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Edited by C. & M. Stuart



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From the editors:

Firstly, we thank all contributors for submitting material for issue number 14 of the newsletter.

Most but not all the material came in at the 'last minute' and we would appeal again for material to be forthcoming well before the deadline of July/August 2019 for issue number 15. Thank you!

For this issue we have a good mix of material and we especially appreciate the field notes.

We feel it would be good if contributors could provide photos/images of themselves at work in the field or laboratory. It is always good to relate a face with a contribution. Hopefully there will be a response from contributors.

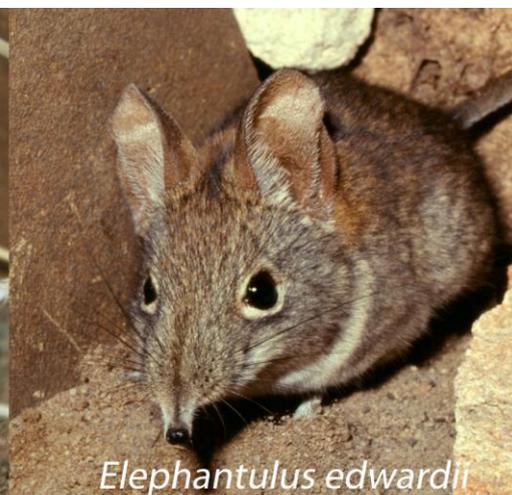
C. & M. Stuart, Waxenberg, Austria
September 2018 (www.stuartonnature.com)



Elephantulus rupestris



Macroscelides proboscideus



Elephantulus edwardii

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Features

Will aardvarks go thirsty under climate change?

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Background

Water is essential for life and understanding the water requirements for a species is more than just an academic exercise. Climate change is causing rising air temperatures and increasingly unpredictable rainfall in Africa (Niang et al., 2014), thereby likely limiting availability of free-standing water for many mammal species. For species living at the limits of their physiological requirements for water in arid regions, reduced water access might lead to their local extinction in future.

The amount of water required by an animal to sustain itself is affected by factors including thermoregulation, sweating and evaporative water loss, metabolic rate, diet, activity levels, and reproductive state, and by environmental factors such as ambient temperature, thermal radiation, and water vapour pressure (Robbins, 1983). While many mammals have to drink to meet their water requirements, some species are water-independent and do not generally need to drink because they are able to meet their needs through preformed water contained in food or metabolic water (Robbins, 1983). Many such species are able to live in arid environments where freestanding water is scarce, for example desert rodents (Bozinovic & Gallardo, 2006) and desert foxes (Geffen, Degen, Kam, Hefner, & Nagy, 1992), as well as large desert herbivores like oryx species and the springbok (*Antidorcas marsupialis*) (Cain, Krausman, Rosenstock, & Turner, 2006). These mammals commonly exhibit behavioural, physiological or anatomical adaptations for water conservation (Fuller, Hetem, Maloney, & Mitchell, 2014) which, together with their environmental conditions, determine the water requirements of mammal species and the degree to which they need access to freestanding drinking water to survive.

One African mammal that might be affected by climate change, and whose drinking habits and water requirements are not yet fully understood, is the aardvark (*Orycteropus afer*). Aardvarks occur in a wide range of habitat types, from tropical forests in central Africa where freestanding water is abundant, to semi-arid areas such as the Karoo and Kalahari in southern Africa, where freestanding water is scarce (Taylor, 2013). Climate change is making conditions in the semi-arid regions of aardvark distribution hotter and drier (Niang et al., 2014). Populations of ants and termites, which aardvarks prey upon to obtain energy and water, can decline during drought (Marsh, 1987; Nel & Hewitt, 1969) and this has raised concerns about the aardvark's capacity to survive in these regions in the long-term due to lower availability of water and prey (Rey, Fuller, Mitchell, Meyer, & Hetem, 2017). While the loss of the aardvark from these regions would be undesirable for the species itself (i.e., the loss of genetic diversity), it might also negatively affect ecosystem functioning through the loss of their digging activities. For example, aardvark burrows provide shelter from extreme temperature and predation for many animal species (Cilliers, 2002; Smithers, 1971; Whittington-Jones, Bernard, & Parker, 2011), and the loss of these microhabitats might be detrimental to the survival of these species, although the impact on survival has not been tested. Similarly, other ant- and termite-eating mammals and birds have a commensal relationship with aardvarks, making use of aardvark feeding activities to supplement their own food resources (Taylor & Skinner, 2000, 2001). Although the degree of dependence on these benefits is unknown, a negative impact of aardvark extirpation on at

least some commensal species is likely. Aardvarks may also have important impacts on populations of ants and termites and on turnover and aeration of soil. These aspects of aardvark ecology deserve further research.

Understanding the water requirements of aardvarks is important for predicting how climate change might affect their geographic distribution, but their water requirements have never been formally studied. Here we present what evidence is currently available for the drinking requirements of aardvarks to improve an understanding of the implications of climate change for future aardvark distribution.

Aardvark water needs and adaptations

Drinking

The need for and frequency of drinking water by aardvarks has been debated. Long-term behavioural observations suggest that aardvarks drink infrequently even when freestanding water is available. During more than 1,000 hours of behavioural observations of two habituated aardvarks over a 12 month period, when aardvarks were watched for varying lengths of time per night (2-8 h), six nights per week and at different times of the night, drinking was only observed on two occasions (Taylor & Skinner, 2004). This study was conducted in the semi-arid Nama-Karoo of South Africa, a summer rainfall region where freestanding water is rare (except for man-made dams), during a period of average annual rainfall. Assuming, hypothetically, that aardvarks need to drink freestanding water once in every 24-h period, with an average aardvark activity period of 8 h in the Karoo (Taylor & Skinner, 2003), about 125 drinking occurrences would have been expected during the 1000 h .

Even studies during which aardvarks were not observed for the entirety of their above-ground activity periods can serve to infer information on aardvark drinking behaviour. For instance, in a 3-year study in the Kalahari, study aardvarks were never observed drinking, and had no access to freestanding water within their home range areas (Weyer, 2018). These individuals likely went long periods at a time without drinking, and might indeed never have consumed drinking water at all.

Recently, Kerley and Tompkins (2017) presented evidence of aardvarks drinking freestanding water on three occasions in the Eastern Karoo and one in the Lowveld Savanna in South Africa. They concluded that aardvarks drink both opportunistically (such as from an ephemeral rain puddle) and in a more purposeful fashion (moving towards a river or dam to drink). Although the authors demonstrated that aardvarks do drink water, which is in line with previous findings (Taylor & Skinner, 2004), the observations mentioned were isolated incidents. There was no assessment of the frequency of drinking or the prevailing environmental conditions under which the aardvarks chose to consume water (i.e., drought or non-drought). Indeed, some of the photographed aardvarks presented were likely subadults, and thus may have had greater water requirements than adult individuals. More important, perhaps, is the fact that three of these images were taken after periods of drought (May 2013 following the 2012-13 drought over southern Africa, and June 2016 after the 2015-16 drought (Archer et al., 2017; Beraki, 2016)). Drought can negatively affect the availability of ants and termites (Marsh, 1987; Nel & Hewitt, 1969), and hence water and energy availability to aardvarks (Weyer, 2018). The Karoo aardvarks photographed drinking during daylight in winter appear to have been in poor physical condition, possibly due to lack of water-providing prey after drought (Weyer, 2018), and might have sought water sources in an attempt to compensate for this drought-related water-deficit.

Feeding

Detailed studies of feeding behaviour have shown that aardvarks eat ants and termites almost exclusively, with the proportions of either prey type depending on location and the availability of prey species (Melton, 1976; Taylor, Lindsey, & Skinner, 2002; Weyer, 2018). Studies from semi-arid regions in South Africa indicated that in the Nama-Karoo, ants dominated aardvark diet (Taylor et al., 2002) whereas in the slightly more arid Kalahari, termites were the predominant aardvark prey and accounted for more than 90% of dietary water for aardvarks, while the remaining water intake was derived from ants (Weyer, 2018). In the absence of drinking water, the high water content of their

main termite prey likely is vital for aardvark survival in an environment as hot and dry as the Kalahari (Weyer, 2018).

No studies to date have specifically examined the water requirements of aardvarks under varying conditions in their natural environments or their ability to obtain sufficient water from their food. However, insights from other ant- and termite-eating mammals can be used for inference. For instance, the aardwolf (*Proteles cristata*), a strict termite-eater (Williams, Anderson, & Richardson, 1997) from the hyena family, has a geographic range that overlaps considerably with the aardvark in southern Africa (Anderson, 2004; Williams et al., 1997). A behavioural and field metabolism study indicates that aardwolves do not drink freestanding water either (Williams et al., 1997). Silky anteaters (*Cyclopes didactylus*) in Panama have a high water economy index (the water turnover relative to energy turnover), and nearly all their water intake (preformed water plus metabolically produced water) is accounted for by water in their ant prey (Nagy & Montgomery, 2012). As a result, silky anteaters do not need to drink freestanding water on a regular basis (Nagy & Montgomery, 2012). Australian numbats (*Myrmecobius fasciatus*) live in arid environments where freestanding water is not available during summer, and their high water economy index allows them to cover all their water requirements from their termite prey without having to drink (Cooper & Withers, 2004).

Behavioural thermoregulation

Free-living large mammals often use evaporative cooling (e.g., sweating, panting) to regulate their body temperature independently of the environmental heat load. This heat loss mechanism is water-dependent, thus mammals that do not readily have access to drinking water must rely on behavioural, rather than physiological, avenues to cope with hotter and drier environments under climate change (Fuller, Mitchell, Maloney, & Hetem, 2016; Hetem, Maloney, Fuller, & Mitchell, 2016). One such avenue is a shift in activity patterns to cooler times of the day. Under normal, non-food-stressed conditions, aardvarks are nocturnal and remain in burrows during the day and become active at night, thereby avoiding exposure to the hottest times of day (Taylor & Skinner, 2003; Weyer, 2018).



Figure 1) Under non-drought conditions, aardvarks sometimes drink, but appear to be largely independent of water, even in the more arid parts of their distribution. (Drawing by L. Rammensee)

However, recent evidence suggests that aardvarks are exclusively nocturnal only when they are in good body condition but become active during the daytime when they are nutritionally-

compromised (Rey et al., 2017; Weyer, 2018), independent of air temperature or season (Weyer, 2018). During periods of insufficient food intake, such as when severe drought causes ant and termite prey populations to decline, armadillos become diurnal (Weyer, 2018). During winter, this response leads to an avoidance of energetically-demanding exposure to cold night time temperatures (van der Vinne et al., 2014). However, diurnal activity of armadillos was also recorded in summer during a severe drought (Rey et al., 2017; Weyer, 2018).



Figure 2) A warming and drying climate likely has negative impacts on armadillos through reduced resources, including water, which might become more important but less available in future. (Drawing by L. Rammensee)

This activity shift exposed the armadillos to daytime heat, and potentially enhanced water loss in the heat could not be compensated for by drinking due to the absence of free-standing water, possibly jeopardising their water balance. An armadillo mass mortality in the Kalahari during that drought was attributed to insufficient prey availability (Rey et al., 2017; Weyer, 2018), and the lack of water might have exacerbated the impacts of starvation on the armadillos.

Anatomy and physiology

The kidney function and water retention capacity in armadillos have not been studied, but anatomically, the armadillo's kidneys appear to lack structures specific to water conservation (Sonntag, 1925). The apparent inability of armadillos to concentrate their urine (Taylor, pers. obs.), combined with their infrequent drinking, suggests that they must cover their water intake from their prey.

The potential impact of climate change and water availability on armadillo distribution

We conclude that, although armadillos might drink occasionally, they are not generally dependent on drinking freestanding water to meet their water requirements. This is because under non-drought conditions, when ant and termite populations are thriving, armadillos likely obtain enough food and water from their ant and termite prey (Weyer, 2018). However, intense drought conditions have severe, negative impacts on ant and termite populations with considerable impacts on the ability of armadillos to maintain energy and water balance from their prey alone (Weyer, 2018). Such drought conditions are increasingly expected under climate change, and we suggest that drinking might become more important for armadillos than at present. At the same time, water access especially in the semi-arid habitats of the armadillo's geographic range might become even more limited under climate change than it already is, potentially restricting the distribution of armadillos.

Further studies are necessary to establish the significance of drinking to aardvarks across African habitats, particularly in the light of a warming and drying climate. Moreover, it is currently not known whether aardvarks employ sweating or other means of evaporative cooling as do other mammals, and whether they are able to regulate their cutaneous evaporative water loss. Novel anatomical and physiological investigations could shed light on the adaptations of the aardvark to cope with the hot, arid conditions expected under climate change.

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References

- Anderson, M. D. (2004). Aardwolf adaptations: a review. *Transactions of the Royal Society of South Africa*, 59(2), 99–104. <https://doi.org/10.1080/00359190409519168>
- Archer, E. R. M., Landman, W. A., Tadross, M. A., Malherbe, J., Weepener, H., Maluleke, P., & Marumbwa, F. M. (2017). Understanding the evolution of the 2014–2016 summer rainfall seasons in southern Africa: Key lessons. *Climate Risk Management*, 16, 22–28.
- Beraki, A. (2016). Current state of climate drivers and seasonal climate projections. *South African Weather Service - Media Release*, 29 August, 1–3.
- Bozinovic, F., & Gallardo, P. (2006). The water economy of South American desert rodents: From integrative to molecular physiological ecology. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, 142(3–4), 163–172. <https://doi.org/10.1016/j.cbpc.2005.08.004>
- Cain, J. W., Krausman, P. R., Rosenstock, S. S., & Turner, J. C. (2006). Mechanisms of Thermoregulation and Water Balance in Desert Ungulates. *Wildlife Society Bulletin*, 34, 570–581. [https://doi.org/10.2193/0091-7648\(2006\)34\[570:MOTAWB\]2.0.CO;2](https://doi.org/10.2193/0091-7648(2006)34[570:MOTAWB]2.0.CO;2)
- Cilliers, S. (2002). The ecological importance of the Aardvark. *Afrotherian Conservation*, 1, 7–8.
- Cooper, C. E., & Withers, P. C. (2004). Termite digestibility and water and energy contents determine the water economy index of numbats (*Myrmecobius fasciatus*) and other myrmecophages. *Physiological and Biochemical Zoology*, 77, 641–650.
- Fuller, A., Hetem, R. S., Maloney, S. K., & Mitchell, D. (2014). Adaptation to Heat and Water Shortage in Large, Arid-Zone Mammals. *Physiology*, 29(3), 159–167. <https://doi.org/10.1152/physiol.00049.2013>
- Fuller, A., Mitchell, D., Maloney, S. K., & Hetem, R. S. (2016). Towards a mechanistic understanding of the responses of large terrestrial mammals to heat and aridity associated with climate change. *Climate Change Responses*, 3(1). <https://doi.org/10.1186/s40665-016-0024-1>
- Geffen, E., Degen, A. A., Kam, M., Hefner, R., & Nagy, K. A. (1992). Daily energy expenditure and water flux of free-living Blanford's Foxes (*Vulpes cana*), a small desert carnivore. *Journal of Animal Ecology*, 61, 611–617.
- Hetem, R. S., Maloney, S. K., Fuller, A., & Mitchell, D. (2016). Heterothermy in large mammals: inevitable or implemented? *Biological Reviews*, 91, 187–205.
- Kerley, G. I., & Tompkins, I. D. (2017). Drinking by aardvark *Orycteropus afer*. *African Journal of Ecology*, 56(1), 128–130.
- Marsh, A. C. (1987). The foraging ecology of two Namib Desert harvester ant species. *South African Journal of Zoology*, 22, 130–136.
- Melton, D. A. (1976). The biology of aardvark (Tubulidentata-Orycteropodidae). *Mammal Review*, 6, 75–88.

- Nagy, K. A., & Montgomery, G. G. (2012). Field Metabolic Rate, Water Flux and Food Consumption by Free-Living Silky Anteaters (*Cyclopes didactylus*) in Panama. *Edentata*, 13, 61–65. <https://doi.org/10.5537/020.013.0106>
- Nel, J. J. C., & Hewitt, P. H. (1969). A study of the food eaten by a field population of the harvester termite, *Hodotermes mossambicus* (Hagen) and its relation to population density. *Journal of the Entomological Society of Southern Africa*, 32, 123–131.
- Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). 4: Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. (pp. 1199–1265). Cambridge University Press.
- Rey, B., Fuller, A., Mitchell, D., Meyer, L. C. R., & Hetem, R. S. (2017). Drought-induced starvation of aardvarks in the Kalahari: an indirect effect of climate change. *Biology Letters*, 13(7), 20170301. <https://doi.org/10.1098/rsbl.2017.0301>
- Robbins, C. T. (1983). *Wildlife feeding and nutrition*. New York: Academic Press.
- Smithers, R. H. N. (1971). Mammals of Botswana. *Mus. Mem. Natl. Mus. Monum. Rhod.*, 4.
- Sonntag, C. F. (1925). A monograph of *Orycteropus afer*. - I. Nervous system, sense-organs and hairs. *Proceedings of the Zoological Society of London*, 95, 331–438.
- Taylor, W. A. (2013). *Orycteropus afer*. Aardvark. In *Mammals of Africa. Volume 1*. Eds. Kingdon et al. (Vol. 1, pp. 210–215). London: Bloomsbury Publishing.
- Taylor, W. A., Lindsey, P. A., & Skinner, J. D. (2002). The feeding ecology of the aardvark *Orycteropus afer*. *Journal of Arid Environments*, 50(1), 135–152. <https://doi.org/10.1006/jare.2001.0854>
- Taylor, W. A., & Skinner, J. D. (2000). Associative feeding between Aardwolves (*Proteles cristatus*) and Aardvarks (*Orycteropus afer*). *Mammal Review*, 30, 141–143.
- Taylor, W. A., & Skinner, J. D. (2001). Associative feeding between Ant-eating Chats, *Myrmecocichla formicivora*, and Aardvarks, *Orycteropus afer*. *Ostrich*, 72, 199–200.
- Taylor, W. A., & Skinner, J. D. (2003). Activity patterns, home ranges and burrow use of aardvarks (*Orycteropus afer*) in the Karoo. *Journal of Zoology (Lond)*, 261, 291–297. <https://doi.org/doi:10.1017/S0952836903004217>
- Taylor, W. A., & Skinner, J. D. (2004). Adaptations of the aardvark for survival in the Karoo: a review: animals. *Transactions of the Royal Society of South Africa*, 59(2), 105–108.
- van der Vinne, V., Riede, S. J., Gorter, J. A., Eijer, W. G., Sellix, M. T., Menaker, M., ... Hut, R. A. (2014). Cold and hunger induce diurnality in a nocturnal mammal. *Proceedings of the National Academy of Sciences*, 111(42), 15256–15260. <https://doi.org/10.1073/pnas.1413135111>
- Weyer, N. M. (2018). *Physiological flexibility of free-living aardvark (Orycteropus afer) in response to environmental fluctuations* (PhD). University of Witwatersrand, Johannesburg.
- Whittington-Jones, G. M., Bernard, R. T. F., & Parker, D. M. (2011). Aardvark burrows: a potential resource for animals in arid and semi-arid environments. *African Zoology*, 46, 362–370.
- Williams, J. B., Anderson, M. D., & Richardson, P. R. K. (1997). Seasonal differences in field metabolism, water requirements, and foraging behavior of free-living aardwolves. *Ecology*, 78, 2588–2602.



During a severe drought in northern Namibia pangolins were moving around and feeding during the day, as here. Note the glossy starlings picking up termites overlooked by the pangolin. ©C. & M. Stuart.

Male rock hyraxes (*Procavia capensis*): Singing tactics and the dynamics of counter-singing events

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Abstract

The goal of communication is the efficient delivery of signals to a target audience. Animals employ various tactics to increase the efficiency of signal delivery and to adjust the timing of signaling in order to maximize the benefits over the associated costs. Rock hyraxes (*Procavia capensis*) use acoustic signals to communicate and mainly adult males produce elaborate vocalizations (known as songs) that serve as honest advertisements of their quality. Singing is initiated spontaneously or in response to conspecific songs and significant social events. We have investigated the factors affecting hyrax singing behavior and the dynamics of male-male vocal exchanges (counter-singing). Our results show that songs performed during and following attention-grabbing events (agonistic interactions, alarm calls, predator presence, and conspecific singing) have an increased syntactic complexity in comparison to spontaneous singing. Also, we showed that songs have a crescendo like progression pattern and climatic increase in its syntactic complexity towards its end. Similar progression patterns are used in music to maintain audience attention and create a long-lasting impression. Male hyraxes employ different counter-singing tactics depending on the differences in residence status and social rank between the participants. While resident listeners tend to reply to conspecific males at high rates regardless of the initiators' rank and residency status, bachelors "respect ownership" and show low reply rates to resident males. However, despite the bachelors' general "respect for ownership", the lowest ranking bachelors tend to exhibit a counter intuitive "Napoleon complex" based tactic. They show a tendency for counter-singing against the highest ranking resident males, possibly as high ranking individuals often show tolerance towards non-threatening low level competitors. Additionally, local males seem to adopt a "nasty neighbor" signaling strategy. They show a higher preference for counter-singing with familiar males and avoid responding to strangers' songs whom they might perceive as low and transient threat.

Introduction

Understanding the nature of animal communication is an important part of the investigation of social behaviour. In many species, vocal signals play a particularly important role in the interactions between individuals [1-3]. It has been shown that animals can signal their identity vocally, indicate their social and mating status, and mediate social interactions [4]. The ability to recognize and decipher information encoded in the transmitted signal allows the receiving individuals to alter their behaviour accordingly [5] (e. g. avoid unfavourable agonistic interactions [6], make a decision regarding a preferable mate [7] or respond with their own audible signal [8]). Vocal confrontations or counter-vocalisation play a vital role in social interactions and their function ranges from announcing territorial boundaries [9] and competing for female attention [10] to making contact with a group or a family member [11]. Here, we summarise some of our recent findings and publications exploring the above factors in the context of long range vocal signals emitted by male rock hyraxes (*Procavia capensis*) [12-15].

Male hyrax songs are a quality based signals reflecting signallers' attributes (i.e., body weight, hormonal levels and social status) [16] and identity [17]. The songs contain several bouts with repetitive elements (termed wails, chucks and snorts) [16]. Initial bouts are usually shorter and consist of only a few vocal elements, but as songs progress bouts become longer and more complex [12]. The songs have been shown to have a syntactic structure reflecting regional dialects which can be traced over a limited geographical distance of up to 5 km [18].

Song syntax and audience attention

Hyraxes engage in male-male counter-singing which may facilitate a comparison of male performance [19]. They also sing following agonistic interactions, alarm calls, and predator presence. However, the majority of singing events are spontaneous (lacking an observable trigger) [19]. By comparing the syntactic structure of male songs, we found that induced songs have an increased structural and syntactical complexity in comparison to spontaneous ones. An examination of song inducing events demonstrated that they also tend to draw hyrax attention, causing hyraxes to cease their activities and address their attention towards the trigger. We believe that this presents male hyraxes with an opportunity to maximize their advertising efforts. Performing a more elaborate and potentially costlier signal is more cost effective when there is a higher certainty of reaching a larger and more attentive audience. Thus, it seems that male hyraxes perceive specific social and environmental events as cues for conspecific alertness and use those communicational windows to self-advertise. (For more details see [15]).

In general, the audience's attention in rock hyraxes may be hard to reach, as temporal and acoustic song progression are potentially tuned towards keeping the listeners engaged with the signal. An analysis of song progression showed that song amplitude and frequency increase progressively during a singing session. The syntactic complexity increases abruptly, peaking in the last quintile. By performing a series of playback experiments we determined that songs with climatic ending are more likely to get a response from conspecific males than songs with invariable or declining syntactic progression. In our attempt to suggest a communicational function to the song progression pattern we appealed to musical principles and tools. In western music, a gradual increase in amplitude (crescendo) is often used to guide the listener towards the most memorable highpoint of the musical piece. It is possible that this structure in hyrax song has an analogous function. The gradual increase in hyrax song amplitude may attract listeners and maintain their attention towards a syntactically complicated climax that is possibly associated with increased effort and demonstration of the signallers' quality. We suggest that creating parallels between features of animal calls and human music might be productive when addressing communicational value of sequences and rhythms of acoustic signals (For more details see [12]). Taken together with the results described in the previous paragraph, it is apparent that producing a syntactically complex song is challenging for male hyraxes. They conserve the efforts of producing complex signals both on the level of songs temporal progression and of their singing timing.

Counter-singing dynamics

Signalling contests are intriguing phenomena and are often subjected to the same game-theoretical rules as physical confrontations [20-22]. Hyrax male-male counter singing is commonly observed. However, the underlying rules and tactical decisions shaping the dynamics of those vocal competitions have not been addressed. In addition to having a hierarchical social structure [16, 23], male hyraxes also occupy two different social niches. Resident males are stably associated with female groups, and bachelor males are mostly solitary and form brief associations with other individuals [23]. We examined counter-singing reply probabilities as a function of male residence status and social rank. The results showed that both factors play a role in shaping male hyrax vocal competition tactics. Resident males tend to respond to all males regardless of the initiators' residency and social rank. Bachelors, on the other hand, tended to avoid responding to residents. Interestingly, the lowest ranking bachelors showed an unexpected tendency to reply to the songs of the highest ranking residents. The residents' "always reply" tactic is straightforward and might be governed by them defending the resource and their position as a group male. Residents have a better access to high quality mating opportunities [24] and are expected to have a high pay-off for defending their resources [25]. Bachelors in general respect residents ownership as predicted by the 'bourgeois model' [22]. The tactic of the lowest ranking males responding to the signals of high-ranking residents might be explained by the "Napoleon complex"[26]. Under specific conditions, weaker individuals could exploit stronger opponents' tolerance towards subordinate contestants [27]. Males signalling following a high-ranking resident might be exploiting the audience's alertness, which are drawn by a high-

quality signal. Another potential benefit might come from publicly demonstrating persistence and motivation for competition [28] under relatively low chances for retaliation by a much stronger opponent (For more details see [14]).

Another observation that arose from the playback trials performed for this work is that hyrax males reply more readily to familiar males than to strangers, operating under the “nasty neighbour” signalling strategy [13]. Nasty neighbour show increased aggression towards familiar individuals [29], driven by the relative threat posed to local individual by neighbours. Local hyrax males showed an increase in reply probability to playbacks simulating strangers, as a function of time that passed from their first appearance but not as a function of the number of singing events. These results could be explained by the perceived threat level from the arrival of a stranger male. Potentially, the initial arrival of the stranger is considered transient and does not present an immediate threat to the local male population. However, as more time passes between the playbacks a male is perceived as an established competitor and local males may become motivated to engage in a competition with him. These results demonstrate that the dichotomy between a “nasty neighbour” and a “dear enemy” strategy can potentially represent two extreme ends of a graded scale. Animals might be able to change their competition preference over time and demonstrate a range of condition-dependent behaviours (For more details see [13]).

Summary

We study male hyrax singing behaviour both as a network wide signal and as localised responses to conspecifics in dyadic interactions. In both cases, rock hyrax males show potential awareness of their target audience, not only in terms of individual recognition but also by direct decoding information from incoming signals and perceiving audience alertness. In a debate between “informational” and “influential” approaches to animal communication [30, 31] these results support the compromised notion of vocal signals lying on a continuum between informational and influential [32]. Male hyraxes exhibit an unorthodox mixed counter-vocalization strategy, which is dependent on both the signalling context, the opponents’ identity, and its individual traits. Such complex and dynamic signalling behaviour is likely to require high processing capacities in order to respond appropriately to highly variable incoming signals. On the other hand, male songs undoubtedly influence conspecific behaviour and males attempt to gain receiver attention by using aversive elements and attention-grabbing events as well as attention grabbing signal structure. Therefore, hyrax songs achieve both aims of manipulating receivers as well as providing them with information.

REFERENCES

1. Taylor, A.M., and Reby, D. (2010). The contribution of source-filter theory to mammal vocal communication research. *Journal of Zoology* 280, 221-236.
2. Reby, D., Joachim, J., Lauga, J., Lek, S., and Aulagnier, S. (1998). Individuality in the groans of fallow deer (*Dama dama*) bucks. *Journal of Zoology* 245, 79-84.
3. Zuberbuehler, K. (2010). Evolution of mammalian vocal signals: development of semiotic content and semantics of human language. In *Handbook of Mammalian Vocalization: An Integrative Neuroscience Approach*, Volume 19, S.M. Brudzynski, ed., pp. 505-513.
4. Mathevon, N., Koralek A, Weldele M, Stephen E Glickman, and Theunissen, F.E. (2010). What the hyena’s laugh tells: Sex, age, dominance and individual signature in the giggling call of *Crocuta crocuta*. *BMC Ecol.* 10.
5. Martin, J., Moreira, P.L., and Lopez, P. (2007). Status-signalling chemical badges in male Iberian rock lizards. *Functional Ecology* 21, 568-576.
6. Behr, O., Knornschild, M., and von Helversen, O. (2009). Territorial counter-singing in male sac-winged bats (*Saccopteryx bilineata*): low-frequency songs trigger a stronger response. *Behav. Ecol. Sociobiol.* 63, 433-442.
7. Leonard, A.S., and Hedrick, A.V. (2009). Male and female crickets use different decision rules in response to mating signals. *Behavioral Ecology* 20, 1175-1184.

8. Fischer, J., Kitchen, D., Seyfarth, R., and Cheney, D. (2004). Baboon loud calls advertise male quality: acoustic features and their relation to rank, age, and exhaustion. *Behav. Ecol. Sociobiol.* *56*, 140-148.
9. Frommolt, K., Goltsman, M., and MacDonald, D. (2003). Barking foxes, *Alopex lagopus*: field experiments in individual recognition in a territorial mammal. *Anim. Behav.* *65*, 509-518.
10. Charlton, B.D., Reby, D., and McComb, K. (2007). Female red deer prefer the roars of larger males. *Biol. Lett.* *3*, 382-385.
11. McComb, K., Moss, C., Sayialel, S., and Baker, L. (2000). Unusually extensive networks of vocal recognition in African elephants. *Anim. Behav.* *59*, 1103-1109.
12. Demartsev, V., Ilany, A., Kershenbaum, A., Geva, Y., Margalit, O., Schnitzer, I., Barocas, A., Bar-Ziv, E., Koren, L., and Geffen, E. (2017). The progression pattern of male hyrax songs and the role of climactic ending. *Scientific Reports* *7*, 2794.
13. Goll, Y., Demartsev, V., Koren, L., and Geffen, E. (2017). Male hyraxes increase countersinging as strangers become 'nasty neighbours'. *Anim. Behav.* *134*, 9-14.
14. Demartsev, V., Ilany, A., Barocas, A., Bar Ziv, E., Schnitzer, I., Koren, L., and Geffen, E. (2016). A mixed strategy of counter-singing behavior in male rock hyrax vocal competitions. *Behav. Ecol. Sociobiol.*, 1-9.
15. Demartsev, V., Kershenbaum, A., Ilany, A., Barocas, A., Bar Ziv, E., Koren, L., and Geffen, E. (2014). Male hyraxes increase song complexity and duration in the presence of alert individuals. *Behav. Ecol.* *25*, 1451-1458.
16. Koren, L., and Geffen, E. (2009). Complex call in male rock hyrax (*Procavia capensis*): a multi-information distributing channel. *Behav. Ecol. Sociobiol.* *63*, 581-590.
17. Koren, L., and Geffen, E. (2011). Individual identity is communicated through multiple pathways in male rock hyrax (*Procavia capensis*) songs. *Behav. Ecol. Sociobiol.* *65*, 675-684.
18. Kershenbaum, A., Ilany, A., Blaustein, L., and Geffen, E. (2012). Syntactic structure and geographical dialects in the songs of male rock hyraxes. *Proceedings of the Royal Society B-Biological Sciences* *279*, 2974-2981.
19. Ilany, A., Barocas, A., Koren, L., Kam, M., and Geffen, E. (2011). Do singing Rock Hyraxes exploit conspecific calls to gain attention? *Plos One* *6*.
20. Searcy, W.A., and Beecher, M.D. (2009). Song as an aggressive signal in songbirds. *Anim. Behav.* *78*, 1281-1292.
21. Hurd, P.L. (2006). Resource holding potential, subjective resource value, and game theoretical models of aggressiveness signalling. *J. Theor. Biol.* *241*, 639-648.
22. Maynard-Smith, J., and Parker, G.A. (1976). Logic of asymmetric contests. *Anim. Behav.* *24*, 159-175.
23. Barocas, A., Ilany, A., Koren, L., Kam, M., and Geffen, E. (2011). Variance in centrality within rock hyrax social networks predicts adult longevity. *Plos One* *6*, e22375.
24. Bar Ziv, E., Ilany, A., Demartsev, V., Barocas, A., Geffen, E., and Koren, L. (2016). Individual, social, and sexual niche traits affect copulation success in a polygynandrous mating system. *Behav. Ecol. Sociobiol.*, 1-12.
25. Bergman, M., Olofsson, M., and Wiklund, C. (2010). Contest outcome in a territorial butterfly: the role of motivation. *Proceedings of the Royal Society B-Biological Sciences* *277*, 3027-3033.
26. Just, W., and Morris, M.R. (2003). The Napoleon Complex: why smaller males pick fights. *Evol. Ecol.* *17*, 509-522.
27. Miyai, C.A., Carretero Sanches, F.H., Costa, T.M., Colpo, K.D., Volpato, G.L., and Barreto, R.E. (2011). The correlation between subordinate fish eye colour and received attacks: a negative social feedback mechanism for the reduction of aggression during the formation of dominance hierarchies. *Zoology* *114*, 335-339.
28. Lotem, A. (1998). Higher levels of begging behavior by small nestlings: A case of a negatively correlated handicap. *Isr. J. Zool.* *44*, 29-45.
29. Temeles, E.J. (1994). The role of neighbors in territorial systems - When are they dear enemies. *Anim. Behav.* *47*, 339-350.
30. Rendall, D., Owren, M.J., and Ryan, M.J. (2009). What do animal signals mean? *Anim. Behav.* *78*, 233-240.

31. Krebs, J.R., and Davies, N.B. (1993). *An introduction to behavioural ecology*, Third edition, (Blackwell Scientific Publications, Osney Mead, Oxford OX2 0EL, England 3 Cambridge Center, Cambridge, Massachusetts 02142, USA).
32. Marler, P., Evans, C.S., and Hauser, M.D. (1992). Animal signals: motivational, referential, or both? In *Nonverbal Vocal Communication: Comparative and Developmental Approaches*, H. Papousek, U. Jrgens and M. Papousek, eds. (Cambridge University Press), pp. 66-86.

Two—or three, or maybe even four—new species of mole tenrec on Madagascar, and the importance of continued scientific collecting for conservation

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Madagascar's tenrecs are a textbook example of adaptive radiation, with many species having converged evolutionarily on distantly related taxa that don't occur on the island. This is reflected in some of the confusing common names given to tenrecs, such as hedgehog tenrecs (2 species) and shrew tenrecs (24 species), which bear superficial resemblance to hedgehogs and shrews, respectively, but are tenrecs (and in their own family, Tenrecidae) all the same. Mole tenrecs, as their common name implies, are superficially mole-like in appearance (Fig. 1) and are adapted to digging but are unrelated to true moles, which are in the family Talpidae.



Figure 1. A five-fingered mole tenrec, *Oryzorictes* sp. (previously and possibly referable to *O. hova*).
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Their occurrence in—and damage to—rice fields is reflected in both their generic name *Oryzorictes* (derived from the Greek words for “rice digger”) and their other common name, rice tenrecs. Until very recently, two readily identifiable species have been recognized based on the number of digits on their forefeet: The Four-toed Mole Tenrec (*O. tetradactylus*) lacks a pollex (thumb), while the Mole-like Rice Tenrec possesses all five digits. Unlike *O. tetradactylus*, which is known from only a handful of localities and is currently classified as Data Deficient on the IUCN Red List, *O. hova* is thought to be widely distributed throughout most of eastern Madagascar in a range of habitats and elevations, and it is accordingly ranked Least Concern.

However, a recent study by Everson et al. (2018) that combines DNA sequence data with skull measurements has concluded that there are actually three (and possibly as many as five!) distinct species currently lumped into *O. hova*. The authors took advantage of an extensive series of frozen tissues and voucher specimens collected over the past 150 years from throughout eastern Madagascar (see Fig. 2), and now housed in eight natural history museums in the US, Europe, and Madagascar, to

test an emerging hypothesis that many of the island's broadly distributed humid-forest taxa are actually composite species containing deeply divergent, latitudinally separated lineages (that may or may not have attained species status). This turns out to be the case for *O. hova*, whose proclivity for digging has led some authors to conclude that it is likely a poor disperser. In such species, genetic mutations that originate and accumulate within a local population are much slower to spread to neighboring populations, and this can ultimately result in speciation, especially if there are external barriers to dispersal such as rivers or areas of unsuitable habitat separating populations.

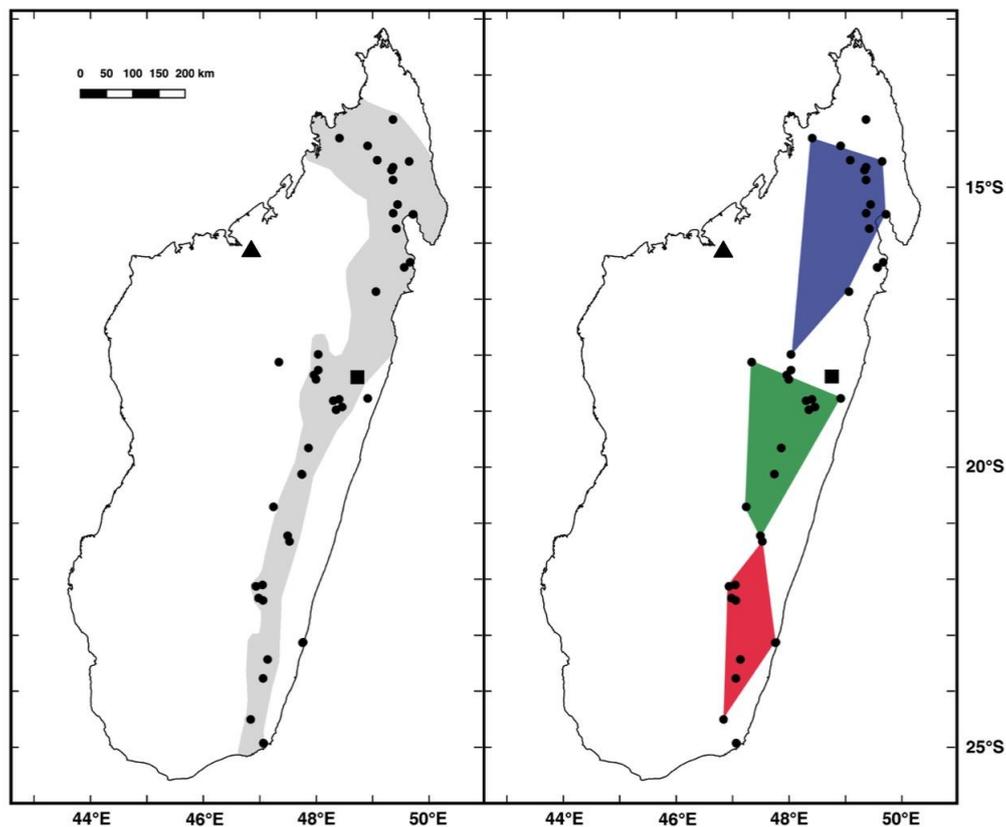


Figure 2. Left: Range of *O. hova* according to the current IUCN Red List (Stephenson et al. 2016). Right: Colored polygons representing the minimum geographic distributions of the three species delimited by Everson et al. (2018). Black dots represent museum specimens included in Everson et al. (2018); those outside colored polygons were not included in genetic analyses. Type localities of *O. hova* and *O. talpoides* indicated with a black square and triangle, respectively.

Everson and coauthors first determined that *O. hova* contains three genetic clusters arranged latitudinally along the eastern humid forest, and that these groups don't appear to overlap geographically (Fig. 2). They then employed a series of analyses to test whether the three populations were reproductively isolated (i.e., not exchanging genes) and morphologically distinct. While the latter criterion is not necessary for recognizing two or more populations as distinct species, it constitutes independent evidence thereof. In the case of *O. hova*, both types of data, in separate and combined analyses, support recognizing each population as distinct, but an interesting (if frustrating) dilemma prevented the authors from assigning formal taxonomic names to *any* of the three species. It turns out there are several troubling inconsistencies between the original description of *O. hova* by A. Grandidier (1870) and the specimen on which it was ostensibly based (the holotype, archived in the type collection at the Muséum national d'Histoire naturelle in Paris), something previous authors had also noted (Goodman et al. 1999; Goodman 2003). Everson et al. (2018) expand on this speculation and suggest that the purported holotype—thought to be collected from a locality in between the two northernmost species (see the square in Fig. 2) and morphologically intermediate between the two—may actually be mislabeled, with the location of the actual holotype unknown. Moreover, the nature of its peculiarities led the authors to conclude that it may represent a species distinct from those

documented by Everson et al. (2018), and known only from a single specimen (so far). While unusual, this would not be without precedent; a second, as-yet unnamed species of the formerly monotypic Mouse-eared Tenrec (*Geogale* sp.) is currently known from a single specimen (Everson et al. 2016), and several other tenrec species have been described from a single locality (e.g., *Microgale dryas* Jenkins 1992, *M. jenkinsae* Goodman & Soarimalala 2004).

Further complicating matters is a previously recognized species of mole tenrec (*Oryzorictes talpoides* G. Grandidier and Petit, 1930), likewise described from a single specimen, that has subsequently been lumped with *O. hova* by Goodman et al. (1999). However, *O. talpoides* is available as a binomen and, according to the International Code of Zoological Nomenclature (ICZN), would have priority over any new name applied to the species to which it is eventually found to belong. In other words, if the holotype of *O. talpoides* is found to belong to one of the three species proposed by Everson et al. (2018), then that species would inherit the name *O. talpoides*. Like the purported holotype of *O. hova*, this specimen is also an adult catalogued at the MNHN in Paris and was included in Everson et al.'s morphological—but not genetic—analyses. In this case, however, the specimen's skull was found to be intermediate between *O. tetradactylus* and all other specimens of *O. hova* the authors measured. Furthermore, its type locality is well outside the range of *O. hova* as currently recognized by the IUCN (see triangle in Fig. 2), and the site is very different ecologically from all other sites at which *O. hova* has been collected (Goodman et al. 2013). So, could the holotype of *O. talpoides* represent yet another species?

Disentangling this and other mysteries reviewed by the authors will require some additional digging through the scientific and historical literature and, ideally, extracting and sequencing DNA from the two type specimens. But until the results of Everson et al. (2018) can be reconciled with the identities of the two holotypes and the nomenclatural rules established and enforced by the ICZN, we are left with between three and up to five species of five-fingered mole tenrec, the names of which are currently indeterminate.

However, other implications need not await nomenclatural clarification. From a conservation perspective, the findings are both exciting—at least two newly recognized species of endemic tenrec we didn't know existed!—and concerning. The three top reasons *O. hova* was ranked as Least Concern on the most recent Red List include its expansive geographic range and two corollaries, large population size and occurrence in a large number of protected areas. But each of these metrics has now been significantly reduced. The range of the southernmost species, for example, as calculated by the minimum polygon connecting all known collecting localities, is 20,071 km², barely over the 20,000-km² threshold set by the IUCN Species Survival Commission (2012) to classify a species as Threatened. Similarly, our already-meager knowledge of the ecology and life history of *O. hova* has been subdivided, and while much of what we do know may be generalizable across all three (or more) species, that is speculation, and our information needs for the conservation of these species have now multiplied.

Most of what we do know about mole tenrecs (and most other tenrecs) comes from information directly or indirectly gleaned from voucher specimens (and their associated data) archived in museum collections. Such specimens “vouch” for the existence of a particular individual of a particular species at a particular place at a particular time, and each specimen is a testable hypothesis in and of itself. Taxonomists routinely “test” the identification of voucher specimens in museums, and often times the initial identifications are found to be incorrect. This sets voucher specimens apart from photographs, recordings, and anecdotal accounts, and is the reason vouchers form the basis of range maps such as those generated by the IUCN (for small-bodied mammals, at least). But specimens yield far more information than mere taxonomic identity. For example, the entirety of our knowledge of the diet of *O. hova* in the wild stems from notes scribbled on the tags of three specimens in the Natural History Museum in London that were collected in the mid-20th century and whose stomach contents were investigated and noted by the collector as he was preparing the specimens (newer methods can determine aspects of diet based on the chemical signatures left in hair, bone, and other tissues available for analysis if voucher specimens are collected). Since that information is forever linked to those

particular specimens, it will carry over to whatever new taxonomy emerges. The same is true of any data that can be unambiguously associated with a voucher specimen.

While unusual in some ways, the general situation with *Oryzorictes* may represent the tip of the proverbial iceberg. Using the same approach, Everson, Goodman, Jenkins, the two of us, and other collaborators have discovered an astounding number of new tenrec species awaiting formal description, each with its own unique suite of challenges (including questions regarding holotypes, a dearth of adult specimens suitable for morphometric analyses, and specimens without accompanying tissue samples amenable to DNA sequencing). Nearly every one will have a ripple effect on the current state of distributional and ecological knowledge of other species. And yet, much of Madagascar, including many of its protected areas, has not been adequately surveyed for small mammals. Because they are small, largely nocturnal, and secretive (like the majority of living mammal species) and often occur in low densities, tenrecs are decidedly difficult to observe in the wild, and the time, energy, and resources available for field work are often better invested in specimen collection than purely observational studies. While it may seem contradictory to simultaneously advocate for the collection of voucher specimens *and* conservation, the two endeavors are inextricably linked in tenrecs and countless other taxa. Increasingly affordable DNA sequencing methods may allow for accurate species determination (although that assumes the species in question is well-enough delineated to make this possible, and that is simply not the case for a staggering number of species) without having to collect an entire specimen, but sampling blood or other tissues is no substitute for the latter, as the diet example above illustrates. Countless other important biological attributes such as age, reproductive status, and the occurrence of endo- and ectoparasites—among many others—cannot be accurately or verifiably assessed in most free-ranging small-mammal species without collecting the entire individual specimen for subsequent inspection and analysis. Madagascar's natural habitats—like so many others worldwide—are disappearing at an alarming and accelerating pace. We can't save what we don't know exists, and to save what we *do* know exists requires knowledge we are otherwise unlikely to obtain without continued, responsible scientific collecting.

Literature cited

- Everson KM, V Soarimalala, SM Goodman, LE Olson. 2016. Multiple loci and complete taxonomic sampling resolve the phylogeny and biogeographic history of tenrecs (Mammalia: Tenrecidae) and reveal higher speciation rates in Madagascar's humid forests. *Systematic Biology* 65: 890–909.
- Everson KM, KBP Hildebrandt, SM Goodman, LE Olson. 2018. Caught in the act: incipient speciation across a latitudinal gradient in a semifossorial mammal from Madagascar, the mole tenrec *Oryzorictes hova* (Tenrecidae). *Molecular Phylogenetics and Evolution* 126: 74–84.
- Goodman SM. 2003. *Oryzorictes*, mole tenrec or rice tenrec. Pp. 1278–1281 in: SM Goodman and JP Benstead (Eds.), *The Natural History of Madagascar*. The University of Chicago Press, Chicago.
- Goodman SM, PD Jenkins, M Pidgeon. 1999. The Lipotyphla (Tenrecidae and Soricidae) of the Réserve Naturelle Intégrale d'Andohahela, Madagascar. *Fieldiana: Zoology (New Series)* 94: 187–216.
- Goodman SM, V Soarimalala, M Raheriarisena, D Rakotondravony. 2013. Small mammals or tenrecs (Tenrecidae) and rodents (Nesomyidae). Pp. 211–269 in: SM Goodman and M Raheirilalao (Eds.), *Atlas of Selected Land Vertebrates of Madagascar*. Association Vahatra, Antananarivo, Madagascar.
- Grandidier, A. 1870. Description de quelques animaux nouveaux découverts à Madagascar en Novembre 1869. *Rev. Mag. Zool. Pur.* App. 22, 50.

Stephenson PJ, V Soarimalala, SM Goodman. 2016. *Oryzorictes hova*. The IUCN Red List of Threatened Species 2016: e.T40589A97203050. <http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T40589A97203050.en>. Downloaded on 21 August 2018.

Exploitation des bois précieux à Masoala, Madagascar : quel impact sur les tenrecs ?

par

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Abstract

The Masoala peninsula, Madagascar is renowned for its biodiversity, its uniqueness, its potential but also its vulnerability. As one of the largest protected areas, with the highest lowland rainforest, the park has a rich diversity and heterogeneity in terms of habitats and ecosystems with remarkable ecological gradients associated with altitudinal and climatic variations. These traits give Masoala its reputation as a refuge for rich flora and fauna diversity most of which are endemic to the island. Unfortunately, the 2009 political crisis has upset the socio-political and socio-economic situation in Madagascar. Lawlessness on different levels has increased, with the consequence of the rush to the wild, illicit and abusive exploitation of all natural resources, especially rosewood timber. The repercussions of this disruption on natural resources and ecosystems in general are considerable.

To assess the impacts of these disturbances, investigations on Tenrecidae were conducted in four park sites. Two different trapping techniques commonly used in Madagascar in past decades have been employed and placed in different habitats: three lines of unbaited pitfalls traps and 100 live traps baited with peanut butter. The duration of the trapping sessions on each of these islands was six nights. Interviews were also conducted with villagers living in the vicinity of the park to provide insights into the tenrecs occurring locally.

From the pitfall traps put in place, notable differences were found in species richness; with eight in Sahabe forest and two in Tampolo site. Capture rates differ from 7.1% at Sarahandrano to 1.3% in Ambohitsitondroina and Tampolo. One species *Microgale drouhardi* represents a new record for the Masoala peninsula. This increases the total number of the species richness for the park. However, three species previously recorded were not captured. In general, low density of trap success could explain that situation. Compared with the other lowland cover in the island, the survey shows evidence of a considerable diversity of endemic tenrecs of the Family Tenrecidae.

Despite the pressures and threats that have weighed on Masoala in recent years, the integrity of tenrecs habitats would still be preserved and most of the species are not likely to be extirpated in the immediate future. However, the establishment of effective mechanisms to prevent the resumption of disruptive activities is essential to avoid any tendency towards the irreversibility of the current situation.

Introduction

Le Parc National (PN) de Masoala représente l'une des plus vastes couvertures forestières s'étendant sur près de 2 300 km² dans la partie Nord-est de Madagascar et figure parmi les tops prioritaires en matière de conservation (Burivalova *et al.*, 2015 ; Kremen *et al.*, 1998 ; 1999). Effectivement, rien que pour les formations végétales, le parc possède une gamme diversifiée, incluant des forêts denses humides de basse et de moyenne altitude, une forêt littorale, des mangroves et des habitats rupestres. Les forêts humides sont réparties depuis le niveau de la mer jusqu'à une hauteur de plus de 1 200 m d'altitude (Kremen *et al.*, 1998). Elles constituent d'ailleurs la formation végétale dominante de Masoala. La forêt littorale occupe principalement la partie Sud et Sud-est du parc, sur des terrains plats constitués par des sols sableux. Les affleurements rocheux sont nombreux au milieu de cette vaste étendue de forêt sempervirente et constitue un autre type d'habitat pour la faune et la flore rupestres.



Figure 1. Massif forestier de Masoala

La biodiversité de Masoala a été supposée comme étant la plus protégée du fait de son isolement par rapport aux autres couvertures forestières du Nord-est (Thorstrom & Watson, 1994) car c'est une zone reculée loin des accès routiers (Borgerson, 2015). Pourtant, ces ressources naturelles sont soumises à des menaces et des pressions d'origine variée.

La situation a été aggravée par la crise politique de 2009 ; il y a eu une ruée vers cette aire protégée, aboutissant à une installation humaine massive et une exploitation illicite, grandissante et abusive de ses ressources naturelles, en particulier les bois de rose et les bois d'ébène (Schuurman & Lowry, 2009 ; Innes, 2010 ; Allnutt *et al.*, 2013).

Avec ces menaces récurrentes, le risque de perte de son intégrité serait à craindre, malgré le fait que les coupes sélectives n'ont pas nécessairement avoir des impacts graves sur le maintien de la biodiversité (Berry *et al.*, 2010). Pourtant, pour les zones tropicales comme Madagascar où l'endémisme et le microendémisme liés à une spécificité écologique quasi-totale sont bien connues, les conséquences de la dégradation et de la perturbation des habitats naturels sur la biodiversité sont bien palpables (Goodman & Rakotondravony, 2000 ; Vallan, 2000 ; Jenkins *et al.*, 2003 ; Scott *et al.*, 2005 ; Rakotoarisoa & Carpella, 2013).

L'impact de ces menaces sur les espèces forestières comme un groupe de petits mammifères endémiques, les tenrecs pourrait être fatal. Elle peut conduire même dans le cas extrême vers l'extirpation locale des populations de ces espèces vulnérables. La famille des Tenrecidae à Madagascar est un groupe taxinomique avec une diversité importante avec 32 espèces et tous sont endémiques de l'île (Soarimalala & Goodman, 2011). D'après les investigations réalisées auparavant à Masoala, la presqu'île abrite 10 espèces de Tenrecidae et la plupart dépendent des habitats forestiers (Andrianjakarivelo *et al.*, 2005 ; Soarimalala & Goodman, 2011 ; Goodman *et al.* 2013). L'évaluation des impacts des diverses menaces sont est alors nécessaire d'une part pour la mise à jour des informations et d'autre part pour disposer des données fiables pouvant être utilisées dans divers domaines. Dans ce but, la synthèse de résultats d'inventaires de Tenrecidae de la forêt de Masoala du 25 octobre au 13 décembre 2015 permettra d'évaluer la tendance de la situation de conservation de ce groupe en faisant des analyses sur la richesse et la composition spécifiques et en évaluant la viabilité des populations d'espèces sensibles, à travers une analyse de leur abondance relative.

Méthodologie

Site d'étude

Pour cette étude, quatre sites ont été choisis dont trois sites sont touchés par l'exploitation des bois de rose et le quatrième est une zone non affectée par cette activité. Les caractéristiques géographiques de chaque site qui représentent les points centraux de la zone de recherche sont illustrés dans le Tableau 1 et les sites d'études étant sur la Figure 2.

Nom des Sites	Coordonnées géographiques	Secteur	Observations par rapport aux exploitations de bois de rose
Site 1 : Sarahandrano	15°27'10,6''S, 50°18'39,2'' E Altitude : 116 m	Secteur Est du PN. Riche en cours d'eau et en fleuve.	Zone touchée par l'exploitation et utilisée à la fois comme zone d'évacuation.
Site2 : Sahabe	15°33'37,3''S, 50°16'54,4'' E Altitude : 30 m	Secteur Est du PN. Présence des cours de fleuve.	Zone touchée par l'exploitation et utilisée à la fois comme zone d'évacuation.
Site 3 : Ambohitsitondroina 600 et +1000 m	15°34'09,7''S, 50°00'12,3''E Altitude : 610 m	Secteur Ouest du PN. Présence des cours d'eau et d'un fleuve débouchant vers la mer.	Zone non touchée par l'exploitation. Cours d'eau utilisés pour l'évacuation, mais relativement loin du site exploré
Site 4 : Tampolo	15°43'45,6''S, 49°57'49,4''E Altitude : 10 m	Secteur Sud-ouest du PN. Cours d'eau. Présence d'un fleuve débouchant vers la mer.	Zone d'acheminement des bois de rose vers la mer. Site fréquemment visité par les touristes.

Tableau 1. Caractéristiques de sites d'étude.



Figure 2. Localisation des sites d'étude explorés dans le Parc National de Masoala.

Méthode de capture

Dans chaque site, les deux techniques de piégeage adoptées (trous-pièges et pièges standard) ont consisté à laisser les pièges en place pendant 6 nuits.

Trous-pièges

La première technique de piégeage est constituée par des lignes de trous-pièges ou « pit-falls » qui sont composées chacune de 11 seaux alignés et enterrés dans le sol et sont espacés de 10 m l'un de l'autre sur la ligne. Une bande plastique de 110 m de longueur environ et de 0,80 m de largeur est dressée sur une hauteur d'environ 0,70 m à partir du sol en passant par le diamètre de chaque seau et en étant maintenue par des piquets. Dans chaque site, trois lignes de trous-pièges ont été installées dans des microhabitats différents, c'est-à-dire, sur une crête, sur un versant et dans une vallée.

Pièges standards

Les pièges standards utilisent deux types de pièges que sont les « Sherman » (22,5 x 8,6 x 7,4 cm) et les « National » (39,2 x 12,3 x 12,3 cm) dans chaque site. Un nombre total de 100 pièges

standard a été mis en place avec un ratio de 4 « Sherman » pour 1 « National ». Ces pièges ont été appâtés au beurre de cacahuète et l'appât était renouvelé tous les après-midi.

Autre méthode de recensement

Une autre méthode qui donne des renseignements qualitatifs sur les Tenrecidae existants est aussi utilisée grâce à une enquête entreprise auprès des habitants des villages proches du lieu d'échantillonnage. Elle vise à compléter les informations qui ne sont pas récoltées par le protocole adopté. Le principe se base sur les noms vernaculaires et la description morphologique des espèces. Des observations générales ont été également procédées durant le jour et la nuit afin de compléter la liste des mammifères existants dans la forêt de Masoala.

Résultats

Richesse et composition spécifiques

Pour l'ensemble des résultats durant le présent inventaire, un total de 8 espèces de Tenrecidae a été recensé (Tableau 2) et tous sont endémiques de l'île. Le site le plus riche est la forêt de Sahabe suivi de Sarahandrano où les nombre d'espèces sont respectivement 8 et 5. La forêt de Tampolo abrite la richesse la plus pauvre avec 2 espèces.

Microgale talazaci et *Hemicentetes semispinosus* sont les espèces les plus communément capturées. *Microgale brevicaudata* et *M. drouhardi* se trouvent seulement dans la forêt de Sahabe. *Tenrec ecaudatus* fréquente également les 4 sites visités mais aucun individu n'a été capturé ni observé mais sa présence a été signalée par la population riveraine.

Tableau 2. Liste des espèces recensées dans la forêt de Masoala. Toutes les informations sont basées sur les animaux capturés dans les pièges, sauf quelques animaux observés ou signalés par la population riveraine qui sont notés en [+].

Espèces	Sarahandrano	Sahabe	Ambohitsitondroina	Tampolo
Altitude (m)	116	30	610	10
Afrosoricida				
<i>Hemicentetes semispinosus</i>	+	+	-	+
<i>Microgale brevicaudata</i>	-	+	-	-
<i>Microgale drouhardi</i>	-	+	-	-
<i>Microgale parvula</i>	+	+	-	-
<i>Microgale principula</i>	+	+	-	-
<i>Microgale talazaci</i>	+	+	+	-
<i>Setifer setosus</i>	-	+	+	-
<i>Tenrec ecaudatus</i>	[+]	[+]	[+]	[+]
Total des Tenrecidae	5	8	3	2



a

b

Figure 3. Tenrecs de Masoala. a. *Microgale principula*, b. *Microgale drouhardi*

Abondance relative des Tenrecidae

Le Tableau 3 résume les résultats de capture à l'aide des trous-pièges des Tenrecidae dans les différents sites explorés. Les taux de capture varient de 1,3 à 7,4 % et le plus important a été obtenu à Sarahandran. Ce taux est très faible (1,3 %) dans la forêt d'Ambohitsitondroina et Tampolo. *Microgale principula* a représenté 58,8 % des individus capturés à Sarahandran.

Parmi les 4 sites inventoriés, un seul individu de *Microgale talazaci* a été capturé à l'aide des pièges Sherman et National à Ambohitsitondroina.

Tableau 3. Résultats des captures de Tenrecidae dans les lignes de trous-pièges dans la forêt de Masoala.

Sites	Sarahandran			Sahabe			Ambohitsitondroina			Tampolo		
Ligne	1	2	3	4	5	6	7	8	9	10	11	12
Nombre de nuits-pièges	7 7	77	77	77	77	77	77	77	77	77	77	77
Taxons												
Tenrecidae												
<i>Hemicentetes semispinosus</i>	-	-	-	-	-	1	-	-	-	-	2	1
<i>Microgale brevicaudata</i>	-	-	-	2	-	-	-	-	-	-	-	-
<i>Microgale drouhardi</i>	-	1	1	1	3	-	-	-	-	-	-	-
<i>Microgale parvula</i>	1	2	-	-	1	1	-	-	-	-	-	-
<i>Microgale principula</i>	1	6	3	1	-	2	-	-	-	-	-	-
<i>Microgale talazaci</i>	-	2	-	-	1	-	-	-	-	-	-	-
<i>Setifer setosus</i>	-	-	-	-	-	1	2	-	1	-	-	-
Nombre d'individus de Tenrecidae	2	11	4	4	5	5	2	0	1	0	2	1
Taux de capture de Tenrecidae	2,6	14,3	5,2	5,2	6,5	6,5	2,6	0,0	1,3	0,0	2,6	1,3
Nombre d'individus de Tenrecidae par site d'étude	17			14			3			3		
Taux de capture de Tenrecidae par site d'étude	7,4			6,1			1,3			1,3		
Indice de diversité de Shannon	0,545			0,693			0,301			0,301		

Discussion

Diversité spécifique

Une information inédite telle la présence d'une espèce de *Microgale drouhardi* a été rapportée pour la forêt du PN de Masoala. Cependant, trois espèces de Tenrecidae, *Microgale cowani*, *M. dobsoni* et *M. taiva* ont été capturées durant les travaux effectués par Andrianjakarivelo *et al.* (2005) dans cette forêt mais elles sont omises pendant ce présent travail. *Microgale cowani* et *M. taiva* ont été capturés à Ambohitsitondroina à 600 jusqu'au 1000 m d'altitude. Ces espèces sont fréquemment trouvées dans les altitudes supérieures et durant cet inventaire, la zone d'étude prospectée se situe entre 30 à 600 m d'altitude. Il est important de signaler que le groupe des Tenrecidae comme *M. cowani* et *M. taiva* sont des fousseurs et la topographie très accidentée et rocailleuse dans cette zone altitudinale supérieure d'Ambohitsitondroina n'est pas très favorable pour ces animaux. Il se peut alors que leur abondance dans la bande d'altitude supérieure à 600 m est un peu faible. *Microgale dobsoni* a été capturé avec une faible abondance représentée seulement par un seul individu à Bedinta et à Andranomainty. Ainsi, durant cette investigation, la forêt dans ces deux sites devient de plus en plus dégradée.

En considérant la richesse spécifique des petits mammifères dans la forêt de Masoala, une différence remarquable a été observée entre les sites inventoriés. Le nombre d'espèces endémiques varie de 2 à 8. Cette variation s'explique principalement par la différence engendrée par la structure d'habitat. Le site de Tampolo qui est une forêt littorale est pauvre en termes de la richesse spécifique. En général, ce faible nombre d'espèces de petits mammifères est déjà confirmé dans d'autres forêts littorales le long de la côte comme Mandena et Manafiafy à proximité de Tolagnaro (Ganzhorn *et al.*, 2000) et la forêt de Tampolo Fénériver-Est (Rakotondravony *et al.*, 1998). Dans ces couvertures forestières, *Microgale pusilla* Major, 1896 a été trouvé dans la forêt littorale de Tolagnaro. *Microgale dobsoni* a été également recensé dans la forêt littorale d'Andranomainty de la forêt de Masoala (Andrianjakarivelo *et al.*, 2005). Par contre, la présence de *Hemicentetes semispinosus* dans la forêt littorale de Tampolo est une particularité de la forêt de Masoala.

Pour les autres types d'habitats, la différence n'est pas notable au niveau de la richesse spécifique entre la forêt de basse altitude de Sarahandrano et Sahabe. L'absence de *Microgale brevicaudata* et *M. drouhardi* dans la forêt de forêt de Sarahandrano pourrait être liée à la faible abondance de ces espèces. La faible richesse à Ambohitsitondroina peut expliquer cette faible abondance en se référant aux résultats des travaux antérieurs. D'après Andrianjakarivelo *et al.* (2005), 9 espèces ont été capturées durant 2984 nuits-pièges et 480 nuits trous-pièges contre 6 espèces durant 700 nuits-pièges et 232 nuits trous-pièges de cette étude. *Microgale cowani* et *M. taiva* qui ont été omises durant cet inventaire a été aussi rencontré à Ambohitsitondroina. Il est clair alors que la session de capture répétitive peut augmenter la chance de capture dans un lieu d'échantillonnage. Ainsi ces espèces fréquentent surtout les zones des altitudes supérieures et les travaux antérieurs ont été opéré jusqu'au 1000 m d'altitude alors que durant cette étude, l'altitude supérieure de la zone d'échantillonnage a été 600 m.

En combinant les résultats de ce présent travail avec les travaux effectués auparavant, l'ensemble de la forêt de Masoala représente 11 espèces Tenrecidae. Dans une altitude plus basse inférieur à 1200 m, la richesse spécifique de petits mammifères tend à être diminuer en général. De nombreux travaux sont venus documenter l'importante diversité en petits mammifères aux altitudes moyennes, en particulier dans les blocs forestiers situés au Centre-sud, au Centre et au Nord de l'île (Soarimalala *et al.*, 2001 ; Soarimalala & Goodman, 2003 ; Soarimalala *et al.*, 2007).

Abondance

Une variation remarquable du taux de capture a été obtenue dans les différents sites de la forêt de Masoala. Le taux de capture est plus élevé dans la forêt de Sarahandrano que dans les autres sites. En général, plusieurs facteurs écologiques agissant simultanément peuvent expliquer cette différence au niveau de l'abondance relative. Il est possible par exemple que la

présence de la pluie sans cesse qui varie de 7 à 65 mm a une influence sur les activités des Tenrecidae dans ce site par rapport aux autres sites qui sont presque secs. L'humidité peut varier l'abondance des insectes du sol qui constituent leur principal régime alimentaire.

En analysant la mesure de la diversité, la forêt de Sahabe représentant des indices les plus élevés a la plus grande régularité des individus entre les espèces. Les conditions écologiques dans ce type d'habitat sont favorables et favorisent par la suite une prolifération des communautés. Par contre, la dominance de *Microgale principula* à Sarahandrano semblerait masquer la répartition des individus au sein de la communauté de cette zone forestière où un faible indice de diversité a été noté.

Affinité biogéographique

En général, la composition des espèces de petits mammifères est étroitement liée à la formation végétale. Les espèces de petits mammifères trouvées à Masoala sont analogues à celles recensées dans d'autres sites en dessus de 1000 m d'altitude. Ce domaine phytogéographique comprend surtout la forêt de basse altitude et celle de la transition entre basse et moyenne altitude (Perrier de la Bâthie, 1921 ; Humbert, 1965). Il est vrai que le pic le plus élevé de la forêt de Masoala est à 1200 m mais le type d'habitat à partir de 600 m d'altitude de Masoala s'installant dans un endroit topographiquement très accidenté et rocailleux n'offre que des conditions écologiques difficiles pour la survie de certaines espèces. En se référant à la bande altitudinale, la forêt de Masoala abrite une richesse spécifique élevée par rapport aux forêts de Marojejy et Anjanaharibe-Sud qui se trouve plus au nord (Soarimalala & Goodman, 2003) ainsi que Mananara-Nord plus au sud (Goodman *et al.*, 2003). La faible richesse des forêts inférieure à 1000 m d'altitude de Marojejy-Anjanaharibe-Sud et Mananara-Nord pourrait liée à la dégradation de la forêt d'origine anthropique, classiquement comme tous les cas de la forêt de basse altitude à Madagascar. La présence de *Microgale drouhardi* à Masoala permet d'enregistrer une nouvelle aire de distribution de cette espèce dans la partie Nord car jusqu'à présent, Masoala est la seule localité qui l'abrite dans l'ensemble du complexe Makira-Marojejy-Anjanaharibe-Sud (Tableau 3).

Par rapport au couloir forestier Mantadia-Zahamena (Rakotondraparany & Medard, 2005), la forêt de Masoala abrite une richesse un peu faible. Toutefois, ce couloir forestier est en continuité avec un grand bloc forestier de large bande de l'Est et cela permettrait aux espèces de se distribuer largement. Il est vrai que la forêt de Masoala est en continuité avec la forêt de Makira mais le contact entre les espèces pourraient être limité à cause de l'isolement de Masoala en tant que presqu'île.

Tableau 4. Liste comparative des espèces de Tenrecidae dans la partie Nord et Sud du PN de Masoala.

Espèces	Masoala ^{1,2}	Makira ³	Mananara-Nord ⁴	Marojejy ⁵	Anjanahari-be-Sud ⁶	Mantadia-Zahamena ⁷
Altitude (m)	0-1000	300-900	0-410	450-775		450-960
Tenrecidae						
<i>Microgale brevicaudata</i>	+	-	-	+	-	-
<i>Microgale cowani</i>	+	-	-	-	-	+
<i>Microgale dobsoni</i>	+	+	-	-	-	+
<i>Microgale drouhardi</i>	+	-	-	-	-	+
<i>Microgale dryas</i>	-	+	-	-	-	-
<i>Microgale fotsifotsy</i>	-	+	-	-	-	+
<i>Microgale gracilis</i>	-	-	-	-	-	+
<i>Microgale longicaudata</i>	-	+	-	-	-	+
<i>Microgale parvula</i>	+	+	+	+	-	+
<i>Microgale principula</i>	+	+	+	-	+	+
<i>Microgale pusilla</i>	-	-	-	-	-	+
<i>Microgale soricoides</i>	-	-	-	-	-	+
<i>Microgale taiva</i>	+	+	-	-	-	+
<i>Microgale talazaci</i>	+	+	+	+	-	+
<i>Microgale thomasi</i>	-	-	-	-	-	+
<i>Oryzorictes hova</i>	-	+	+	+	-	+
<i>Hemicentetes semispinosus</i>	+	+	+	-	-	-
<i>Setifer setosus</i>	+	+	+	+	+	+
<i>Tenrec ecaudatus</i>	+	+	+	+	+	-
Nombre total d'espèces de Tenrecidae	11	12	7	6	3	15

Sources : ¹Cette étude, ²Andrianjakarivelo *et al.* (2005), ³Rakotomalala *et al.* (2007), ⁴Goodman *et al.* (2013), ⁵Carleton & Goodman (2000), ⁶Goodman & Jenkins (2000), ⁷Goodman & Jenkins (1998), ⁸Goodman & Carleton (1998) et ⁹Rakotondraparany & Medard (2005).

Menaces et impacts de l'exploitation forestière

La destruction des habitats naturels constitue une grande menace pour la viabilité à long terme des espèces animales dépendantes d'une forêt relativement intacte (Soarimalala & Raherilalao, 2008 ; Irwin *et al.*, 2010). D'autant plus que l'exploitation des bois de rose a été toujours accompagnée d'autres faits incitateurs et dévastateurs qui ont accentué les menaces et les pressions sur les habitats et la biodiversité de la forêt de Masoala. Cette forêt est victime de l'exploitation massive des bois de rose depuis 2009. Plusieurs souches de ces arbres ont été observées surtout à Sarahandrano et Sahabe et des clairières formant une piste de 3 à 4 m de largeur et 200 m de longueur pour l'acheminement des rondins de bois ont été aussi trouvés. Effectivement, la crise occasionnée par l'exploitation de ces bois précieux a incité les gens qui n'ont rien avoir avec l'exploitation de cette ressource tant convoitée à entrer dans la forêt pour d'autres objectifs comme la chasse ou l'abattage d'autres ressources ligneuses rentables (palissandre, madrier, etc.). Toutes ces formes de perturbations ont des impacts sur les communautés animales (Goodman & Raherilalao, 2003 ; Vallan, 2003).

Tenrec ecaudatus a été absent durant cette étude. Les travaux effectués auparavant n'a pas aussi relevé sa présence sauf dans le site d'Andranobe et Bedinta où il était seulement observé. Cette espèce est fortement chassée et apprécié par sa viande qui a plus du goût et sa taille qui est un peu plus grande. Il est probable alors que son absence est due à la chasse massive et la population riveraine confirme la rareté de cette espèce actuellement.

Conservation

Malgré l'exploitation massive à Masoala, la communauté de la faune de Tenrecidae est bien représentée dans cette forêt. En effet, la diversité importante de Tenrecidae dans ce parc a montré que la population de ce groupe animal ne semble pas être perturbée par l'exploitation massive et les menaces survenues dans ce parc grâce encore à l'intégrité de leurs habitats et que ces animaux qu'il héberge ne risquent pas d'une extirpation majeure dans l'immédiat. Les différents stades de développement des animaux capturés témoignent la présence des populations en équilibres, en particulier dans les forêts de Sarahandrano, de Sahabe. Il se peut que le niveau de dégradation n'a pas encore dépassé le seuil de la capacité de résilience de l'habitat et de tolérance des tenrecs. Les habitats naturels sont encore capables d'assurer ses rôles dans le maintien des processus écologiques nécessaires à la survie de ces animaux qu'ils hébergent et la régénération naturelle progressive de la forêt sera certainement en faveur de ce groupe animal dans cette forêt. Cette situation Toutefois, comme il s'agit des espèces forestières la mise en place des dispositifs efficaces pour prévenir la reprise des activités perturbatrices s'avère indispensable afin d'éviter toute tendance vers l'irréversibilité de la situation. Toutefois comme il s'agit des espèces forestières le risque d'une rupture de l'équilibre écologique serait encore à craindre si des éventuelles menaces s'exerceraient de nouveau sur l'écosystème. Le seuil de tolérance face à une quelconque perturbation varie beaucoup d'une espèce à l'autre au sein d'une communauté biologique, les espèces à populations à faible abondance restent désormais les plus vulnérables et qui ont besoin de plus de stabilité.

Références bibliographiques

- Allnutt, T.F., Asner, G.P., Golden, C.D. & Powell, G.V. N. 2013. Mapping recent deforestation and forest disturbance in northeastern Madagascar. *Tropical Conservation Science*, 6 (1): 1-15.
- Andrianjakarivelo, V., Razafimahatratra, E., Razafindrakoto, Y. & Goodman, S.M. 2005. The small mammals of the Parc National de Masoala, northeastern Madagascar. *Acta Theriologica*, 50: 537-549.
- Berry, N.I. Phillips, O.L., Lewis, S.L., Hill, J.K., Edwards, D.P., Tawatao, N.B., Ahmad, N., Magintan, D., Khen, C.V., Maryati, M., Ong, R.C. & Hamer, K.C. 2010. The high value of logged tropical forests: Lessons from northern Borneo. *Biodiversity Conservation*, 19: 985-997.
- Borgerson, C. 2015. The effects of illegal hunting and habitat on two sympatric endangered primates. *International Journal of Primatology*, 36: 74-93.
- Bronner, G.N. & Jenkins, P.D. 2005. Order Afrosoricida. In *Mammal species of the World. A taxonomic and geographical reference*, eds. D.E. Wilson & D. M. Reeder, pp. 71-81. The John Hopkins University Press, Baltimore.
- Burivalova, Z., Bauert, M.R., Hassold, S., Fatroandrianjafinonjasolomiovazo, N.T., & Koh, L.P. 2015. Relevance of global forest change data set to local conservation: Case study of forest degradation in Masoala National Park, Madagascar. *Biotropica*, 47(2): 267-274.
- Carleton, M.D. & Goodman, S.M. 2000. Rodents of the Parc National de Marojejy, Madagascar. In *A floral and faunal inventory of the Parc National de Marojejy, Madagascar: With reference to elevational variation*, ed. S.M. Goodman. *Fieldiana : Zoology*, new series, 97: 231-263.
- Duplantier, J.-M. & Duchemin, J.-B. 2003. Introduced small mammals and their ectoparasites: A description of their colonization and its consequences. In *The natural history of Madagascar*, eds. S.M. Goodman & J.P. Benstead, pp. 1191-1194. The University of Chicago Press, Chicago.
- Ganzhorn J.U., Goodman S.M., Ramanamanjato J.-B., Rakotondravony D., Rakotosamimanana B. & Vallan D. 2000. Vertebrate species in fragmented littoral

forests of Madagascar. In *Diversité et endémisme de Madagascar*, eds W R. Lourenço & S. M. Goodman, pp. 155-164. Mémoires de la Société de Biogéographie, Paris.

- Goodman, S.M. 1996.** The carnivores of the Réserve Naturelle Intégrale d'Andringitra, Madagascar. In *A floral and faunal inventory of the eastern slopes of Réserve Naturelle Intégrale d'Andringitra, Madagascar: with reference to elevational variation*, ed. S.M. Goodman. *Fieldiana: Zoology*, new series, 85: 293-305.
- Goodman, S.M. 2012.** Les Carnivora de Madagascar. Association Vahatra, Antananarivo.
- Goodman, S.M. & Carleton, M.D. 1998.** The rodents of the Réserve Spéciale d'Anjanaharibe-Sud, Madagascar. In *A floral and faunal inventory of the Réserve Spéciale d'Anjanaharibe-Sud, Madagascar: With reference to elevational variation*, ed. S.M. Goodman. *Fieldiana: Zoology*, new series, 90: 201-221.
- Goodman, S.M. & Jenkins, P.D. 1998.** The insectivores of the Réserve Spéciale d'Anjanaharibe-Sud, Madagascar. In *A floral and faunal inventory of the Réserve Spéciale d'Anjanaharibe-Sud, Madagascar: With reference to elevational variation*, ed. S.M. Goodman. *Fieldiana: Zoology*, new series, 90: 139-161.
- Goodman, S.M. & Jenkins, P.D. 2000.** Tenrecs (Lipotyphla: Tenrecidae) of the Parc National de Marojejy, Madagascar. In *A floral and faunal inventory of the Parc National de Marojejy, Madagascar: With reference to elevational variation*, ed. S.M. Goodman. *Fieldiana: Zoology*, new series 97: 201-229.
- Goodman, S.M. & Rakotondravony, D. 2000.** The effects of forest fragmentation and isolation on insectivorous small mammals (Lypotyphla) on the highland central plateau of Madagascar. *Journal of Zoology, London*, 250: 193-200.
- Goodman, S.M. & Raherilalao, M.J. 2003.** Effects of forest fragmentation on bird communities. In *The natural history of Madagascar*, eds. S.M. Goodman & J.P. Benstead, pp. 1064-1066. The University of Chicago Press, Chicago.
- Goodman, S.M., Ganzhorn, J.U. & Rakotondravony, D. 2008.** Les mammifères. In *Paysages naturels et biodiversité de Madagascar*, eds. S.M. Goodman, pp. 435-511. Muséum national d'Histoire naturelle, Paris.
- Goodman, S.M. & Soarimalala, V., Raheriarisena, M. & Rakotondravony, D. 2013.** Oiseaux ou Aves. Dans *Atlas d'une sélection des vertébrées terrestres de Madagascar*, eds. S.M. Goodman & M. J. Raherilalao, pp. 63-168. Association Vahatra, Antananarivo.
- Humbert, H. 1965.** Description des types de végétation. In *Notice de la carte de Madagascar*, eds. H. Humbert & G. Cours Darne. *Travaux de la Section Scientifique et Technique de l'Institut Français de Pondichéry*, hors série, 6: 46-78.
- Innes, J.L. 2010.** Madagascar rosewood, illegal logging and the tropical timber trade. *Madagascar Conservation and Development*, 5(1): 6-10.
- Irwin, M.T., Wright, P.C., Birkinshaw, C., Fisher, B.L., Gardner, C.J., Glos, J., Goodman, S.M., Loiselle, P., Rabeson, P., Raharison, J.L., Raherilalao, M. J., Rakotondravony, D., Raselimanana, A., Ratsimbazafy, J., Sparks, J. S., Wilmé, L. & Ganzhorn, J.U. 2010.** Patterns of species change in anthropogenically disturbed forests of Madagascar. *Biological Conservation*, 143: 2351-2362.
- Jenkins, P.D. 1992.** Description of a new species of *Microgale* (Insectivora: Tenrecidae) from eastern Madagascar. *Bulletin British Museum Natural History (Zoology)*, 58: 53-59.
- Jenkins, P.D. 1993.** A new species of *Microgale* (Insectivora: Tenrecidae) from eastern Madagascar with an unusual dentition. *American Museum Novitates*, 3067: 1-11.
- Jenkins, P.D., Raxworthy, C.J. & Nussbaum, R.A. 1997.** A new species of *Microgale* (Insectivora, Tenrecidae), with comments on the status of four other taxa of shrew tenrecs. *Bulletin of the Natural History Museum, London (Zoology)*, 63: 1-12.

- Jenkins, R. K.B., Brady, L.D., Bisoa, M., Rabearivony, J. & Griffiths, R.A. 2003.** Forest disturbance and river proximity influence chameleon abundance in Madagascar. *Biological Conservation*, 109: 407-415.
- Kremen, C., Raymond, I. & Lance, K. 1998.** An interdisciplinary tool for monitoring conservation impacts in Madagascar. *Conservation Biology*, 12: 549-563.
- Kremen, C., Razafimahatratra, V., Guillery, R.P., Rakotomalala, J., Weiss, A. & Ratsisompatrarivo, J.-S. 1999.** Designing the Masoala National Park in Madagascar based on biological and socioeconomic data. *Conservation Biology*, 13 (5): 1055-1068.
- Kremen, C. 2008.** La presqu'île Masoala. Dans *Paysage naturels et biodiversité de Madagascar*, ed. S.M. Goodman, pp. 523-536. Muséum national d'Histoire naturelle, Paris.
- Musser, G.G. & Carleton, M.D. 2005.** Superfamily Muroidea. In *Mammal species of the World. A taxonomic and geographical reference*, eds. D.E. Wilson & D.M. Reeder, pp. 894-1531. The John Hopkins University Press, Baltimore.
- Perrier de la Bâthie, H. 1921.** La végétation malgache. *Annales de l'Institut Botanique géologique Colonial de Marseille*, série 3, 9: 1-226.
- Rakotoarisoa, J.E. & Carpella, A.P. 2013.** Forest-bird species assemblages in the lowland rainforest of Madagascar: The effects of forest fragmentation revisited. *The Open Conservation Biology Journal*, 7: 27-41.
- Rakotomalala, Z., Andrianjakarivelo, V., Rasataharilala, V. & Goodman, S.M. 2007.** Les petits mammifères non volants de la forêt de Makira, Madagascar. *Bulletin de la Société Zoologique de France*, 13(2): 117-134.
- Rakotondraparany, F. & Medard, J. 2005.** Diversité et distribution des micromammifères dans le corridor Mantadia-Zahamena, Madagascar. In *Une évaluation biologique rapide du corridor Mantadia-Zahamena, Madagascar*, eds. J. Schmid & L. E. Alonso. *RAP Bulletin of Biological Assessment* (Conservation International, Washington, D.C.), 32: 8-97.
- Rakotondravony, D., Goodman S. M., Duplantier J.- M. & Soarimalala V. 1998.** Les petits mammifères. In *Inventaire biologique de la forêt littorale de Tampolo (Fenoarivo Atsinanana)*, eds. J. Ratsirarson & S. M. Goodman. *Recherches pour le Développement, Série Sciences Biologiques*, 14: 197-212.
- Schuurman, D. & Lowry II, P.P. 2009.** The Madagascar rosewood massacre. *Madagascar Conservation and Development*, 4 (2): 98-102.
- Scott, D.M., Brown, D., Mahood, S., Denton, B. Silburn, A. & Rakotondraparany, A. 2005.** The impacts of forest clearance on lizard, small mammal and bird communities in the arid spiny forest, southern Madagascar. *Biological Conservation*, 127 (1): 72-87.
- Soarimalala, V. & Goodman, S.M. 2003.** Diversité biologique des micromammifères non-volants (Lipotyphla et Rodentia) dans le complexe Marojejy-Anjanaharibe-Sud. Dans *Nouveaux résultats d'inventaires biologiques faisant référence à l'altitude dans la région des massifs montagneux de Marojejy et d'Anjanaharibe-Sud*, eds. S.M. Goodman & L. Wilmé. *Recherches pour le Développement, Série Sciences Biologiques*, 19: 231-278.
- Soarimalala, V. & S.M. Goodman 2011.** Les petits mammifères de Madagascar. *Les petits mammifères de Madagascar*. Association Vahatra, Antananarivo.
- Soarimalala, V. & Raherilalao, M.J. 2008.** Pressions et menaces dans la région forestière sèche malgache. Dans *Les forêts sèches de Madagascar*, eds. S M. Goodman & L. Wilmé. *Malagasy Nature*, 1: 157-161.
- Soarimalala, V., Goodman, S.M., Ramiaranjanahary, H., Fenhery, L.L. & Rakotonirina, W. 2001.** Les micromammifères non-volants du Parc National de Ranomafana et du couloir forestier qui le relie au Parc National d'Andringitra. Dans *Inventaire biologique du Parc National de Ranomafana et du couloir forestier qui la relie au Parc National*

d'Andringitra, eds. S.M. Goodman & V.R. Razafindratsita. *Recherches pour le Développement, Série Sciences Biologiques*, 17: 199-229.

Soarimalala, V., Ramanana, L. T., Ralison, J.M. & Goodman, S.M. 2007. Les petits mammifères non-volants du « Couloir forestier d'Anjozorobe-Angavo ». In Inventaires de la faune et de la flore du couloir forestier d'Anjozorobe-Angavo, eds. S.M. Goodman, A.P. Raselimanana & L. Wilmé. *Recherches pour le Développement, Série Sciences Biologiques*, 24: 141-182.

Thorstrom, R. & Watson, R.T. 1994. Avian inventory of Masoala Peninsula, Madagascar. Unpublished report. The Peregrine Fund, Inc., Boise.

Vallan, D. 2000. Influence of forest fragmentation on amphibian diversity in the nature reserve of Ambohitantely, highland Madagascar. *Biological Conservation*, 96 (2000): 31-43.

Using myological data to study afrothere evolutionary relationships

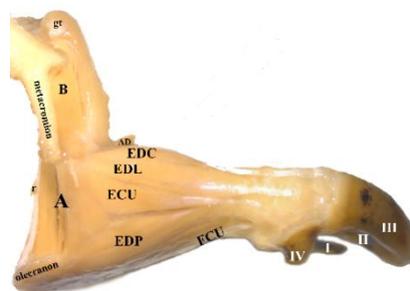
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Introduction

The controversies over the phylogenetic relationships of Afrotherian mammals are well documented (Seiffert, 2007; Tabuce et al, 2008; Asher et al, 2003, 2009; Asher & Seiffert, 2010), as this diverse grouping of mammals has little morphological support (Rose, 2006). I used primary dissection data to identify myological characters of the forelimb to test the conflicting phylogenetic hypotheses of the relationships of *Orycteropus* generated by morphological and molecular data. The forelimb myology of *Orycteropus* has never before been compared directly with that of both ungulates and small afrotherian insectivores. The dissected mammals were *Orycteropus afer* (Tubulidentata); *Potamogale velox*, *Microgale dobsoni*, *Huetia (Calcochloris) leucorhinus* (Afrosoricida); *Rhynchocyon cirnei*, *Elephantulus brachyrhynchus*, *Petrodromus tetradactylus* (Macroscelidea); *Procavia capensis*, *Heterohyrax brucei* (Hyracoidea); and *Pecari tajacu*, and *Tragulus napu* (Artiodactyla). Figure 1 shows examples of my dissection work.

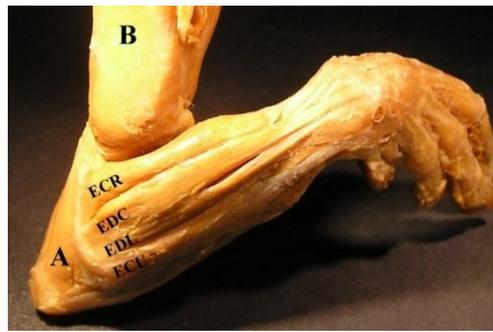
The use of myological data for intraordinal phylogenetic analysis is not new, but it has rarely been used to determine interordinal relationships due to the difficulty of homologizing myological features across Mammalia. I created an anatomical database based on my dissections and previously published anatomical descriptions, standardizing muscle names and summarizing muscle attachments for most orders of mammals. A total of 60 characters of forelimb myology were identified and scored for 46 orders or families of mammals and the program Mesquite 2.75 used for parsimony analyses (Maddison & Maddison, 2011).



A. *Huetia leucorhinus*



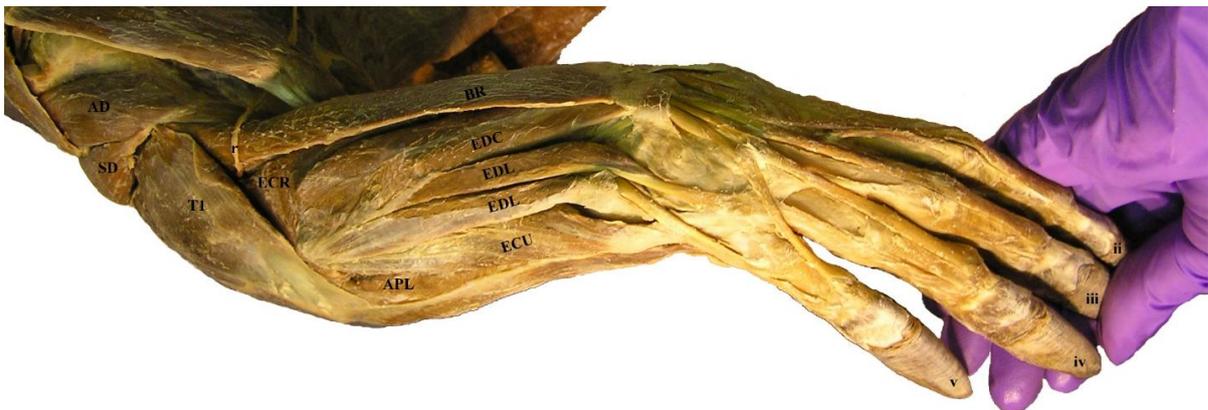
B. *Heterohyrax brucei*



C. *Potamogale velox*



D. *Petrodromus tetradactylus*



E. *Orycteropus afer*

Figure 1. Lateral forearm (extensors) musculature of five afrothere species.

A- anconeus, AD- acromiodeltoideus, APL- abductor pollicis longus, B- brachialis, BR- brachioradialis, CD- clavodeltoideus, ECR- extensor carpi radialis, ECU- extensor carpi ulnaris, EDC- extensor digitorum communis, EDL- extensor digitorum lateralis, EDP- extensor digitorum profundus, r- radial nerve, SD- spinodeltoideus, TLA/TLO- triceps brachii caput lateralis / caput longum.

Results

The 50% majority rules consensus tree of the 178 most parsimonious phylogenies of Mammalia calculated only from the 60-character forelimb myology data matrix (Figure 2) places *Orycteropus* along with Tenrecidae and Macroscelididae as basal eutherian mammals. Surprisingly, the paenungulates and ungulates are nested deep in the phylogeny, providing no support for the traditional placement of *Orycteropus* as a basal ungulate. Paenungulata retains some primitive features in common with *Orycteropus*, Afrosoricida, and Macroscelidea, but also shares derived myological features with the ungulates. Thus, the myological data do not convincingly place Paenungulata within Afrotheria. The joining of Tenrecidae and

Macroscelididae is an unusual result for morphological characters which typically group tenrecs and chrysochlorids with Eulipotyphla (Novacek, 1986; Novacek & Wyss, 1986; Asher et al., 2003; O’Leary et al., 2013). The basal position of three afrothere groups in this analysis lends support to the hypothesis that Afrotheria is the most basal clade of placental mammals (Murphy et al., 2001b; Kjer & Honeycutt, 2007; Asher, 2007; Waddell & Shelley, 2003).

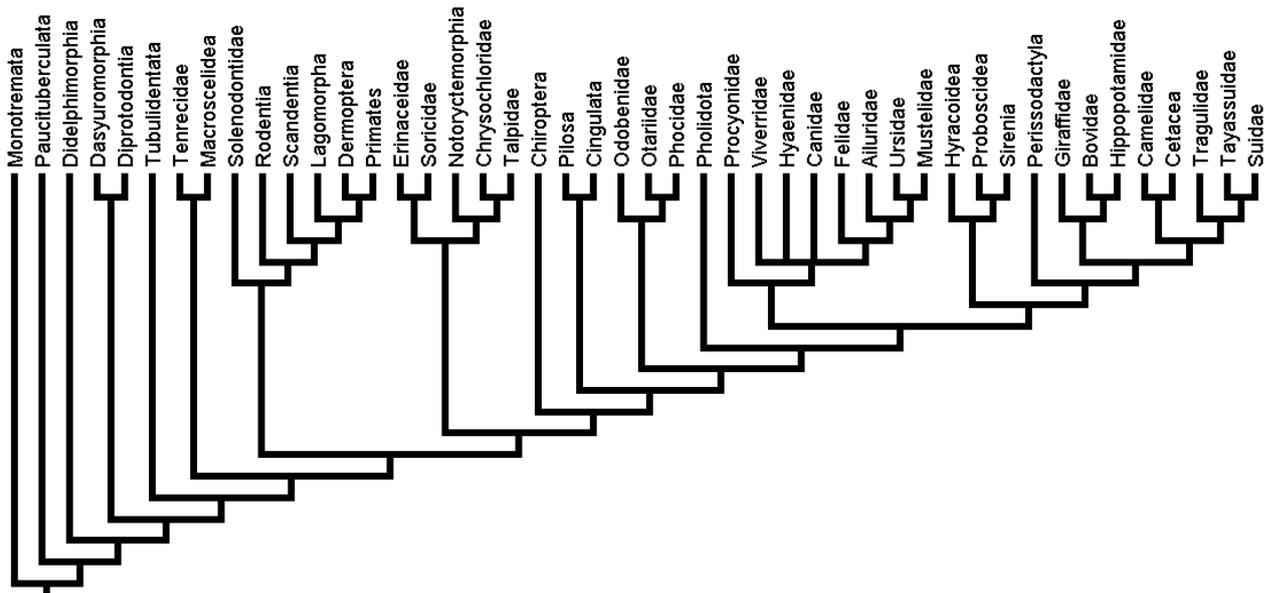


Figure 2. Phylogeny of mammals; 50% majority rules consensus tree based on parsimony analysis of 60 characters of forelimb myology (CI 0.2511, RI 0.5740)

The specializations of fossorial locomotion, such as the lack of most intrinsic muscles of the manus, seem to overwhelm any phylogenetic signal in the myology. Chrysochloridae, which typically lies near Tenrecidae in both morphological and molecular phylogenies, instead forms a “mole” clade with Talpidae and Notoryctemorphia. Utilization of myological characters from regions of the body not associated with digging may ease this problem.

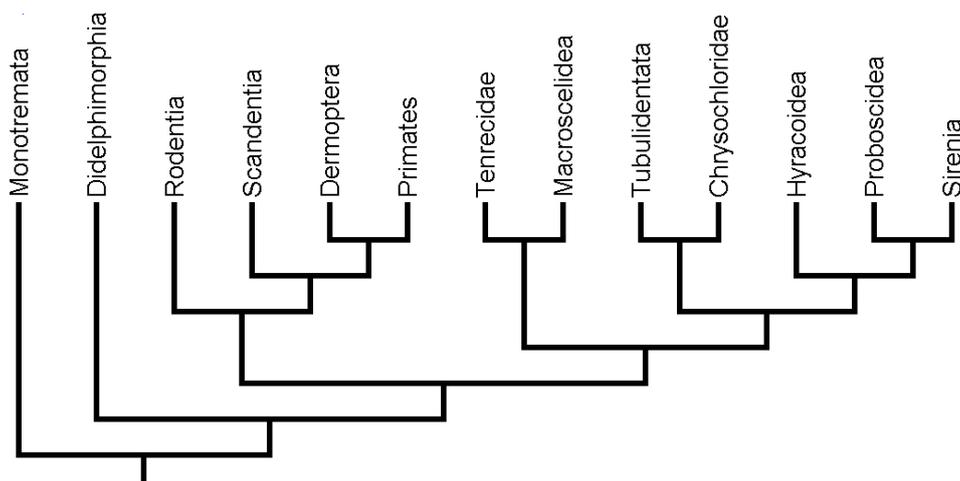


Figure 3. Phylogeny of Afrotheria; 50% majority rules consensus tree of 23 most parsimonious trees from parsimony analysis of 60 characters of forelimb myology. (TL 134, CI 0.604, RI 0.619).

Another parsimony analysis determined the most parsimonious phylogeny of Afrotheria based only on the 60-character forelimb myology data matrix (Figure 3). The 50% majority rules consensus tree of the 23 most parsimonious trees indicates that forelimb myology places *Orycteropus* as sister group to Chrysochloridae which is supported by, for example, features of the flexor muscles of the forearm and the scapular attachment of m. dorso-epitrochlearis. This

sister group relationship is recovered in some other phylogenetic analyses based on molecular data (Kjer & Honeycutt, 2007; Murphy et al., 2007), and supported by a feature of the internal carotid artery (Asher, 2001), but this is not a common result (Asher & Seiffert, 2010). Rather, in many phylogenies, Tenrecidae and Chrysochloridae are united in Afrosoricida (Stanhope et al., 1998; Springer et al., 1999; Murphy et al., 2001a, 2001b; Amrine-Madsen et al., 2003; Asher et al., 2003; Waddell & Shelley, 2003; Seiffert, 2007; O’Leary et al., 2013). The “fossorial” clade resulting from the first analysis of all mammals (Figure 2) suggests a functional signal in the myology, so it seems wise to consider the myological features shared by *Orycteropus* and both Tenrecidae and Chrysochloridae. A close relationship between *Orycteropus* and Afrosoricida is supported by unusual myological features such as the origin of m. flexor carpi ulnaris only from the ulna in *Orycteropus*, *Potamogale*, Chrysochloridae, and Cetacea, and the fact that the radial head of m. flexor digitorum profundus is found in most mammals including *Orycteropus*, *Potamogale*, and *Tenrec*, but is absent in the other afrotheres.

Conclusion

Overall, the preliminary analyses of the myological dataset using Mesquite 2.75 (Maddison & Maddison, 2011) suggest that myological data has been underutilized in phylogenetic analysis, particularly large-scale analysis of mammalian interrelationships. Characters of the hind limb, head, and neck myology should also be investigated to strengthen the dataset and reduce the influence of locomotor habit. Additional afrothere specimens for dissection and collaborations with specialists in afrothere behavior and locomotion are necessary to improve the existing dataset and anatomical descriptions in progress. Reliable, modern anatomical data demonstrating the anatomical specializations found in Afrotheria may promote conservation efforts.

References

- Amrine-Madsen H, Koepfli K-P, Wayne RK, Springer MS. 2003. A new phylogenetic marker, apolipoprotein B, provides compelling evidence for eutherian relationships. *Molecular Phylogenetics and Evolution* 28:225-240.
- Asher RJ. 2001. Cranial anatomy in Tenrecid insectivorans: character evolution across competing phylogenies. *American Museum Novitates* 3352:1-54.
- Asher R. 2007. A web-database of mammalian morphology and a reanalysis of placental phylogeny. *BMC Evolutionary Biology* 7:108.
- Asher RJ, Novacek MJ, Geisler JH. 2003. Relationships of endemic African mammals and their fossil relatives based on morphological and molecular evidence. *Journal of Mammalian Evolution* 10:131-194.
- Asher RJ, Bennett N, Lehmann T. 2009. The new framework for understanding placental mammal evolution. *BioEssays* 31:853-864.
- Asher RJ, Seiffert ER. 2010. Systematics of endemic African mammals. In: Sanders WJ, Werdelin L, editors. *Cenozoic Mammals of Africa*. Berkeley: University of California Press. p 903-920.
- Kjer KM, Honeycutt RL. 2007. Site specific rates of mitochondrial genomes and the phylogeny of eutheria. *BMC Evolutionary Biology* 7:8.
- Maddison WP, Maddison DR. 2011. Mesquite: a modular system for evolutionary analysis. Version 2.75. In. <http://mesquiteproject.org>.
- Murphy WJ, Eizirik E, Johnson WE, Zhang YP, Ryder OA, O'Brien SJ. 2001. Molecular phylogenetics and the origins of placental mammals. *Nature* 409:614-618.

- Murphy WJ, Eizirik E, O'Brien SJ, Madsen O, Scally M, Douady CJ, Teeling E, Ryder OA, Stanhope MJ, De Jong WW, Springer MS. 2001. Resolution of the early placental mammal radiation using Bayesian Phylogenetics. *Science* 294:2348-2351.
- Murphy WJ, Pringle TH, Crider TA, Springer MS, Miller W. 2007. Using genomic data to unravel the root of the placental mammal phylogeny. *Genome Research* 17:413-421.
- Novacek M. 1986. The skull of leptictid insectivorans and the higher-level classification of eutherian mammals. *Bulletin of the American Museum of Natural History* 183:1 - 111.
- Novacek MJ, Wyss AR. 1986. Higher-level relationships of the recent Eutherian Orders: morphological evidence. *Cladistics* 2:257-287.
- O'Leary MA, Bloch JI, Flynn JJ, Gaudin TJ, Giallombardo A, Giannini NP, Goldberg SL, Kraatz BP, Luo Z-X, Meng J. 2013. The placental mammal ancestor and the post-K-Pg radiation of placentals. *Science* 339:662-667.
- Rose KD. 2006. *The Beginning of the Age of Mammals*. Baltimore: The Johns Hopkins University Press.
- Seiffert ER. 2007. A new estimate of afrotherian phylogeny based on simultaneous analysis of genomic, morphological, and fossil evidence. *BioMed Central Evolutionary Biology* 7:224.
- Springer MS, Amrine HM, Burk A, Stanhope MJ. 1999. Additional support for Afrotheria and Paenungulata, the performance of mitochondrial versus nuclear genes, and the impact of data partitions with heterogeneous base composition. *Systematic Biology* 48:65-75.
- Stanhope MJ, Waddell VG, Madsen O, de Jong WW, Hedges SB, Cleven GC, Kao D, Springer MS. 1998. Molecular evidence for multiple origins of Insectivora and for a new order of endemic African insectivore mammals. *Proceedings of the National Academy of Sciences, USA* 95:9967-9972.
- Tabuce R, Asher RJ, Lehmann T. 2008. Afrotherian mammals: a review of current data. *Mammals* 72:2-14.
- Waddell PJ, Shelley S. 2003. Evaluating placental inter-ordinal phylogenies with novel sequences including RAG1, γ -fibrinogen, ND6, and mt-tRNA, plus MCMC-driven nucleotide, amino acid, and codon models. *Molecular Phylogenetics and Evolution* 28:197-224.

Notes on sengis (Macroscelididae) in the Ancuabe district of Quirimbas National Park, Mozambique

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Abstract:

We present observations of the occurrence of sengis (Macroscelidea) in the Taratibu Reserve (Reserva de Taratibu), Quirimbas National Park, Northern Mozambique, along with notes on their habitat associations. Based upon field observations and trapping, we found *Rhynchocyon cirnei* and *Petrodromus tetradactylus* to occur in the Taratibu Reserve. *Rhynchocyon cirnei* was present in closed canopy *Warnekea* sp. and *Parkinsonia* sp. bush, and inselberg vegetation habitats. *Petrodromus tetradactylus* was also present in closed canopy *Warnekea* sp. and *Parkinsonia* sp. bush. This information is a new local record for each species and extends their confirmed distributions further south-west in the Quirimbas National Park.

Introduction:

The elephant-shrews or sengis (Macroscelididae) are represented by 20 species (Dumbacher et al. 2012; Carlen et al. 2017; Rathbun 2017a) which fall into two well-defined sub-families; the soft-furred sengis (Macroscelidinae) and the giant sengis (Rhynchocyoninae). The soft-furred sengis are the more speciose, numbering 15 in four genera whilst the giant sengis are represented by a single genus (*Rhynchocyon*) containing five species (Carlen et al. 2017). Sengis are endemic to the mainland African continent where they are absent only from the central Sahara Desert and tropical West Africa (Rathbun 2009a). *Rhynchocyon* are more restricted in range than the soft-furred sengis; being restricted to tropical and sub-tropical regions between the Congo River basin in the North West and Zambezi River in the South East, whereas representatives of the soft-furred sengis are found from North Africa to the Cape (Rathbun 2017b). Soft-furred and giant sengis are readily discernible morphologically, with giant sengis being considerably larger (350-700g) than soft-furred (35-200g) (Rathbun 2009a). Their pelage also differs significantly, the soft-furred sengis are, as expected, covered in soft, dense fur in a range of muted white, brown, and sand hues whereas *Rhynchocyon* have sparser, coarser hair and exhibit more striking colouration and patterns (Corbett & Hanks 1968). *Rhynchocyon* are generally restricted to closed canopy humid forests and woodland, riparian forests, and dense thickets whilst soft-furred sengis inhabit a wider range of environments, from humid closed canopy forests to arid deserts (Rathbun 2009a).

Mozambique is home to four soft-furred sengi species, *Elephantulus brachyrhynchus* (Smith, 1836), *Elephantulus fuscus* (Peters, 1852), *Elephantulus myurus* (Thomas & Schwann, 1906), *Petrodromus tetradactylus* (Peters, 1846), and one giant sengi, *Rhynchocyon cirnei* (Peters, 1874) (Rathbun 2009b). In Mozambique *R. cirnei* occurs from Quelimane in Zambezia Province to Cabo-Delgado Province, but not north of the Ruvuma River into Tanzania (Coals & Rathbun 2013). The only other sengi species known to occur in north-east Mozambique is *P. tetradactylus* (Corbett & Hanks 1968; Rathbun 2017b). However, the distribution of sengis in Mozambique is generally poorly known and has received little study (Coals & Rathbun 2013). There are only 12 records of *R. cirnei* and 8 of *P. tetradactylus* in Cabo Delgado Province. The majority of records, and the only specimens, are from the south-east of the Quirimbas National Park in Pemba-Metuge district (Coals & Rathbun 2013; Rathbun 2017b). Here we ask whether *R. cirnei* and *P. tetradactylus* are found in the central-west section of the Quirimbas National Park in Ancuabe district. We also provide notes on the vegetation types in which each species was observed.

Methods:

Field surveys were carried out in the Taratibu Reserve conservation area (Portuguese: Reserva de Taratibu) which covers an area of $\pm 34,000$ ha of the Quirimbas National Park in the district of Ancuabe in the Cabo-Delgado Province. The climate of the region is tropical humid with two distinct seasons; a hot and rainy season from November to April and a cooler, dry season from May to October. Surveys (by VL) were spread between four visits to the field site: 16th–28th June 2016, 3rd–9th July 2016, 6th–12th March 2017, and 28th–29th March 2017. Surveys were undertaken in an approximately 10 x 20 km area centred on the Taratibu Bush-camp (12°49'0.23"S 39°41'46.21"E).

Three distinct habitat types were defined within the study area: closed canopy bush of *Warnekea* sp. and *Parkinsonia* sp. (Fig. 1), Miombo open woodland dominated by *Julbernardia globiflora*, *Millettia stuhlmannii*, and *Brachystegia boehmii* (Fig. 2), and the lower slopes of rock inselbergs covered predominantly by *Englerophytum* sp. and *Erythrina* sp. (Fig. 3).



Figure 1. Closed canopy bush of *Warnekea* sp. and *Parkinsonia* sp



Figure 2. Miombo open woodland dominated by *Julbernardia globiflora*, *Millettia stuhlmannii*, and *Brachystegia boehmii*



Figure 3. Lower slopes of rock inselbergs covered predominantly by *Englerophytum sp.* and *Erythrina sp.*

During the 16 to 28 June 2016 visit we surveyed each habitat type during 4 days. We captured sengis using live-capture traps; five Sherman Aluminium box traps (31 x 8 x 9cm) and an additional two locally made bamboo funnel traps (Fig. 4). Traps were deployed from 16 to 28 June 2016 (12 days). They were placed at 07h00 and were checked twice daily after sunrise and before sunset. After two days, traps were relocated within the same habitat type for a further two days. Traps were set in likely places for the capture of *P. tetradactylus*, such as trails and choke-points in understory vegetation. We used a mix of peanut butter, dry peanuts and sardines as bait. Giant sengi trapping success has been shown not to be affected by bait presence (Sabuni et al. 2011), so we used no bait.



Figure 4. Locally made bamboo small-mammal funnel traps.

Rhynchocyon sengis were targeted using camera-traps. From 6 to 12 March 2017 (six days) two Bushnell TrophyCam® camera-traps were deployed for two days in each habitat type. We placed camera-traps near ground level along trails and next to vegetation choke points. Although *Rhynchocyon* do not build and maintain trails, where they are sympatric with *P. tetradactylus*, as in Quirimbas National Park, they will use their trails (Coals & Rathbun 2013).

During all visits to the field site we also included active visual searches that involved walking slowly through habitats looking for sengis. Our searches (by VL) were conducted after

sunrise and before sunset to target the crepuscular *P. tetradactylus* and diurnal *Rhynchocyon cirnei*.

Results & Discussion:

We caught one *Petrodromus tetradactylus* (Fig. 5) in a Sherman trap. (12°52'8.04"S 39°42'14.37"E), and one *Rhynchocyon cirnei* (Fig. 6) with a camera-trap in closed canopy bush (12°48'36.39"S 39°42'57.47"E). In addition, we observed *Rhynchocyon* once on the lower slope of a rock inselberg (12°48'30.80"S 39°41'38.90"E).



Figure 5: *Petrodromus tetradactylus*



Figure 6. Camera-trap photograph of *Rhynchocyon cirnei*

Low live-trapping success was expected due to the low effort, which totalled 84 trap-days (70 Sherman, 14 bamboo, 1 trap placed for only 1 day) and resulted in a Sherman trapping success of 1.43%. Live-trapping success of sengis is often low (Coals & Rathbun 2013; Rathbun et al. 2015). The traditional bamboo funnel traps were not successful in capturing sengis. This may be due to the low number (two) deployed. Additionally, although sengis are eaten as bush-meat by a number of indigenous African populations, the local population surrounding southern Quirimbas National Park do not routinely trap and consume sengis (PC *personal observation*). Local trap designs are therefore likely to be optimised for other small

animal species such as rodents. It is also likely that the funnel style of trap would be more effective if sengis were flushed into the traps set on their trails (see technique described in this issue on page 51).

Our total camera-trap days was 12. Camera traps have proved successful for the identification and surveying of giant sengis (Rovero et al. 2013). Although limited by availability of cameras and time in the field, our preliminary study suggests camera-trapping has potential to be further used in giant sengi surveys in northern Mozambique.

Both species of sengi were captured and observed in closed canopy forest and were not trapped or observed in the open Miombo woodland. These observations are in accordance with what is known of the habitat associations of *R. cirnei* and *P. tetradactylus* (Rathbun 2009a). Coals & Rathbun (2013) captured *R. cirnei* and *P. tetradactylus* in closed canopy riverine forest in the south-east of Quirimbas National Park. Our observations indicate that these species are also found in similar habitat in the central-west region of Quirimbas National Park. We therefore expect these two sengis to occur across northern Mozambique in closed canopy humid forest habitats. However, to-date our data represent the furthest west that *P. tetradactylus* has been recorded in Cabo-Delgado Province (Fig. 7).

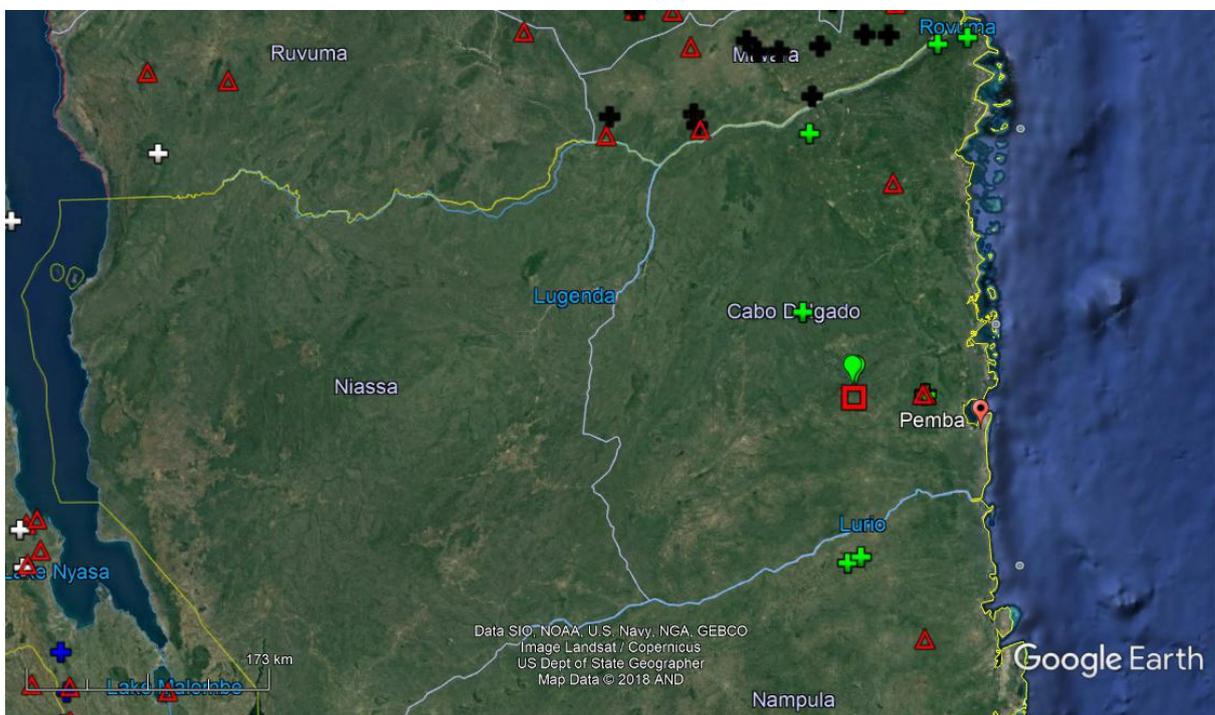


Figure 7. Google Earth satellite image of Northern Mozambique (Cabo-Delgado and Niassa Provinces) showing our new sengi capture locations in relation to previous records (Rathbun 2017b) of *Rhynchocyon cirnei* and *Petrodromus tetradactylus*. Blue cross: *R. c. shirensis*; Black cross: *R. c. macrurus*; White cross: *R. c. reichardi*; Green cross: *R. c. cirnei*; Red triangle: *P. tetradactylus*; Green place-mark: New *R. c. cirnei*; Red square: New *P. tetradactylus*

The photograph of *R. cirnei* that we obtained is similar to the specimens illustrated and described by Coals & Rathbun (2013) from south-east Quirimbas National Park, thus our record is likely *R. c. cirnei* and is another location within the Quirimbas National Park, and the first in Ancuabe district.

Northern Mozambique remains relatively poorly known biologically and recent surveys have revealed a number of new species of vertebrates (e.g. Branch & Bayliss 2009; Taylor et al. 2012). Lack of local capacity appears to be a hindrance to comprehensive and long-term study of much of the region. We therefore call for increased support of local biologists to undertake biodiversity inventory surveys and encourage the sharing and publication of locally collected field-data in this generally under-studied region.

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Authorship:

VL conceived and designed the study; VL collected field data; PC & VL wrote the manuscript.

References:

- Branch, W.R., Bayliss, J. (2009): A new species of *Atheris* (Serpentes: Viperidae) from northern Mozambique. *Zootaxa* 2113: 41–54.
- Carlen, E. J., Rathbun, G. B., Olson, L. E., Sabuni, C. A., Stanley, W. T., & Dumbacher, J. P. (2017). Reconstructing the molecular phylogeny of giant sengis (Macroscelidea; Macroscelididae; Rhynchocyon). *Molecular phylogenetics and evolution*, 113, 150-160.
- Coals, P.G.R., Rathbun, G.B., (2013). The taxonomic status of giant sengis (genus Rhynchocyon) in Mozambique. *J. East African Nat. Hist.* 101, 241–250. <http://dx.doi.org/10.2982/028.101.0203>.
- Corbet, G.B. & Hanks, J. (1968). A revision of the elephant-shrews, Family Macroscelididae. *Bulletin of the British Museum of Natural History (Zoology)* 16: 1-111.
- Dumbacher, J. P., Rathbun, G. B., Smit, H. A., & Eiseb, S. J. (2012). Phylogeny and taxonomy of the round-eared sengis or elephant-shrews, genus *Macroscelides* (Mammalia, Afrotheria, Macroscelidea). *PLoS One*, 7(3), e32410.
- Rathbun, G.B. (2009a). Why is there discordant diversity in sengi (Mammalia; Afrotheria; Macroscelidea) taxonomy and ecology? *African Journal of Ecology* 47: 1-13.
- Rathbun, G.B. (2009b). *Distribution of Sengi (Elephant-shrew) Species by Country* <http://www.sengis.org/distribution-table.php> Accessed online 16 July 2018.
- Rathbun, G. B., (2017a) Sengi Taxonomy – a 2017 update. *Afrotherian Conservation - Newsletter of the IUCN-SCC Afrotheria Specialist Group* 13: 10-11.
- Rathbun, G.B. (2017b). *Sengi distributions* <http://www.sengis.org/distribution.php> Accessed online 16 July 2018.
- Rovero, F., Collett, L., Ricci, S., Martin, E., & Spitale, D. (2013). Distribution, occupancy, and habitat associations of the gray-faced sengi (*Rhynchocyon udzungwensis*) as revealed by camera traps. *Journal of mammalogy*, 94(4), 792-800.
- Sabuni, C., A. Beddetti & H. Leirs (2011). Can giant sengis (genus Rhynchocyon) be captured with baited traps? *Afrotherian Conservation - Newsletter of the IUCN-SCC Afrotheria Specialist Group* 8: 9-12.
- Taylor, P.J., Stoffberg, S., Monadjem, A., Schoeman, M.C., Bayliss, J., Cotterill, F.P. (2012): Four new bat species (*Rhinolophus hildebrandtii* complex) reflect Plio-Pleistocene divergence of dwarfs and giants across an Afromontane archipelago. *PloS One* 7: e41744.

Observations on an Unusual “Arrhythmic” Gait in Sengis

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Running has shaped the life of the sengi. Morphological specializations in sengis such as long, slender limbs ending in digitigrade feet, parasagittal motion of the limbs, and elongation of the metatarsals are classic features associated with cursorial locomotion (Polly 2007). In general, sengis do not usually retreat to protective shelters, such as burrows, when faced with predators. Instead, they escape by running along pathways in the undergrowth, which they meticulously maintain. Of the two extant subfamilies of sengis, Macroscelidinae (soft-furred sengis) and Rhynchocyoninae (giant sengis; see Rathbun 2017 for summary of taxonomy), the soft-furred sengis are particularly specialized for cursorial locomotion, with small litters of 1 – 3 precocial young that are able to walk and run within hours of birth. This suite of correlated morphological, behavioral, ecological, and life history characters in sengis has been identified as a microcursorial adaptive syndrome (Rathbun 1979; Lovegrove and Mowoe 2014).

Unusual arrhythmia has been previously reported in the locomotion of a soft-furred sengi, *Macroscelides proboscideus* (Schmidt and Fischer 2007a; Schmidt and Fischer 2007b). Additional observations by GBR on the footfall patterns of other soft-furred sengi species reveal an occasional “skip” in the footfall pattern, when one of the limbs is kept suspended during the gait cycle when it would otherwise be expected to make contact with the ground, based on the preceding strides. This begs some fundamental questions: Under what conditions does skipping occur? Do all sengis skip? And why skip at all?

In our preliminary exploration of these questions, we analyzed film footage of four sengi species from both Macroscelidinae and Rhynchocyoninae subfamilies: *Petrodromus tetradactylus* (Macroscelidinae; footage from GBR), *Elephantulus rufescens* (Macroscelidinae; footage from NHK television series “Darwin’s Amazing Animals: Quick and Tidy! – Sengi, Africa”), *Rhynchocyon petersi* (Rhynchocyoninae; footage from Zoo Antwerpen by YouTube user Gilles Delhayé), and *Rhynchocyon chrysopygus* (Rhynchocyoninae; footage from GBR). We analyzed video sequences of uninterrupted locomotion and constructed gait diagrams to illustrate the pattern of footfalls during each frame of the video (*Figure 1*).

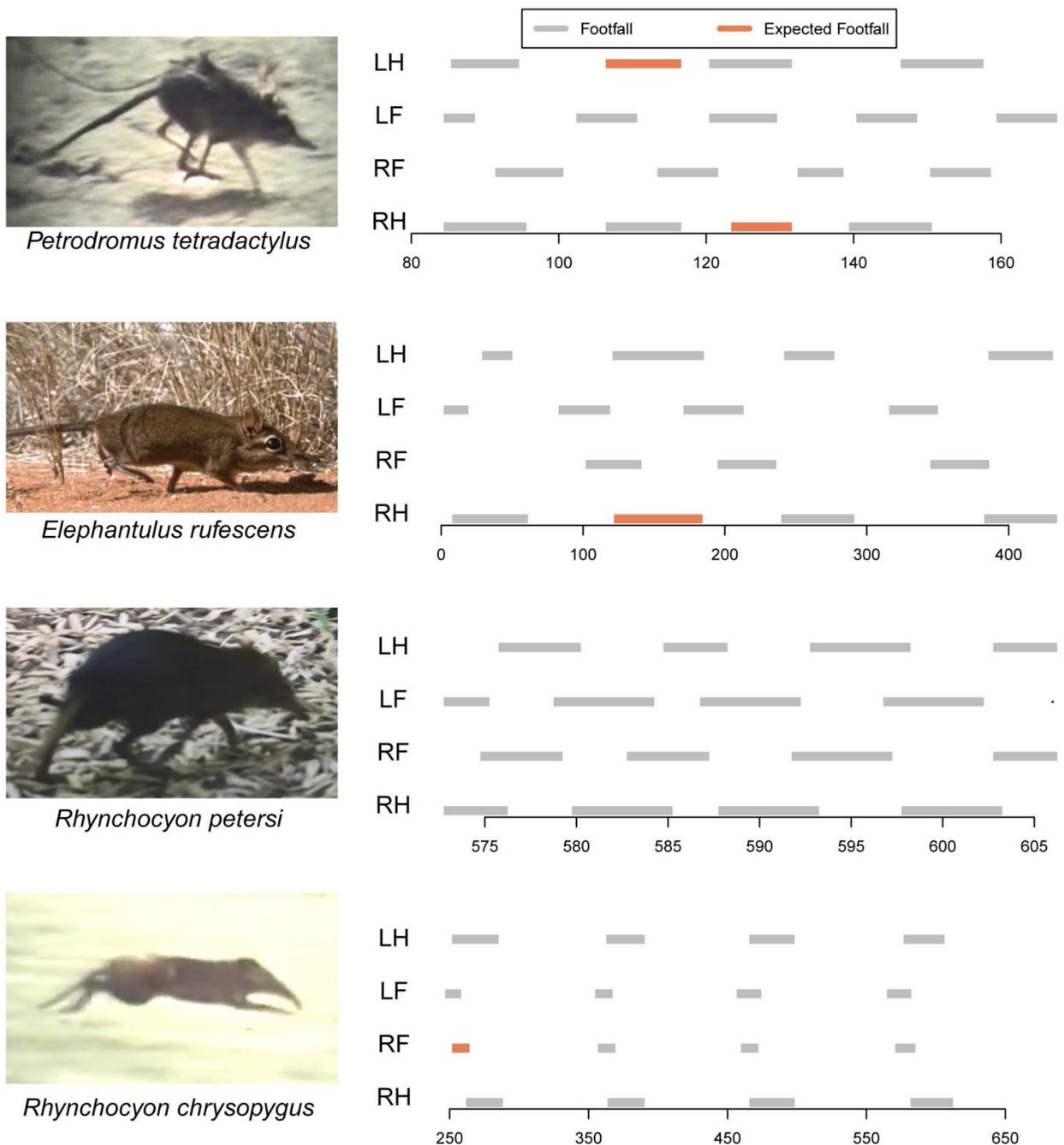


Figure 1. Four species of sengi (left) with corresponding gait diagrams (right). The top two species are in the subfamily Macroscelidinae (soft-furred sengis), the bottom two in Rhynchocyoninae (giant sengis). The gait diagrams show the video frames, labeled on the x-axis, when each foot is in contact with the ground (“footfall” in grey) or when a foot does not make ground contact and is kept suspended in a skip (“suspended expected footfall” in orange). Abbreviations: LH = left hindfoot; LF = left forefoot; RF = right forefoot; RH = right hindfoot. All instances of skipping were seen during the half-bound gait, in which the hindlimbs move together as a synchronous pair. Soft-furred sengis *Petrodromus tetradactylus* and *Elephantulus rufescens* employed the half-bound gait at slow and high speeds, respectively, with hindlimb skipping observed in both instances. In contrast, the giant sengi *Rhynchocyon petersi* used a trotting gait at low speeds with no observed skipping and *R. chrysopygus* showed forelimb skipping only during a fast half-bound. Note that all the gait diagrams represent a selected portion of the total analyzed video sequence to show four continuous gait cycles for clarity of comparison.

The video footage of *P. tetradactylus* is of a wild-caught animal with a leash around its abdomen moving across a flat, mowed grassy substrate (footage from GBR; “Tethered locomotion” on <http://www.sengis.org/videographic.php>). The sengi moves using a slow half-bound gait in which the right and left forelimbs move with alternating strokes, but the hindlimbs swing together as a generally synchronized pair. This is unlike the half-bound of mustelids, in

which forelimbs are synchronized in movement, but the hindlimbs move alternately (Hildebrand 1989). In the approximately 10-second-long sequence, we observed a total of five skips. Most of these skips occurred as consecutive left-right couplets in the following sequence: (1) as the hindlimbs swing forward, only the right hindlimb contacts the ground while the left hindlimb is suspended in the air; (2) the right hindlimb pushes off as the left hindlimb remains flexed; (3) as the hindlimbs swing forward again, only the left hindlimb makes ground contact while the right hindlimb remains suspended. This occurred twice, with a few “normal” gait cycles in between. There does not seem to be a bias towards skipping with one hindlimb or the other. Interestingly, later in the film sequence, the sengi is moving at a faster half-bound and the forelimb alone makes a skip. There appears to be limited spinal flexion at both low and high speeds.

We also used video footage of *E. rufescens* from a nature documentary that filmed animals in their natural surroundings in Kenya. This individual is filmed speeding along its small trail cleared through the leaf litter in a fast half-bound with aerial phases in which none of the feet are in contact with the ground. However, unlike the *P. tetradactylus* that incorporated skips as a regular part of its gait cycle, the *E. rufescens* appears to have kept one of its hindlimbs suspended in order to avoid a small stand of dried grass, suggesting a dynamic adjustment of the gait in response to obstacles. The spine flexes noticeably during the aerial phase.

To compare the two sengi subfamilies, we selected a video of the giant sengi *R. petersi* moving at what appeared to be a similar speed to the skipping *P. tetradactylus*. The captive giant sengi was in a zoo exhibit with a substrate of loose wood chips. Instead of a half-bound gait, this individual moved briskly through its enclosure using a trotting gait, in which contralateral limbs moved synchronously: right forelimb with left hindlimb, and left forelimb with right hindlimb. No skipping was observed.

A video of *R. chrysopygus* in Kenya (footage from GBR; “Tethered locomotion” on <http://www.sengis.org/videographic.php>) shows a leashed sengi half-bounding across an open sandy ocean beach at high speed (limited to about as fast as GBR could run on sand). In contrast to the predominantly hindlimb skipping observed in the soft-furred sengi video footage, this animal skipped only with its forelimbs. There was a total of three skips – each occurrence separated by several normal gait cycles – with the following limbs suspended: right forelimb, both forelimbs, and left forelimb. The sengi also showed significant spinal flexion while in motion.

Despite the apparent uniformity of cursorial features across the sengi clade, there appear to be differences in the mode of locomotion between the two subfamilies. Both Macroscelidinae in our preliminary observations showed instances of hindlimb skipping during the half-bound gait at different speeds. While the sampled Rhynchocyoninae video footage showed a slower trot gait with no skipping and a high speed half-bound with forelimb skipping.

We hypothesize that the gait alterations employed by the smaller Macroscelidinae sengis are associated with further miniaturization of a microcursor, resulting in allometrically long and overpowered hindlimbs relative to torso length. We suspect that the flexible spine of the relatively longer torso of Rhynchocyoninae helps redirect the force produced by the hindlimbs into forward motion, while increasing stride length, as in quadrupedal rodents (Gasc 2001). In a smaller sengi, the powerful “rear-wheel drive” and decreased torso length may potentially require behavioral adaptations to prevent the animal from pitching forward during each stride. In order to accommodate this anatomical configuration, the Macroscelidinae sengis may adjust the stride frequency by keeping a limb suspended during the gait cycle and/or perhaps even decouple movement of the hindlimbs from the forelimbs to redistribute the force of each bound and smooth their stride, as the decoupled tölt gait does for Icelandic horses (Andersson *et al.* 2012). A greater sampling across body sizes would allow us to determine whether there is a relationship between gait arrhythmia and size in sengis. Furthermore, a comparison to other cursorial clades exhibiting a range of body size would elucidate whether gait arrhythmia is a general consequence of cursorial miniaturization or remains unique to sengis.

We aim to examine these questions about sengi locomotion in greater depth by expanding our research into collaborative partnerships with zoos, field stations, or other institutions. While our preliminary observations were based on a few serendipitous video recordings, without observations and data collection under controlled conditions, it is challenging to fully understand the biomechanical mystery of skipping sengis. Our goal is to collect data on locomotory patterns of different sized sengi species at different speeds using high-speed video cameras, a treadmill, and force plates. Using these non-invasive methods, we hope that our findings will contribute to the understanding of the natural history of sengis and also inform conservation efforts by defining normal behavioral repertoire. For instance, these data can help identify whether or not observed gait patterns in captive animals are pathological. Likewise, this information can be applied towards the design of better enclosures and substrates to enhance the well-being of sengis by allowing for the full range of locomotory performance, something that is a defining element of this unusual evolutionary lineage of microcursorids.

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References

- Andersson, L. S., Larhammar, M., Memic, F., Wootz, H., Schwochow, D., Rubin, C. J., ... & Imsland, F. 2012. Mutations in DMRT3 affect locomotion in horses and spinal circuit function in mice. *Nature*, 488(7413): 642.
- Gasc, J.-P. 2001. Comparative aspects of gait, scaling and mechanics in mammals. *Comparative Biochemistry and Physiology Part A*, 131: 121-133.
- Hildebrand, M. 1989. The Quadrupedal Gaits of Vertebrates. *BioScience*, 39(11): 766-775.
- Lovegrove, B.G. and M.O. Mowoe. 2014. The evolution of micro-cursoriality in mammals. *Journal of Experimental Biology*, 217(8): 1316 – 1325.
- Polly, P.D. 2007. Limbs in Mammalian Evolution. Pp. 245-268 in *Fins into Limbs: Evolution, Development, and Transformation*, Brian K Hall (ed.). University of Chicago Press: Chicago.
- Rathbun, G.B. 1979. The Social Structure and Ecology of Elephant-Shrews. *Zeitschrift für Tierpsychologie Supplement*, 20: 1 – 77.
- Rathbun, G.B. 2017. Sengi Taxonomy – a 2017 update. *Afrotherian Conservation*, 13: 10 – 11.
- Schmidt, A. and M.S. Fischer. 2007a. Locomotion of the short-eared elephant shrew, *Macroscelides proboscideus* (Macroscelidea, Mammalia): effects of elongated hind limbs. Poster presentation at 8th International Congress of Vertebrate Morphology, Paris, France.
- Schmidt, A. and M.S. Fischer. 2007b. Limb proportions and their effects on locomotion in the short-eared elephant shrew, *Macroscelides proboscideus* (Macroscelidea, Mammalia). Poster presentation at 100th Annual Meeting of the German Zoological Society, Köln, Germany.

Notes from the Field

The Nimba Otter-Shrew is Uplisted to Vulnerable on the IUCN Red List of Threatened Species

PJ Stephenson, Jan Decher, Ara Monadjem

The Nimba otter-shrew (*Micropotamogale lamottei*) is a small, semi-aquatic afrotherian endemic to a very limited part of the Upper Guinea Region in Côte d'Ivoire, Guinea and Liberia (see Vogel 1983 for a species account). Biologists have long suspected the species was threatened and assessments for the IUCN Red List of Threatened Species from 1990 to 2008 classified it as Endangered. The justification was that “the species is confined to an area less than 5,000 km², which is severely fragmented and still declining”, and the “ecology and biology of this species make it more susceptible to habitat loss in the region” (Vogel 2008). However, when the Afrotheria were re-assessed in 2015-16, a more rigorous assessment of existing distribution data led to a revised calculation of Extent of Occurrence (EOO) and the new figure – 22,540 km² – meant the species was downlisted to Near Threatened (Stephenson 2016). While a downlisting on the IUCN Red List “is always to be welcomed, whether resulting from successful conservation intervention or improved knowledge of status and trends” (Mallon & Jackson 2017: page 605), in this instance there were ongoing concerns about the lack of accurate range data and unquantified levels of threat from mining and bycatch (Stephenson 2016).



Nimba otter shrew, ©Ara Monadjem

Recent studies in the Putu mountains of east-central Liberia (Decher et al. 2016) and the Nimba range in northern Liberia (Monadjem et al. 2018) have confirmed the restricted range of the species and provided evidence of a direct threat from mining. Due to the new data the EOO has been recalculated at 14,725 km² (Monadjem et al. 2018). Combined with the deteriorating habitat and the precarious status of the only two protected areas conserving otter-shrew habitat (Stephenson et al. in press a), the species has been uplisted from Near Threatened to Vulnerable B1ab(i,ii,iii) (Stephenson et al. in press b).

The case of the Nimba otter-shrew demonstrates the problems of assessing the conservation status of species with limited data. The emphasis placed by scientists and conservationists on current status also fails to reflect not only data issues but any impact of conservation action. Perhaps without the two protected areas in its range – Mount Nimba Strict Nature Reserve in Guinea and Côte d'Ivoire and East Nimba Nature Reserve in Liberia – the Nimba otter-shrew would already have been even closer to extinction. The proposal to create an IUCN Green List of Species, with less of a focus on current status alone and more on conservation needs and legacy, should help rectify some of these issues (Akçakaya et al. 2018). The Nimba otter-shrew case also further underlines the arguments made for improved field-based monitoring of biodiversity in general (Stephenson et al. 2017) and neglected small mammals such as the Afrotheria in particular (Stephenson 2017).

Literature:

- Akçakaya, H.R., Bennett, E.L., Brooks, T.M., Grace, M.K., Heath, A., Hedges, S., Hilton-Taylor, C., Hoffmann, M.K., Keith, D.A., Long, B., Mallon, D.P., Meijaard, E., Milner-Gulland, E.J., Rodrigues, A.S.L., Rodriguez, J.P., Stephenson, P.J., Stuart, S.N. & Young R.P. 2018. Quantifying species recovery and conservation success to develop an IUCN Green List of Species. *Conservation Biology*. <https://doi.org/10.1111/cobi.13112>
- Decher, J., Gray, C. R., Garteh, J. C., Kilpatrick, C. W., Kuhn, H. J., Phalan, B. Monadjem, A., Kadjo, B., Jacquet, F. & Denys, C. 2016. New evidence of the semi-aquatic Nimba otter shrew (*Micropotamogale lamottei*) at Mount Nimba and in the Putu Range of Liberia – Uncertain future for an Evolutionary Distinct and Globally Endangered (EDGE) species in the face of recent industrial developments. *Journal of Contemporary Water Research & Education*, 157: 46-57.
- Mallon, D.P. & Jackson, R.M., 2017. A downlist is not a demotion: Red List status and reality. *Oryx*, 51(4): 605-609.
- Monadjem, A., Decher, J., Crawley, W.-Y., & McCleery, R.A. 2018. The conservation status of a poorly-known range-restricted mammal, the Nimba Otter shrew *Micropotamogale lamottei*. *Mammalia*. <https://doi.org/10.1515/mammalia-2017-0144>
- Stephenson, P.J. 2016. *Micropotamogale lamottei*. The IUCN Red List of Threatened Species 2016: e.T13393A21287657. <http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T13393A21287657.en>
- Stephenson, P.J. 2017. Small mammal monitoring: why we know so little about the Afrotheria. *Afrotherian Conservation*, 13: 34-42.
- Stephenson, P.J., Brooks, T.M., Butchart, S.H.M., Fegraus, E., Geller, G.N., Hoft, R., Hutton, J., Kingston, N., Long, B. & McRae, L. 2017. Priorities for big biodiversity data. *Frontiers in Ecology and the Environment*, 15: 124-125.
- Stephenson, P.J., Monadjem, A. & Decher, J. in press a. Uplisting a threatened small mammal: the Nimba otter-shrew of West Africa. *Oryx*.
- Stephenson, P.J., Monadjem, A., Decher, J. & Phalan, B. in press b. *Micropotamogale lamottei*. The IUCN Red List of Threatened Species 2018.
- Vogel, P. 2008. *Micropotamogale lamottei*. *The IUCN Red List of Threatened Species 2008*: e.T13393A3880038. <http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13393A3880038.en>
- Vogel, P. 1983. Contribution à l'écologie et à la zoogéographie de *Micropotamogale lamottei* (Mammalia, Tenrecidae). *Revue d'Écologie (La Terre et la Vie)*, 38: 37–49.

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A Traditional Method of Hunting Dusky Sengis in Southern Malawi

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In late May 2018, we spent about a week in the lower Shire Valley of southern Malawi assessing the rarity of the dusky sengi, *Elephantulus fuscus*. This species has a relatively restricted distribution in the region (www.sengis.org/distribution), and its phylogenetic relationship to other species in the genus is not well understood (Corbet and Hanks 1968, Smit et al., 2011). Both of these factors are important in determining the IUCN Red List status of the Dusky Sengi.

We were based at the Thangadzi River Conservancy in the Kaombe Ranch in the lower Shire Valley, and we had the opportunity to observe the local Sena people using their traditional method of capturing these sengis. We learned that their technique is very efficient because it takes advantage of several aspects of the unusual natural history of the smaller sengis (Rathbun 2009), including their highly cursorial and swift locomotion, their adherence to a well-defined trail system that the sengis maintain through the surface litter, and their lack of burrow use. Below, are several photos (by authors) and captions illustrating the trapping method the Sena people used.



Figure 1: The Dusky Sengi is the size of a mouse, about 23 cm long including the tail, and weighing about 45 g. It is found mainly in southern Malawi and barely extends into Mozambique and Zambia.



Figure 2: Chief Stuart Semba (left) and his son Moses made six traps, which were about 75 cm long funnels woven from dried palm leaves. The circular mouths of the funnels were about 7 cm in diameter, and the small pointed ends were tied closed with a rubber band, probably cut from a bicycle inner tube.



Figure 3: Dusky Sengis actively build and maintain trails through habitat mosaics of grass and bush thickets. Their trails are usually a distinct straight series of little bald spots (between yellow stars) in the leaf litter, where they land while moving along their trail.



Figure 4: *The funnel traps were placed on these trails, all facing in the same direction, so that a sengi racing along a trail would encounter a funnel.*



Figure 5: *Once the traps were carefully placed on trails, several hunters lined up on the opposite end of the thicket, and with sticks, rocks, and clumps of soil “beat” the vegetation to flush and drive sengis from their resting places and down their trails towards the traps. Because these sengis do not usually retreat into burrows, there was a reasonably good chance that a trap would be encountered.*



Figure 6: The fleeing sengis raced along their well-maintained trails at a high speed ahead of the beaters, and rushed blindly into one of the funnels, which they apparently perceived as an open tunnel through the dense vegetation surrounding their neatly maintained trail.



Figure 7: The high speed of the sengi wedged it into the narrow end of the funnel, with its long antelope-like legs protruding through the woven funnel and preventing it from backing out. Sengis were easily removed from a trap by unwinding the rubber band at the narrow end of the funnel.

The four-toed sengi, *Petrodromus tetradactylus*, is captured in the same way because it has similar natural history traits as *E. fuscus*. However, because *Petrodromus* is larger in girth than *Elephantulus*, the funnel opening is made slightly larger. Typically, young boys hunt both sengis, which are cooked and eaten. They report that the sengis are quite tasty.

This capture technique was repeated for us in different thicket patches, and the team of six people were able to capture four sengis in only a couple hours one morning. This suggests that *E. fuscus* may not be particularly rare, where its habitat mosaic of thicket and grass has not been removed for subsistence farming. Unfortunately for this sengi, the human population in southern Malawi is large, and relatively little land remains uncultivated.

We are grateful to Chief Stuart Semba and his family and neighbours, who expertly demonstrated their sengi capture method. We also thank Bouke Bijl, Bruce Carruthers, and Simon Ibeetson of Agricane Ltd. for their hospitality and support while we were in Malawi.

Literature Cited:

Corbet, G. B., and J. Hanks. 1968. A revision of the elephant-shrews, Family Macroscelididae. Bulletin of the British Museum (Natural History) Zoology **16**:47-111.

Rathbun, G. B. 2009. Why is there discordant diversity in sengi (Mammalia: Afrotheria: Macroscelidea) taxonomy and ecology? African Journal of Ecology **47**:1-13.

Smit, H. A., B. J. Van Vuuren, P. C. M. O'Brian, M. A. Ferguson-Smith, F. Yang, and T. J. Robinson. 2011. Phylogenetic relationships of elephant-shrews (Afrotheria, Macroscelididae). Journal of Zoology, London **284**:133-143.

Message from the Co-chairs

We welcome Link Olson, who has been a member of our group since the beginning, as a joint co-ordinator of the **Tenrec Section** with Voahangy Soarimalala. We look forward to working with them both to continue advancing tenrec conservation, research, and general awareness.

We have added one **new member** to our specialist group. Steven Heritage, a PhD student at Duke University, brings expertise on the paleontology of afrotheres, especially sengis. His treatment of the sengis in the recently published volume 8 of “Handbook of the Mammals of the World” is excellent (see review on page 60). We welcome Steven and look forward to working with him towards continuing to achieve our goals.

In addition to the chapter on sengis in volume 8 of “**Handbook of the Mammals of the World**”, authored by Steven Heritage, three other Afrotherian groups have been added to this set of books, including the tenrecs (authored by Paulina Jenkins), otter-shrews (authored by Ara Monadjem) and golden moles (authored by Andrew Taylor, Samantha Mynhardt and Sarita Maree). There is also a chapter on Conservation Actions and Priorities, coauthored by PJ Stephenson.

Back and future issues of our **newsletter** “Afrotherian Conservation” are now being archived at libraries: The California Academy of Sciences in San Francisco and the IUCN library in Gland, Switzerland. The newsletter can easily be found in digital format at the Biodiversity Heritage Library (BHL), a free, globally accessible, searchable digital library that is part of the Encyclopedia of Life project. Access is via the web at: <https://www.biodiversitylibrary.org/>. Of course the newsletter can also be found and downloaded from our web site: www.afrotheria.net. We thank all three institutions for working with us to archive the newsletter, and make it freely and easily available to everyone on the web.

Our other major contribution to educating the public about the smaller afrotheres is **our web site**. Galen has recently updated the macroscelid pages, but some of the other pages could use some updating. This is especially true of the aardvark and tenrec pages, as well as the conservation pages. If any readers are interested to give this a go, please contact Galen for some background and options on how this might be done.

As many of you may know, the Species Survival Commission of IUCN and the National Geographic Society have formed a partnership to fund research. Link Olson and several of his colleagues that work on tenrecs have submitted an excellent proposal – so we await with fingers crossed to hear the results soon. **BREAKING NEWS:** we just learned that the proposal was unfortunately and surprisingly not funded.

A link to our **2016-2017 SG report** can be found at: <https://www.iucn.org/ssc-groups/mammals#Afrotheria>

Andrew Taylor, co-chair, (taylor.wa@gmail.com)

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An imminent updated (2017) taxonomy for golden moles

Submitted by Gary Bronner¹ (ASG Golden mole Section Co-ordinator) on behalf of all mentioned ASG Golden mole Section members.

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Several changes to the α -taxonomy of golden moles have been suggested by publications over recent years. Some of the taxonomic and nomenclatural changes outlined below are supported by two papers co-authored by several ASG members (Asher et al. 2010; Mynhardt et al. 2015), and variably formalized in the book “Mammals of Africa” (Bronner 2013). But most of the amendments to the prevailing systematic tapestry for the family are based on a “total analysis” phylogenetic analysis of the family undertaken by a research team that includes various ASG members (Sarita Maree, Paulette Bloomer, Nigel Bennett, Rob Asher and I). This phylogenetics study, employing DNA sequences for five genes and 126 morphological/cytogenetic characters, is at revision stage following submission to, and favourable comments from reviewers for, the journal *Cladistics*. Probable taxonomic changes outlined below *should thus be regarded as provisional until final results are published*.

The major taxonomic changes for chrysochlorids that are predicated by our analyses are:

- elevation of three subspecies (*Amblysomus hottentotus meesteri*, *A. h. longiceps* and *Eremitalpa granti namibensis*) to species rank, thereby increasing chrysochlorid diversity to 24 species;
- elevation of the subgenus *Kilimalpa* to genus rank for Stuhlmann’s golden mole;
- downgrading of *Cryptochloris* to only a subgenus within *Chrysochloris*;
- recognition of 3 subfamilies, instead of 2; and possibly allocation of *Huetia* to a new subfamily, though we are running new analyses to better elucidate the phylogenetic placement of this genus relative to *Eremitalpa* as model-based (Bayesian) and maximum parsimony/likelihood approached have thus far yielded conflicting results.

A provisional new classification of the Chrysochloridae is presented below.

Asterisks denote proposed changes to the currently accepted taxonomy, superscript numerals denote recent sources supporting such amendments. The listing for each species in the most recent IUCN global Red List (IUCN 2017) is given in square parentheses [DD-Data Deficient; LC-Least Concern; NT-Near Threatened; VU-Vulnerable; EN-Endangered; CR-Critically Endangered], with changes (from the 2008 Red List) shown in red, as per the 2014 re-assessment done by members of the Golden mole section of the ASG.

Subfamily: Eremitalpinae

Genus: *Eremitalpa*

Eremitalpa granti [LC] LC

*Eremitalpa namibensis**³ not assessed

Possible new Subfamily: Huetinae?

Genus: *Huetia**^{1,2,4}

Huetia leucorhina DD

Huetia tytonis DD (holotype only)

Subfamily: Chrysochlorinae

Genus: *Kilimalpa*

*Kilimalpa stuhlmanni**³ LC

Genus: *Chrysochloris*

Subgenus: *Chrysochloris*

Chrysochloris asiatica LC

Chrysochloris visagiei DD (holotype only)

Subgenus: <i>Cryptochloris</i> ^{*3}	
<i>Chrysochloris zyli</i>	EN
<i>Chrysochloris wintoni</i>	CR
Subfamily: Amblysominae	
Genus: <i>Chrysospalax</i>	
<i>Chrysospalax trevelyani</i>	EN
<i>Chrysospalax villosus</i>	VU
Genus: <i>Chlorotalpa</i>	
<i>Chlorotalpa duthieae</i>	VU
<i>Chlorotalpa sclateri</i>	LC
Genus: <i>Carpitalpa</i> ^{*1,2,3}	
<i>Carpitalpa arendsi</i>	VU
Genus: <i>Neamblysomus</i>	
<i>Neamblysomus gunningi</i>	EN
<i>Neamblysomus julianae</i>	EN (Bronberg subpopulation CR)
Genus: <i>Amblysomus</i>	
<i>Amblysomus corriae</i>	NT
<i>Amblysomus hottentotus</i>	LC
<i>Amblysomus longiceps</i> ^{*3,4}	not assessed
<i>Amblysomus meesteri</i> ^{*3,4}	not assessed
<i>Amblysomus marleyi</i>	EN
<i>Amblysomus robustus</i>	VU
<i>Amblysomus septentrionalis</i>	NT
Genus: <i>Calcochloris</i>	
<i>Calcochloris obtusirostris</i>	LC

The proposed new “total evidence phylogeny”³ will increase known chrysochlorid species richness to 24, equivalent to ~26% of afrothere α -diversity, making the Chrysochloridae the second most diverse afrotherian family after the Tenrecidae. It reaffirms that chrysochlorids are the most speciose afrotherian lineage found on the African continent (Bronner 2013), with origins as far back as the Lutetian stage of the Eocene in Namibia (Pickford 2015⁶). Of the 25 threatened extant afrotherian species listed by the IUCN⁵, 10 (40%) are chrysochlorids according to this provisional new classification, rendering this family a priority for future afrotherian conservation actions. Given that previous phylogenies sampled only a small portion of total afrotherian diversity⁷, this recent study will also substantially improve taxon and nucleotide representation for future investigations into broader evolutionary patterns within the Afrotheria clade.

References

1. Asher R.J., Maree S., Bronner G., Bennett N.C., Bloomer P., Czechowski P., Meyer M., Hofreiter M. 2010. A phylogenetic estimate for golden moles (Mammalia, Afrotheria, Chrysochloridae). *BMC Evolutionary Biology* 10:69.
2. Bronner GN. 2013. Family Chrysochloridae. Pp. 223-225 in: *Mammals of Africa Volume 1: Introductory chapters and Afrotheria* (Kingdon J. et al, eds.). Bloomsbury Publishing, London.
3. Maree S., Bloomer P., Bennett N.C., Oosthuizen C.J., Asher R.J., Hofreiter M., Bronner G.N. (in preparation). Resolving a Rare Branch of the Afrotherian Phylogenetic Tree: a Total Evidence Phylogeny for Golden Moles (Mammalia: Chrysochloridae). To be submitted shortly to *Cladistics*.
4. Mynhardt S., Maree S., Pelser I., Bennett N.C., Bronner G.N., Wilson J.W., Bloomer, P. 2015. Phylogeography of a Morphologically Cryptic Golden Mole Assemblage from South-Eastern Africa. *PLoS ONE* 10(12): e0144995. doi:10.1371/journal.
5. IUCN 2016. The IUCN Red List of Threatened Species. Version 2016-2. <<http://www.iucnredlist.org>>. Downloaded on 27 September 2016.

6. Pickford M. 2015. Late Eocene Chrysochloridae (Mammalia) from the Sperrgebiet, Namibia. *Comm. Geol. Surv. Namibia*. 16:153–193.
7. Kuntner M., May-Collado L.J., Agnarsson I. 2011. Phylogeny and conservation priorities of afrotherian mammals (Afrotheria, Mammalia). *Zool. Scripta* 40:1–15.

**Review of Wilson, D.E. and R. A. Mittermeier (eds.)
Handbook of the Mammals of the World, Volume 2,
Hoofed Mammals (2011) and Volume 8, Insectivores,
Sloths and Colugos (2018). Lynx Edicions, Barcelona,
Spain.**

Upon receiving the two volumes of Handbook of the Mammals of the World from the publisher for review, I was not prepared for their size and weight, which is 32 x 25 cm and >5 cm thick and weigh ~4 kg (vol. 2) and ~3 kg (vol. 8). This stretches the meaning of “handbook” (usually, a small conveniently carried book), but regardless there is little doubt that this beautiful set of tomes is very nicely produced (see <https://www.lynxeds.com/catalog/hmw> for the publisher’s information on the 9-volume series). Volume 2 includes the armadillo and hyraxes, while volume 8 includes the Afrotheria and Macroscelidea. The authors of the various orders or families (clades) are among the most knowledgeable authorities on each (and many are members of our specialist group), and thus the information presented is accurate, clear, and comprehensive. The format for each clade is consistent, starting (Figure 1) with an overview that includes: systematics, morphology, habitat, general habits, communication, food and feeding, breeding, movements, home range and social organization, relationship with humans, status and conservation, and a bibliography (there are no in-text citations, so the bibliography is rather general). This overview, essentially a synopsis of the natural history of the group, is followed by species accounts (Figure 2) that include information on the same topics as in the overview, but focused on each species.



Figure 1: First page of golden mole section in Handbook of the Mammals of the World, vol. 8, showing title page, including size range figure and high-level taxonomy. Following page shows a photo embedded in overview text.

The numerous photographs that are scattered throughout the overviews are excellent, and are among the best available. The photographs not only illustrate a wide selection of species in each group, but just as importantly also illustrate many typical habitats and behaviors. Small drawings clearly illustrate the size range of species in each clade, as well as taxonomic subdivisions (Figure 1). Each species is also beautifully and accurately illustrated in color, although for many small mammals, such as sengis, the difference between many species is beyond this type of illustration because the variation in external morphology and color patterns

sometimes is too cryptic or complicated to adequately illustrate (Figure 2). The generalized distribution maps located in the species accounts are also well done, being useful and clear (although species with highly localized distributions are very small, a compromise likely made to keep a consistent map format across all accounts).



Figure 2: Plate of sengi species in *Handbook of the Mammals of the World, Vol. 8*, followed by first two species accounts with distribution maps, showing a narrow and wide distribution on maps of similar scale.

Even with such a nicely produced and useful series of books, I found three broad issues worth mentioning:

1. HMW did not follow a phylogenetic arrangement in the tomes, but rather for “practical” reasons (according to the editors) volume 2 includes all the hoofed mammals, but oddly also the armadillo (Tubulidentata) and hyraxes (Hyracoidea) along with the largest afrotheres, the elephants (Proboscidea). Then, three years later Volume 4 was produced that includes sea mammals, and thus the manatees and dugong (Afrotheria Order Sirenia). Finally, seven years after volume 2 was published, volume 8 was produced, which includes the remaining Afrotheria - the sengis (Macroscelidea), and tenrecs and golden moles (Afrosoricida), along with “Insectivores” (thus perpetuating the confusion with the archaic order Insectivora), sloths and colugos. There is nothing practical about this arrangement in a science-based handbook, perhaps with the exception of volume 4 and convenience and perhaps benefits for the publisher. Not only are the Afrotheria fragmented in space and time, but in neither volume 2 nor 8 is there any attempt by the editors to tie the fragmented Afrotheria together, despite the nearly universal acceptance of Afrotheria, which is arguably among the more interesting mammal radiations, especially in terms of phylogeography and phylogenetics. Fortunately, the authors have included a short discussion of Afrotheria in their systematic overview of each clade, but the editors missed the opportunity to help tie the Afrotheria clades together.
2. Regrettably, the actual author(s) of the text for each clade are not included on the clade’s title page. Rather, the authors are cryptically listed in the Table of Contents, and their affiliations listed on a different page. This arrangement perpetuates the habit by many authors when citing specific sections in this type of book to use the editors instead of the actual authors. To help avoid this annoying practice by those of us working on the Afrotheria, and provide more details on the contributions in volumes 2 and 8, here are

abbreviated citations with important details for the each clade (in order of appearance in the two volumes):

- Taylor, W.A. 2011. Order Tubulidentata. Pp. 18-25 in: HMW Volume 2.
 - Hoeck, H.N. 2011. Order Hyracoidea. Pp. 28-47 in: HMW Volume 2.
 - Kennerley, R.J., T.E. Lacher, Jr, V.C. Mason, S.D. McCay, N.S. Roach, P.J. Stephenson, M. Superina, and R.P. Young. Conservation Priorities and Actions for the Orders Cingulata, Pilosa, Afrosoricida, Macroscelidea, Scandentia, Dermoptera, and Eulipotyphla. Pp. 15-27 in: HMW volume 8.
 - Jenkins, P.D. 2018. Order Afrosoricida, Family Tenrecidae. Pp. 134-17 in: HMW Volume 8.
 - Monadjem, A. 2018. Order Afrosoricida, Family Potamogalidae. Pp. 174-178 in: HMW Volume 8.
 - Taylor, W.A., S. Mynhardt and S. Maree. 2018. Order Afrosoricida, Family Chrysochloridae. Pp. 180-203 in: HMW Volume 8.
 - Heritage, S. 2018. Order Macroscelidea. Pp. 206-234 in: HMW Volume 8.
3. The HMW is a visually stunning, comprehensive, authoritative reference on mammals, and it is understandable given the high quality of the books that they are costly to produce. Unfortunately, this results in the handbooks being prohibitively expensive for many individuals, universities, museums and libraries and thus not widely available. For example, of the ten separate libraries of the University of California (together, likely one of the larger library systems in the world), only four hold one or more volumes of HMW. I could not check holdings in Africa, where the tomes are likely even rarer, yet this is where this kind of resource is desperately needed to achieve broader scientific literacy and more effective conservation. It is not clear how the conflicting goals of producing such a useful and beautiful set of books can be reconciled with getting copies to where they are especially needed. Perhaps a useful model is that followed by the editors and publisher of Kingdon, J., D. Happold, M. Hoffmann, T. Butynski, M. Happold, and J. Kalina (eds). 2013. *Mammals of Africa*. Bloomsbury, London: sets were donated to important and deserving universities and museums in Africa.

Having access to HMW will be very useful to many of us when we want to quickly check on some aspect of the natural history of one of the afrotheres. The authors, editors, and publisher have produced an excellent resource, overall.

I greatly appreciate that the publisher provided me a copy of volumes 2 and 8 so I could produce an informative review of this important contribution to the literature of the Afrotheria. I will ensure that these two volumes eventually find their way into a deserving library. Also, I appreciate discussions with Steven Heritage that lead up to this review.

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Noticeboard

Tenrec Resources and Information - www.tenrec.org

The website Tenrec Resources and Information is (as might be deduced from its somewhat awkward name) a child of the 1990's and has been available at www.tenrec.org for a number of years.

Its center point is a bibliography of the Tenrecidae which currently comprises 690 publications, a large proportion of which are provided with links to abstracts and full texts (approximately 200 links to free full texts). I am always grateful to receive suggestions on additional publications or corrections of mistakes in the bibliography.

Other parts of the website - which could be geared more towards the general public - are still in their early stages. I would like to expand the website in order to create more awareness of the Tenrecidae and their conservation issues. For this, I would like to include illustrated species descriptions for all tenrec species. Help with this effort would be very welcome - especially concerning pictures of Oryzoricinae and Geogalinae species.

I am open to other ideas - please contact me:

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Recent Literature

Compiled by T. Lehman, G.B. Rathbun

Afrotheria general

- Beck, R. M., & Baillie, C. (2018). Improvements in the fossil record may largely resolve the conflict between morphological and molecular estimates of mammal phylogeny. *bioRxiv*, 373191.
- Emerling, C. A., Delsuc, F., & Nachman, M. W. (2018). Chitinase genes (CHIAs) provide genomic footprints of a post-Cretaceous dietary radiation in placental mammals. *Science advances*, 4(5), eaar6478.
- Hegerl, C. A. R. L. A., Burgess, N. D., Nielsen, M. R., Martin, E., Ciolli, M., & Rovero, F. (2017). Using camera trap data to assess the impact of bushmeat hunting on forest mammals in Tanzania. *Oryx*, 51(1), 87-97.
- Kingdon, J. (2018). *The Kingdon pocket guide to African mammals*. Bloomsbury Publishing.
- Nowak, R. M. (2018). *Walker's Mammals of the World: Monotremes, Marsupials, Afrotherians, Xenarthrans, and Sundatherians*. JHU Press.
- Rovero, F., Owen, N., Jones, T., Canteri, E., Iemma, A., & Tattoni, C. (2017). Camera trapping surveys of forest mammal communities in the Eastern Arc Mountains reveal generalized habitat and human disturbance responses. *Biodiversity and conservation*, 26(5), 1103-1119.
- Sharma, V., Lehmann, T., Stuckas, H., Funke, L., & Hiller, M. (2018). Loss of RXFP2 and INSL3 genes in Afrotheria shows that testicular descent is the ancestral condition in placental mammals. *PLoS biology*, 16(6), e2005293.
- Taylor, P. J., Neef, G., Keith, M., Weier, S., Monadjem, A., & Parker, D. M. (2018). Tapping into technology and the biodiversity informatics revolution: updated terrestrial mammal list of Angola, with new records from the Okavango Basin. *ZooKeys* 779: 51–88.

Golden Moles

- Mason, M. J., Bennett, N. C., & Pickford, M. (2018). The middle and inner ears of the Palaeogene golden mole *Namachloris*: A comparison with extant species. *Journal of morphology*, 279(3), 375-395

Hyrax

- Asher, R. J., Gunnell, G. F., Seiffert, E. R., Pattinson, D., Tabuce, R., Hautier, L., & Sallam, H. M. (2017). Dental eruption and growth in Hyracoidea (Mammalia, Afrotheria). *Journal of Vertebrate Paleontology*, 37(3), e1317638.
- Mbise, F. P., Fredriksen, K. E., Fyumagwa, R. D., Holmern, T., Jackson, C. R., Fossøy, F., & Røskoft, E. (2017). Do hyraxes benefit from human presence in Serengeti?. *African Journal of Ecology*, 55(4), 672-678.
- Tabuce, R., Seiffert, E. R., Gheerbrant, E., Alloing-Séguier, L., & von Koenigswald, W. (2017). Tooth enamel microstructure of living and extinct hyracoids reveals unique enamel types among mammals. *Journal of Mammalian Evolution*, 24(1), 91-110.
- Tabuce, R., & Schmitt, S. (2017). De l'ombre aux Lumières et réciproquement: redécouverte du crâne de *Procavia capensis* (Pallas, 1766)(Hyracoidea, Mammalia) décrit en 1767 par Daubenton dans l'Histoire naturelle. *Zoosystema*, 39(4), 487-499.

Wible, J. R., & West, A. R. (2017). The Basicranial Axis in the Rock Hyrax, *Procavia capensis* (Pallas, 1766)(Mammalia, Afrotheria, Hyracoidea): Novel Structure of the frontal bone. *Annals of Carnegie Museum*, 84(4), 287-300.

Sengis

(for a virtually complete searchable bibliography see: www.sengis.org/bibliography.php)

- Carlen, E. J., Rathbun, G. B., Olson, L. E., Sabuni, C. A., Stanley, W. T., & Dumbacher, J. P. (2017). Reconstructing the molecular phylogeny of giant sengis (Macroscelidea; Macroscelididae; *Rhynchocyon*). *Molecular phylogenetics and evolution*, 113, 150-160.
- Carter, A. M. 2018. Classics revisited: C. J. van der Horst on pregnancy and menstruation in elephant shrews. *Placenta* 67:24-30.
- Doty, J. B., J. M. Malekani, L. N. Kalembe, W. T. Stanley, B. P. Monroe, Y. U. Nakazawa, M. R. Mauldin, T. L. Bakambana, T. L. D. Liyandja, Z. H. Braden, R. M. Wallace, D. V. Malekani, A. M. McCollum, N. Gallardo-Romero, A. Kondas, A. T. Peterson, J. E. Osorio, T. E. Rocke, K. L. Kareem, G. L. Emerson, and D. S. Carroll. 2017. Assessing Monkeypox Virus Prevalence in Small Mammals at the Human-Animal Interface in the Democratic Republic of the Congo. *Viruses-Basel* 9.
- Flasch, L., N. von Elm, & P. Wester. 2017. Nectar-drinking *Elephantulus edwardii* as a potential pollinator of *Massonia echinata*, endemic to the Bokkeveld Plateau in South Africa. *African Journal of Ecology* 55(3): 376-379.
- Gumbi, B. C., J. T. Shapiro, T. Mahlaba, R. McCleery, D. MacFadyen, and A. Monadjem. 2018. Assessing the impacts of domesticated versus wild ungulates on terrestrial small mammal assemblages at Telperion Nature Reserve, South Africa. *African Zoology* 53:23-29.
- Heritage, S. 2018. Family Macroscelididae (Sengis). Pages 206-234 in D. E. Wilson and R. A. Mittermeier, editors. *Handbook of the Mammals of the World - Volume 8 Insectivores, Sloths and Colugos*. Lynx Edicions, Barcelona, Spain.
- Hoffmann, S., Webster, H. J., Teske, P. R., Lutermann, H., Bennett, N. C., & van Vuuren, B. J. (2017). Characterization of 14 polymorphic microsatellite loci developed for an Afrotherian species endemic to southern Africa, *Elephantulus myurus* (Macroscelidea: Macroscelididae). *Applied entomology and zoology*, 52(1), 139-145.
- Jones, S. E. I., J. K. Clause, L. Geeraert, G. A. Jamie, E. Sumbane, T. van Berkel, and M. Jocque. 2017. The Njesi Plateau expedition: a biological assessment of Mt Chitagal, Mt Sanga and the Njesi Plateau in Niassa Province, Mozambique., Biodiversity Inventory for Conservation, Belgium.
- Kavoi, B. M. 2018. Light and scanning electron microscopy of the olfactory mucosa in the rufous sengi (*Elephantulus rufescens*). *Anatomia, Histologia, Embryologia* 47:167-173.
- Kennerley, R. J., T. E. Lacher Jr, V. C. Mason, S. D. McCay, N. S. Roach, P. J. Stephenson, M. Superina, and R. P. Young. 2018. Conservation priorities and actions for the orders Cingulata, Pilosa, Afrosoricida, Macroscelidea, Scandentia, Dermoptera, and Eulipotyphla. Pages 15-27 in D. E. Wilson and R. A. Mittermeier, editors. *Handbook of the Mammals of the World - Volume 8 Insectivores, Sloths and Colugos*. Lynx Edicions, Barcelona, Spain.
- Payne, S., E. Witkow, and C. Symes. 2017. The delectable *Aloe peglerae*. *Weld & Flora* **June 2017**:65-69.
- Payne, S. L., C. T. Symes, and E. T. F. Witkowski. 2016. Of feathers and fur: Differential pollinator roles of birds and small mammals in the grassland succulent *Aloe peglerae*. *Austral Ecology* 41:952-963.

- Pohlstrand, H., and L. Siege. 2017. Filling a gap in the distribution of sengis in Ethiopia. *Afrotherian Conservation - Newsletter of the IUCN-SCC Afrotheria Specialist Group* **13**:43-46.
- Rathbun, G. B. 2017. Identifying the different forms of giant sengi (*Rhynchocyon*) based on external colour pattern. *Afrotherian Conservation - Newsletter of the IUCN-SCC Afrotheria Specialist Group* **13**:7-9.
- Rathbun, G. B. 2017. Sengi Taxonomy - a 2017 update. *Afrotherian Conservation - Newsletter of the IUCN-SCC Afrotheria Specialist Group* **13**:10-11.
- Rovero, F., N. Owen, T. Jones, E. Canteri, A. Iemma, & C. Tattoni. 2017. Camera trapping surveys of forest mammal communities in the Eastern Arc Mountains reveal generalized habitat and human disturbance responses. *Biodiversity and Conservation* **26**(5): 1103-1119.
- Sharma, V., T. Lehmann, H. Stuckas, L. Funke, and M. Hiller. 2018. Loss of *RXFP2* and *INSL3* genes in Afrotheria shows that testicular descent is the ancestral condition in placental mammals. *PLOS (Public Library of Science) Biology* **16**:e2005293
- Stekolnikov, A. A. 2018. African chiggers (Acariformes: Trombiculidae) in the collection of Alex Fain, with a description of a new genus and three new species. *Acarologia* **58**:265-286.
- Symes, C. T. 2017. Notes on the flowering and pollination of the endemic grassland *Aloe reitzii* var. *reitzii* (Asphodelaceae). *Bothalia* **47**.
- Tabuce, R. 2018. New remains of *Chambius kasserinensis* from the Eocene of Tunisia and evaluation of proposed affinities for Macroscelidea (Mammalia, Afrotheria). *Historical Biology* **30**:251-266.
- Willems, F. 2017. Presence of Chequered Giant Sengi (*Rhynchocyon cirnei*) in Shiwa N'gandu in northern Zambia. *Afrotherian Conservation - Newsletter of the IUCN-SCC Afrotheria Specialist Group* **13**:3-6.

Tenrecs

- Everson, K. M., Hildebrandt, K. B., Goodman, S. M., & Olson, L. E. (2018). Caught in the act: Incipient speciation across a latitudinal gradient in a semifossorial mammal from Madagascar, the mole tenrec *Oryzorictes hova* (Tenrecidae). *Molecular phylogenetics and evolution*, *126*, 74-84. * Harrison, T. M., & Harrison, S. H. (2017). Evaluation of husbandry and mortality in lesser hedgehog tenrecs (*Echinops telfairi*). *Journal of Zoo and Wildlife Medicine*, *48*(2), 440-445.
- Mack, A. F., Künzle, H., Lange, M., Mages, B., Reichenbach, A., & Härtig, W. (2018). Radial glial elements in the cerebral cortex of the lesser hedgehog tenrec. *Brain Structure and Function*, 1-9.
- Thompson, K. A., Agnew, D., Nofs, S. A., & Harrison, T. M. (2017). OBSTETRICAL AND POSTPARTUM COMPLICATIONS IN LESSER MADAGASCAR HEDGEHOG TENRECS (*ECHINOPS TELFAIRI*): FOUR CASES. *Journal of Zoo and Wildlife Medicine*, *48*(2), 446-452.

Aardvark

- Kerley, G. I., & Tompkins, I. D. (2017). Drinking by aardvark *Orycteropus afer*. *African Journal of Ecology*, *56*(1), 128-130.
- Martin, S. (2017). *The aardvark as an ecological engineer in the Eastern Karoo: dig patterns and emergent processes* (Master dissertation, Nelson Mandela Metropolitan University).

- Rey, B., Fuller, A., Mitchell, D., Meyer, L. C. R., & Hetem, R. S. (2017). Drought-induced starvation of aardvarks in the Kalahari: an indirect effect of climate change. *Biology Letters*, 13(7), 20170301. <https://doi.org/10.1098/rsbl.2017.0301>
- Weyer, N. M. (2018). *Physiological flexibility of free-living aardvark (Orycteropus afer) in response to environmental fluctuations* (PhD). University of Witwatersrand, Johannesburg.

Guidelines for Authors

Articles, species profiles, reviews, personal perspectives, news items and announcements for the noticeboard are invited on topics relevant to the newsletter's focus. Material for edition number 15 should be sent to Chris & Mathilde Stuart (candm@stuartonnature.com). Articles should follow the format of this edition. The editors reserve the right to edit all contributions for style and content.

Subscription Information

Afrotherian Conservation is available on the IUCN/SSC Afrotheria Specialist Group website at: <http://www.afrotheria.net/>. If you wish to be alerted when new editions are posted on the website, please send your name and email address to Galen Rathbun (grathbun@calacademy.org)