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Edited by C.& M. Stuart

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Galen and his beloved sengis

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Find out more about the Group on our website at http://afrotheria.net/ASG.html and follow us on Twitter **@Tweeting_Tenrec**

From the editors:

This will be our final stint at editing the *Afrotherian Conservation* newsletter. It has been an interesting time and Galen Rathbun was the corner-post who persuaded us to tackle the work from 2016. However, we had known Galen, and his wife Lynn, for many years prior to this. They became good friends, visiting us at our Karoo home, and we them in California. We trapped two sengis amongst rocks close to our farm base and Galen seemed puzzled - these are something different he stated and he was right, they were the newly described Karoo Rock Sengi. On the visit to their California home he showed us the Acorn Woodpeckers and their acorn storage tree, the dreys of Western Grey Squirrel, the lodges of Dark-footed Pack Rats all in, or close to, his property. The "secret" way to avoid crowds at the nearby elephant seal colony by a back track - fortunately we didn't bump into any FWS officials; he told us how to avoid them as well. We valued his openness and he never minced his words, a rarity in this ever more circumscribed world. Galen we salute you wherever you are and we will always remember your friendship, wisdom, blunt humour, willingness to advise and an outspoken approach to authority and bunny-huggers. Aye Galen. And to Lynn - we often think of you and will keep in touch.

We thank all those who have made contributions to this and the previous three newsletters. It has not always been plain sailing hauling the articles and notes in but we know that many of you are busy and it is not easy to set a few hours aside to put virtual pen to paper. Tim Osborne we value your insight into Galen's early years, much that many of his friend's were not aware of!

We would like to thank PJ for taking back the editorial reins at a time when we just have to move on. Not enough hours, not enough days. But of course we are not alone in this are we?

Hanta Yo and Yol Bolson

C. & M. Stuart, Lusaka, Zambia
September 2019 (www.stuartonnature.com)

Features

Recent additions to the fossil record of tenrecs and golden moles

Robert J. Asher

Department of Zoology, University of Cambridge, Downing St., CB2 3EJ, United Kingdom
http://people.ds.cam.ac.uk/rja58/

Tenrecs (Tenrecidae) are a diverse clade of small afrotherians, with slightly over 30 species in eight genera on the island of Madagascar, and three species in two genera distributed in the African tropics, from Liberia in the west to Kenya in the east. Golden moles (Chrysochloridae) are the extant sister clade of tenrecs, and are less ecologically and taxonomically diverse, consisting of just over 20 small, subterranean species throughout subsaharan Africa, most of which are in Southern Africa and few (3 spp.) in central and eastern Africa. Phylogenetic estimates exist for both groups, although more data have been published for tenrecids (e.g., Olson & Goodman 2003; Asher & Hofreiter 2006; Poux et al. 2008; Everson et al. 2016) than chrysochlorids (Bronner 1995; Asher et al. 2010). Unfortunately, the nomenclature for the two clades and the subgroups within each varies among authors. Here, for reasons outlined in Asher & Helgen (2010) and in contrast to some of my esteemed colleagues in the IUCN Afrotheria specialist group, I use Tenrecoidea (McDowell 1958) for the clade consisting of all descendants of the last common ancestor of extant tenrecs and golden moles, Chrysochloridae for the clade of golden moles, and Tenrecidae for the clade of tenrecs, including extant African (*Potamogale* and *Micropotamogale*) and Malagasy species (i.e., Tenrecinae following Asher & Helgen 2010: figs. 1, 2 and pp. 6-7).

Descriptions of chrysochlorid and tenrecid fossils have appeared in the literature sporadically over the past century (Broom 1941, 1948; Butler 1984; Mein & Pickford 2003; Asher & Seiffert 2010) and consist of fragmentary jaws, teeth, skulls, and the occasional skeletal element. Thus far, reports of tenrec fossils are known from the African continent, but no chrysochlorid has been recovered from Madagascar. In contrast to primates (Fleagle 2013), tenrecs do not have an abundant Malagasy subfossil record, although the long-enigmatic Malagasy "aardvark" *Plesiorycteropus* (Macphee 1994) may represent an extinct, large-bodied tenrec (Buckley 2013). Uncontroversial remains of fossil tenrecs and golden moles generally come from Neogene (roughly 23-2.5 million years ago) exposures in South Africa, Namibia, and near Lake Victoria in east Africa. To date, the oldest potential records include those of Gheerbrant (1994) and Seiffert et al. (2007), who described North African dental remains of possibly insectivoran-grade afrotheres from (respectively), the late Paleocene (just over 56 million years ago) and late Eocene (around 33.5 million years ago). Asher & Avery (2010) reported more complete, but much younger, cranioskeletal remains of *Chrysochloris arenosa* and *C. bronneri* from the early Pliocene (around 5 million years ago) of Langebaanweg, South Africa. Another recent Namibian discovery is that of Pickford (2018a), who described and figured a left mandible of a new tenrec, *Promicrogale namibiensis*, with a canine (c), three premolars (p) and three molars (m) from deposits interpreted to represent the early Miocene, just over 20 million years in age, in what is today Elisabethfeld, Namibia.

Until 2015, the fossil record of animals potentially related to golden moles and tenrecs were primarily limited to fragments of Miocene or younger skulls and teeth. This record has improved recently with publications in the *Communications of the Geological Survey of Namibia* by Martin Pickford (2015a, b, c; 2018b). Pickford described fossils from Namibia, including the localities "Black Crow" and "Eocliff", as shown on his map in Pickford 2015c: fig. 2 (available via the link for "volume 16" here:

http://www.mme.gov.na/publications/?designation=gsn), and interpreted to sample (respectively) the Lutetian and Bartonian. Following Cohen et al. (2013), these marine stages are over 41.2 and 37.8 million years old, respectively, making the fossils potentially the oldest yet known for either group. Dental terminology is key to evaluate this material, and relevant cusps are shown for *Setifer setosus*, *Potamogale velox*, and *Didelphis virginiana* in Fig. 1 based on homologies established by Butler (1937) and Patterson (1956; for further details and justification see Asher & Sanchez-Villagra, 2005).

Black Crow

Pickford (2015a) named an isolated lower molar from this Namibian locality *Diamantochloris*, which exhibits distinctive features such as a mesiodistally compressed trigonid and large talonid basin. The talonid resembles that of the North African Oligocene fossil *Eochrysochloris* (Seiffert et al. 2007: fig. 5), and---despite their names---neither *Eochrysochloris* nor *Diamantochloris* have chrysochlorid-like molars. The fossil in Pickford (2015a) was complemented by a later description (Pickford 2018b) of a diminutive right mandible with p3-m2, plus upper cheek teeth tentatively associated based on size. Some extant chrysochlorids, such as *Chrysochloris asiatica*, lack a talonid basin altogether; others (e.g., *Amblysomus hottentotus* and the fossil *Prochrysochloris*) show a small heel with a single cusp and no basin, a morphology also evident in Pickford's photographs of *Namachloris* (Pickford 2015b: fig. 26). It is possible to have a protocone on the upper molars with an un- or minimally-basined talonid heel (e.g., *Amblysomus*, *Potamogale*, and *Solenodon*; see Asher & Sánchez-Villagra 2005 and *Namachloris* Pickford 2015b: figs. 23-25). However, the talonid basin on the Black Crow molars figured by Pickford (2015a: fig. 7; 2018b: figs. 1-2) is, to my knowledge, larger than that seen in any living or fossil chrysochlorid, and also appears larger than the talonid basin illustrated for at least some of the Namibian fossil tenrecs (e.g., *Namagale*, Pickford 2015c: fig. 20).

The basined talonid of the lower molar, and correspondingly small ectoflexid just buccal (or lateral, on the cheek side) to it, are informative regarding the shape of the occluding upper molars of *Diamantochloris*. The uppers would have exhibited not only a prominent protocone (as do some extant chrysochlorids) to occlude with the talonid, but also a metacone and unenlarged paracone, in contrast to the anatomically "zalambdodont" (in reference to the triangular shape of the Greek letter lambda) upper molars of tenrecs and golden moles, in which the metacone is small or absent and the paracone large (see Fig. 1 and Asher & Sánchez-Villagra 2005). Two isolated upper molars assigned by Pickford (2018b: fig. 5) to *Diamantochloris* do in fact show prominent metacones; these are lingual to a large stylar region with a projecting parastyle and without any hint of a hypocone. A maxilla fragment containing a P4 and broken M1 assigned to *Diamantochloris* show conule-like emarginations (Pickford 2018b: fig. 4) on the pre- and post-protocrista buccal to its M1 protocone, a morphology reminiscent of the North African *Widanelfarasia* (Seiffert et al. 2007: fig. 2B) and *Dilambdogale* (Seiffert 2010: fig. 6). The stylar region of *Diamantochloris* is larger than that of, say, the much older North African fossil *Todralestes* (Gheerbrant et al. 2016: fig. 7) or indeed another todralestid also found at Black Crow (*Namalestes* Morales & Pickford 2018: fig. 4). Todralestids also have prominent metacones and large, basined talonids, and Morales & Pickford (2018:78) used possession of a "well-developed metacone" to exclude *Namalestes* from "the basal Tenrecoidea". While some ancestral, insectivoran-grade afrothere likely had prominent metacones, I agree with Morales & Pickford (2018) regarding *Namalestes*. The teeth of *Diamantochloris* resemble those of African insectivoran-grade mammals of uncertain affinity, such as *Widanelfarasia* (Seiffert et al. 2007), more than those of chrysochlorids. The phylogenetic analysis of Seiffert (2010: fig. 12) weakly supports *Todralestes*, *Dilambdogale*, and *Widanelfarasia* as successively distant sister-taxa to a tenrec-golden mole clade. *Diamantochloris* shows dental morphology consistent with a similar phylogenetic placement, outside of the crown clade of living tenrecs and golden moles.

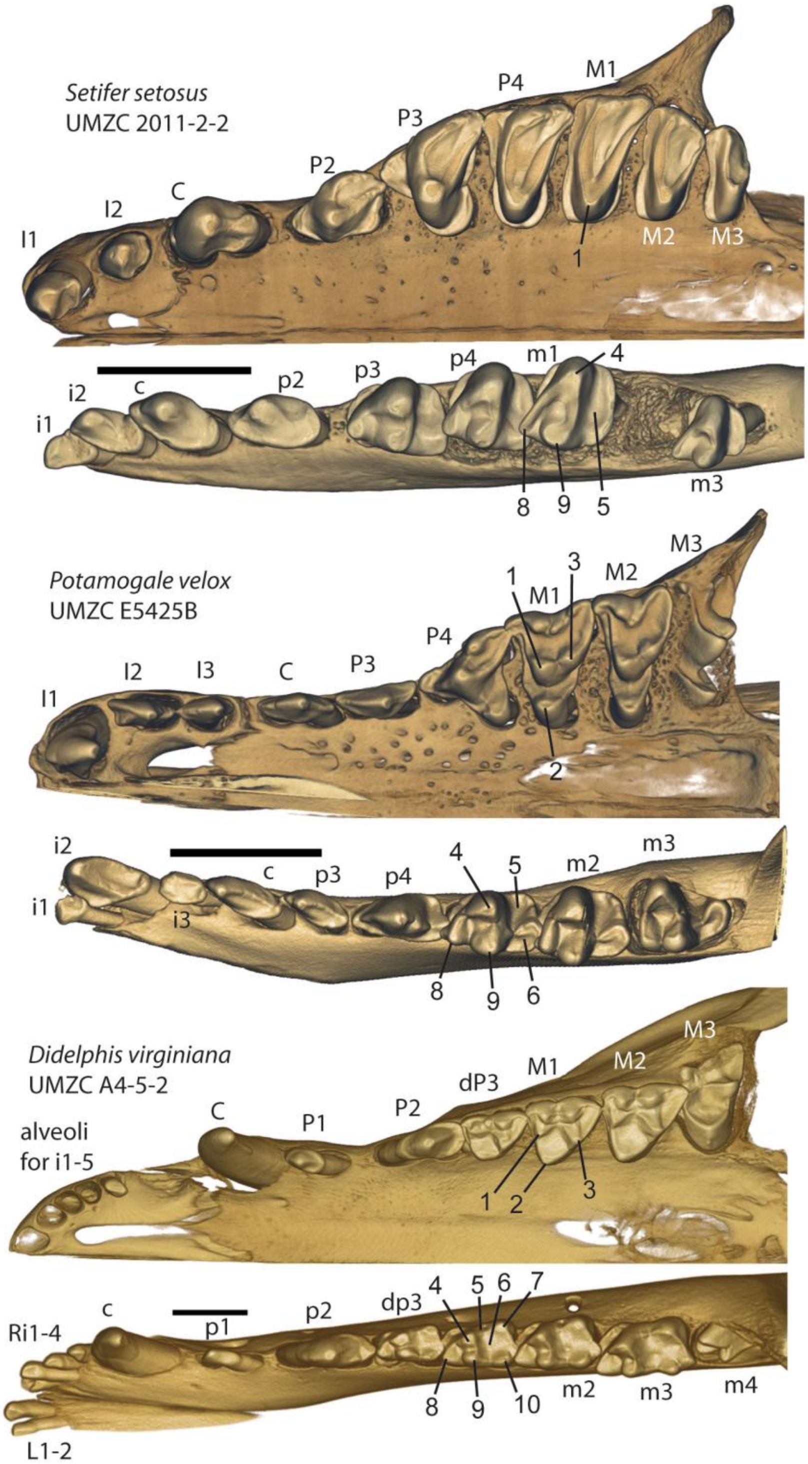

Fig. 1. Dental cusp nomenclature in *Setifer* (top), *Potamogale* (middle) and *Didelphis* (bottom) following Butler (1937), Patterson (1956) and Asher & Sanchez-Villagra (2005). Upper & lower case I, C, P, and M indicate (respectively) upper and lower incisors, canines, premolars, and molars. "d" indicates a deciduous tooth. Individual cusps are 1 = paracone, 2 = protocone, 3 = metacone, 4 = protoconid, 5 = ectoflexid, 6 = talonid basin, 7 = hypoconid, 8 = paraconid, 9 = metaconid, 10 = entoconid. Scale bars = 5mm. UMZC = University Museum of Zoology, Cambridge. Images derived from CT scans taken at the Cambridge Biotomography Centre (www.cbc.zoo.cam.ac.uk/) and reconstructed in 3D using Drishti 2.6.4 (Limaye 2012).

A feature of the *Diamantochloris* mandible that would greatly strengthen its identification as a chrysochlorid is Pickford's interpretation that it shows an articulation of the lower jaw (or dentary) angular process with the hyoid bone. Such a feature is unique to golden moles (Bronner 1991). Based on the p3-m2 dentary fragment, which ends posteriorly at the exposed m2 root and lacks any remnant of the condyle or jaw angle, Pickford (2018b 61): writes "the bend in the mandible of *Diamantochloris* at the junction between the premolar and molar rows, indicates that this genus may have been endowed with a hyoid-mandible articulation. However, more completely preserved fossils are required to confirm or falsify this inference." There appears to be some torsion of the alveolar row in the mandibular fragment of *Diamantochloris*, such that the posterior teeth appear to occlude in a slightly more lingual direction than the anterior teeth (Pickford 2018b: fig. 7). However, as Pickford notes, this is by itself not sufficient to signify a dentary-hyoid articulation and further material is needed to confirm this intriguing possibility.

Eocliff chrysochlorids

Compared to the Black Crow fossils, fossils from Eocliff (Pickford 2015b, c) are more complete and diagnostic. Pickford (2015b) named *Namachloris arenatans* based on multiple individuals with associated skulls, jaws, teeth, and postcranial elements. Many of these elements show unique, shared characters with extant golden moles, such as reduction of the metacone, talonid, and the coronoid process of the dentary, distinct anterolateral processes of the premaxilla, prominent nuchal crests and domed occiput, elongate medial epicondyle of the humerus and metacromion of the scapula, compressed and comma-shaped first rib, keeled manubrium sterni, among other features. In my view, Pickford (2015b) has made a convincing case that *Namachloris* is the anatomically best preserved fossil species of golden mole yet known.

The species epithet for this taxon, "arenatans", is based on the interpretation that *Namachloris* was "fully adapted to sand swimming" as documented in the extant *Eremitalpa granti* (Fielden et al. 1990). *Eremitalpa* differs from most other chrysochlorid genera in its peculiar locomotor regime in which its foraging tunnels collapse behind it as it moves in its sandy burrowing medium (Gasc et al. 1986; Narins et al. 1997). Some populations of the Western Cape mole (*Chrysochloris asiatica*) occur in arid and sandy substrates of the west coast and Namaqualand of South Africa, but most populations are present in more mesic areas of the Western Cape. In general, chrysochlorids are known from regions with much more rainfall than the Namib desert of northwestern South Africa and southern Namibia, such as *Amblysomus hottentotus*, widespread throughout the Eastern Cape and Kwazulu-Natal provinces of South Africa. Several, much more rare chrysochlorid species, also exist in areas throughout South Africa and other countries with substantially more rainfall than the Namib desert (Bronner & Jenkins 2005; chapters by Bronner et al. in Child et al. 2016).

Most golden moles are not "sand-swimmers" but have activity patterns highly dependent on the frequency of rains. They tend to dig both transient, superficial burrows and more permanent, deep burrows with seasonally durable nesting chambers (Bronner 1995; Hickmann 1990). Asher & Avery (2010) noted that the humeral dimensions of *Eremitalpa* are unusual for chrysochlorids of its body size and are approximated only by the much larger *Chrysospalax*, a taxon which, so far as is known, generally forages on the surface (Maddock & Hickman 1985; Skinner & Smithers 1990). The humeral distal margin (including the medial epicondyle) in *Eremitalpa* and *Chrysospalax* is large compared to non-chrysochlorids, but for a golden mole it is narrow. Relative to the overall length of the humerus, *Eremitalpa* has a mean length:distal width ratio near 1.4, similar to the ratio in the extinct *Chrysochloris arenosa* but in contrast to extant species such as *C. asiatica* and similarly-sized *Amblysomus*, *Neamblysomus*, and *Chlorotalpa*. As a proportion of humeral length, the medial epicondyle in most golden moles is significantly longer than in *Eremitalpa*, leading to a mean length:distal width ratio close to 1.0, with no overlap with either *Eremitalpa* or *C. arenosa* (Asher & Avery 2010: fig. 2). Asher &

Avery (2010) interpreted the smaller epicondyle of *Eremitalpa* and the extinct *C. arenosa* as evidence for a smaller muscle mass of the extrinsic digital flexors, muscles relevant to the dorsoventral (or parasagittal) digging motion of this and other subterranean mammals (Rose & Emry 1983). Relative to the arm-movements that typify parasagittal digging in the "sandy loam" and "alluvium" of most chrysochlorid habitats, the "pure, loose dune sand" (Skinner & Smithers 1990:24) of *Eremitalpa* habitats would presumably entail less recruitment of extrinsic digital flexors while digging; this may also be the case for the larger, surface-foraging *Chrysospalax*. Extrinsic digital flexors are obviously still important for locomotion, but unlike most other chrysochlorid species, *Eremitalpa* is not known to typically construct permanent burrows and may not use these flexor muscles as much as other chrysochlorids. Complicating this assessment is the fact that one of the rarest chrysochlorid taxa, *Cryptochloris wintoni* (and possibly *C. zyli*), occurs sympatrically with *Eremitalpa* but retains the low humeral length:width ratio of extant golden moles such as *Chrysochloris* and *Amblysomus* (Asher & Avery 2010: fig. 6). As of this writing there is no explanation for this difference, for example if *Cryptochloris* and *Eremitalpa* occupy distinct micro-habitats in the areas where they co-occur. Clearly more data on the habitat of *C. wintoni* would be needed to determine if and how the two species differ in locomotor strategy.

Pickford (2015b:182) writes that the "humerus of *Namachloris arenatans* is almost as broad distally as it is long due to the extreme elongation of the medial epicondyle". This would suggest a ratio close to one, as seen in non-sand-swimming chrysochlorids and unlike the atypical, sand-swimming habitat of *Eremitalpa*. However, photographs of the *Namachloris* humerus (Pickford 2015b: fig. 33) suggest a length of about 14mm and a distal margin (from supinator crest laterally to medial tip of the epicondyle) of about 8mm. This humeral length is slightly larger than the average in *Amblysomus hottentotus* (Asher & Avery 2010: table 1) but the length:distal width ratio of ca. 14:8 (= 1.75) is even larger than that seen in *Eremitalpa* (ca. 1.4; Asher & Avery 2010:fig. 2) and would be consistent with a "sand-swimming" locomotor capacity. Such measurements taken from 2D photographs undoubtedly have error, and whether these photos, or the description of Pickford (2015b:182) of the *Namachloris* humerus as "almost as broad distally as it is long", are accurate must await further analysis.

Another recent paper based on these Namibian chrysochlorid remains is Mason et al. (2017), who compare the auditory anatomy of *Namachloris* with that of extant chrysochlorids. Using microCT scans of two of the Eocliff skulls (GSN Na 1 and 2), they reveal a number of important and diagnostic features. Mason et al. suggest that *Namachloris* had a highly coiled cochlea, likely between 3 to 3.5 turns, resembling the coiling of around 1100° seen in extant chrysochlorids (Crumpton et al. 2015). They also note that the mallear morphology of *Namachloris* lacks the hypertrophy seen in several extant species, such as *Eremitalpa* and *Chrysochloris* and, proportionally, is more similar to the non-hypertrophied malleus of *Amblysomus hottentotus*. These new data further illuminate the mosaic nature of the chrysochlorid middle ear, showing for example that increased coiling (three turns or more in all species known so far) likely evolved prior to mallear hypertrophy (not present in *Namachloris* and some living species), consistent with previous studies (e.g., Crumpton et al. 2015) and amenable to further testing via phylogenetic analysis.

Mason et al. (2017) also comment on one of the more controversial aspects of these fossils: their age. Pickford et al. (2013: table 2) list K-Ar radiometric dates of 40-45 million years based on samples of "phonolite cobbles from the overlying Gemsboktal Conglomerate", supporting their interpretation of a Lutetian age (41.2-47.8 following Cohen et al. 2013) for the "Black Crow" locality which yielded the right lower molar discussed above. The more complete and diagnostic fossils for both tenrecids and chrysochlorids are from the younger locality, Eocliff. Biochronologically, the fauna of Eocliff does not appear to be unambiguously Eocene. Mason et al. (2017) note the radiometric data from Pickford et al. (2008, 2013) in support of a Lutetian age, but also acknowledge some contradictory evidence from biostratigraphy. For example, they note Sallam & Seiffert's (2016) suggestion that a locality with anthracotheres (a group which has no African record at all prior to ca. 35Ma) could be, at the oldest, near the Eocene-Oligocene boundary in age. Coster et al. (2012) similarly argued for a post-Eocene age for these Namibian limestone deposits based on the rodent fauna. Marivaux et al. (2014) went further, suggesting a Miocene age. An Eocliff fauna including hyracoids such as "*Rupestrohyrax lacustris*" (a possible synonym of *Titanohyrax angustidens*) and rodents such as *Metaphiomys* and *Neophiomys* ("*Phiomys aff. phiomyoides*" in Pickford et al., 2014) have first appearance dates after the Eocene-Oligocene boundary and suggest that the Eocliff tenrecs and golden moles are post-Eocene. Even if it is a late Paleogene or Neogene fossil, *Namachloris* still comprises the anatomically most complete record of a pre-Pliocene golden mole.

Eocliff tenrecids

Pickford (2015c) described three genera of tenrecs from Eocliff: *Namagale*, *Sperrgale*, and *Arenagale*. His taxonomy implies a close relationship of *Namagale* to potamogalines and of *Sperrgale* and *Arenagale* to tenrecines (i.e., Malagasy tenrecs following the taxonomy of Asher & Helgen 2010). He assigns numerous, isolated jaw and cranial elements to each taxon. Postcranially, he assigns two isolated distal humeri to *Namagale* (Pickford 2015c: table 1), tarsal elements, fore- and hindlimb elements, and pelvic elements to *Sperrgale* (2015c: table 3), and tarsal elements to *Arenagale* (2015c: table 6). As with the remains of *Namachloris*, these fossil tenrecids were found in dense concentrations of many individuals, perhaps as a result of predator regurgitates and/or scats, some of which "contain one or two skeletons of small mammals" (Pickford 2015c: 124). It is not clear which tenrecid elements are associated from any single pellet, or which elements were associated based on size and/or relative abundance. In any event, given the associations presented by Pickford (2015c) and with the qualifications noted above regarding the age of Eocliff, these fossils represent the anatomically most complete, pre-Pliocene fossil tenrecs yet known.

The holotype of *Namagale grandis* (Pickford 2015c: fig. 6) shows molars with a large stylar shelf and an M3 with an elongate parastyle but no metastyle. The M2 on this specimen shows both paracone and a small metacone, situated close to each other, and a protocone at the tooth's lingual margin. Lower molars assigned to *Namagale* (Pickford 2015c: figs. 15-16) show a small, teardrop-shaped talonid basin. Such features are reminiscent of the unworn dental morphology of extant *Potamogale.* Malagasy tenrecids have a reduced/absent metacone and talonid basin, and are thus relatively more zalambdodont.

Fossils assigned to the diminutive *Sperrgale* similarly possess upper molars with prominent metacones and paracones, a lingual protocone, and the distinctive M2-M3 stylar morphology noted above for *Namagale*. Indeed, the metacone in *Sperrgale* appears to be larger than that of *Namagale* and unlike anything seen among Malagasy tenrecs; it also has a small, teardrop-shaped talonid basin, as in the extant *Potamogale* (Fig. 1). The third Eocliff tenrecid, *Arenagale*, also shows a metacone (Pickford 2015c: fig. 33) which, among the three Eocliff tenrecids, appears to contribute the least to the stylar shelf and thus exhibit some similarity to tenrecines rather than potamogalines. Lower molars have not yet been figured or described for *Arenagale* so it is unclear if this taxon had basined talonids. All of the Eocliff fossils assigned to tenrecs by Pickford (2015c) exhibit a cleft between the para- and metastyles on at least some of their cheek teeth (character #79 in Asher et al. 2010), resembling a number of insectivoran-grade afrotheres and other zalambdodont mammals (see Asher 1999).

Based on the combined morphology-DNA dataset and strict consensus of eight MP trees shown in Asher et al. (2010), a number of hard-tissue characters optimize as shared-derived characters for tenrecids as a whole (relative to chrysochlorids as their sister taxon, and *Elephantulus* and *Procavia* as successively distant outgroups to the tenrecoid clade), and for potamogalines to the exclusion of other tenrecids. This does not mean that these characters lack homoplasy or do not occur in other groups, only that they optimize as shared derived of varying consistency on optimal cladograms in Asher et al. (2010). For example, fully grown tenrecids lack a major contribution of the entotympanic to the auditory bulla (character #6, state 0, numbered according to Asher et al. 2010), have a ring-like ectotympanic (#10, 0), a squamosal contribution to the mastoid tubercle (#24, 1), a maxilla that extends posterior to the toothrow on the ventrum of the pterygoid (#46, 1), and a reduced zygomatic arch (#51, 1). Potamogalines show a closed tubal canal (character #8, state 1), a semiphaneric ectotympanic (#9, 1), medially positioned foramen for the ascending pharyngeal artery (#18, 1), a fenestrate basioccipital (#22, 1), a frontal bone anteroposteriorly shorter than the parietal (#43, 2), reduction of the lacrimal foramen (#55, 0), a reduced scapular metacromion and acromion (#108 and #110, 1), lack a humeral epicondylar foramen (#118, 1), and show an iliopectineal tubercle (#133, 1).

Most of these features are currently either unknown or undocumented in the Eocliff tenrecs, as basicrania, complete skulls, and most of the postcranial skeleton are not yet published. However, there are a few characters that could help to test the assertion that *Sperrgale* and *Arenagale* are more closely related to tenrecines than potamogalines, and that *Namagale* is related to potamogalines. As noted above, extant potamogalines have reduced lacrimal foramina, lack an entepicondylar foramen on their distal humerus, and show an iliopectineal tubercle on each os coxae. Pickford (2015c: 127) notes that *Namagale* has a lacrimal foramen (unlike potamogalines); humeri and pelvic elements are listed for *Sperrgale*, and humeri for *Namagale*, but the requisite anatomical details have not yet been figured or described.

Phylogeny is not typology, and a patent lacrimal foramen (for example) would not disqualify *Namagale* as a close relative to the two extant potamogaline genera, *Micropotamogale* and *Potamogale*, as implied by the taxonomy of Pickford (2015c). Similarly, presence of upper molar metacones would not necessarily disqualify todralestids (or *Diamantochloris*) from a close evolutionary relationship to tenrecids or chrysochlorids, as noted above. Ultimately, the assignment of a given taxon to this or that clade will require a phylogenetic analysis. I agree with Pickford (2015b, c) that the fossils from Eocliff represent tenrecids and chrysochlorids, two clades of insectivoran-grade afrotheres that have long suffered from a limited fossil record. Hopefully, the Eocliff fossils are amenable to further study, including a quantitative phylogenetic analysis. MicroCT scans of the kind already published by Mason et al. (2017) represent the kind of detailed anatomical investigation that can enable future phylogenetic analyses. Particularly with more efforts to establish their phylogenetic affinities, these fossils will prove to be among the most important and anatomically well-known to shed light on the still enigmatic evolutionary history of endemic African mammals.

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A short history of scientific illustration of sengis

Patrick Arnold

Evolutionary Adaptive Genomics group, Institute for Biochemistry and Biology, University of Potsdam, Karl-Liebknecht-Straße 24/25, D-14476 Potsdam, Germany

Introduction

Sengis or elephant shrews are small-sized afrotherians that combine traits of insectivores, rodents, and ungulates. They have a checkered taxonomic and scientific history which is here briefly traced by means of historical illustrations. All related historical publications are publicly available at www.archive.org.

Early sengi illustrations

One of the first illustration depicting a sengi specimen was drawn by Hendrik Claudius in 1685 during the Namaqualand expedition of the later governor of the Cape Colony Simon van der Stel (Fig. 1A). This and other early illustrations highlighted the most obvious anatomical peculiarities of sengis: the proboscis-like nose, the long hind but short forelimbs and the clumsy body during resting (Fig. 1). The lack of museum specimens resulted in several authors redrawing and modifying Claudius' sengi. In addition, its taxonomic affinities stayed obscured in the following decades and various names (common and scientific) were assigned to it (see Fig. 1 caption). Pennant eventually created the common name "Elephant shrew" and placed it in the family of shrews in its *History of Quadrupeds*, 1793 (Fig. 1E).

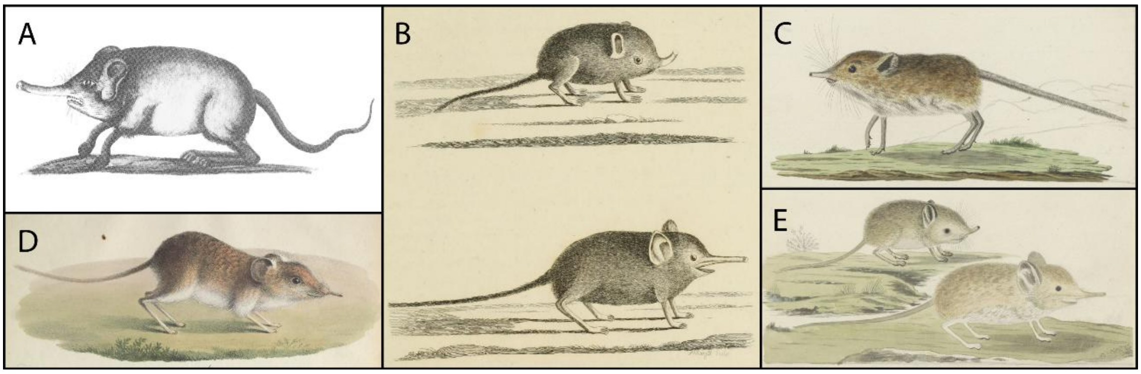

Figure 1. Early illustrations of sengis

A) "curious field-mouse […] on the other side of the Elephant River", illustration from Hendrik Claudius in *Journal of a Voyage to the Cape of Good Hope*, 1685, p. 737-738 (Waterhouse 1924). B) *Mus araneus capensis*, illustration in *Gazophylacium* 1767, Dec. iii tab xxiii fig. 9. C) Oliphantsmuis, illustration in *Journal of Gordon's fourth voyage*, 1779-1780, p. 230. D) *Rhinomys jaculus*, illustration in *Darstellung neuer oder wenig bekannter Säugethiere in Abbildungen und Beschreibungen*, 1827-1834, pl. xxxviii. E) Elephant Shrew, illustration in *History of Quadrupeds*, 1793, p. 226.

The typical and biped elephant shrew

Shaw (1800) provided the first scientific description of the animal and introduced the scientific name *Sorex macroscelides*, thus assigning it to red-toothed or long-tailed shrews. Smith (1849) later created a new species epithet when he assigned it to its own genus: *Macroscelides typicus*. Following this, the sengis were represented by the "typical elephant shrew" in many publications (Fig. 2). Deeper knowledge on their ecology was nevertheless still lacking as they were usually illustrated as biped or in an upright body posture (Fig. 2). This locomotion mode, however, has never been observed in sengis (Brown 1964).

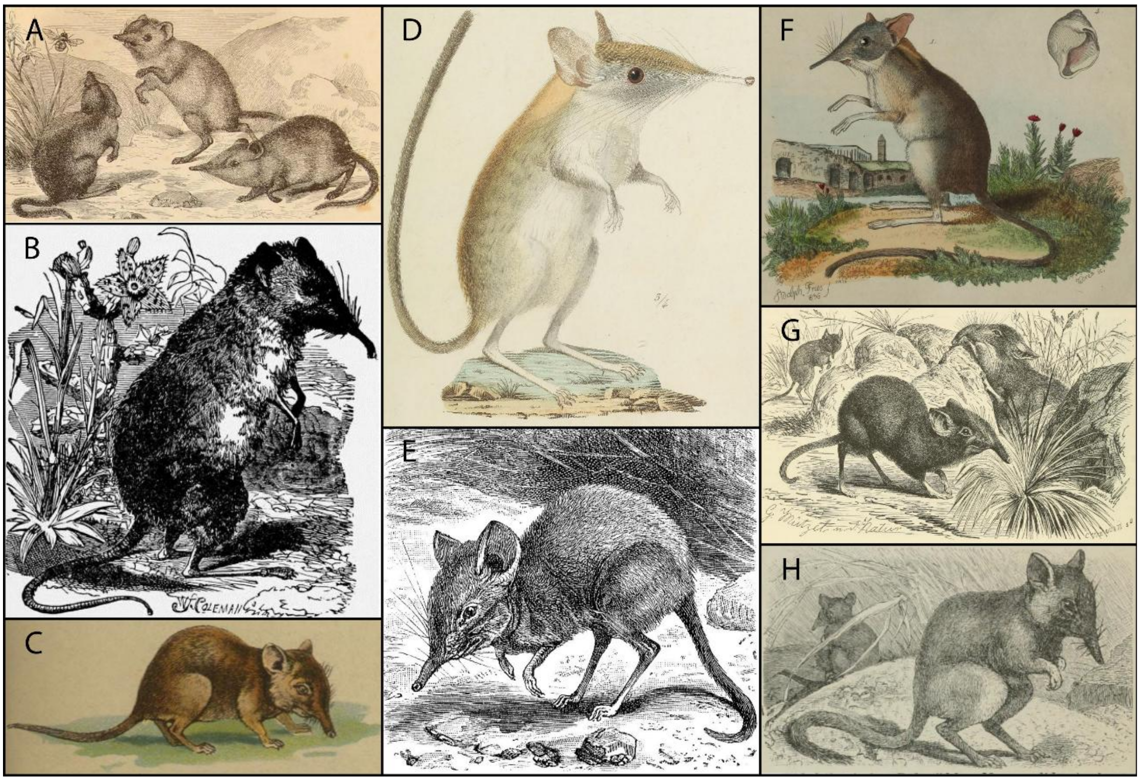

Figure 2. The typical and biped elephant shrew: *Macroscelides typicus*.
A) Südafrikanischer Rohrrüssler, illustration in *Meyers Großes Konversations-Lexikon*, 1874, pl. Insektenfresser. B) Elephant shrew, illustration in *The Popular Natural History*, 1884, p. 103. C) Elephant shrew, illustrations in *The Handy Natural History*, 1910, pl. iv fig. 8. D) Macroscelide type, illustration in Atlas the Zoologie, ou collection de figures d'Animaux nouveaux, 1844, pl. 2. E) Rohrrüssler, illustration in Meyers Konversationslexikon, 6th Edition, 1907, pl. Insektenfresser fig. 2. F) Macroscelide, illustration in *Dictionnaire pittoresque d'histoirelle*, 1836, pl. 316 fig. 1. G) Elephantenspitzmaus, illustration in *Brehms Tierleben*, 1900, p. 384. H) Südafrikanischer Rohrrüssler, illustration in *Brockhaus' Konversations-Lexikon*, 14th Edition, 1894, pl. Insektenfresser fig. 4.

Sengi species diversity

Despite the "typical elephant shrew", species diversity among sengis was also illustrated either in expedition and travel reports, species investigation or encyclopedias (Fig. 3). Smith's (1849) early work is outstanding among them in illustrating five species comparatively (Fig. 3A-E). In addition, Peters (1852) provided one of the few (the only?) historical depictions of rare macroscelidin species such as *Elephantulus fuscus* or *Petrodromus tetradactylus* in its travel report to Mozambique (Fig. 3H, I). An upright body posture, however, was frequently assigned to the different species, too (Fig. 3C, G-J, L).

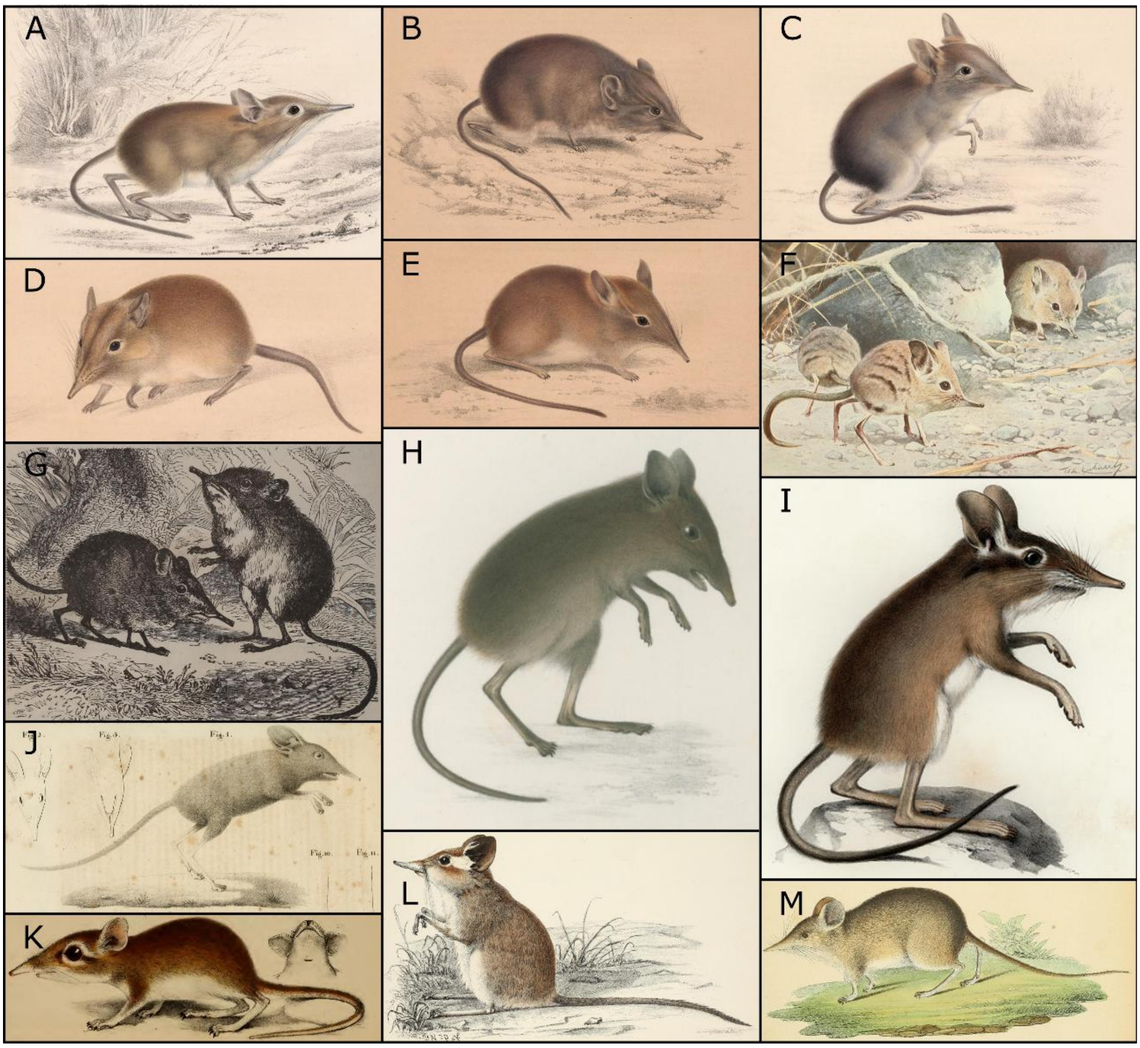

Figure 3. Illustrations of species diversity.

A-E) Illustrations in *Illustrations of the Zoology of South Africa*, 1849: *Macroscelides intufi*, pl. 12 (A); *Macroscelides typicus*, pl. 10 (B); *Macroscelides edwardii*, pl. 14 (C); *Macroscelides brachyrhynchus*, pl. 13 (D); *Macroscelides rupestris*, pl. 11 (E). F) Nordafrikanische Elefantenspitzmaus, illustration in *Brehms Tierleben*, 1912. G) Macroscélide de Rozet, illustration in *Histoire naturelle des mammifères*, 1854, p. 237. H-I) Illustrations in *Naturwissenschaftliche Reisen nach Mozambik*, 1852: *Macroscelides fuscus*, pl. xix (H); *Petrodromus tetradactylus*, pl. xx (J). *Macroscelides rozeti* (Duvernoy 1830), pl. 1. K) *Macroscelides rufescens*, illustration in *Über die von Hrn. J. M. Hildebrandt während seiner letzten ostafrikanischen Reise gesammelten Säugethiere und Amphibien* (Peters 1878), pl. 1 fig. 3. L) *Macroscelides revoili* (Huet 1882), pl. 1. M) *Macroscelides rozeti*, illustration in *Die Säugethiere in Abbildung nach der Natur beschrieben*, 1855, p. 37.

Illustrations of giant sengis.

In contrast to macroscelidins, giant sengis (Rhynchocyoninae) have rarely been depicted in historical illustrations. Most of them have been copied by several authors, thus there seem to be only four different illustrations (Fig. 4). They cover much of the species diversity but also show how limited the knowledge on this subfamily was and still is.

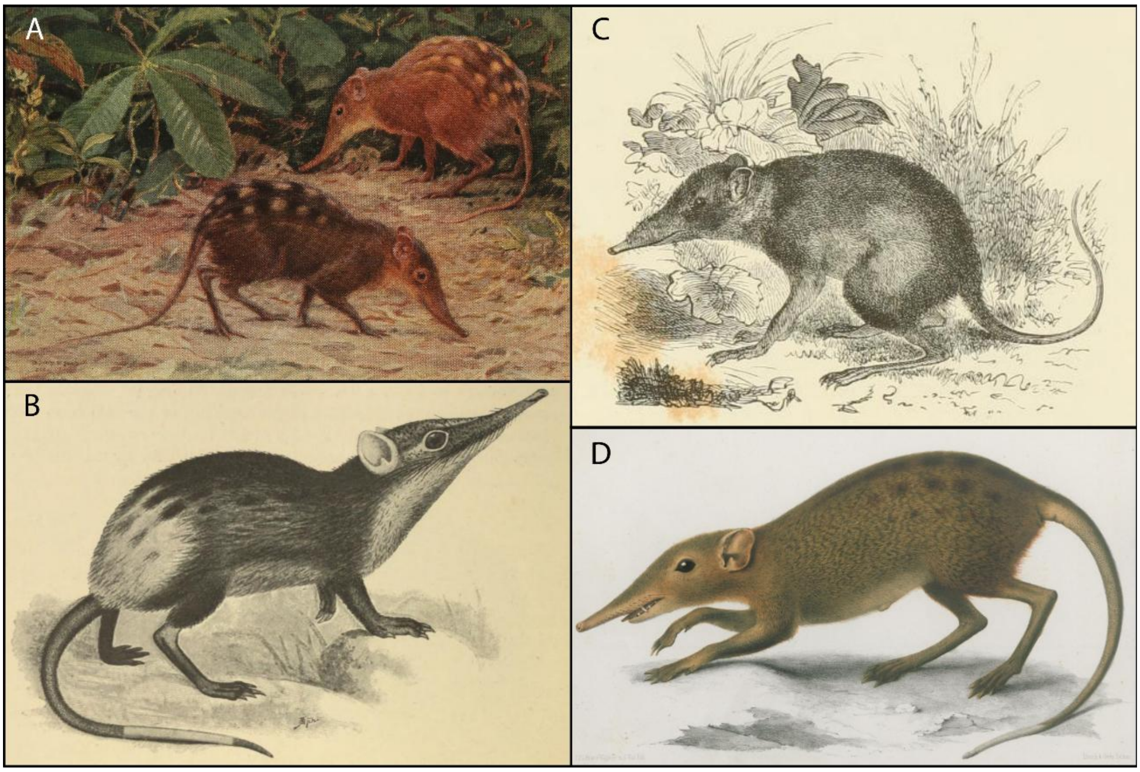

Figure 4. Illustrations of giant sengis

A) *Rhnychocyon stuhlmanni claudi*, illustration in *The Congo Expedition of The American Museum of natural History*, 1919, vol. xlvii pl. 1. B) *Rhynchocyon chrysopygus*, illustration in *The Cambridge Natural History*, 1902, vol. 2. P. 516 fig. 250. C) De grootse Spring-spitsmuis *Macroscelides cirneri* (sic), illustration in *De Dierentuin van het Koninklijk Zoologisch Genootschap Natura Artis Magistra te Amsterdam*, 1872, p. 61. D) *Rhynchocyon cirnei*, illustration in *Naturwissenschaftliche Reisen nach Mozambik*, 1852, pl. xxi.

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Notes from the Field

Observations on what may stimulate exit from hibernation in *Tenrec ecaudatus*

Gilbecca Rae Smith and Frank van Breukelen

University of Nevada, Las Vegas

We have maintained a colony of common tenrecs, *Tenrec ecaudatus*, at the University of Nevada, Las Vegas since 2014. These animals employ a unique form of hibernation (Treat et al, 2018). During the austral winter, tenrecs are consistently torpid and do not employ periodic euthermic arousals. Instead, tenrecs may be more or less torpid. When disturbed, hibernating tenrecs may be partially aroused from torpor but are ataxic and lack coordination in their movements. For instance during the active season, resting heart rate was 151.3 ± 10.8 beats • min^{-1} at room temperature (Fig. 1; N=7). We handled tenrecs while they were hibernating at room temperature. Heart rate increased during handling to as high as 87 beats • min^{-1} (71.2 ± 5.15 beats • min^{-1}; N=5 tenrecs) but quickly returned to values of 32.6 ± 2.04 beats • min^{-1} within 94.4 ± 35.7 sec. During handling, tenrecs were mobile.

In our 4 years of experience with this species in the laboratory, the tenrecs have maintained an austral cycle; tenrecs enter hibernation as early as January but most animals begin being torpid approximately mid-March or April. Exit from hibernation has been observed as late as December but typically occurs sometime in mid to later August or September. The variable nature of the hibernation season length as well as the independence of hiberation use from ambient temperature makes a well controlled experiment essentially impossible but our observations support social and environmental cues as being important initiators or faciliators for entry or exit from hibernation. We have observed that tenrecs exposed to 28 °C may oftentimes delay entry into hibernation whereas subsequent exposure to cold temperatures appear to coax reluctant tenrecs to initiate use of hibernation. Similarly, warmer temperatures appear to facilitate tenrecs exiting hibernation at the end of the hibernation season. The presence of relatively active tenrecs may lessen the depth and extent of torpor use of cage mates and may even affect other tenrecs maintained in the same room but in separate cages. Male tenrecs will oftentimes attempt to mate with hibernating female tenrecs and appear to help force these tenrecs from hibernation. Finally, we also believe weather to be an important cue for dictating hibernation season length. While Las Vegas, NV, USA oftentimes experiences monsoons in mid to late August, an aseasonally early monsoon struck on July 10, 2018. Within a day or two of this monsoon, virtually every tenrec in the colony (~40 tenrecs at the time) exited hibernation, resumed eating, and extensive breeding activity was observed. Tenrecs lacked the ataxia characteristic of hibernation. Within a week of this event however, these tenrecs re-entered hibernation and were somewhat slow in exiting from hibernation with relatively few breeding attempts observed in September and October as compared to previous years. Interestingly, tenrecs gave birth as early as October whereas previous year litters were born starting in November but more frequently December, January, and February. One questions if housing these tenrecs in other areas with different weather patterns may result in altered hibernation seasons. Furthermore, any future field work monitoring hibernation season should be related to the weather for that season or locale.

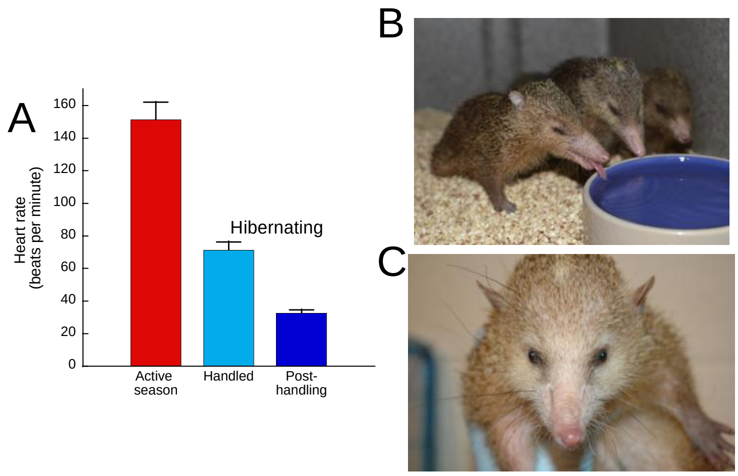

Fig. 1 Demonstration that tenrecs are consistently torpid during the hibernation season but that the extent of torpor may be variable. A) Animals have a lower heart rate during the hibernation season even after being handled. These animals were ataxic but mobile and B) may even occassionaly drink in the laboratory. Note the retracted eyes of hibernating tenrecs. C) During the active season, eyes bulge and animals lack the ataxia of hibernation. Active season tenrecs are capable of entering into a facultative torpor during the active season. However, there are no indications of uncoordinated movements or eye retraction even within moments of arousal from that torpid state.

. Extreme physiological plasticity in a hibernating basoendothermic mammal, *Tenrec ecaudatus*..

Michael D. Treat, Lori Scholer, Brandon Barrett, Artur Khachatryan' Austin J. McKenna, Tabitha Reyes, Alhan Rezazadeh, Charles F. Ronkon, Dan Samora, Jeremy F. Santamaria, Claudia Silva Rubio, Evan Sutherland, Jeffrey Richardson, John R. B. Lighton, & Frank van Breukelen.

Journal of Experimental Biology 221, jeb185900. doi:10.1242/jeb.185900, 2018

Physiological plasticity allows organisms to respond to environmental changes. However, can being *too plastic* actually limit an organism? Malagasy common tenrecs, *Tenrec ecaudatus* display extreme plasticity in thermoregulation and metabolism, a novel hibernation form, variable annual timing, and remarkable growth and reproductive biology. In other words, tenrecs may be the most plastic mammal described to date.

- Tenrec body temperature (T_b) may approximate ambient temperature to as low as 12°C even when tenrecs are fully active (tenrecs can swim when T_b is as low as ~12°C). Conversely, tenrecs can hibernate with T_bs of 28°C.
- During the active season, oxygen consumption may vary 25-fold with little or no changes in T_b.
- During the Austral winter, tenrecs are consistently torpid but the depth of torpor may be variable. A righting assay revealed that T_b contributes to but does not dictate activity status.
- Homeostatic processes are not always linked e.g. a hibernating tenrec experienced a ~34% decrease in heart rate while maintaining constant body temperature and oxygen consumption rates.
- Tenrec growth rates vary but young may grow ~40-fold in the 5 weeks until weaning and may possess indeterminate growth as adults.

Models for the evolution of endothermy suggest a profound selective advantage to being more endothermic/homeothermic. While pregnant, tenrecs may allow T_b to vary; one tenrec has a T_b of ~13.5°C for ~24 h when ~3 weeks pregnant. However, T_b is higher and less variable when tenrecs give birth. This means tenrecs *can* be more homeothermic. Why aren't tenrecs more homeothermic all the time if there is the presumed selective advantage? The answer may lie in where tenrecs are found. Despite all of this profound plasticity, tenrecs are surprisingly intolerant to extremes in ambient temperature (<8 or >34°C). If such extremes can be avoided, the strategy of the tenrec may be successful; a 1 kg tenrec can readily maintain its weight when fed less than 5 g per day since its metabolism is so plastic. However and when exposed to temperature extremes, these tenrecs appear unable to effectively regulate T_b. Plasticity may confer energetic advantages in consistently moderate environments. Moreover, environmental extremes may have limited the success and distribution of plastic basal mammals like these afrotherians. These data may help explain why the modern mammals (boreoeutherians) with their higher and less variable T_bs were so successful as evidenced by their global distributions.

Afrotheria News

Message from the Chair

As our members will be aware, this year saw the passing of our SG founder and long-time Chair, Galen Rathbun. Galen had a recurrence of melanoma earlier this year and died in April 2019. This is a great personal loss for many members of the group, not to mention a terrible loss for the Afrotheria at a professional level. Although I only met Galen in person for the first time last year, I had corresponded with him via email from the time when he started the Afrotheria SG, which was nearly 20 years ago. Our work interactions increased when we began updating the Afrotheria Red List back in 2012 and then more so when I became co-chair with Galen in 2017. I really enjoyed chatting with Galen online, not just about Afrotheria matters, but also about life and the general state of the world. I learned from him and appreciated his honest opinions. I miss him and having read about some of his earlier exploits in life, I realize there was a lot I did not know about him. In memory of Galen, his contribution to science and his critical efforts in gaining recognition of the Afrotheres, this newsletter has some short recollections of his life.

This will be the last newsletter edited by Chris and Mathilde Stuart, and we are very grateful for their hard work over the last four years to bring the newsletter together. This is not a straight-forward task as it is not easy for our SG members to take time out of busy schedules to write articles, so a big thank you to Chris and Mathilde for their persistence. Fortunately for the newsletter, PJ Stephenson has volunteered his services once again, and will be reprising his role as editor for next year. Thank you PJ.

On the issue of submitting articles for the newsletter, we recognize that it is becoming harder to find time to write non-peered reviewed articles, but I would continue to encourage people to do so. It is one of the few ways we have to keep our group relevant under the current difficult funding climate, and it is important that we remain on the radar of the IUCN SGs. Please consider submitting articles regularly, even if they are only short essays or paper reviews relevant to your study species, as these help our members (and the general public) keep up to date with what other research is going on.

Our group's other major contribution to educating the public about the smaller Afrotheres is our web site. We continue to seek funds to maintain this and have now been awarded an Internal Grant from the IUCN SSC to be used specifically for this purpose. The money gratefully received will be used to host and maintain the current website, and to update the links for the tenrec and aardvark sections, both of which are in need of revision.

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

Andrew Taylor (taylor.wa@gmail.com)

Afrotheria Specialist Group: 2017–2020 Quadrennium targets

Andrew Taylor

Back in early 2018 the IUCN SSC leadership requested all specialist groups to identify targets for the 2017-2020 quadrennium. We did this with the assistance of our section coordinators, and in early 2019 followed up with a feedback report on how well we are doing in meeting these targets. So far, these targets have only been used internally by the IUCN but may be of interest to Afrotheria SG members curious about the work of other taxonomic group sections. Table 1 shows these targets, anticipated results and progress towards meeting the targets for all our taxonomic groups. A key message from these assessments is that obtaining funding for our Afrotheria work is getting harder, which is a bad sign for the conservation of our species, not least because it will become more difficult to attract scientists to focus on them.

Table 1. Targets, expected results and progress towards targets for the 2017–2020 quadrennium.

Taxa	Target	Anticipated results	Progress
All groups	Reassess Red List categories in species for which new information arises	Red List assessments for 1 to 4 species, including re-assessments based on new information, and new assessments for newly described species	We re-assessed the status of one species during 2018 (the Nimba Otter Shrew, for which we have new EOO data)
All groups	Update and maintain Afrotheria.net website	The website should be functioning efficiently and be regularly updated for easy access to the IUCN and the general public	This is ongoing but was paid for personally by Galen Rathbun. We have just obtained funding to maintain the website for 2 years
All groups	Produce one Afrotheria SG newsletter every year	The annual newsletter provides the latest news on Afrotheria, including popular articles on Afrotherian biology, ecology and conservation	Our annual newsletter was successfully completed in September 2018 (and now the 2019 edition…)
All groups	Develop standardized monitoring protocols for each Afrotherian group to track trends over time and produce more data for Red List assessments	Monitoring protocol outputs will be used to provide better understanding of conservation needs and update Red List assessments	There is currently no financial support for this kind of work, even though it is basic research and is important to direct conservation efforts
Golden moles	Complete 2-4 reassessment of taxonomy of golden moles in species where this is necessary	Updated taxonomy will be used to reassess conservation status of newly described (as well as previously described) species	To complete such re-assessments, more detailed information in species' distributions and phylogenetic status is needed but, as of Feb

Taxa	Target	Anticipated results	Progress
			2019, funding had not yet been secured for the associated fieldwork
Golden moles	Collect basic data for 3-4 on golden moles species, including geographic distributions and natural history data	New information would be used for updating conservation status of species	Various projects have been developed to obtain data (e.g. for the giant golden mole, the Amblysomus lineages in the Eastern Cape and the two threatened Cryptochloris species in Namaqualand), but funding is elusive
Hyraxes	Conduct surveys to determine distribution and abundance of five hyrax species	Updated distribution maps will be used to reassess conservation status of hyraxes	The work is awaiting funding
Hyraxes	Revise taxonomy of five hyrax species	Updated taxonomy will be used to reassess conservation status of newly described (as well as previously described) species	This work is under way, with two SG members taking the lead
Sengis	Develop and assess field trials for standardised camera trapping methods to determine population estimates for giant sengis	A validated camera trapping method for estimating populations will simplify surveys for giant sengis and improve our ability to measure their conservation status	There is currently no financial support for this kind of work, even though it is basic research and is important to direct conservation efforts
Sengis	Conduct surveys to assess distribution, abundance, threats and taxonomic status of the Data Deficient sengi species	New information will contribute towards a better understanding of the conservation status of these species and assist with updating the Red List	There is currently no financial support for this work
Sengis	Build on current research to determine the systematics of giant sengis, especially Rhynchocyon species	Better knowledge of systematics will contribute towards improving Red List assessments and assist with setting conservation goals	There is currently no financial support for this work
Aardvark	Survey aardvark populations to determine abundance, distribution and trends	The revised distribution maps will be used to update the Red List, while initial population estimates will be used as a baseline against which	This work has not started due to a lack of financial resources needed to conduct the field work. Until such time as finances are found, it will

Taxa	Target	Anticipated results	Progress
		to compared future populations	not be conducted
Aardvark	Conduct taxonomic studies to determine the systematics of aardvarks, with a focus on contrasting aardvarks from central African forests with southern African savanna aardvarks	Updated taxonomy will be used to reassess conservation status of aardvarks from different regions	This project is ongoing. Genetic material has been obtained from collections (fresh material is difficult to obtain with the new Nagoya protocol). More funding will be needed for more detailed and expensive sequencing
Tenrecs	Integrate the monitoring of tenrecs in the management of key protected areas with threatened species in order to track their status and threats and identify key conservation concerns	Monitoring tenrec species is necessary to understand trends and conservation needs	At present, there is no consistent approach to monitoring, while identification of small-bodied tenrecs is very difficult. Also, there are very few longitudinal demographic studies to provide baselines. 'Monitoring' remains a premature concept for these species, and inventories are still needed
Tenrecs	Conduct genetic studies to clarify the taxonomy and species diversity within the genus Microgale	Basic taxonomic knowledge will go a long way to understanding and conserving this genus	This work is ongoing, with a manuscript in review and several more in various stages of preparation. Many newly circumscribed species will be published over the next few years

A roadmap for future aardvark research

Andrew Taylor[1§], Thomas Lehmann[2§] & Nora Weyer[3§]

[1]*The Endangered Wildlife Trust, Pinelands Office Park, Modderfontein, Gauteng, South Africa,* taylor.wa@gmail.com
[2]*Senckenberg Research Institute and Natural History Museum, Frankfurt, Germany,* thomas.lehmann@senckenberg.de
[3]*Brain Function Research Group, School of Physiology, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa; current affiliation: Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany. Weyer.nora@gmail.com*
[§]*IUCN/SSC AFROTHERIA SPECIALIST GROUP, Aardvark Section*

BACKGROUND

Although aardvarks (*Orycteropus afer*) are widespread across sub-Saharan Africa, a combination of factors including their nocturnal activity patterns, solitary and elusive behaviour, and low population densities, have made them difficult to study. It is widely recognised that aardvarks have significant impacts on the ecosystems in which they occur (e.g. Cilliers, 2002; Whittington-Jones et al. 2011), primarily due to their perpetual digging activities, but what exactly are these impacts? How important are aardvarks for the maintenance of functioning ecosystems? What might happen if their numbers declined? What are the trends in aardvark populations and how can we better understand what the future may hold for this species? In this article, we highlight what we consider some important shortcomings in the existing knowledge on aardvark biology and conservation, and we suggest areas for future research.

INTERACTIONS OF AARDVARKS WITH THEIR PREY

The most rigorously studied aspect of aardvark biology is their feeding ecology. Findings from Melton (1976), Willis (1988), Taylor et al. (2002) and Weyer (2018) suggest that the main selection criteria by aardvarks for their ant and termite prey are availability, abundance and body size. Aardvarks tend to preferentially select large ant or termite species that occur in relatively high abundance, with both these factors being influenced by locality. Rudimentary measurements of prey intake rates suggest that aardvarks consume more than 50,000 ants and termites in 24 hours (Taylor 1998), although this is possibly an underestimate. The cumulative impact of this estimate appears considerable because it amounts to nearly 20 million ants and termites eaten by one aardvark within its home range over the course of a year. The question then arises: how does this rate of predation affect prey populations?

It has been suggested that predation by aardvarks helps regulate ant and termite populations, which could be important given that some ant and termite species can become agricultural pests if left unchecked (Logan et al, 1999). However, the actual existence and extent of such a regulating function is unstudied. A potential way to test the impacts of aardvark predation on ant and termite populations could be to compare sites where aardvarks occur and where they do not, while a more rigorous, experimental approach would be to set up exclusion experiments at sites where aardvarks occur. Due to the longevity of termite colonies and their slow recovery from environmental impacts such as drought, studies on termite populations would need to be conducted over several years. We are not aware of any studies to date that have examined the short- or long-term impacts of myrmecophagous mammal species on ant or termite populations in Africa.

IMPACTS ON OTHER SPECIES' FITNESS

A second aspect of aardvark ecology that has received some research attention, albeit at a superficial level, is the interaction between aardvarks and other sympatric species. One well-

documented interaction is the use of aardvark burrows by other animal species for a variety of reasons including shelter from climatic extremes and from predators, and because burrow conditions are conducive to reproduction and the raising of young. Many animal species have been observed using aardvark burrows (Smithers, 1971; Cilliers, 2002; Whittington-Jones et al., 2011), including some species that are classified as threatened on the IUCN Red List (e.g. the blue swallow, *Hirundo atrocaerulea*). Being the most prolific burrowing species in Africa by far, aardvarks cannot be functionally replaced by any other species, yet the actual dependence of commensal species on aardvark burrows has not been quantitatively assessed. An interesting research question might ask whether aardvark burrows increase the reproductive success of species that commonly use them. If there is a quantifiable benefit, the loss of these microhabitats might be detrimental to the survival of these commensal species.
In addition, some myrmecophagous 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). The impacts of these relationships have also not been quantified. For example, to what extent are aardwolves (*Proteles cristata*) dependent on the supplemental benefits obtained by following aardvarks around at night in winter? Do ant-eating chats (*Myrmecocichla formicivora*) have greater reproductive success in areas of relatively high aardvark density because they are able to feed on ants and termites left behind in aardvark feeding pits?

PHYSIOLOGY AND REPRODUCTION

In our previous *Afotherian Conservation* article (Taylor et al., 2018), we argued that under 'normal' circumstances, aardvarks can obtain sufficient water from their ant and termite prey even in semi-arid habitats, making them independent of free-standing water (even though they might choose to drink if water is available). However, under increasingly hot and dry conditions, prey availability and free-standing water sources might decline, potentially limiting the ability of aardvarks to maintain water balance from their prey alone (Weyer, 2018). At the same time, aardvarks might be losing more body water to the environment through evaporative water loss, making them more dependent on water intake. Yet neither the daily water requirements of aardvarks nor their capacity for evaporative cooling have been quantified to date. Moreover, it is currently unknown whether aardvarks employ sweating or other means of evaporative cooling as do other mammals, and whether they are able to regulate the amount of water lost evaporatively through their skin. Establishing the significance of water loss and intake could help us understand the capacity of aardvarks to thrive in African habitats despite the climate warming and drying.

In a comprehensive study in the Kalahari, the use of miniature data-loggers (biologgers) allowed quantitative measurements of physiological and behavioural responses of aardvarks to environmental fluctuations, such as drought-related prey scarcity (Weyer, 2018; see also Rey et al., 2017). The recorded patterns of aardvark body temperature and activity were useful indicators of aardvark well-being over several years. A mass mortality of aardvarks during this study was attributed to an exceptionally hot and dry drought summer (Rey et al., 2017). Long-term records of body temperature have also served as indicators of well-being in other large mammal species (reviewed in Hetem et al., 2016). Although the capture of aardvarks is challenging (see below), biologgers are relatively easy to implant and can serve to assess aardvark ecophysiology in other habitats. The ecophysiology of aardvarks in the Kalahari and in other hot and dry parts of their distribution could be compared to that of aardvarks from less dry (including tropical, i.e., hot but non-arid) habitats, to examine aardvark sensitivity to heat and aridity along a gradient of climatic regimes. In addition, physiological responses of aardvarks to drought could be investigated in other habitats where ants, as opposed to drought-sensitive termites, are the preferred prey of aardvarks.

Little is known about the reproduction of aardvarks in the wild. Aardvark females have a long (~7 months) gestation period, after which they usually give birth to single young which they raise for about one year (Shoshani et al., 1988). However, it is unknown how often a female can have young during her lifetime, how high their breeding success is, whether they breed seasonally or at any time of year, and how environmental fluctuations affect aardvark fecundity. During the Kalahari study, the study aardvarks did not reproduce during drought years. Although aardvarks might be capable of delaying reproduction to productive seasons or years, it is more likely that starving aardvarks had a pathological inability to reproduce. Therefore, reproduction of aardvarks in the wild remains to be thoroughly investigated.

TAXONOMY AND EVOLUTION

Aardvark taxonomy remains poorly understood. Although 18 subspecies were once described (Shoshani et al., 1988), their validity is doubtful and limited intraspecific variation studies have been conducted (for reviews, see Lehmann 2006; 2007; 2009). So far, only a single study has compared genetic samples of captive populations and showed no distinct difference between Tanzanian and Namibian aardvarks (Pohlova et al., 2014). In a systematic revision, Lehmann (2009) compared the sizes of fossil and extant aardvark species. Comparisons of individuals from two extant populations in South Africa (*O. afer afer*) and Central Africa (*O. a. eriksonni* and *O. a. faradjius*) revealed significant size differences between populations in both front legs and teeth, but when other extant subspecies were taken into account, their measurements formed a continuum of size variations across the entire species from *O. a. afer* to *O. a. eriksonni/O. a. faradjius* (Lehmann, unpublished data).

In addition to these morphological observations, anecdotal evidence suggests regional differences in feeding behaviour (Pagès, 1970), which hints at aardvark speciation as well. If, hypothetically, a combination of genetic, behavioural and anatomical data were to show that the Central African aardvark population (which is threatened by bushmeat hunting, human expansion, and habitat loss) were a separate species, the conservation status of this new species, along with the status of the remaining African aardvark populations would need to be reassessed. It is therefore desirable to conduct widespread genetic sampling of aardvarks across Africa (preferably to the genotype level) to determine whether the aardvark comprises more than a single species, and to validate these data with behavioural observations in the field and with existing anatomical/size variation records.

The aardvark's uniqueness in the animal kingdom is only a recent phenomenon on evolutionary timescales. Aardvark species were somewhat more numerous and widespread in the past (Lehmann, 2006; 2009). Their diversity and biogeography peaked during the Miocene (between 25 and 5 million years ago), when several species coexisted and aardvarks even occurred in Europe and Asia. These Eurasian species disappeared ~3 Million years ago (Lehmann, 2009) but the reasons are poorly understood. Understanding the mechanisms underlying the demise of aardvarks in Eurasia might help predict how aardvarks would cope under environmental changes in Africa in the future, including global climate change.

CONSERVATION STATUS

The aardvark is currently listed as Least Concern on the IUCN Red List of Threatened Species (Taylor & Lehmann, 2015), based on the species widespread distribution across Africa south of the Sahara, its occurrence in many large protected areas and apparent common occurrence in suitable habitats. Although there is no good evidentiary reason to adjust the Red List status at present, we have no knowledge of aardvark population trends anywhere, which is concerning. The reason for this is that aardvarks cannot be monitored as easily as diurnal species (see challenges to research below) and we have not yet found a way to estimate densities. Aardvark burrow densities do not appear to correlate with aardvark densities where these have been estimated (this has only been done in the Karoo), so alternative methods need to be developed if we wish to consistently determine population densities and monitor trends.

CHALLENGES TO RESEARCH

Finally, while we encourage research on aardvark biology to further understand their conservation needs, we believe that some guidance on the practicalities of studying aardvarks is beneficial to help prospective researchers avoid some of the common pitfalls. The reason that aardvarks remain relatively understudied is because they are hard to find, hard to catch, challenging to fit with tracking devices and hard to monitor and observe once appropriate tracking equipment has been fitted.

Two key decisions that need to be made before embarking on aardvark research are the location of the study site and the capture method. To have any chance of relocating study animals on a regular basis, aardvarks must first be captured and fitted with some form of tracking device. We have found two methods of capture to be successful: The first is to chase an aardvark into a burrow and place a cage trap at the entrance of the burrow to catch the animal when it emerges (Nel et al. 2000). In this case the trap must be placed in such a way to prevent the aardvark exiting the burrow by digging around the side of the trap. An aardvark will not simply walk into a cage, and we have not identified a suitable bait. The second method is to dart aardvarks while active above ground (Rey et al., 2014), which requires great care to not injure the animal with the tranquiliser-dart, and to prevent the animal from entering a burrow before the anaesthetic takes effect. Anaesthetised aardvarks can become hypothermic due to their low metabolism, and thus need to be kept warm throughout anaesthesia. Hence, a darted aardvark that enters a burrow must be extracted immediately once the anaesthetic effects set in, and a successfully captured aardvark must not be allowed to enter a burrow until it has fully recovered from anaesthesia.

Regarding the study site selection, although aardvarks are widespread and occur in many habitat types, not all habitats are equally suitable when it comes to capturing this species. Aardvarks are fast sprinters and might need to be pursued with a vehicle in order to chase them into a burrow for subsequent trap placement. This method would be almost impossible in heavily wooded savanna where visibility is limited and trees prevent free vehicle movement. More ideal sites for aardvark capture are open habitats such as the Karoo or Kalahari, where vehicles have free movement or where an aardvark can be stalked silently for darting, and where it can easily and quietly be followed while the anaesthetic is taking effect, until the animal becomes recumbent. Another potential advantage of working in the Karoo or Kalahari is that during periods of food scarcity such as winter, aardvarks occasionally become active during daylight in the late afternoon, which can aid sighting and capturing them. Despite good visibility, grasslands are not generally known for good aardvark sightings, while to our knowledge, no aardvark studies have been conducted in forested habitats, and no information is available on attempts of capture and research on forest aardvarks.

In terms of tracking equipment, our experience has shown that collars are not suitable for aardvarks because they get encased in soil and mud, rub the skin around their neck and ears, and cause abrasions, which can cause infections that may compromise the aardvark's health and survival. It is, therefore, strongly recommended to use implantable tracking devices which require the assistance of an experienced veterinarian to perform the surgical procedure. This technique has been well described (Nel et al., 2000; Rey et al., 2014). It also needs to be considered that telemetry devices must be replaced before the batteries expire, for which an implanted aardvark needs to be recaptured. Such recaptures can prove extremely difficult because some aardvarks cannot be recaptured.

Lastly, even once an aardvark is successfully implanted with a tracking device, it will likely remain hard to observe directly. Although some individuals may become habituated to human presence (Taylor et al., 2002), habituation is a very laborious process that requires a lot of patience and effort. Thus, aardvark research should be well planned, the ethical considerations on the possible impacts of any intervention concerning free-living individuals should clearly point out the benefits of such a study, and significant financial resources are required to conduct rigorous research on this species.

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Priority conservation actions for Madagascar's tenrecs assessed for the first time since 1990

In *Afrotherian Conservation 11*, I reported on a workshop held in April 2015 by the Tenrec Section of the Afrotheria Specialist Group around the edges of the Twelfth African Small Mammal Symposium in Mantasoa, Madagascar (Stephenson, 2015). The workshop developed key elements of a conservation strategy for tenrecs and I am pleased to be able to report that the results of the meeting, along with a detailed review of IUCN Red List of Threatened Species assessments, was recently published (Stephenson et al., 2019).

The paper is the first assessment of tenrec conservation needs in Madagascar since the strategy produced by Martin Nicoll and Galen Rathbun almost three decades ago (Nicoll & Rathbun 1990). Sadly, the outlook for tenrecs has not improved greatly in that time. While our knowledge of tenrecs has advanced considerably since 1990, no conservation projects have targeted the Tenrecidae explicitly, in spite of the threats they continue to face. Six of the 31 species of tenrec (19.4%) are threatened (4 Vulnerable, 2 Endangered) and a single species was classified as Data Deficient. The primary threat to these endemic small mammals is habitat loss, mostly due to slash-and-burn agriculture, while some species are hunted for their meat or incidentally captured in fishing traps. In the longer-term, climate change is expected to alter species habitats and ranges. However, the lack of data for most tenrecs on population size, ecology and distribution, as well as frequent changes in taxonomy (with many cryptic species being discovered based on genetic analyses) and the poorly understood impact of bushmeat hunting on spiny species, hinders conservation planning. Priority conservation actions identified in the paper focus on the conservation of forest habitats (especially through improved management of protected areas) and filling essential knowledge gaps. The authors conclude that tenrec research, monitoring and conservation should be integrated into broader sustainable development objectives and programmes targeting higher profile species, such as lemurs, if we are to see an improvement in conservation status in the near future.

Please write to me if you want a copy of the paper. You can also find more on the Cambridge Core Blog (Stephenson, 2019).

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PJ Stephenson
Gingins, Switzerland
StephensonPJ@gmail.com

The life of Galen or the tall tales of Zeke and Zeb

I first met Galen when I was 14 years old. We were both Boy Scouts, me in Woodside and Galen in Portola Valley troops. We joined an Explorer Scout troop that covered both our towns. One of the first activities our troop did was to canoe the Russian River during the winter when it was cold and the water level was actually too high to safely navigate it. We survived without losing our canoe but several of the other scouts hit the sweepers on the river's edge and their canoes were lost as they were wedged in too tight to pull them out. No one died but it could have been worse.

Galen was three months older than I so we hit it off and did a lot of things together. I met his family and visited their house which was on a hill overlooking Sears Lake and the terminus of the Stanford Linear Accelerator (SLAC). His father of German heritage, was an electrical engineer working for Westinghouse. Later he had his own company, Western Switchboard. Prior to living in Portola Valley Galen's father was the caretaker for the Sharon estate, a several hundred-acre estate located on Sand Hill Road. It is now in the heart of Silicon Valley and the SLAC runs through the property.

Galen's mother came from a very interesting background. She was half German and half Mexican. Galen grew up in a bilingual household which aided him later when he had to learn Kiswahili. His maternal grandmother Mamamita, knew no English and lived in a chicken coop which was converted into a small house on the Southgate estate. His mother was one of 4 siblings. One of her sisters married Galen's uncle (his father's brother). Another married a Mr. Southgate, a millionaire who owned a nice piece of Portola Valley. While in the Bay Area Galen would stay with his cousin Richard Rathbun. The last sister married an Englishman by the name of Felix Greene. When I was at Humboldt State University I once went to the movies and saw documentary on China. This was during the time Chairman Mao was killing lots of people through the "Great Leap Forward". The movie only showed happy people building all sorts of wonderful products. When I went back to the room I shared with Galen I told him about the movie. He asked who filmed it and when I said Felix Greene he told me that that was his uncle, who was a commie and that he had been booted out of the USA and was living in London. It turns out that Felix's clan, the Greens, were from two brothers in the UK, Charles and Edward. On one side there were 6 children who all went on to great things (one of them was the author Graham Greene) while on the other side also with 6 children the siblings did not amount to much. The 12 cousins were "tall, much married and highly intelligent" according to a book about the clan. Felix was described as a "useful idiot" to Mao.

Galen also has a sister Karin, who unfortunately got involved with a new age hippie in Sausalito, CA and ended up with a drug induced life. After his parents died Galen had to act as ward to his sister who lives in Palo Alto. One of the adventures Galen and I had was to take Karin out to the Fillmore Auditorium. She was 16 at the time and Galen was leaving the next day for New York to start Peace Corps training. The headline stars at the concert were the Grateful Dead, Jimmy Hendrix and Janis Joplin. After about 3 hours we convinced Karin that it was time for something else. We drove to the San Francisco Playboy club and entered. The music was more to our liking and we somehow managed to get Karin in by not lying about her age. We also introduced her to the "pull the purse prank". Near Galen's house was a bridge over a small creek. There were good hiding places so we would throw a purse, tied to a string out on the road and waited. A car would come along, the occupants would spy the purse and stop to fetch it. We would pull the purse out of the road and when the victims got out of the car they would find nothing. However once the string got hooked up and we could not get it off the road. Just as a woman got up close we jerked the string and the purse jumped. She screamed and jumped back. Her husband who was driving said what is the matter? His wife said it jumped and I am not going to touch it. He got out and grabbed the purse, broke the string and they drove off with it. End of game.

Both of us went to Woodside High School, as freshmen, which was a brand new school. Both of us were on the swim and water polo teams. We lived in the water quite a bit. Galen built a fiberglass kayak which saw many adventures with the two of us.

In high school Galen did well in biology and one summer was lucky enough to get an invite to join Charles Thayer on an expedition to study pocket gophers. He learned how to make museum skins. Freeze drying was all the rage then so Galen built a small freeze-dryer and started out with newts, shrews and window killed birds. I think he used it as a school science project. One of his goals was to freeze dry nudibranchs as the only other option for saving them was formalin which bleached the color out of them. We spent hours in the tide pools looking for them. Galen was quite the inventor.

Both Galen and I went to College of San Mateo (CSM) for the first two years of college. We commuted daily to the Coyote Point campus the first year and then to the campus on the hill, closer to our homes. About this time Galen got a model A Ford pickup which he restored. Early on he asked me to help him get the frame to a steam cleaner in Redwood City. I drove to his house where he had the frame ready to be towed by his 1956 Chevy pickup. The frame had the steering wheel mounted, a 2x12 plank across the middle and the brakes functional. It was about 5 miles to the cleaner. Off we went with me sitting on the plank. After about 4 miles I noticed that one of the rear wheels was rocking back and forth. I signaled to Galen to stop. Just then the wheel came off and Galen leaped out of the truck and ran off in pursuit of the errant tire. It looked a Keystone Cops adventure and I cracked up laughing at the sight. Galen must have covered 100 yards and was almost to the tire when it turned right into a gas (petrol) station. The tire rolled up and hit the door of a car whose owner was pumping gas into it. The door had a black mark on it from the tire which had picked up a tiny stone so there was a dimple in the middle of the mark. The owner had a fit. He sputtered out "This is my brand new car, this is my first tank of gas, you have ruined it." Galen picked up his tire and apologized profusely to no avail. Of course it did not help that I was in hysterical laughter. Galen threatened to kill me. In the end Galen had to fork over $50 to have door repainted.

While Galen was restoring the Model A, he did not have a welder, but on advice from his father I suppose, Galen just had a wire hooked up to the 220-volt circuit and was welding with that. The welding rod once got stuck and before Galen could pull it off, it fried the transformer on the pole. We did not enlighten PG&E when they arrived to repair it, but I think that was when Galen's father got him a proper welder.

The Rathbun family were all good skiers. Galen's grandfather Grandpapa Rex once took Galen, Karin and I skiing to Sugarbowl in the Sierras. We all bunked in together the first night but on the second night Rex moved into a room to himself. We asked why and he said that he could sleep better if ski boots did not fall from the ceiling. Galen felt bad about throwing the boots but it did stop Rex from snoring for a while.

Galen had a pet crow called Banti Chiquita who spoke Spanish and a Yellow-billed Magpie.

After CSM I applied to Cal Poly and Galen to Humboldt so I also applied there also. We both were accepted to Humboldt and some friends Gerry Nordstrom and Mary Carey from CSM were also going to HSU. We all caravanned the 300 miles to Arcata at a top speed of 50 mph. With Gerry we had applied to stay at an apartment complex called Mai Kai with 200 studio rooms, men only, no pets allowed. Each studio had 2 beds and a bathroom and was connected to another bedroom by a common kitchen. An interesting side note, Gerry occupied the other side and so management booked a stranger into the room. When the roomie, Steven Spellenburg, arrived it turned out that he lived at Burnt Ranch a small community on the Trinity River. Later when I told my father who our other roommate was, he asked me to inquire from

Steven if his father once lived in Redwood City. He did and as it turned out his father was the principal of the school where I went to kindergarten and first grade.

By the time we got to HSU, Galen and I were used to making trapping trips and collecting all critters large and small. Most weekends would find us in the high desert near Herlong and Susanville. We had quite the collection of kangaroo rats, pack rats and others. Some we brought back alive. We installed a 1x3 boardwalk network hanging from the ceiling and nightly either the flying squirrel or the bush tailed pack rat would run along them. We had K-rats in an aquarium and for a while an oiled loon was in the bathtub. Of course none were "pets". There was lots of room for mischief in the complex. We discovered that if you removed the bathroom medicine cabinet that behind it was the back of the cabinets for our neighbors on the other side of the building. We routinely used a piece of wire to push open their cabinet door. There was talk of ghosts and they never did figure it out. The other trouble we caused was that the building was rather flimsy so that if one jumped onto our floor, from the bed it would rattle enough to break the filament in the ceiling mounted light in the apartment below. Of course it could only be done if no one was home down below. They finally figured it out a few months later and retaliated throwing a beer can with tear gas in our apartment one night. I was alone in the room and heard the hissing. I got up, grabbed the can and tried to open the sliding glass door. They had also put a stick in the door to lock me in. I knew that one could lift the door and by pushing out could bypass the stick. Galen and Gerry were just coming back from the library when they saw the door bulge once and then explode outwards. About that time the tear gas started to affect me and I dropped the can and headed for the sink. Obviously the police were called by the manager. Everyone who lived downstairs told the police that they had picked up the can, so sorry their fingerprints were on it. They bought us a new window, we all had a good laugh and the light did not suffer again. Mary Carry who married Gerry remembers the stories of way Galen used to sleep. In the mornings Galen would neatly make his bed military style, so perfect. In the evening he would climb in and then rip out the sheets on all sides and curl up in the cocoon muttering "my bed, my bed, my bitchen bed".

Humboldt was great as it opened up a new habitat for us to collect animals. We set many traps for *Zapus*, *Microtus* and *Aborimus*. We were intrigued about the mountain beaver and soon added it to our collection. We visited one of the rocks in Trinidad Bay and found it riddled with holes in the grass. It was only accessible during a spring low tide so we planned to camp over. We gathered up our traps and crossed over. In the morning our traps were empty but we did pick up a few dead black birds. We showed them to Doc Stan Harris who identified them as Leach's Storm Petrels. We looked in the literature and found that a certain C. I. Clay had been on the island in 1914 and had collected both birds and eggs from the island and wrote it up in the Condor. We found out that he was still alive and living in Eureka. We drove over to see him and were impressed to see California Condors, stuffed, at the top of his stairway. Once inside we found lots of other rare birds like Carolina Parakeet, Ivory-billed Woodpecker and Passenger Pigeon. Clay said that most of the birds he traded to obtain but the condors were his, "I got mine before they became rare." The last taken in Humboldt county.

Armed with that knowledge we convinced Doc Harris to go to the island during the next spring tide to try and band some birds. We mounted the expedition and with Fred Zeillermaker (who had a banding license) made our way out to Little River Rock. Doc Harris told Galen and myself we were there to help but as we were not licensed we could not band or extract birds from the mist net. We put up one net on the top and another down the side on a 30-degree angle. We asked how many birds we might catch and Doc said maybe 5-6 per hour. About midnight we caught a few birds and gathered around to watch Doc and Fred band the birds. Suddenly Doc said that he had a splitting migraine headache, he swallowed some pills and passed out. We looked at the nets which were full of petrels and trial by fire, we started to extract the birds. Galen did all the banding and I ran the slope net, while Fred ran the top net. After a few hours Doc woke up after the birds quit flying. He asked how many did we do and Galen said 350 birds including a couple Fork-tailed Storm Petrels. It was such fun that every month at low tide we went out to the rock to band birds. We found out later that some people on shore had seen our headlights on the rock and thought we were in distress. A sheriff's deputy found Doc Harris's car and after running a make, got a phone number and phoned Doc's wife who said we were just banding birds.

Of course Jake Houck was a marine mammal specialist at HSU so we spent many hours cutting off the heads of seals, whales and any other dead thing washed up on the beach. We noticed bats flying around the lamp posts at Founders Hall. We asked Jake who we should ask for permission to collect some and he gave us 2 pieces of advice. One: if you are afraid of the answer do not ask the question and Two: it is better to ask for forgiveness than permission. One dark night we went up the hill, broke out the .22 and .410, blasted the bats, we scooped them up and jumped off an ivy sloped hill just before the cops showed up.

When Galen and I took mammology. Houck was on leave so Walter Sheppe taught the class. It was tradition for the students to collect 10 mammals and prepare museum skins from them. Galen and I were assigned to teach the rest of the students how to do museum skins but we were not allowed to just turn in 10 specimens. Sheppe suggested we do projects instead. Galen the inventor was intrigued by the Red-backed tree voles *Arborimus* so he found some nests in a stand of conifers and caught some of the mice. He toed clipped the mice to identify them individually and then went about affixing to the branches small milk cartons, open on both ends, with smoked 3x5 cards inside. As the mice ran through the cartons their foot prints on the smoked cards would identify who was making the tracks. He was able to build home ranges for each one. I decided to set traps along the high tide line and then looked at what food the *Peromyscus* were eating. Sheppe who did his PhD on *Peromyscus* at UBC was keen on my results which found that the mice were eating insects and washed up sea critters. Several years later in response to a study where the mice were eating animal meat he sent me a MS of my study (just fill in the blanks) which was published in JM.

About this time we were also told we had to get a dead cat from the pound and prepare a cleaned skull to turn in as part of class. Galen and I went to the pound and collected 2 dead cats and took them back to our apartment. After taking measurements and skinning the skull Galen decided to tack the scalp of his black cat on the Mai Kai notice board with a note "This cat was found on the premises, no pets allowed, any pets found will be similarly dealt with." Ha ha, good joke. A day later our door way darkened with the entire HSU football team. One member was crying because their black kitten was missing and was that its skin on the notice board? Ever the scientist Galen immediately said no not possible to be yours, and read off the measurements total length 360 mm, tail 180 mm, etc. I found this highly amusing that Galen was talking in millimeters to football jocks who had no clue what a mm was. Then he produced the cleaned skull. They were starting to roll up their sleeves prior to beating us up. I was in hysterics by this time as I thought we might die, but I could not stop laughing. Eventually a couple of the team realized that our cats were too big and they left. Once again Galen could have killed me himself.

Sometime around 1964 the Eel River flooded extensively. It wiped out the road to HSU from the south and as the Trinity River was also flooded, the road from the east. This all happened during the Christmas beak so that all the students that drove home for the holidays were stuck. HSU announced that classes were going to start anyway so everyone had to fly into the area. Galen had driven his Model A to school in September, was not looking forward to the long ride home so he left the vehicle. As it turned out he had almost the only vehicle on campus. Whenever we went somewhere there were dozens of students sitting in the back or hanging on the running boards.

Once we trapped a spotted skunk and decided to keep it as a pet. After a while we gathered all the equipment we would need to anesthetize it and de-scent it. That night as we were preparing for the surgery we heard small squeaks coming from the cage. She had 3 babies. We figured it would be better to train them than operate. Over the next few months we tamed them and then released the mother. Both Galen and I needed a physics class so we decided to take it at CSM during the summer. One day I drove to the school and parked next to the 56 Chevy. I was sure that Galen had hit a skunk. I went to class and commented on his road kill. Alas it was not that simple. He was bringing one of the babies in to give to someone when it got out of the box as he was driving and started to crawl under the seat. Galen grabbed it by the tail and dragged it out. Pow! It cut loose inside the truck! It took weeks for that smell to dissipate. No one wanted to borrow that truck.

Back in those days before the endangered species act, the marine mammal act, protect it all acts, you could do what you wanted. Shortly before Galen joined the Peace Corps he decided we should go visit Anno Nuevo Island. We both got our cameras, wrapped them up well to water proof them, me in my wet suit, Galen in his Speedo swim suit and an air mattress swam out to the island. We explored and took lots of photos. After an hour or so we started back to shore. The waves had come up a bit higher but with Galen lying on his mattress and me on his back kicking with my fins we were doing well. Suddenly we were accompanied by 5 sea lions on either side only a few feet away. Their teeth looked real big. All of us caught the next wave and started surfing to shore. Galen's legs were shaking so much I could barely hang on. It was a 100 yard ride that qualified as an "adventure": a life threating event that upon survival and reflection was not so bad after all. We made it to shore and there found a baby California sea lion that had been washed ashore with no momma around. Galen threw his jacket over it and caught it. It proceeded to bite through the jacket and mashed Galen's thumb. We put it the truck and took it to Galen's house and released it in his shower. His sister who shared the bathroom with Galen was not thrilled. The next day Galen left for New York with a black thumb. I took the sea lion with me up to HSU in the back of my VW Beetle but that is another story.

Because I flunked organic chemistry I was half a year behind Galen, Mary and Gerry. They all joined the Peace Corps and Galen went to Kenya, while Mary and Gerry went to Tonga.

Galen had lots of sayings that he would say at the right times like: Three can keep a secret if two are dead. He called people without brains wedge heads when they riled him up. Galen was methodical and well organized if you were not he would say "Lead, follow or get out of the way". Although we were good friends Galen never hesitated to call me on anything. "Osborne you are so full of it your eyes are brown".

After I graduated I left on a trip that would eventually take me around the world. I wanted to visit New Zealand on a one-way ticket but they said I needed a ticket out, so I got an air ticket to Australia but to get an Aussie visa I need a ticket out, so I went to the South African Consul in SFO and got a visa. I bought a boat ticket from Freemantle to SA. The south Africans wanted to see a ticket out so I bought a Suzuki 80 motorbike and started driving north from Durban. Top speed was 30 mph and I discovered it was cold in SA during May. There was frost on the roads in the mornings. I had numerous hassles in Rhodesia but eventually got to Zambia. Walter Sheppe had taken a 3-year post as a lecturer at the Univ. of Zambia in Lusaka. He was trying to create a post for me as a research assistant to collect mice. I wanted to visit Galen before I started the job so I hitch hiked to Mirogi where Galen was teaching science. It was school term break so we hitched down to Mombasa where we dropped in on a distant cousin of my grandmother, a Mrs. Clark. From there we went to Malindi. We got a ride with a nice gent but Galen could not understand him. Finally, Galen asked what language he was speaking. Why Kiswahili of course! Galen's Peace Corps and upcountry Swahili was no match for the real stuff.

Galen had an oxpecker as a pet. Students had found one with a broken wing so Galen was nursing it back to health. It would ride on his shoulder and pick flies off his head. Quite handy.

At Nairobi he gave it to someone at the museum to take care of while we went to the coast. When we returned it was stuffed as it had "died". The local director of the PC was going to visit some people near the Lolita Hills and invited us along. We stayed at a rest house and after a few days met some police who had just showed up to arrest a Masai who had rustled 30 head of cattle from an Asian at Lake Magadi. They were planning to take the cattle back and so they invited Galen and I to accompany them. It was 60 miles. There were 2 herd boys, 2 policemen, 30 head of cattle and us. Next morning, we took off traveling on elephant trails where the bush was so thick it was like a jungle. We walked up into the hills and started down the other side. The place was full of wild animals like zebra, gazelles and topi. At night they built thorn bomas and fires to keep the lions at bay. In the morning we looked down on a herd of 500 buffalo. After watching for a while the police fired their guns and the buffalo ran off. Towards the end of the day we were at the bottom of the escarpment and camped next to a Masai village. Galen caught a sand snake with his hands which impressed the locals. Next day we walked to the edge of Lake Magadi, a vast shallow, pure white soda lake. There is a causeway across the middle of the lake that is about 5 miles long. Since we were on the home stretch, we had left the cattle and the rest behind. It was probably 120F out there and as we walked a man in a Land Rover drove up from behind us and offered us a ride. We both said no thanks we intended to walk the whole way. About a mile later we both said "That was stupid". Rather parched we stumbled into the town of Magadi. We were quite a ways from Nairobi and were wondering how we were going to hitch. After a bit the cattle showed up and the police said that because this was a restricted area they would tell the next vehicle to take us along. An hour or so later a Land Rover pickup arrived with 2 people up front and 2 in the back. The driver said OK and we climbed in the back. The gent in the back introduced himself as Vesey or "some call me Fitzgerald". The other was a servant. The driver seemed to be not in a good mood. Meanwhile I was soaking up knowledge from Mr. Vesey-Fitzgerald who was director of the International Red Locust control. He was a very famous person. After 30 minutes the driver halted and said in a loud voice "chai (tea) time". The passenger in front, a woman from Aden introduced herself as a botanist. The servant laid out a cloth on the ground and got the water boiling for tea. The driver took a sip of tea and promptly introduced himself as Dr. Greenway. He I had also heard of as the author of the Flora of Kenya and numerous other books on vegetation in East Africa. He need that tea before he came sociable. Next morning Galen hitched back to Mirogi near Lake Victoria and I started hitching back to Zambia. The trip to Kenya took 4 days, the trip back took 6 days.

Galen taught at Mirogi for 2 years and then worked under Richard Leakey for another 2 years at the National Museum. About this time Galen was 26 years old and had been recieving draft deferments. That is when the draft board decided to pick people by a lottery based on your birth date. I was back in California by then and went to visit Galen's parents. They were upset because Galen's lottery number was 4. I said no it was 364 saying he was born 24 June. His mother said no he was born 23 June. It was rather ludicrous that I was arguing with his parents over which date he was born. I went home and there was a letter from Galen thanking his lucky stars. I drove back to his house and showed his parents the letter.

Galen was a prolific writer so I would get a letter from him about every 2 weeks. I saved his letters but they are in Alaska and I am in Namibia so I cannot refer to them. He also kept a journal most of the time.

I went off to Texas A&M University in 1969 after I returned to the states. I had worked for Sheppe for 18 months. Texas was a culture shock and I only lasted one semester. That is another story but little did I realize that that was the year they integrated and there was a bigger furor about letting in women than blacks. Turns out that year they had 12,000 men, 600 blacks and 200 women, not my kind of place. I returned to Humboldt and started on a master's degree working on the islands and rocks off Humboldt and Del Norte counties. Laurel had heard all about both Galen and I the first year she was at Humboldt. I was the wild one and Galen the calm one. I met Laurel, who I married and after 2 years we were off to Africa. It took us 3 months to get to Kenya via cheap student charter flights but we eventually made it. Galen was then living at the Gedi ruins looking at the Golden-rumped Sengi. We hitch hiked our way towards Mombasa, stopping for a few days with Ray Mayer, who picked us up and was driving to his cattle ranch between Tsavo east and west He had a microscope on the floor of his truck and we asked if he was a vet. No he had cows dying and wanted to take blood smears to see if it would tell him anything. I told him Laurel was an expert with a microscope and blood slides so he invited us to stay at his place several days. Turns out that his cattle had blood parasites. The place was nice with lots of wild animals. There was a big water tank nearby where elephants came to drink at the overflow. We then continued on our way to Gedi. Galen was living in a mud and wattle building with palm leaves for the roof. He was just starting his project and we were able to help him catch his first sengi. This was in the days before radio tracking gear and the beasts were bedecked with color rings on their legs and color coded earrings. The only way to determine home range was to sit in the forest and wait for one to pass him by. In the process he saw forest cobras and African Pittas (very rare birds). Galen spent hours in the forest and scratches on his body would infect immediately. His lower legs were full of yaws.

When Galen was going to the University of Nairobi he lived in a small house on the Athi plains called Siokimaw, next to Nairobi NP. There were several houses on the property all occupied by various researchers like David Western, Alison, Enrico Hoek, Lou Hurxthal, it was the center of intelligence for research in Kenya.

Galen had managed to acquire a fold-a-boat 2-man kayak which was a rubber shell with wooden slats. He wanted to try it out on the outflow of Watamu Bay. When the tide ran out of the bay and it hit the ocean waves it produced some nice white water running. Laurel sat on the beach relaxed knowing that for once I was with the sedate one and she had no worries. We launched the kayak and headed out to sea. The waves were a lot bigger than we estimated and some of the wooden stays started to crack and break. We shipped some water and wisely headed for some coral heads that were sticking out of the water. With the change of the tide we paddled back. Safely on shore we met some locals who were astonished by what we did. They said that the water was full of sharks just waiting for the tide to bring them something to eat. So much for the safety of being with Galen.

A few years later Galen and a friend paddled down the Tana River and at one point passed a bunch of big crocs on the river bank. Several slipped into the water and headed out to investigate a change of diet! Galen always carried a simi (a Masai sword about 16 inches long) with him and he unsheathed it as the crocs got closer. They paddled like mad and were able to escape.

From Gedi, Laurel and I hitched-hiked to Zambia where we spent 9 months working on various research projects. We kept in touch with Galen via post. We went back to Humboldt where I finished the writing on my Master's thesis and then went back to Zambia to work as a biologist for Zambian Parks and Wildlife. By then Galen had finished his PhD and was in Washington DC where he met Lynn. But some time before going back to the states he visited the Bogoria Hot Springs with Linda Perez and while exploring the area he fell into one of the boiling pools. It was thigh deep and he parboiled his legs. Linda drove him to the hospital at Naivasha where he walked into the ER. A nurse took one look at his legs and fainted. Eventually he got treated but ever since he has worn long pants as he could not take the sun on his legs. A side note on Linda, she was teaching in Zambia when we met. Her parents lived in San Antonio, Texas. They came to visit with a friend who was Dr. James Tear from Texas A&M Univ. Tear, who was a wildlife specialist, is the one who encouraged me to apply to A&M and said that they were gearing up to have lots of African research projects. When Linda was finished on her contract in Zambia she planned to travel to Kenya, I gave her Galen's details and that is how they met. I believe she is presently emu farming in Texas.

After Washington DC Galen got a job with USF&W service in Florida working on manatees. He then moved to California and was at Piedras Blancas Research station working on sea otters. When he first started to work there he encouraged me to join the "Friends of the Sea Otters" an NGO group. I did not and within one year Galen could not stand the group. They were against any research on the otters and if one of the radio tagged otters should happen to die the "friends" would file suit to shut down the operation. Radio tags were implanted inside the otters and if Galen wanted to tag one they would have to capture it, drive in an air conditioned vehicle to Monterey have a vet implant it and then drive back to where it was captured and release it. Quite the procedure. Galen got out of sea otters and began working on endangered frogs, and also had a large research program on Carrizo Plain National Monument looking at K-rats, mice and rattle snakes. The plain had domestic cattle grazing on it and one of the studies was looking at whether the grazing was detrimental to the ecology of the area. Galen's final analysis on the situation upset the local bunny huggers. He concluded that cattle grazing at the low level actually improved the plain for the other species. One of the other problems he had at the coast was that the population of elephant seals rapidly increased and the critters found out that they could crawl away from the beach to the paved Highway 1 where the road was warm. At night there is nothing to reflect on a seal and they were getting hit by vehicles. The staff had to build walls to keep the seals on the beach.

I retired from Alaska Fish and Game in 1997 and we came to Namibia to do research on the kori bustard, the world's heaviest flying bird. I think Galen retired in 1999 when he and Lynn came to Namibia to visit us. Galen was interested on working on the dassie rat *Petromus typicus*. Within a few hours of arriving at our farm we had caught one in a Sherman live trap. We put it into a bag and slowly pulled out the parts of the critter we wanted to examine. It was quite tame we thought it was like a K-rat and did not bite. We also captured the local sengi. We cruised around the country together, up into Himbaland down Van Zyls Pass which is a very steep rocky track. You put the vehicle into low range 4x4 first gear and slowly crawl down keeping the brakes on most of the time. To the right are rocks and to the left is a straight drop of hundreds of feet. In the track are big rocks that you must drive over which sometimes tips your vehicle way over to the left. We survived the pass and went to the Kunene River in the Marienfluss valley. The area is very scenic. We showed Galen the sights and stayed at the Erongo Wilderness Lodge, owned by Donnie Holloway. Galen decided this would be a good place to conduct research on the dassie rat as they were quite numerous.

The next year Galen returned with radio tracking equipment. He set out traps and caught several. He told Donnie that these rats did not bite and were tame. He reached his hand into the trap to extract the rat and like a buzz saw it savaged his hand. It seems that the Windpoort rat was exceptionally tame, all the rest of the rats bit viciously if given the opportunity,

Galen made several trips out to work on dassie rats, sengis, black mongoose and others. On one trip he planned to work on the golden mole, a small critter who lives in sand dunes and has no eyes. He brought out 2-gram radio tags to glue to their backs. He had a local assistant at the area where the moles are numerous but Galen was unable to catch any. After a fruitless week Galen asked the local guy if he knew how to catch them. The man replied "How much money do I get for catching them?". Galen was getting desperate so offered Nam$ 500 each. In one day the guy caught 10. He watched Galen struggle but wanted to get paid for his expertise. After a few weeks of tracking the moles Galen declared they were the most boring of critters to study. You can see them when you catch them but then never see them again after you release them. They are like sand sharks swimming through the sand and then surface to snatch a beetle on the surface then back into the sand.

Galen became an associate fellow of the California Academy of Sciences. He and the curator of birds and mammals, Jack Dumbacher came on a trip to work on the round-eared sengi, *Macroscelides*. That sengi lives close to the coast so they collected all the specimens that were housed in various museum and collected more in Namibia to have some fresh genetic material. As they were examining the specimens there was one which was different from all the rest, both physically and genetically. It had been collected by Mike Griffin years earlier near a place called Mikburg. Laurel and I made a collecting trip out to the place. After camping 5 days we managed to get one. The following year Galen and Jack came out and caught several more. Laurel and I expanded the search north and south and also caught more. They were not common as all told we were only able to catch 4 for every 1000 traps set out. The area was very scenic and very enjoyable. We heard lions calling, hyenas were seen and rhino and elephants were about.

The last field trip we did with Galen was to see if we could find the four-toed sengi in Namibia. It occurs within 100 km of Namibia in Zambia. Dave Ribble joined the expedition. We camped the first night in Bwabwata NP not in an approved spot and all night we could hear elephants tearing down trees. The area had been trashed by elephants. The next night we were farther east in what is referred to as the Golden Triangle, and it was also trashed. We then moved to the Zambian/Namibia border. About 10 years earlier we had driven along the track and I remembered seeing thickets. That is the habitat the sengi is found in. We drove along the track and found good bush to set traps but did not see any sign of our quarry. It was a fun trip.

Galen wanted to critically review the sengi genus *Elephantulus* as he had genetic material from all but 3 species. We planned a big collecting trip to Malawi with Jack, Galen, Laurel and I. Unfortunately, the doctors discovered a small cancerous lump in my back and insisted on removing it, thus we had to cancel. Jack and Galen went. We rescheduled our plane tickets but then Laurel fell and broke her leg so the trip was postponed permanently.

So the last time we saw Galen was when he left Namibia in 2017. Just before dying he sent a cryptic email. "Hey Zeke all is well to viove to mail I hope rain all good. Quack slows of course. Z". Translated he was using voice to write the sentence since he could not move his fingers to type, he wished us good luck with rain as we were in a drought in Namibia and his cancer doctor was not moving fast enough to satisify Galen. Zeb. Over the years the names Zeke and Zeb would be included in emails as a CC or such and it left folks wondering who they were. To some Galen explained but the rest were left in the dark. And who is/are Zeke and Zeb. Only 2 people know for sure, one is not talking and the other took it to the grave.

Tim Osborne

Galen B. Rathbun 1944–2019

Andrew Taylor

In mid-April 2019, Galen Rathbun, the founder and long-time chair of the Afrotheria Specialist Group died from cancer. Galen had a long and distinguished career as a mammalogist and spent much of his field work years, which continued right up until early 2019, working in Africa. Galen was the pre-eminent sengi (elephant-shrew) biologist and made a massive contribution to our understanding of their biology and conservation. The Afrotheria Specialist Group is indebted to Galen for his ongoing efforts to maintain a presence for our little-known taxonomic group in the conservation world.

Although our SG members knew Galen primarily for his work on sengis, he also made significant contributions to the study and conservation of marine mammals, especially dugongs, manatees, and sea otters. In the journal Marine Mammal Science, Thomas O'Shea and colleagues warmly remember Galen as a man of wide-ranging abilities across the zoological field, having worked across multiple biomes (including marine and terrestrial) and vertebrate taxa (including many mammal species, frogs, turtles and snakes) (O'Shea et al., 2019).

Galen was born in California in 1944 and earned a Bachelor of Science degree in Zoology from Humboldt State University in 1966. After graduating, Galen served five years in the Peace Corps, first as a school teacher in western Kenya, and then as a museum education officer with the National Museums of Kenya in Nairobi. During this time Galen was instrumental in establishing the Wildlife Clubs of Kenya, a youth conservation organization that is still active today. Galen then did a PhD on sengi behavioural ecology at the University of Nairobi, after which he moved back to the US.

From 1978 Galen developed a professional career as a Federal research biologist for the U.S. Fish and Wildlife Service. Initially he worked on Sirenians in Florida, where he was a driving force behind research and conservation of this taxonomic group, and where he helped develop methods to track and monitor them. In 1985 Galen returned to California where he focused on the conservation of sea otters, working on a translocation programme intended to create a new population to act as a security against the risks of extinction should some calamity occur to the main population.

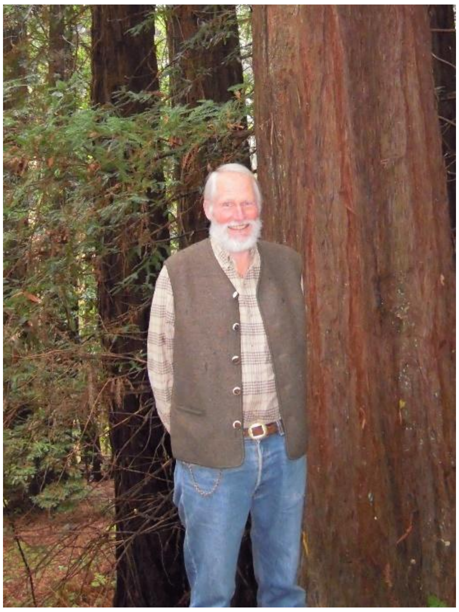
Galen retired from the USFWS in 1999 but started an affiliation with the California Academy of Sciences, under which he reignited his work in Africa and on sengis. Galen published over 130 professional and popular papers, some of which can be found on his website: http://www.rathbunx2.com/galen/index.php

I first met Galen via email in 2001 when he established the IUCN Afrotheria Specialist Group. Our communications remained fairly limited for many years, but then increased substantially after 2012 when I became the Red List coordinator for the SG and then co-chair in 2017. I was only fortunate enough to meet Galen once in person because we lived on different continents and because when in Africa, he was not often in my neck of the woods. I am grateful to have had this opportunity though, which came near the end of 2018 while he was passing through OR Tambo International Airport on his way to Malawi for another Sengi research expedition with his colleague Jack Dumbacher.

Galen lived a full life with plenty of adventure, but perhaps the most fitting tribute would be to quote O'Shea and colleagues in saying that Galen 'will be remembered by his many friends and colleagues throughout the world for a job and a lifetime solidly well done'. I know that many in our SG will miss him, especially those who had the good fortune to spend time with him. A second obituary is expected to be published by his terrestrial mammal colleagues in the Journal of Mammalogy. Galen is survived by his wife of over four-decades, Lynn Rathbun.

O'Shea, T. J., Brownell, R. L., Marsh, H., & Ralls, K. (2019). Galen B. Rathbun (1944–2019). *Marine Mammal Science*, mms.12628. https://doi.org/10.1111/mms.12628

Memories of Galen



I have very fond memories of the one and only time I met Galen. I was attending a conference a few miles down the road from where he lived in California and he offered to drive out to meet me at the weekend. We had both been in the Afrotheria Specialist Group for many years but our paths had never crossed. After a working lunch where we planned how to develop the group's work, he insisted on taking time out to show me the natural wonders of the region. I'll never forget his kind hospitality and my first views of the giant redwoods and the sealions. My only regret is that I was never able to reciprocate and host him in Europe.

Like many other members, I greatly appreciated everything Galen did for the specialist group. It's only through his dogged determination that we've manged to remain active over the years - and keep turning out newsletters. I am always going on about how smaller mammals are neglected in favour of large ones. But it really is mostly thanks to Galen that his beloved sengis, and all the other Afrotheria "critters", remain in the public eye and will not be forgotten. We'll always be grateful to Galen for that. He will be greatly missed.

PJ Stephenson

Gingins, Switzerland

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 Andrew Taylor (taylor.wa@gmail.com).