the genet sits is located at the entrance of the cave.
Video S6	4819—Outside Boundou Cave	20 May 2022 at 03:11 am	Predatory behavior on ground insects in the leaf litter outside the cave	Several bats flying around, but genet not paying attention.
Video S7	8144—Inside Boundou Cave	17 January 2023 at 04:35 am	Predatory behavior on ground insects in the guano litter inside the cave	High abundance of beetles on the ground. Several bats flying around, but genet not paying attention.
Video S8	8378—Inside Boundou Cave	3 February 2023 at 03:15 am	Predatory behavior on insects in the guano litter inside the cave	Very dark video.

appears to be searching for something on the cave floor (guano litter) before suddenly moving and catching a ground insect which is quickly consumed before moving elsewhere in the cave. The last video (Video S8, very dark) shows a genet coming rapidly into the camera's field of view, looking for something close to the ground before suddenly moving and quickly catching an insect with its two front legs. After eating it, the individual continues to move inside the cave in search of new prey (Video S8).

DISCUSSION

Our study is the first to record sequences of feeding behaviors of genets, namely rusty-spotted genets, on bats through predation and/or scavenging in Africa. We also recorded rodent and insect consumption inside and outside the cave. During each event filmed by the cameras, genets were active during the night period between 03:00 am and 06:00 am. These results are in line with the biology of the species presented by Fuller et al. (1990), with 70% of their activity taking place between 07:00 pm and 07:00 am. It is important to stress that we only detected a few feeding behaviors on bats, rodents and insects. However, it is quite possible that their frequency is underestimated due to camera angle (only 65% of the cave interior was covered by the camera), video quality and detection distance (notably for inside Mont Belo cave, where no genet was detected).

Genets are known to frequently include arthropods in their diet (Kingdon & Hoffmann, 2013; Skinner & Chimimba, 2005; Virgós et al., 1999), and three videos in this study prove this behavior (Videos S6–S8). However, we observed limited insect consumption despite their constant presence year-round in the cave guano. We can hypothesize that the insect species present at the time were not priority targets, or that the genet individuals that came into the cave had an opportunity of catching more nutritious prey such as bats or rodents. Our observations support Palmeirim and Rodrigues (1991), who reported that common genets (*G. genetta*) in South Portugal regularly hunt cave-dwelling bats, taking advantage of their roosting behavior.

Our data on the presence of genets in Boundou cave show that they were very active throughout the seasons, with at least two behaviors involving bat consumption and up to two cases of rodent consumption (Videos S1–S4). In addition, one video showed the hunting behavior of a genet at the entrance of the cave, precisely in the bottleneck where the bats pass to exit and reenter the cave (Video S5). The configuration of Boundou cave has three specific features that may both favor and facilitate the consumption of bats by genets: (1) rocky promontories that allow bats to reach significant heights, hence providing opportunities to hunt bats; (2) a narrow rocky neck that allows genets to hunt bats flying through that narrow space; and (3) a high concentration of bats per square meter at certain periods of the year, which forces some individuals to sleep very low on the walls and provides a regular and predictable amount of carcasses, as some bats naturally die while roosting. On

FIGURE 2 Putative scavenging behavior of a rusty-spotted genet (*Genetta maculata*) on a bat inside Boundou cave in the Republic of Congo (screenshot of Video S3).

the contrary, Mont Belo cave has very high ceilings and no rocky promontories allowing access to the bat colony, which could be one of the reasons why we did not observe any genets inside the cave. At Mont Belo, as the servaline genet has not been observed using the cave for feeding, we can hypothesize that it does not seek food in this ecological niche.

One of our videos shows a genet potentially killing a bat on the ground (see Video S4). Normally, cave bats have no reason to be on the cave floor. The majority of bat species spend most of their lives perched upside down, clinging to surfaces using their hindlimbs, which have a digital tendon locking mechanism that does not require any energy expenditure (Quinn & Baumel, 1993; Schutt, 1993). The most likely hypotheses for the presence of a bat on the ground would be due to an injury, the weakness of the individual or an inexperienced young bat that has fallen.

We assumed that at least one identified bat consumption event (see Video S3) is a necrophagic behavior, as we had no prior record of genet hunting activity in the cave for the day of the event. The scavenging behavior of genets on dead bats in the cave raises a number of questions. The mortality of bats in their natural environment can be due to several factors such as (1) collision and/or injury, (2) natural death, (3) predation, and (4) diseases due to bacterial, viral, and parasitic infection (Gillette & Kimbrough, 1970; Mühldorfer et al., 2011; O'Shea et al., 2016; Wilson, 2015). Knowledge of mortality events and their frequency in cave bat colonies is incomplete. Recent studies have focused on the mortality rate of bats following the introduction of white-nose syndrome fungus into colonies (Hoyt et al., 2021; Langwig et al., 2017), but not on the mortality rate in healthy colonies. It is therefore difficult to estimate mortality rate in the caves in our study, even if the observation of bat carcasses in caves is quite common (M. Bourgarel, personal observation).

The scavenging behavior of genets can have two potential impacts on pathogen circulation in the ecosystem. Firstly, by consuming dead animals, many scavengers promote a "healthier" environment by removing the carcasses and thus, limit the spread of potential diseases, especially in communities that live in enclosed spaces (Vicente & VerCauteren, 2019). Secondly, it might facilitate the circulation of pathogens in the ecosystem. Indeed, some bat species are known or suspected to be maintenance hosts for pathogens, some of which are a risk for human populations (Brierley et al., 2016; Han et al., 2015; Smith & Wang, 2013). Scavenging could create a pathway for pathogen circulation between the bat host, to a bridge host, the genet, which then can continue the chain of transmission toward other hosts, including humans. The latter step could be relevant, as genet consumption and the bushmeat trade in Congo and other West and Central African countries are sustained (Angelici et al., 1999; Gaubert et al., 2015; Lindsey et al., 2013). Given that the secretive and nocturnal lifestyle of bats limits direct contacts between bats and humans, the role of potential bridge hosts must be taken into consideration in the ecology of bat-borne diseases. So far, bridge hosts have been demonstrated for Hendra virus and the role of horses; the initial emergence of Nipah virus and the role of the pig farm; some outbreaks of Ebola and the role of hunted or scavenged nonhuman primates; and the emergence of SARS-coronavirus and the presence of masked palm civets (*P. larvata*) in wet markets (Murray et al., 1995; Pulliam et al., 2011; Sanchez et al., 1999; Walsh et al., 2007; Wong et al., 2007). More recently, the bridge host role of masked palm civets has also been suspected in the emergence of SARS-COV-2 (Worobey et al., 2022).

In conclusion, our data confirm that rusty-spotted genets are opportunistic carnivores that can feed on a wide variety of prey in a single habitat, ranging from insects to small mammals. In Boundou cave, the wide availability and accessibility of bats seems to favor opportunistic predation behavior on bats. To evaluate whether genets' predatory and even scavenging behavior toward bats is limited or widespread, future studies could similarly make use of camera trap monitoring in other caves and countries, and/or collect genet feces from individuals living in the vicinity of these caves for diet analysis.

AUTHOR CONTRIBUTIONS

Morgane Labadie conceptualized the study (equal contribution), led data curation, formal analysis, and methodology, and was also responsible for visualization and writing the original draft. Emmanuel Do Linh San equally contributed to conceptualization, formal analysis, investigation, and visualization, led species identification, and took the lead in writing the review and editing. Serge Morand provided supervision and contributed equally to writing the review and editing. Alexandre Caron shared supervision and writing review and editing responsibilities equally. Fabien Roch Niama supported funding acquisition, project administration, and writing review and editing. Guytrich Franel Nguilili supported data curation, while Tobi N'Kaya equally contributed to project administration and supported writing review and editing. Hélène Marie De Nys contributed equally to funding acquisition, supervision, writing review and editing, and project administration. Mathieu Bourgarel led funding acquisition, contributed equally to supervision, writing review and editing, and project administration.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Videos S1–S8 are available in supplementary material. A full analysis of this and other camera trap data has been the subject of another article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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