Conservation Priorities and Actions for the Orders Cingulata, Pilosa, Afrosoricida, Macroscelidea, Eulipotyphla, Dermoptera and Scandentia.

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Citation:
Kennerley, R.J., Lacher, T.E. Jr., Mason, V., McCay, S., Roach, N., Stephenson, P.J., Superina, M. & Young, R.P. 2018. Conservation priorities and actions for the Orders Cingulata, Pilosa, Afrosoricida, Macroscelidea, Eulipotyphla, Dermoptera and Scandentia. Pp 15-27 in D.E. Wilson & R.A. Mittermeier (eds.), *Handbook of the Mammals of the World - Volume 8. Insectivores, Sloths and Colugos.* Lynx Edicions, Barcelona, Spain. ISBN: 9788416728084.

INTRODUCTION

Volume 8 of the Handbook of Mammals of the World is unlike many of the previous volumes; it contains an unusual compilation of a number of important, but smaller orders, which we now know have either distant or no taxonomic relation. The orders covered in this volume include Cingulata (the armadillos), Pilosa (the sloths and anteaters), Afrosoricida (the tenrecs and golden moles), Macroscelidea (elephant shrews), Eulipotyphla (shrews, moles, hedgehogs and solenodons), Dermoptera (colugos or flying lemurs), and Scandentia (tree shrews). Two of these orders, Cingulata and Pilosa, are sister groups in the superorder Xenarthra. This superorder is considered one of the basal orders of placental mammals, together with the superorder Afrotheria. This volume covers all the Xenarthra, including the only two extant orders. Several orders of Afrotheria have already been covered in previous volumes of the Handbook of Mammals of the World. The order Sirenia, manatees and dugongs, was covered in volume 4, Sea Mammals, and the orders Proboscidea (elephants), Hyracoidea (hyraxes), and Tubulidentata (aardvarks) were all addressed in volume 2, Hoofed Mammals. This volume treats the remaining two orders of Afrotheria: Macroscelidea and Afrosoricida. The orders Dermoptera and Scandentia are in the superorder Euarchontoglires, in a larger clade with Primates, Rodentia, and Lagomorpha. Dermoptera is considered the sister order to Primates, and recent research suggests Scandentia is either a basal clade in Euarchontoglires or sister to the clade that contains rodents and lagomorphs.

The remaining three orders in this volume have in the past been considered to be closely related. Indeed, five of the orders in volume 8 are part of the twisted history of the former order Insectivora, a loose polyphyletic assemblage no longer considered valid. In the 1967 volume of the Recent Mammals of the World, by Sidney Anderson and J. Knox Jones, chapter five addresses two orders, Insectivora, and Dermoptera. Although listed as a separate order, the colugos were at one time considered to be allied to the insectivores, primarily due to the presence of a more primitive insectivore-like three cusped pattern on the cheek teeth. This same arrangement was presented in the 1972 edition of Mammalogy by Terry A. Vaughan, where Insectivora and Dermoptera were covered as separate orders but in the same chapter.

The chapter on Insectivora in the 1967 Recent Mammals of the World, by James Findley, organized eight extant families in four of the orders from this volume into two clades, the Lipotyphlans and the Menotyphlans (Table 1). Advances in phylogenetic analyses, in particular the advent of molecular approaches, have revamped this “waste-basket” taxon and placed the families presented in the 1967 chapter, plus two additional families, into the current accepted phylogeny. They are now spread out across four mammalian superorders (Table 1), and many of the morphological traits that had clustered them all in Insectivora are now known to be examples of convergence associated with insectivorous habits. The presentation of these orders together in one volume, therefore, does capture the interesting past history of their collective taxonomy, and provides insights on the value of new approaches in phylogenetic analyses in clarifying evolutionary relationships.

The gold standard for assessing the potential risk of extinction is the International Union for Conservation of Nature’s *The IUCN Red List of Threatened Species*™. All species of mammals were assessed against IUCN criteria, and the results were published in 2008. Given

the rapid change in the global environment, species require re-evaluations every 4–10 years, and the process of completing a full reassessment of all the world's mammals is nearing completion. The status of mammals has been assessed twice previously with the leadership of IUCN and collaboration of several partner institutions. Mammals were previously assessed in 1996 and 2008. Where possible, previous assessors were invited to help revise the species drafts and other experts were consulted. This introductory chapter covers brief summaries of the seven orders with a focus on their current Red List status, risk of extinction, and conservation efforts. Authors of this chapter have been engaged with IUCN Species Specialists groups, and thus present a unique IUCN perspective on conservation priorities and actions for these diverse and important orders. The current process of reassessing all of the species of mammals in the world, to update the 2008 assessment, allows us the opportunity to present most up to date data on the status of these orders with regard to threat and state of knowledge (Table 2). Priority species for this analysis are those that are listed in one of the IUCN categories of threat (Vulnerable, Endangered, or Critically Endangered) and species for which there is a poor knowledge base and cannot be assessed using IUCN criteria (classified as Data Deficient).

Each section below also presents a selection of priority species for conservation action. For each species, its current *IUCN Red List* status along with its date of assessment, its Evolutionarily Distinct and Globally Endangered (EDGE) ranking, when available, and the countries in which it occurs are summarized below. Species with high EDGE rankings are those threatened species that represent a greater amount of unique evolutionary history. A brief discussion of each species that includes a summary, threats, and current and future conservation efforts, is also provided.

CINGULATA

Cingulata species are commonly known as armadillos. They are classified into two families, nine genera, and 20 recognized species, all of them restricted to the Americas. They are typical elements of the South American mammal fauna, with only two species occurring in Central America and one, the nine-banded armadillo *Dasypus novemcinctus*, having extended its range into North America. Armadillos range in body weight from 100 g to 40 kg. These burrowing mammals spend a significant proportion of their lives underground, and most have crepuscular or nocturnal habits. Some are difficult to observe in their natural habitat and are virtually unknown to science. Armadillos are natural predators of ants and other invertebrates and therefore play an important role as natural control agents of agricultural pests. In addition, armadillos oxygenate the soil and help nutrient cycling when digging for food or creating a burrow. The omnivorous species contribute to seed dispersal. Armadillos are an important food source for predators such as pumas, jaguars and other wild carnivores, as well as of raptors and large snakes.

The few extant armadillo species that remain are a small remnant of a highly diverse and abundant assemblage that populated the Neotropic from the middle Eocene. More than 100 fossil armadillo genera have been described to date, including enormous species reaching a body mass of around 2000 kg. The greatest declines in diversity occurred during the Pleistocene, with no extinctions recorded in recent times. Only two out of 20 extant

Cingulata are listed in a threatened category on *The IUCN Red List*, which may give the impression that armadillos are not facing significant threats. Only four species have, however, stable populations, whereas the population trend is decreasing in six and unknown in ten species. Five species are listed as Near Threatened and may be included in a threatened category in the near future. More importantly, 25% of all Cingulata are so poorly known that they are considered Data Deficient. The latter reflects one of the most pressing problems for realistically assessing the conservation status of Cingulata: there is a well known lack of conservation-relevant information for most species. The majority of ecological research has focused on only four armadillo species, and extrapolations to other Cingulata are difficult, due to their highly variable ecological requirements. This lack of solid data is largely due to the small number of researchers conducting field research on Cingulata, but also to the difficulties of studying them in the wild. It is probable that changes in the Red List category of species will be necessary as more field data become available. Indeed, in 2015 the Northern Long-nosed Armadillo *Dasypus sabanicola* was re-categorized from Least Concern to Near Threatened, because fieldwork by the Conservation and Management Program for the Armadillos of the Llanos of Colombia, a program endorsed by the IUCN SSC Anteater, Sloth and Armadillo Specialist Group (ASASG), revealed that it was affected by a serious increase in hunting pressure as well as a significant reduction in habitat quantity and quality.

Three other species underwent non-genuine changes in the three re-assessments performed by the ASASG since 2006. All of them were re-categorized to Data Deficient because the lack of information on their distribution, population size and trends, and threats did not justify their previous listing as Vulnerable (*Dasypus pilosus*) or Near Threatened (*Chlamyphorus truncatus* and *Calyptophractus retusus*). Ongoing taxonomic revisions are also expected to lead to changes in *The Red List* categories of Cingulata. Recent molecular and morphometric analyses revealed that the Andean Hairy Armadillo *Chaetophractus nationi*, which inhabits high altitudes in Bolivia, northern Chile, and northern Argentina, was not a valid species. As a consequence, this Vulnerable species was synonymized with the Screaming Hairy Armadillo *Chaetophractus vellerosus* (present at lower altitudes in Bolivia, Chile, Paraguay, and Argentina) and listed as Least Concern mainly due to its wide range. Nevertheless, the high-altitude populations require conservation attention due to their intense harvesting for use in the manufacture of traditional musical instruments and handicrafts. Morphological analyses of the Greater Long-nosed Armadillo *Dasypus kappleri* support its splitting into three separate species, but molecular studies are needed to confirm this. This species is currently listed as Least Concern due to its large geographic distribution. Splitting it into several species may well lead to at least one of them being included in a threatened category, as *D. kappleri* is restricted to pristine tropical rainforests, which are rapidly disappearing.

Virtually all armadillo species are hunted throughout their range. They are mainly used as a protein source, but some species are persecuted and killed due to cultural beliefs or because they are considered a pest. Habitat reduction and degradation are other significant threats affecting most Cingulata. Some species, such as the Hairy Armadillo *Chaetophractus villosus*, can adapt to land use change and thrive in agricultural plantations, whereas others, such as the Giant Armadillo *Priodontes maximus*, are restricted to pristine habitats and seem

to be very susceptible to habitat loss and transformation. Other threats to Cingulata include road traffic and predation by dogs and cats. The use of insecticides, which reduce the availability of their main food, is thought to take its toll on several species but needs to be assessed.

Conservation efforts for Cingulata are scarce. As they are traditionally not considered charismatic species, they attract less public interest and funding opportunities than large, charismatic mammals. Field research is, however, urgently needed to understand the ecological needs of armadillos, the threats that are affecting them, and to develop and implement effective conservation strategies.

PILOSA

The Order Pilosa comprises two disparate suborders, Folivora (sloths) and Vermilingua (anteaters). Although at first sight sloths and anteaters do not seem to have much in common, together with the Cingulata they form an ancient lineage of placental mammals that share a variety of different unique characteristics. One of them, the presence of additional articulations on their vertebrae, gave rise to the name of the superorder Xenarthra that includes anteaters, sloths, and armadillos. Folivora includes two families, two genera, and six species of sloths; the name of the order points to their diet, which consists primarily of leaves. The insectivorous suborder Vermilingua contains two families, three genera, and ten species of anteaters. All Pilosa are restricted to the Neotropic.

All extant Folivora are arboreal, with the smallest species weighing around 2.5 kg and the largest up to 12 kg. The oldest fossil records of Folivora date back to the late Oligocene and were recovered from southern South America. The rich and highly diverse fossil record includes over fifty taxa of ground dwelling sloth species,but no arboreal ones, which makes it difficult to understand the origin and diversification of the Folivora. Most species of ground sloths went extinct by the end of the Pleistocene, with only a few species surviving until the middle-late Holocene. No extinctions are known to have occurred since 1600.
Cryptic, slow-moving, and restricted to the forest canopy (or, less frequently, to canopy trees in agricultural landscapes), tree sloths are difficult to study in the wild. As a consequence, information on their ecology, population densities and trends, and even their exact distribution, is scarce. The populations of the four Folivora species having the widest distribution are presumably large, because of which they are classed as Least Concern on *The IUCN Red List*. Local declines have, however, occurred, and can mainly be attributed to habitat loss; the ability of Folivora to adapt to disturbed habitats is limited, as they depend on canopy trees to survive. Habitat loss and fragmentation has already affected one sloth species, the Maned Three-toed Sloth *Bradypus torquatus*, at a level that led to its categorization as Vulnerable on *The Red List*, and is driving the Pygmy Sloth *Bradypus pygmaeus*, listed as Critically Endangered, to the brink of extinction.

Poaching is increasingly affecting Folivora and is reaching worrying levels, especially in Colombia. The impact of hunting of sloths for consumption of their meat or their use in traditional medicine, is negligible, as it is limited to some rural and indigenous communities. However, poaching of sloths to supply the (illegal) pet trade is reaching alarming levels in

some parts of their range. Poachers kill sloth females to get hold of their young, which are then illegally sold to tourists or exported for the pet trade in other countries. Mortality rates of these offspring are extremely high, both shortly after capture and after they are sold as pets because they fail to adapt to captivity or are kept in inappropriate conditions.

Vermilingua species show a notable variation in size and habits. The smallest anteater species weigh around 300 g and are exclusively arboreal, whereas the largest species is terrestrial and has a body mass of up to 40 kg. The two species of intermediate size are semi-arboreal. Fossil records of Vermilingua are scarce and fragmentary.

Vermilingua play a vital role in ecosystem functioning, because they control insect communities and are a food source for large predators. Although visually attractive and charismatic, only few scientists are performing research on anteaters. The Giant Anteater *Myrmecophaga tridactyla* has been the subject of far more scientific research than the other Vermilingua, but gaps in knowledge abound even for this species. As a consequence, there is limited knowledge of their ecological needs, the threats affecting them, and their ability to adapt to a changing environment, which hinders the realistic assessment of their conservation status. The Giant Anteater is the only Vermilingua species currently listed in a threatened category, whereas the other species are listed as Least Concern because they are considered widespread and abundant. There is no doubt that habitat loss and fragmentation is affecting all Vermilingua. Additional threats are associated to other human activities, such as road traffic, fires, poaching, and attacks by dogs. Because they feed almost exclusively on ants and termites, it is probable that they are also affected by the use of pesticides; indeed, some Giant Anteater deaths have been attributed to the use of chemical agents against ants.

Taxonomic uncertainties exist for all Vermilingua, which has important implications for the assessment of their conservation status and the development of conservation plans. This was recently evidenced by a thorough, decade-long study on the taxonomy of *Cyclopes* that revealed that the only recognized silky anteater, *Cyclopes didactylus*, was in fact a species complex comprising seven different species. The original species was categorized as Least Concern on *The IUCN Red List* primarily due to its wide distribution and presumably large population. The seven recently recognized species of silky anteaters will, however, require a careful assessment of their conservation status. At least two of them inhabit areas that are facing an increasing pressure from human activities, especially mining and agriculture, that may warrant listing them in a threatened category and require conservation action. Conservation efforts for Pilosa are limited to certain areas and species. As with Cingulata, conservation-relevant research is direly needed, but funding opportunities are scarce.

Developing Conservation Priorities for Cingulata and Pilosa

Formerly known as Edentate Specialist Group, the ASASG was established in 1980 to initiate conservation efforts for armadillos, sloths, anteaters, “and other Edentates”. The latter refers to Pholidota and Tubulidentata, which were once thought to be closely related to the former. Molecular studies have, however, shown that they belong to different basal clades of placental mammals. The ASASG is responsible for two different orders of mammals, the Cingulata and Pilosa, which together form the Superorder Xenarthra. The ASASG is made up

of 25 world experts, who volunteer their time and exceptional knowledge to advance conservation of these fascinating species.

Although it cannot be stressed enough that Cingulata and Pilosa should not be kept as pets, the ASASG has registered an alarming increase in the number of animals rescued from the illegal trade or from private persons who (illegally) kept them in inappropriate conditions. Unlike many other IUCN SSC Specialist Groups, a considerable proportion of members of the ASASG, therefore, work partially or exclusively in zoological institutions or rehabilitation centers. Their expertise is key to increasing survival rates of confiscated and rescued animals, improving the husbandry conditions of individuals under human care, and developing ex-situ conservation and reintroduction programs. In parallel, these members are vital for reaching another goal of the ASASG: disseminating information about Cingulata and Pilosa and raising awareness about their conservation needs among the general public.

Five armadillo species are so poorly known that their extinction risk cannot be assessed, but significant gaps in knowledge exist even for those Cingulata and Pilosa whose conservation status has been evaluated for *The IUCN Red List*. Xenarthrans are largely tropical in distribution, with richness peaking in several focal areas in the Amazon basin, with another peak in the region of the Pantanal and Chaco (Figure 1a). The map of threat, however, is highest in a region of transition between the Amazon basin the Caatinga of northeastern Brazil (Figure 1b), so identifying key areas for conservation emphasis in this region is critical. One of the priorities of the ASASG is, therefore, to increase the knowledge on the ecology, population numbers and trends, and threats affecting Cingulata and Pilosa. These data will be key to understanding the effective conservation status of species and the threats they are facing, defining taxonomic and regional conservation priorities, and developing effective action plans. Due to the low number of researchers currently working with Cingulata and Pilosa, this goal requires that the ASASG intensifies its efforts in training and capacity building. Teaching courses for students and professionals, providing technical advice to researchers and authorities, disseminating scientific information through the ASASG's newsletter and journal Edentata, and supporting research and conservation programs, are some of the approaches used. In the long term, capacity building will also allow the ASASG to reach its goal of having at least one expert for each species' range country among its members. This is currently not possible because no research or conservation action for Cingulata or Pilosa exists in some range countries. These training, research and conservation efforts will of course require significant economical investments. Creative approaches will be needed to overcome the challenge of obtaining funding to study these species that have traditionally been neglected by the scientific community and excluded from conservation programs.

Priority Cingulata Species

Brazilian Three-banded Armadillo (*Tolypeutes tricinctus*)
***The IUCN Red List* status, VU (2015); EDGE ranking N/A; Country: Brazil**
***Description**:* The Brazilian Three-banded Armadillo is one of only two Cingulata species that are capable of rolling themselves into a ball when feeling threatened. It is endemic to the semiarid arboreal and scrub caatinga of northeastern Brazil; few records exist from the bush

savanna of the Cerrado. This rare species with patchy distribution occurs at extremely low densities near populated places. It was thought to be extinct until its rediscovery in 1988. The species is now mainly restricted to protected areas and regions with undisturbed habitat and low human densities.

***Major Threats**:* The Brazilian Three-banded Armadillo is subject to intense hunting pressure for food. It is also affected by habitat reduction and modification, especially the conversion of its natural habitat to sugar cane and soybean plantations. Local extinctions have been recorded.

***Current Conservation Efforts**:* An Action Plan is in place for the species. The Three-banded Armadillo Program, led by Associação Caatinga and endorsed by the ASASG, is currently focusing on field research to collect basic information on its ecology and threats, the establishment of an ex-situ conservation program, and the declaration of state and national parks that will provide effective protection.

Giant Armadillo (*Priodontes maximus*)

***The IUCN Red List* status, VU (2015); EDGE ranking N/A; Countries: Argentina, Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Venezuela. Probably extinct in Uruguay.**

***Description**:* The Giant Armadillo is the largest of all extant armadillos. Although its range extends over a large proportion of South America, it has a patchy distribution and always occurs at low densities. It can be found in undisturbed forests and savannas.

***Major Threats**:* The Giant Armadillo population has suffered a decline of at least 30% over the past 20 years and has become locally extirpated in some areas. Habitat loss and fragmentation due to deforestation and land use change are heavily affecting this species. It is also hunted for meat and sometimes collected for illegal trafficking. As a consequence, the Giant Armadillo is listed in a threatened category in eight out of eleven range countries.

***Current Conservation Efforts**:* The Programa de Conservación y Manejo de los Armadillos de los Llanos Orientales (Conservation and Management Program for the Armadillos of the Llanos of Colombia), led by Fundación Omacha and endorsed by the ASASG, is performing research as well as awareness and education programs on Giant Armadillos and other Cingulata in the Orinoco Llanos of Colombia as part of a regional Armadillo Action Plan. In Brazil, the Giant Armadillo Project is carrying out research and performing an awareness program on the species. A long-term research and conservation project on Giant Armadillos is being initiated in Argentina.

Priority Pilosa Species

Pygmy Sloth (*Bradypus pygmaeus*)

***The IUCN Red List* status, CR (2015); EDGE ranking 21; Country: Panama**

***Description**:* This smallest of all sloths is endemic to Escudo de Veraguas, a small island of 4.3 km^2 in the Bocas del Toro archipelago, Panama, where it primarily inhabits red mangroves (*Rhizophora mangle*). Recent studies suggest that the species also uses the dense tropical rainforest on the interior of the island. No accurate information is available, but the total population size is likely to be relatively small.

***Major Threats**:* Seasonal visitors to the island harvest timber, thus reducing the suitable habitat for the Pygmy Sloth. Additionally, as it has become more widely recognized internationally, there is growing interest in collecting them for captivity. This is considered a threat because *Bradypus* sloths are notoriously difficult to keep under human care and have never bred in controlled conditions. Although Escudo de Veraguas has been designated as a protected landscape, there are plans for developing tourism infrastructure on the small island that would further reduce the available habitat quality and quantity. It would also lead to an increase in visitors to the island, which represents a stress factor for native wildlife, including sloths.
***Current Conservation Efforts**:* Current efforts focus on raising awareness, involving the local community in conservation efforts, and increasing scientific knowledge about the species. A comprehensive conservation plan, using the Pygmy Sloth as a flagship species, is underway to protect the island. It will bring together the local community, wildlife authorities in Panama, the ASASG, and the national and international scientific community.

Maned Three-toed Sloth (*Bradypus torquatus*)
***The IUCN Red List* status, VU (2015); EDGE ranking N/A; Country: Brazil**
***Description**:* As its common name implies, the Maned Three-toed Sloth has a black mane around the dorsal regions of the neck. This species only occurs in three isolated subpopulations in the Atlantic coastal forests of eastern Brazil. The population density is not well known. Although some animals have been observed in forest fragments as small as 20 hectares, the long-term persistence at these sites is unknown, especially because of its limited dispersal behavior.
***Major Threats**:* Its population is fragmented and exhibits little genetic diversity. Deforestation for land use change and city sprawl is severely affecting the species through the continuing loss and fragmentation of suitable habitat. Up to 90% of the forest in this densely populated area of Brazil has already been lost, and the remaining Atlantic forest is highly fragmented. Additional threats include subsistence hunting and accidental mortality on roads.
***Current Conservation Efforts**:* It is included in the Action Recovery Plan for mammals of the Central Atlantic Forest.

Giant Anteater (*Myrmecophaga tridactyla*)
***The IUCN Red List* status, VU (2015); EDGE ranking 149; Countries: Argentina, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, French Guiana, Guyana, Honduras, Nicaragua, Panama, Paraguay, Peru, Suriname, Venezuela**
***Description**:* The Giant Anteater can be easily recognized by its elongated rostrum, long bushy tail and the characteristic dark fur with a black band with white outlines stretching from the throat to the shoulder. Although widespread geographically, it is locally uncommon to rare. It can be found in a notable diversity of landscapes, ranging from grasslands and savannas to forests. It requires large areas with forested patches for its survival.
***Major Threats**:* The dietary specificity, low reproductive rates, large body size, along with threats affecting the species have proved to be significant factors contributing to its decline. Habitat loss is taking a heavy toll on the population. In grassland habitat, the species is

particularly susceptible to fires. Road traffic is another significant threat to the species. In some areas, it is hunted for food, as a pest, for pets, or for illegal trade. It is considered to be the most threatened mammal of Central America, where it has disappeared from much of its range. Local extinctions have also occurred in the southern parts of its range. It is listed in a threatened category in almost all regional and national Red Lists.

***Current Conservation Efforts**:* The Instituto de Pesquisa e Conservação de Tamanduás do Brasil (Institute for Research and Conservation of Brazilian Anteaters; Projeto Tamanduá) has been performing research, education and awareness programs, and conservation actions for Giant Anteaters in different parts of Brazil since 2005. More recently, Fundación Cunaguaro initiated a conservation program in Colombia. In Argentina, The Conservation Land Trust has rescued and released around 100 individuals as part of a restoration program in the Iberá Wetlands that was initiated in 2006.

AFROTHERIA: ORDERS AFROSORICIDA AND MACROSCELIDEA

The orders Afrosoricida and Macroscelidea are African and Malagasy small mammals, placed within the supercohort Afrotheria with phylogenetically related species (hyraxes, elephants, sirenians and the aardvark). The Afrosoricida comprises three families: the tenrecs (Tenrecidae), 31 species endemic to Madagascar; the otter shrews (Potamogalidae; sometimes considered a subfamily of the Tenrecidae), three semi-aquatic species from central and west Africa; and the golden moles (Chrysochloridae), 21 fossorial species, mostly from southern Africa. The Macroscelidea comprises 20 species of sengi (formerly known as elephant-shrews) found across Africa. Common traits of the two orders include African origins, small body size (under 1 kg), a diet comprised primarily of invertebrates, abdominal testes and (in several species) the use of torpor to conserve energy. Most species are primarily nocturnal. Taxonomy is labile in both orders, with revisions ongoing. New species are still being described, the most recent in each order being Grandidier's Shrew Tenrec (*Microgale grandidieri*) in 2009 and the Etendeka Round-eared Sengi (*Macroscelides micus*) in 2014.

Tenrecs underwent a huge adaptive radiation on Madagascar to fill a variety of niches, with convergent evolution leading to physical traits similar to other orders. Large species adapted for foraging on the ground evolved defensive spines and look like hedgehogs (such as the Tailless Tenrec *Tenrec ecaudatus* and the Greater Hedgehog Tenrec *Setifer setosus*). Smaller species found on the forest floor or climbing trees look like shrews (shrew tenrecs in the genera *Microgale* and *Nesogale*); and mole tenrecs (genus *Oryzorictes*) have adapted to burrowing under leaf litter. The Aquatic Tenrec (*Microgale mergulus*) is adapted morphologically and physiologically to life in water. Dietary specializations include earthworms (mole tenrecs, streaked tenrecs) termites (the Large-eared Tenrec, *Geogale aurita*) and aquatic invertebrates (Aquatic Tenrec). Tenrecs also have a diversity of reproductive strategies, some having small numbers of slow-developing young (e.g. *Nesogale talazaci*, *Geogale aurita*), others having larger litters of more quickly developing young (*Hemicentetes semispinosus, Tenrec ecaudatus* – the latter having up to 32 neonates, the second largest litter size in the Mammalia). The Large-eared Tenrec is one of the few placental mammals to exhibit post-partum oestrus, where lactating females can be pregnant

with a second litter. Streaked tenrecs (*Hemicentetes*) evolved a unique stridulating organ where spines on their backs rub together to create ultrasound for communication. Tenrecs are mostly found in forest habitats, although some prefer shrublands and grasslands. Modern genetic techniques are helping discover cryptic species, especially among the shrew tenrecs and mole tenrecs, and more species will be described in coming years.

Otter shrews resemble small otters in appearance. The tail is the main propulsion for swimming; only the Ruwenzori Otter Shrew *Micropotamogale ruwenzorii* has webbed feet. They are found in rivers, streams and pools in the forests of central and west Africa where they feed on aquatic invertebrates, fish and amphibians. The Giant Otter Shrew *Potamogale velox* has a preference for crabs.

Golden moles are adapted for a fossorial existence, with fusiform bodies, wedge-shaped heads, vestigial eyes, absence of ear pinnae and sturdy, clawed forelimbs for digging. They occur in a range of habitats from arid and desert environments (e.g. Grant's Golden Mole, *Eremitalpa granti*) to grasslands and savannas (e.g. Robust Golden Mole, *Amblysomus robustis*) and to forests (e.g. Congo Golden Mole, *Huetia leucorhina*) but are generally restricted to soils that are easy to dig through and that have sufficient invertebrate prey (earthworms are particularly favoured). Several species (including the Hottentot Golden Mole, *Amblysomus hottentotus*, and Duthie's Golden Mole, *Chlorotalpa duthieae*) can thrive in human environments such as gardens and golf courses. Most species feed underground in tunnels, foraging more actively after rain has made the soil softer and prey more abundant. The Fynbos Golden Mole (*Amblysomus corriae*) sometimes catches prey on the surface, dragging it below ground to eat. Like many tenrecs, golden moles have relatively low metabolic rates for their body size, are often heterothermic and sometimes enter daily or seasonal torpor. Little is known of their reproduction, though litter sizes appear to be small – just 1-3 neonates. Two species – the Somali Golden Mole (*Calcochloris tytonis*) and Visagie's Golden Mole (*Chrysochloris visagiei*) – are known only from the type specimens.

Sengis are characterised by extended rear limbs (adapted for running and leaping), elongated snouts and well-developed eyes and ears. Their life history features include limited use of nests, social monogamy, and absentee maternal care of neonates. Sengi metabolic rates are higher than many other Afrosoricids, though some species enter daily torpor. All species feed on invertebrates, though smaller species like the Karoo Round-eared Sengi (*Macroscelides proboscideus)* specialise in ants and termites and supplement their diet with fruits, seeds, and green plant matter. Most species reside singly or in monogamous pairs. Young are born precocial in small litters of 1-2 neonates, although the young of larger species like the Golden-rumped Sengi (*Rhynchocyon chrysopygus*) are more altricial. Sengis are found across Africa, except for the west and the Sahara. *Rhynchoycon* species and *Petrodromus* species are largely confined to lowland and montane forests and dense woodlands, while species in the genera *Elephantulus* and *Macroscelides* are found in savannas, scrublands, rocky outcrops and deserts. *Rhynchocyon* species are diurnal; other species are crepuscular and active day and night. The bizarre morphology and behaviour of sengis represent a merging of features usually associated with either small antelopes or anteaters.

Developing Conservation Priorities for Afrosoricida and Macroscelidea

The IUCN SSC Afrotheria Specialist Group (www.afrotheria.net) facilitates the conservation of sengis, golden moles, tenrecs and otter shrews (as well as hyraxes and the aardvark) and their habitats by providing scientific advice and guidance to governments and NGOs and developing research and conservation programmes. The group maintains 30-40 members, scientists with knowledge of the species and their habitats. With so much of the research and conservation attention in Africa and Madagascar focused on larger mammal species, especially primates, carnivores and pachyderms, it remains a challenge to gain interest in smaller mammals. Therefore, a large role for the group is to raise awareness of the target species and to find ways to integrate their needs into broader conservation and sustainable development programmes.

Forty-eight per cent of golden moles are considered threatened in the IUCN Red List (1 CR, 5 EN, 4 VU), an exceptionally high proportion for any mammalian taxon. A third of otter shrews (1 VU), 18% of tenrecs (2 EN, 4 VU) and 11% of sengis (1 EN, 1 VU) are also under threat of extinction, and 2 golden moles are Near Threatened. The greatest threat to these species, as with all small mammals, is habitat loss, degradation and fragmentation. In most cases land conversion is driven by agriculture, logging of timber and urbanization. Mining – for coal, iron ore or minerals – is also a major driver of habitat loss across Africa and Madagascar, and is a significant problem for species like the Nimba Otter Shrew (*Micropotamogale lamottei*; threatened by iron ore mining in Guinea and Liberia), the Rough-haired Golden Mole (*Chrysospalax villosus*; coal in South Africa) and Juliana's golden mole (*Neamblysomus julianae*; quartzite in South Africa). Gem mining, especially for sapphires, is also a threat to many forests important for tenrecs in Madagascar. Other disturbance, such as uncontrolled fires and trampling by cattle and tourists, may cause the loss of key microhabitats. Another common threat is climate change. Although little modelling has been conducted for small mammals, work on larger mammals and their habitats suggests human-induced climate change will impact heavily on the available niches and cause changes or reductions in the projected ranges for many species. Some of the larger tenrecs (especially the Tailless Tenrec, *Tenrec ecaudatus)* and sengis (e.g. the Chequered Sengi, *Rhynchocyon cirnei*) are hunted for food. The Giant Otter Shrew (*Potamogale velox*) is widely hunted for its skin. Golden moles are sometimes killed by domestic dogs and cats or by gardeners protecting their lawns. The Aquatic Tenrec and all three otter shrews are threatened by incidental capture and drowning in fishing nets, as well as the silting up of rivers due to deforestation.

The main conservation action required for Afrosoricids and Macroscelids is the protection of suitable habitat, primarily through the creation and effective management of protected areas. Sustainable forest management regimes may also be successful if adequate habitat is retained. Habitat restoration may be needed in some sites impacted by mining or logging. Across the two orders, the proportion of species distributions that falls within protected areas needs to be identified, to help pinpoint priority conservation sites still needing protection. In key protected areas housing threatened species, the monitoring of small mammals needs to be integrated into reserve management to track species population trends and threats, and to produce more data for IUCN Red List assessments and local conservation planning. This will in some cases require the development of standardized

monitoring protocols adapted to local needs and habitats, using modern techniques such as camera trapping and specialized techniques for hard-to-trap fossorial, arboreal and aquatic species. Many small mammals are good indicators of habitat health and diversity and more effort is needed to use some of the unique and spectacular Afrosoricids and Macroscelids as flagships for broader environmental conservation. For example, otter shrews and the Aquatic Tenrec would make ideal flagship species for integrated forest and freshwater conservation programmes in eastern Madagascar and central-west Africa. Work to conserve forest habitats and maintain clear unsilted streams will benefit not only aquatic mammals but a range of other plant and animal life, as well as local people. Similarly, the Golden-rumped Sengi could be a flagship for coastal forest conservation in Kenya and several golden mole species the focus of conservation in a range of habitats in southern Africa.

Conservation of all species is hindered by the lack of adequate data on species distributions, abundance, habitat needs and threats, as well as ongoing confusion over taxonomy. Therefore, dedicated research projects targeting key information gaps are essential. Research priorities include quantifying the impact of hunting. If species offtake is causing significant declines and is unsustainable, lobbying for appropriate legislation may be required to protect the species concerned. In many cases, improving protected area management and stopping hunting in reserves should be adequate. Similarly, the degree to which bycatch is affecting aquatic species populations needs to be investigated and relevant action taken. Other research priorities include implementing a concerted survey programme to find and study the eight Data Deficient species which have only been recorded in a handful of locations: these are the Four-toed Mole Tenrec *Oryzorictes tetradacylus* (Madagascar), the Dusky Sengi *Elephantulus fuscus* (southern Africa), the Karoo Rock Sengi *Elephantulus pilicaudus* (South Africa), the Congo Golden Mole *Huetia leucorhina* (central Africa), the Somali Golden Mole *Calcochloris tytonis* (Somalia), Visagie's Golden Mole *Chrysochloris visagiei* (South Africa), the Somali Sengi *Elephantulus revoilii* (Somalia) and the Dusky-footed Sengi *Elephantulus fuscipes* (central Africa). The last four species listed have not been recorded in over 50 years so may even be extinct! Conclusively resolving ongoing taxonomic confusion, and identifying cryptic species, will require concerted genetic studies. Integrating their findings with data on morphology, distribution, ecology, physiology and behaviour is essential. Species of priority for taxonomic studies include the genera *Microgale*, *Oryzorictes* and *Rhynchocyon*, Juliana's golden mole and the three Data Deficient species of golden mole.

Priority Species of Afrosoricida and Macroscelidea

Aquatic Tenrec (*Microgale mergulus*)
IUCN Red List: VU (2016); EDGE ranking 234; Country: Madagascar
***Description**:* Although this species was previously allocated its own genus (*Limnogale*) and is morphologically, behaviourally, ecologically and physiologically distinct, genetic evidence suggests it is a synonym of the genus *Microgale.* Aquatic Tenrecs are known from only 10 sites in Madagascar where they are restricted to free-flowing, unpolluted streams with an abundance of invertebrate prey. They appear to live at low population densities.

***Major Threats**:* The species is threatened by incidental capture in fish traps and by deforestation causing siltation of rivers and streams.
***Current conservation efforts**:* There are no conservation projects specifically targeting the species. Conservation will depend on the management of key protected areas in its range: Ambositra-Vondrozo Forest Corridor Natural Resource, Andringitra National Park and Ranomafana National Park. More effort is needed to identify key river habitats for the species and reduce deforestation that is causing siltation. Some fishing communities may also need to be encouraged to alter fishing techniques to avoid bycatch.

Nimba Otter Shrew (*Micropotamogale lamottei*)
IUCN Red List status, VU (2018); EDGE ranking, N/A; Country: Côte d'Ivoire, Guinea, Liberia.
***Description**:* The species is endemic to a small region of west Africa: the Nimba mountains of Liberia, Guinea and Côte d'Ivoire and the mountains of the Putu Range, Liberia. It appears to be largely solitary, occurring at low population densities.
***Major Threats**:* The mountains in the species range have been severely impacted by large-scale iron ore mining operations. In addition, individuals are drowned in fish nets.
***Current conservation efforts**:* This species is present in the Mount Nimba Strict Nature Reserve, a UNESCO World Heritage site in Guinea and Côte d'Ivoire. However the reserve is threatened by a mining enclave, poaching and fires, and is considered a World Heritage Site in Danger. The species has also recently been recorded in East Nimba Nature Reserve in Liberia. Only improved management of these two protected areas can ensure survival of the species.

Golden-rumped Sengi *(Rhynchocyon chrysopygus)*
IUCN Red List status, EN (2015); EDGE ranking, 57; Country: Kenya.
***Description**:* Occurs in small, highly fragmented patches of coastal forest in Kenya where populations at studied sites have been declining for at least 25 years.
***Major Threats**:* The major threat to this species is habitat loss. Many of the small kaya (sacred) forests in its range have been severely degraded by tree-felling and pole collecting, and their boundaries eroded by agricultural encroachment and fire. Within the larger Arabuko-Sokoke Forest, the species appears to be adversely affected by logging. Some animals are also trapped for food.
***Current Conservation Efforts**:* The main hope for the species is the conservation of Arabuko-Sokoke Forest, managed jointly by the Forest Department and Kenya Wildlife Service and the recipient of support from Nature Kenya and international donors. In addition, Kaya forests need to better protected and their sengi populations monitored.

Juliana's Golden Mole (*Neamblysomus julianae)*
IUCN Red List status, EN (2015); EDGE ranking, 103; Country: South Africa.
***Description**:* Known from only three isolated and range-restricted subpopulations in South Africa.

***Major Threats**:* The main threat is habitat loss, modification and fragmentation as a result of urbanization, agriculture and quartzite mining. Minor threats are predation by domestic pets and persecution by gardeners and land owners.
***Current Conservation Efforts**:* Two of the three known subpopulations are protected within the Kruger National Park (south-western Pretoriuskop, Matjulwana and Numbi gate areas) and Nylsvley Provincial Nature Reserve, but the most threatened Bronberg Ridge subpopulation is unprotected and is considered Critically Endangered. Lobbying for stronger legal protection of the species is needed.

EULIPOTYPHLA

Eulipotyphla is the order in this volume which contains the most species, widely distributed across the globe, with species found on all continents except Antarctica. They are largely absent from the Arctic. In the New World they occur in North and Central America, including the Caribbean islands, but only as far south as Peru in South America. In the Old World they are found almost everywhere, except mainland Australia and New Zealand, as well as being largely absent in most of the Sahara desert region and the upper reaches of the Himalayas. A number of Eulipotyphla have become so adaptable and successful that they are considered invasive species. Such is the case with the Asian House Shrew (*Suncus murinus*), which is listed on the Global Invasive Species Database (GISD), having been introduced as a result of human activities to parts of Africa, coastal Arabia, and islands in the Indian Ocean, plus many other islands. It causes damage to native flora and fauna, since for example it is considered to have contributed to the wiping out of reptiles on several islands.

Most of the Eulipotyphlans have a fairly generalized diet consisting mainly of invertebrate prey, hence their common name of “insectivores”. However, different groups within the order show a remarkable range of adaptations to different lifestyles and ecological habitats. Moles are highly specialized for subterranean burrowing, with powerful forelimbs and large paws, and reduced eyes and ears; whereas water shrews and desmans have become adapted to hunting in fast-flowing streams and rivers. Hedgehogs have instead evolved extremely specialized defensive adaptations, with an armoury of spines and the ability to roll up into a protective ball, using highly developed back muscles. Several Eulipotyphlans are also venomous – several species of shrews and moles are known to have venomous saliva for paralyzing their prey, and the two living species of solenodon also have specialized grooves in their teeth for delivering venom directly from modified salivary glands. The order contains some species which have truly ancient lineages, and are sometimes described as ‘living fossils’. Such is the case for the two species of Solenodons, one of which is endemic to the island of Hispaniola and the other to Cuba. Solenodons diverged from other mammals over 70 million years ago, meaning they shared the planet for some time with dinosaurs.

Amongst the oddities on the EDGE top 100 mammals list is the Nelson's Small-eared Shrew (*Cryptotis nelsoni*), which is a Critically Endangered species endemic to the forested slopes of a small volcano in southern Mexico. An eruption of the volcano back in 1793 destroyed the vegetation around the crater. However, the shrew survived this event, as it was rediscovered in 1894, and the volcano is now extinct. For some time it was not seen

again, leading scientists to think that it might have disappeared altogether. A survey in 2003 provided good news, with three individuals located in the same area in which it was first discovered. The species has a very small range, which is under pressure from human activities, such as logging, cattle grazing, fires and agriculture.

The Red List currently recognises 461 species of extant Eulipotyphla. This number is creeping upwards, as research continues to help us better understand the true diversity that exists. Such is the case with the Armored Shrew (*Scutisorex somereni*) which was previously a single species in its genus, found in Central Africa within the Congo Basin and adjacent mountain range. However, in recent years, Thor's Hero Shrew (*Scutisorex thori*) was discovered and described in the Democratic Republic of the Congo. These species have a spinal structure which is unique amongst all mammals, because it is extremely thick, with vertebrae that interlock like the teeth of two combs. This means that relative to its body mass, the spine of the hero shrew is stronger than that of any other vertebrate.

The newly described Batak Shrew (*Crocidura batakorum*) is known from just a single specimen which was found in a small cave, though it is thought that it has wide distribution across Palawan Island in the Philippines. This serves to illustrate the degree of poor knowledge about many of the other species in this order; when it is assessed for the first time on the Red List, it will be listed as Data Deficient.

Whilst new species are being discovered, it is important to acknowledge some notable extinctions that have taken place within Eulipotyphla in the recent past. For example, the sad loss of whole families, such as the West Indian Shrews (Nesophontidae). To date, at least six species have been described. These are thought to have become extinct shortly after the arrival of Europeans in the Caribbean, just over 500 years ago, probably due to the introduction and subsequent ecological release of black rats (*Rattus rattus*). We are also likely to be continuing to be losing species, as is the case with the Christmas Island Shrew (*Crocidura trichura*). Australia's only native shrew is currently listed as Critically Endangered. At the end of the nineteenth century when people settled on the Island the species was widespread. However, by 1908 it had declined so rapidly that is was presumed extinct, having succumbed to the same disease, trypanosomisis, that wiped out two endemic rodents during that decade. Then in 1985, two shrews were found in separate forest patches, though intensive survey efforts since 2000 have failed to rediscover it. The species may well now be extinct, with extensive clearance of its rainforest habitat for mining, introduced diseases, and invasive predators all playing a role in its demise.

Studying the relationships of groups of eulipotyphla has revealed we have more than we previously thought. For example, as has been understood when recently unravelling the complex taxonomy of the *Crocidura monax* clade. Morphometric traits and phylogenetic analysis was used to examine the species clade from the montane islands of Tanzania. These analyses revealed several distinct lineages, which are treated as six allopatric species: *C. monax*, *C. tansaniana*, and *C. usambarae*, and three new species (*C. mdumai*, *C. munissii*, *C. newmarki).*

Developing Conservation Priorities for Eulipotyphla

The IUCN SSC Small Mammal Specialist Group (SMSG) (http://www.small-mammals.org/) is responsible for three different orders of mammals that account for more than half of all

mammal species: Eulipotyphla, Scandentia (see later section in this chapter), and Rodentia. Formed in 2011, the SMSG is an expanding global network of scientists and conservationists numbering over 120 members, who are the world's experts on these small mammals. For the majority of the Eulipotyphla species there is a lack of even basic ecological knowledge and very few people are working to conserve them. This means that the group must ensure that where possible more research takes place and information is gathered to better inform the conservation status of these species. The SMSG works to ensure that strategic priorities are set, as well as to support the implementation of practical conservation actions in the field. The group is implementing three programmes of work to encourage people to care, research and help to conserve small mammals. Firstly, promoting small mammal conservation within the world's leading zoos, whether that be in playing a greater role in captive breeding for conservation purposes or providing more funding and expertise to in-situ conservation efforts in the field. Secondly, it is developing champions for key small mammal species which would include assistance with funding and training, support for research activities, providing networking opportunities and facilitating action planning. Finally, it aims to build capacity in key small mammal regions where there are particularly high densities of Globally Threatened and Data Deficient species. Beginning efforts in key regions will have maximum benefits to a whole suite of small mammal species (Figure 2).

For Eulipotyphla, the Cameroonian highland forests and Sri Lankan moist forests were shown to be particularly important regions (Figure 2b). The forested highlands in the border region between Cameroon and Nigeria, stretching over to Mt. Cameroon, support an impressive small mammal fauna with 12 species of Eulipotyphla, many of which are shrews within the *Crocidura* genus. It has seven globally threatened shrews, of which two are AZE-trigger species: the Rumpi Mouse Shrew (*Myosorex rumpii*) and the Mt. Cameroon Forest Shrew (*Sylvisorex morio*). Habitat loss and degradation driven by agricultural encroachment, firewood exploitation and overgrazing is the most severe threat to the small mammals of this region. With a high human population density and very little forest under formal protection, the habitats of small mammals within this region are highlighted as being disproportionately under-protected. With the support of a number of conservation NGOs, Cameroon is starting to establish a national protected area network. This includes new national parks and the creation of a number of community managed reserves in the most important forest and mountain areas. Our knowledge of this small mammal fauna is very limited, and fieldwork is desperately needed to understand the ecology of these species. Five Data Deficient species occur in this region, in most cases because of insufficient knowledge to assess their conservation status.

The upland and lowland rainforests of southwestern Sri Lanka are notable for their exceptionally high rates of endemism (Figure 2c). In terms of small mammals, the Sri Lankan moist forests support species of Eulipotyphla, seven of which are globally threatened. Two of these, Pearson's Long-clawed Shrew (*Solisorex pearsoni*) and Kelaart's Long-clawed Shrew (*Feroculus feroculus*) are the sole representatives of two genera found only on Sri Lanka. Threats to the small mammal fauna on Sri Lanka are primarily from habitat loss and degradation. The majority of rainforest has been lost to rice paddies, housing, and plantations of tea, rubber, and coconut, with the remaining fragments still being cleared for agriculture. Half of the remaining southern lowland forests are protected in the Sinharaja

Natural Heritage Wilderness Area. In the montane forests, five protected areas exist but good protection measures and conservation are limited. Knowledge of the small mammal fauna of this region is poor and detailed fine scale distribution surveys are needed.

Priority Eulipotyphla Species

Cuban Solenodon (*Atopogale cubana*):
***The IUCN Red List* status, EN (2008); EDGE ranking, 6; Country: Cuba**.
Description: It is only thought to remain in the southeastern part of the country, in two populations found in the Pico Cristal National Park and Alejandro de Humboldt National Park. It is found at elevations above 400-800m, where it inhabits dense humid forest and brush.
Major Threats: Introduced mammals are considered to be a threat, including feral dogs which have been known to predate the species, cats that may also predate it, and black rats which may compete for dens. There is also habitat loss across its range, due to deforestation and mining operations.
Current Conservation Efforts: Recently, surveys have been undertaken in previously unstudied areas. One team of researchers collected samples to learn more about the genetics and ecology of the species. They are intending to hold action planning workshops. Accurate information about the true distribution is essential as well as better understanding of the severity of the different possible threats.

Russian Desman (*Desmana moschata*):
***The IUCN Red List* status, EN (2016); EDGE ranking, 63; Country: Kazakhstan, Russian Federation, Ukraine**.
Description: A riparian species, primarily along oxbow lakes, less frequently by rivers and ponds. At the beginning of the 20th century the Desman was common in several large river basins. However, it has recently disappeared from many areas where it formerly occurred, such as Belarus, and its current range is very fragmented. At the end of the 19th century it disappeared from Ukraine, but was reintroduced in the 1950s.
Major Threats: Caught as bycatch in fixed fishing nets used by poachers. The increased use of nets is due to cheapness and wide availability. Where electric fishing takes place there is also likely to be reduced availability of its prey, namely fish and aquatic invertebrates. Habitat loss and degradation: species' range contracted hugely due to water pollution, drainage, clearance of riparian vegetation, and uncontrolled agricultural exploitation of flood plains. Some of these practices have abated.
Current Conservation Efforts: In Russia there are regular surveys of large areas/lengths of some water-bodies, and good historical data. However, there is an urgent need to expand the areas surveyed and for understanding the severity of the threats, in particular, research to understand the impact of illegal fishing nets and electrofishing.

Hainan Gymnure (*Neohylomys hainanensis*):
***The IUCN Red List* status, EN (2016); EDGE ranking, 73; Country: China**.

Description: This species is restricted to mainly mountainous tropical rainforest in the central and western parts of Hainan Island, off southern China. Very little is known about its ecology. Its population size is unknown, but the species is believed to be rare and declining.
Major Threats: Its habitat is under threat from clearance for timber and agricultural expansion.
Current Conservation Efforts: No specific conservation measures are in place, although most forests where the species currently occurs have been designated as nature reserves. Surveys are needed to establish the exact distribution of the species, followed by research into the animal's ecology and habitat requirements, in order for appropriate conservation actions to be implemented.

DERMOPTERA

Colugos are arboreal, gliding, nocturnal mammals distributed throughout parts of Southeast Asia and the Southeast Asian archipelago. Colugos are specially adapted for gliding through the canopy of evergreen forests using their dermal gliding membrane, or patagium. The patagium is the colugos' most striking evolutionary adaptation and clearly inspired the name of their order Dermoptera, which translates as "skin wing". The patagium interconnects all of their distal appendages (arms, legs, and tail), connects their arms to their neck, and even spans interdigitally between their fingers and toes to maximize the surface area for gliding. Colugos have also evolved specialized musculoskeletal morphology such that their arms, legs, and phalanges have become elongated, which also increases their gliding efficiency. These specialized adaptations enable the colugo to glide for distances greater than 100m with an incredible 10:1 horizontal to vertical distance ratio; however, they are incapable of true powered flight like bats. After analysing colugos' gliding kinetics, scientists have shown that the longer the glide the softer the landing. Before landing, colugos turn their bodies vertical to slow their impact and position themselves to land on a tree trunk. Perhaps longer glides enable colugos to correctly orient themselves in the air and reduce the risk of injury.

Although proficient gliders, colugos have little to no dispersal capabilities outside of forested areas. While on the ground colugos move in a series of short powerful hops, though their patagium obstructs their movement by catching on foliage, logs, or other protruding objects. Although colugos can glide over (and therefore possibly tolerate) small gaps in forested habitat, other barriers to dispersal such as wide rivers, savannas, or montane environments can be significant barriers to dispersal. Some sources of human induced fragmentation or loss of habitat include major highway systems, logging, and monocrop plantations. Some monocrop plantations have trees (such as rubber or coconut) though, colugos are still rarely observed within these plantations and are found at a significantly higher frequency within tropical forests with greater than 95% canopy cover. By the year 2010, deforestation had claimed 70% of the original lowland rainforests within Sundaland (the Malay Peninsula, Borneo, Sumatra, Java, and surrounding islands). Therefore, to maintain genetic continuity of colugo species it is imperative to limit further habitat loss and preserve the remaining continuous tracks of forested habitat with closed canopies.

Despite colugos being known to scientists for centuries, and their relevance to early Primate evolution as the sister ordinal lineage to Primates, colugos remain poorly

understood. In part, this could be due to their cryptic nocturnal and arboreal nature, or that colugos do not survive for long periods in captivity, making them a difficult species to sample or study. Accurate population surveys and taxonomy is of particular importance for conservation of species. However, population assessments have been limited to Singapore, and therefore little information is available for other regions in Sundaland and the Philippines.

Develop Conservation Priorities for the Dermoptera

Colugos have had a troubled taxonomic history throughout the last century. The order Dermoptera has been allied with insectivores, bats, and even nested within Primates, and the number of species defined within Dermoptera has fluctuated from twenty five to two species making it difficult to make informed conservation decisions. Currently the two recognized species of colugo, the Sunda colugo (*Galeopterus variegatus*), and the Philippine colugo (*Cynocephalus volans*), are classified as Least Concern by the International Union for Conservation of Nature (IUCN). Given that colugos have limited dispersal capabilities and are present on more than 50 islands within two well-known biodiversity hotspots, Sundaland and Southern Philippines, it is somewhat surprising that only two species exist. Throughout the last decade molecular DNA evidence representing maternal, paternal, and biparental inheritance patterns has shown that the current taxonomy is insufficient to represent the large amount of genetic diversity within the Sunda colugo, and to a lesser extent, the Philippine colugo.

Some of the morphological variation within the Sunda colugo is currently represented by four subspecies: 1) *G. variegatus variegatus* representing colugos from Java, 2) *G. variegatus borneanus* representing colugos from Borneo, 3) *G. variegatus peninsulae* representing colugos from Peninsular Malaysia, the surrounding islands, and the Southeast Asian mainland, and 4) *G. variegatus temminckii* representing Sumatra and surrounding islands. However, current maximum likelihood and Bayesian phylogenetics indicate that six species of Sunda colugo and two species of Philippine colugo should be considered for species classification. For the Sunda colugo these species would include colugos from Indochina, Peninsular Malaysia and Sumatra, West Borneo, East Borneo, Northeast Borneo, and Java. For the Philippines this would separate colugos into northern and southern species between Leyte and Mindanao. The current IUCN status indicates that they are not dependent on conservation. However if the taxonomy is modified to represent the evidence from molecular phylogenetics, this could subsequently change the IUCN classifications for colugos.

Much of our knowledge of colugo taxonomy has been derived from historical museum specimens. These have been invaluable sources for morphometric data, and more recently, DNA analyses of left over dried adherent tissue. However from a conservation standpoint, future studies should prioritize population surveys within the geographic regions described above, and sampling colugos from isolated central island populations that were rarely sampled by seafaring explorers on museum expeditions. The current molecular evidence suggests that Borneo could house three currently unrecognized species with greater than 5 million years of nuclear genetic divergence between east and west colugo populations. However, no colugos from the isolated mountainous interior of Borneo were

successfully analysed. In addition, the majority of molecular evidence is from colugo museum specimens (50-150 years old) representing populations that were present in lowland forests near the perimeter of islands. This lowland habitat has been the most susceptible to deforestation. At best, the current molecular evidence represents relictual populations and, at worst, these populations may not currently exist. Therefore, up to date colugo population surveys, and filling the gaps in phylogenies is essential for an accurate representation of modern colugo populations to inform future conservation efforts.

SCANDENTIA

The tree-shrews are a small group of over 20 species of typically tree-dwelling small mammals, found in south-east Asia from southern India and China to the islands of Indonesia and the Philippines (Figure 3). The number of species continues to fluctuate, with increased recent improvements in taxonomic understanding of the group. They are superficially squirrel-like in appearance, and the tree-shrew genus name Tupaia comes from "tupai", the Malay word for squirrel. However, their evolutionary relationships to other mammals have been the subject of considerable debate for over a century, with different studies suggesting that they are either most closely related to primates or to the colugos. All species are within the family Tupaiidae, except the Pen-tailed treeshrew (*Ptilocercus lowii*) which is alone in the family Ptilocercidae. Despite their relatively low species diversity, tree-shrews are among the most remarkable and interesting small mammals. They have the highest brain to body mass ratio of any mammal, and display several other intriguing biological characteristics; for example, pen-tailed tree shrews (*Ptilocercus lowii*) have been used to investigate alcohol tolerance in humans, as they consume large amounts of fermented nectar, yet do not exhibit signs of intoxication. Several tree-shrews have also developed symbiotic relationships with pitcher plants, feeding on nectar from the plants and in return defecating into them to supply them with much or all of their required nitrogen. It is highly likely that many more surprises await researchers investigating these enigmatic and understudied mammals. The majority of tree-shrews are not threatened, except for the Golden-bellied Treeshrew (*Tupaia chrysogaster*) and the Nicobar Treeshrew (*Tupaia nicobarica*), which are listed as Endangered. Additionally, four species are listed as Data Deficient and these require survey attention to understand their true conservation status.

Developing Conservation Priorities for the Scandentia

This order of mammals is represented by the IUCN SSC Small Mammal Specialist Group (SMSG). See the Eulipotyphla section for details of the SMSG.

Priority Scandentia Species

Nicobar Treeshrew (*Tupaia nicobarica*):
***The IUCN Red List* status, EN (2016); EDGE ranking, none; Country: India**.

Description: This species occurs only on the Indian islands of Great Nicobar and Little Nicobar. It is predominantly an arboreal species, occasionally seen on the forest floor, but mainly occupying the lower and mid-canopy of rainforests.
Major Threats: The major threats to this species are forest loss and fragmentation, and predation by domestic dogs and cats.
Current Conservation Efforts: Whilst it has been recorded from several protected areas, including Galathea National Park and Campbell National Park, there are no known ongoing conservation actions taking place.

Acknowledgments

The SMSG team would like to thank our colleagues in the Global Mammal Assessment team based at Sapienza University of Rome, in particular Francesca Cassola and Federica Chiozza. New World assessments were conducted at Texas A&M University and assessments for Old World species were coordinated at Durrell Wildlife Conservation Trust. Assessments of the Cingulata and Pilosa were coordinated by the ASASG's Red List Authority Agustín M. Abba. We sincerely thank all members of the IUCN SSC Anteater, Sloth and Armadillo Specialist Group as well as the many additional researchers and conservationists who contributed to the assessments of Cingulata and Pilosa.

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Table 1. Arrangement of the eight recognized extant families of "insectivorous" mammals in their putative monophyletic groups in the old, and now defunct, Order Insectivora. Current order and superorder also listed, indicating the dramatic revision of the phylogeny of the former Insectivora.

Lipotyphlan Families			Menotyphan Families		
Family	Current Order	Superorder	Family	Current Order	Superorder
Chrysochloridae	Afrosoricida	Afrotheria	Macroscelididae	Macroscelidea	Afrotheria
Erinaceidae	Eulipotyphla	Laurasiatheria	Tupaiidae[2]	Scandentia	Euarchontoglires
Solenodontidae	Eulipotyphla	Laurasiatheria			
Soricidae	Eulipotyphla	Laurasiatheria			
Talpidae	Eulipotyphla	Laurasiatheria			
Tenricidae[1]	Afrosoricida	Afrotheria			

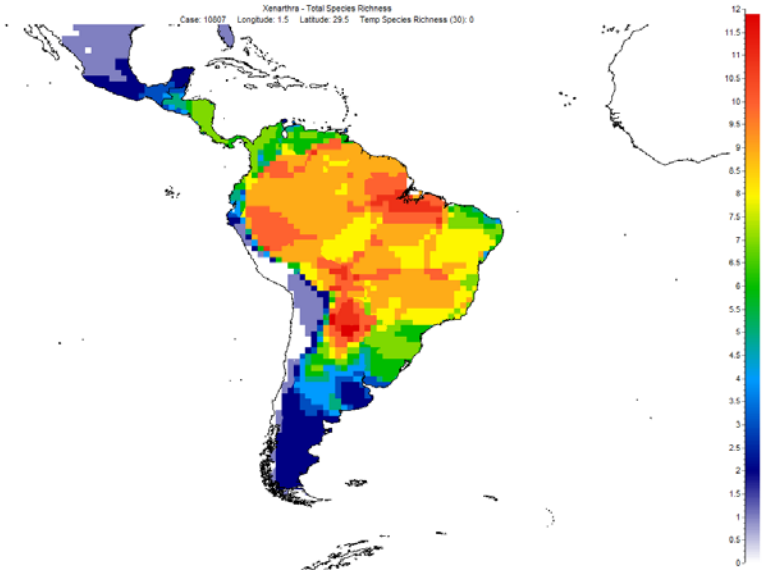
[1]Tenricidae formerly contained the subfamiliy Potamogalinae, now elevated to Potamogalidae.
[2]Genus *Ptilocercus* of the Tupaiidae now elevated to family status as Ptilocercidae

Table 2. The most recent IUCN conservation status of the world's Cingulata, Pilosa, Afrosoricida, Macroscelidea, Eulipotyphla, Dermoptera and Scandentia, with numbers of Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Data Deficient (DD) species of orders by family, the total number of extant species, percentages of DD, and the percentage of threatened species (within categories CR, EN, and VU); data were downloaded on 28 February 2018 from The IUCN Red List.

Order/Family	CR	EN	VU	DD	Total	DD %	Threatened %
AFROSORICIDA							
CHRYSOCHLORIDAE	1	5	4	3	21	14	48
TENRECIDAE		2	4	1	34	3	18
CINGULATA							
CHLAMYPHORIDAE			2	3	13	23	15
DASYPODIDAE				2	7	29	0
DERMOPTERA							
CYNOCEPHALIDAE					2	0	0
EULIPOTYPHLA							
ERINACEIDAE		2	1	1	24	4	13
SOLENODONTIDAE		2			2	0	100
SORICIDAE	11	34	24	81	393	21	18
TALPIDAE		2	2	5	42	12	10
MACROSCELIDEA							
MACROSCELIDIDAE		1	1	4	19	21	11
PILOSA							
BRADYPODIDAE	1		1		4	0	50
CYCLOPEDIDAE					1	0	0
MEGALONYCHIDAE					2	0	0
MYRMECOPHAGIDAE			1		3	0	33
SCANDENTIA							
PTILOCERCIDAE					1	0	0
TUPAIIDAE		2		4	21	19	10

Figure 1. Patterns of species richness for the superorder Xenarthra (a) and regions with the highest number of threatened species (b). Warmer colors represent higher species richness or number of threatened species.

a)



b)

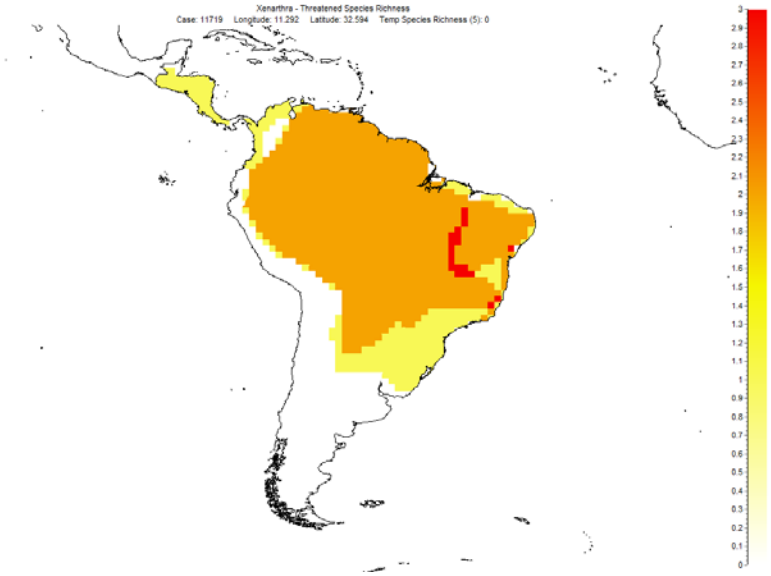
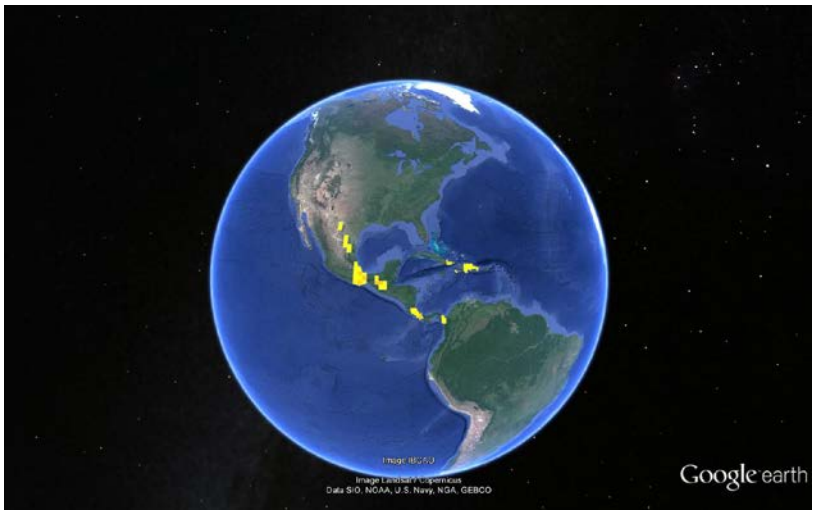
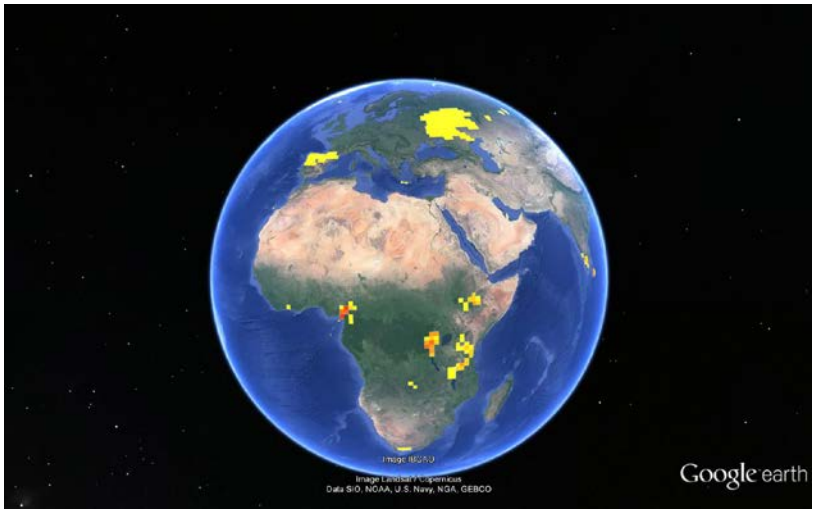


Figure 2. Map showing the priority regions for conservation of the Eulipotyphla in the Americas (a), Africa (b), and Asia (c). Warmer colors represent higher priority regions.

a)



b)



c)

Figure 3. Global distribution of Scandentia, showing species categorised as Least Concern on the IUCN Red List in green (16 species), Data Deficient in purple (4 species), and Endangered in red (2 species). Of the Endangered species, *Tupaii nicobarica* is indicated by the upper arrow and *Tupaia chrysogaster* by the lower arrow.