Short Communication

Identifing priority ecoregions for rodent conservation at the genus level

Giovanni Amori and Spartaco Gippoliti

Abstract Rodents account for 40 per cent of living mammal species. Nevertheless, despite an increased interest in biodiversity conservation and their high species richness, Rodentia are often neglected by conservationists. We attempt for the first time a world-wide evaluation of rodent conservation priorities at the genus level. Given the low popularity of the order, we considered it desirable to discuss identified priorities within the framework of established biodiversity priority areas of the world. Two families and 62 genera are recognized as threatened. Our analyses highlight the Philippines, New Guinea, Sulawesi, the Caribbean, China temperate forests and the Atlantic Forest of south-eastern Brazil as the most important (for their high number of genera) 'threat-spots' for rodent conservation. A few regions, mainly drylands, are singled out as important areas for rodent conservation but are not generally recognized in global biodiversity assessments. These are the remaining forests of Togo, extreme 'western Sahel', the Turanian and Mongolian–Manchurian steppes and the desert of the Horn of Africa. Resources for conservation must be allocated first to recognized threat spots and to those restricted-range genera which may depend on species-specific strategies for their survival.

Keywords Biodiversity, conservation priorities, rodents, threatened genera, world ecoregions.

Introduction

With 26–32 recognized extant families and more than 2050 recognized species (Hartenberger, 1985; Wilson & Reeder, 1993; Nowak, 1999), Rodentia is the richest order among mammals. Rodents occur naturally on every continent (except Antarctica and some major islands such as New Caledonia and New Zealand, which have no native species) and in every habitat, and show a considerable diversity in morphology, behaviour, habitat utilization and life history strategy. Because of this widespread presence, rodents are the most commonly used mammals in ecological studies, and can serve as exceptionally good indicator species to detect changes in habitat quality resulting from natural or human-induced changes (Yensen & Hafner, 1998). Although 330 species of rodents are considered threatened (IUCN, 1996) and many species are known to play a unique role in sustaining ecosystems and current biodiversity (Maser & Maser, 1988; Yensen *et al.*, 1992; Miller *et al.*, 1994; Forget, 1997), conservation efforts for threatened rodents seem a low priority at the moment (Amori & Gippoliti, 2000).

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Conservation efforts for rodents must be included in the general framework of mammalian diversity conservation, focusing on a biodiversity/area approach. It is extremely urgent to identify endangered taxonomic groups, endemism and species-rich areas to maintain current rodent diversity. Areas of concern for rodents may overlap with previously identified 'hotspots' or restricted-range species areas (Myers, 1988, 1990; Stattersfield *et al.*, 1998), megadiversity countries (e.g. Mittermeier, 1988), major tropical wilderness areas (Mittermeier *et al.*, 1998) or, instead, represent specific priorities for the IUCN/SSC Rodent Specialist Group.

It has been proposed that higher taxon richness be used as a surrogate of species richness in rapid biodiversity surveys (Williams & Gaston, 1994). Given the great number (probably still underestimated) of existing rodent species, and the lack of enthusiasm and resource allocation for rodent conservation, strategies must be primarily directed to prevent the complete extinction of whole phylogenetic lineages at the genus, subfamily and family level, an event already recorded, for example, in the case of the Heptaxodontidae in the West Indies (Nowak, 1999). In this work, we propose determining conservation priorities for the order Rodentia at the genus level (see Reinthal, 1993). Efforts toward the identification of priorities at this taxonomic level appear more realistic, and provide a more stable basis (albeit not definitive, see Carleton & Goodman,

Table 1 Threatened rodent genera and their geographical range. Monotypic families are in bold.

Genera	Zoogeographic region	Range	Number of species	Family
Biswamoyopterus	Oriental	India (Tirap district Assam)	1	Sciuridae
Eupetaurus	Oriental	India, Pakistan (West Himalaya)	1	Sciuridae
Myosciurus	Afrotropical	Cameroon, Bioko Island, Gabon, Nigeria	1	Sciuridae
Hyosciurus	Oriental	Sulawesi	2	Sciuridae
Trogopterus	Oriental	Central-eastern China	1	Sciuridae
Zygogeomys	Nearctic	North-central Michoacan, Mexico	1	Geomyidae
Cardiocranius	Palearctic	Mongolia, East Kazakhstan, China	1	Dipodidae
Eozapus	Palearctic/Oriental	Yunnan, West Sichuan, Quinghai & South Gansu (China)	1	Dipodidae
Euchoreutes	Palearctic	China, Mongolia	1	Dipodidae
Abrawayaomys	Neotropical	Brazil	1	Muridae
Abditomys	Oriental	Luzon (Philippines)	1[a]	Muridae
Ammodillus	Afrotropical	South-west Ethiopia, Somalia	1	Muridae
Anonymomys	Oriental	Mindoro (Philippines)	1	Muridae
Anotomys	Neotropical	Ecuador	1	Muridae
Archboldomys	Oriental	Luzon (Philippines)	2	Muridae
Crateromys	Oriental	Luzon, Mindoro, Dinagat, Panay (Philippines)	4	Muridae
Eropeplus	Oriental	Central Sulawesi	1	Muridae
Gymnuromys	Afrotropical	East Madagascar	1	Muridae
Hypogeomys	Afrotropical	West Madagascar	1	Muridae
Komodomys	Oriental	Lesser Sunda Islands	1	Muridae
Kunsia	Neotropical	North-east Argentina, West-eastern Central Brazil, North-east Bolivia	2	Muridae
Lamottemys	Afrotropical	Mt. Oko, West Cameroon	1	Muridae
Leimacomys	Afrotropical	Central Togo	1	Muridae
Leporillus	Australian	South Australia, Franklin Island	1	Muridae
Limnomys	Oriental	Mindanao (Philippines)	1[a]	Muridae
Macruromys	Australian	New Guinea	1	Muridae
Mayermys	Australian	North-east New Guinea	1	Muridae
Megadendromus	Afrotropical	East Ethiopia	1	Muridae
Melasmothrix	Oriental	Sulawesi	1	Muridae
Microhydromys	Australian	New Guinea	2[a]	Muridae
Muriculus	Afrotropical	Ethiopia	1	Muridae
Mystromys	Afrotropical	South Africa, Lesotho	1	Muridae
Nesoryzomys	Neotropical	Galapagos (Ecuador)	2[a]	Muridae
Neohydromys	Australian	Central-eastern New Guinea	1	Muridae
Nilopegamys	Afrotropical	Ethiopia	1[a]	Muridae
Palawanomys	Oriental	Palawan (Philippines)	1	Muridae
Papagomys	Oriental	Flores Island (Indonesia)	3	Muridae
Paulamys	Oriental	Flores Island (Indonesia)	1[a]	Muridae
Phaenomys	Neotropical	Rio de Janeiro, East Brazil	1	Muridae
Podomys	Nearctic	Florida (USA)	1	Muridae
Pseudohydromys	Australian	New Guinea	2	Muridae
Rhagomys	Neotropical	Rio de Janeiro, East Brazil	1	Muridae
Solomys	Australian	Bouganinville Island, Santa Ysabel Island (Solomons)	4	Muridae
Tateomys	Oriental	Sulawesi	2	Muridae
Tokudaia	Oriental	Okinawa, Amami, Tokuno-shima Islands (Japan)	3	Muridae
Tryphomys	Oriental	North Luzon (Philippines)	1	Muridae
Vernaya	Oriental	Central-south China, Myanmar	1	Muridae
Xeromys	Australian	South-eastern Qeensland, coastal Northern Territory, Melville Islands	1	Muridae
Pedetes	Afrotropical	East and South Africa	1	**Pedetidae**
Felovia	Afrotropical	Senegal, Mali, Mauritania	1	Ctenodactyilidae
Chaetocauda[b]	Oriental	China	1	Gliridae
Glirulus	Palearctic	Honshu, Shikoku E Kyushu Islands (Japan)	1	Gliridae
Myomimus	Palearctic	Bulgaria, West Turkey, Iran, Turkmenistan, Uzbekistan	3	Gliridae

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Table 1 (Continued).

Genera	Zoogeographic region	Range	Number of species	Family
Selevinia	Palearctic	South-eastern East Kazakhstan	1	Gliridae
Chinchilla	Neotropical	North-west Argentina, Peru, Bolivia, North Chile	2	Chinchillidae
Dinomys	Neotropical	Colombia, West Bolivia, Brazil	1	**Dinomyidae**
Tympanoctomys	Neotropical	Mendoza Province (Argentina)	1	Octodontidae
Chaetomys	Neotropical	South-east Brazil	1	Echimyidae
Geocapromys	Neotropical	Jamaica, Bahamas	2	Capromyidae
Isolobodon	Neotropical	Hispaniola	1	Capromyidae
Mesocapromys	Neotropical	Cuba	4	Capromyidae
Plagiodontia	Neotropical	Hispaniola	1	Capromyidae

[a]Missing genera from the *IUCN Red List* (1996) but here considered threatened.
[b]Tentatively, we accept *Chaetocauda* (following Corbet & Hill, 1992; Storch, 1995) as a full genus for the recently described Sichuan dormouse.

1996, 1998) for conservation planning than presently allowed by continually updated species lists (e.g. Groves & Flannery, 1994; Rickart *et al.*, 1998; da Silva, 1998). At this level, it is also possible to identify, and thus emphasize the conservation importance, of ancient, species-poor lineages that contribute heavily to the diversity of the order at the expense of more recent, speciose clades (Vane-Wright *et al.*, 1991; Krajewski, 1994). In fact, the extinction of a member of the genus *Rattus* cannot be considered of equal importance to the loss of the only species of the family Hydrochaeridae. This simple phylogenetic criterion is not entirely satisfactory because it undervalues the role of rodents in natural ecosystems (Power *et al.*, 1996), but paucity of ecological studies make objective assessment on a global scale impossible at the present time. It is auspicious, however, that the preservation of major terrestrial biomes by existing protected area systems serves to guarantee protection for most rodent species.

Methods

The systematics followed are those reviewed in Wilson & Reeder (1993). We considered as threatened species those classified by IUCN (1996) as Critically Endangered (CR), Endangered (EN) and Vulnerable (VU); threatened genera as those having all extant species listed by IUCN (1996) as threatened (see also Rylands *et al.*, 1997) or, possibly, extinct; potentially threatened genera as those having all extant species listed in the threatened (CR, EN and VU), Lower Risk (Conservation Dependent and Near Threatened) and Data Deficient categories. The latter subdivision has been included because we feel that the endangered status of many little-known rodent taxa is presently undervalued.

We included in the threatened genera category a few taxa omitted in the 1996 IUCN Red List, because of the very few specimens known and/or very restricted ranges.

We mainly followed Olson & Dinerstein (1997) for the identification and nomenclature of major world ecoregions. We list major environmental threats (as deduced by Olson & Dinerstein, 1997 and Stattersfield *et al.*, 1998) for each ecoregion with particular attention to those considered of importance to rodents (G. Amori and S. Gippoliti, in preparation).

Results and discussion

The present assessment provides a first global framework to direct scarce resources towards the conservation of phylogenetically distinctive and apparently threatened members of the order Rodentia.

In the present analysis 62 genera are recognized as threatened and 45 as potentially threatened (Tables 1 and 2). Also, two monotypic families, Pedetidae and Dinomyidae, appear to be threatened. The Oriental region has the highest number of threatened and potentially threatened genera (21 and 13, respectively, see Table 3). Some areas are clearly singled out as threat spots for rodent conservation (see Table 4). The Philippines (excluding Palawan) have six threatened endemic genera and two potentially threatened genera, five of which occur in the Luzon faunal division. The highland and lowland forests of New Guinea have five threatened endemic genera and one potentially threatened genus. Sulawesi has four threatened endemic genera. China's temperate forests have four threatened genera (one non-endemic) and two potentially threatened genera. In the Neotropics, the most important threat spot is represented by the Atlantic Forest of south-eastern Brazil, where four threatened genera and one potentially threatened genus (all endemic) are found. Four threatened genera occur in the Caribbean, two of which are restricted to Hispaniola. Among Afrotropical

Table 2 Potentially threatened rodent genera.

Genera	Zoogeographical region	Range	Number of species	Family
Aeretes	Oriental	Hebei and Sichuan (China)	1	Sciuridae
Epixerus	Afrotropical	West-central Africa	2	Sciuridae
Euglacomys	Oriental	Pakistan, India	1	Sciuridae
Syntheosciurus	Neotropical	Costa Rica, North Panama	1	Sciuridae
Belomys	Oriental	India, China, Indochina, Taiwan	1	Sciuridae
Pteromyscus	Oriental	South Thailand, Sumatra, Borneo	1	Sciuridae
Chionomys	Palearctic	South-eastern Central Europe, Middle East	3	Muridae
Dinaromys	Palearctic	Balkans	1	Muridae
Myopus	Palearctic	North Europe, North Asia	1	Muridae
Proedromys	Oriental	Gansu, Sichuan (China)	1	Muridae
Beamys	Afrotropical	East Africa	2	Muridae
Dendroprionomys	Afrotropical	Congo	1	Muridae
Platacanthomys	Oriental	India	1	Muridae
Prionomys	Afrotropical	Cameroon, South Central African Republic	1	Muridae
Microdillus	Afrotropical	Somalia	1	Muridae
Carpomys	Oriental	North Luzon (Philippines)	2	Muridae
Celaenomys	Oriental	North Luzon (Philippines)	1	Muridae
Diomys	Oriental	North-east India, West Nepal	1	Muridae
Diplothrix	Oriental	Okinawa, Amami, Tokuno-oshima Islands (Japan)	1	Muridae
Hapalomys	Oriental	Hainan Island, North Laos, South Vietnam, South-east Myanmar,Thailand, Malay Peninsula	2	Muridae
Kadarsanomys	Oriental	West Giava	1	Muridae
Leggadina	Australian	Australia	2	Muridae
Mesembriomys	Australian	Australia	2	Muridae
Rhabdomys	Afrotropical	Eastern South Africa	1	Muridae
Stenocephalemys	Afrotropical	Ethiopia	2	Muridae
Srilankamys	Oriental	Sri Lanka	1	Muridae
Xenuromys	Australian	New Guinea	1	Muridae
Brachyuromys	Afrotropical	Central Madagascar	2	Muridae
Chibchanomys	Neotropical	West Venezuela, Colombia, Peru	1	Muridae
Hodomys	Nearctic	Mexico	1	Muridae
Juscelinomys	Neotropical	Central East Brazil	2	Muridae
Lenoxus	Neotropical	South-east Peru, West Bolivia	1	Muridae
Podoxymys	Neotropical	Guyana	1	Muridae
Xenomys	Nearctic	Mexico	1	Muridae
Zenkerella	Afrotropical	Central Africa	1	Anomaluridae
Eliomys	Palearctic	Europe, Middle East, North Africa	2	Gliridae
Muscardinus	Palearctic	Europe, Turkey	1	Gliridae
Glis	Palearctic	Europe, Middle East	1	Gliridae
Heliophobius	Afrotropical	Eastern South Africa	1	Bathyergidae
Dolichotis	Neotropical	Argentina, South Bolivia, Paraguay	2	Cavidae
Agouti	Neotropical	Mexico to South Brazil	2	Agoutidae
Olallamys	Neotropical	Colombia, West Venezuela	2	Echimydae
Isothrix	Neotropical	Bolivia to Central Brazil, French Guiana	3[a]	Echimydae
Carterodon	Neotropical	Minas Gerais (East Brazil)	1	Echimydae
Mysateles	Neotropical	Cuba	5	Capromyidae

[a]One species described in 1996.

Table 3 A summary of the number of species, threatened species, extinct species, and threatened and potentially threatened genera of rodents by each zoogeographical region.

	Afrotropical	Oriental	Palearctic	Nearctic	Neotropical	Australasian
Number of species	375	369	367	350	568	139
Extinct species	–	4	2	2	28	9
Threatened species	53 (14.0%)	91 (24.6%)	49 (13.3%)	47 (13.3%)	56 (9.8%)	35 (25.1%)
Threatened genera	12	21	5	2	14	8
Potentially threatened genera	10	13	6	2	11	3

Table 4 Priority ecoregions identified in this work, major conservation threats and respective endemic threatened and potentially threatened rodent genera.

Ecoregion (by zoogeographical region)	Threatened genera	Potentially threatened genera	Major threats
Palearctic region			
Southern Europe and Middle East montane forests	*Myomimus*	*Chionomys* *Dinaromys* *Eliomys* *Glis* *Muscardinus*	Deforestation and habitat fragmentation
Central Asian deserts	*Cardiocranius* *Euchoreutes* *Selevinia*		Steppes are under pressure from sheep farming, agriculture and increasing human population
Japan evergreen forest	*Glirulus*		Deforestation and tree plantations
Oriental region			
Western Himalayan temperate forests	*Eupetaurus*	*Euglacomys*	Remaining forests in the region are threatened by increasing logging, agriculture expansion and fuelwood collection
Palawan moist forests	*Palawanomys*		Deforestation rate is increasing
Philippines moist forests	*Abditomys* *Anonymomys* *Archboldomys* *Crateromys* *Limnomys* *Tryphomys*	*Carpomys* *Celaenomys*	Deforestation on much of the Philippine Islands (i.e. western Visayan) is severe
Sulawesi moist forests	*Hyosciurus* *Eropeplus* *Melasmothrix* *Tateomys*		In the last 20 years Sulawesi has lost 67% of lowland and montane forest
North-east India and Myanmar hill forests	*Biswamoyopterus*		Deforestation and habitat degradation
Nansei Shoto archipelago forests	*Tokudaia*	*Diplothrix*	Deforestation and introduction of exotic or domestic predators
Lesser Sunda dry and monsoon forests	*Papagomys* *Komodomys* *Paulamys*		Forest clearance
South-west China temperate forests	*Trogopterus* *Chaetocauda* *Eozapus* *Vernaya*	*Aeretes* *Proedromys*	Agriculture expansion and timber harvesting
Afrotropical region			
Western Sahel	*Felovia*		Habitat degradation as a result of overgrazing
Southern African region grassland	*Pedetes* *Mystromys*		Overgrazing of the highveld by domestic livestock
Eastern subdesert and dry bushland	*Pedetes*	*Heliophobius*	Increasing agriculture
Central Togo	*Leimacomys*		Severe reduction and fragmentation of forests
Congolian coastal forests	*Myosciurus* *Lamottemys*	*Zenkerella*	Deforestation
Ethiopian Highlands	*Megadendromus* *Muriculus* *Nilopegamys*	*Stenocephalemys*	Deforestation and overgrazing
Horn of Africa desert	*Ammodillus*	*Microdillus*	Habitat degradation as a result of overgrazing
Madagascar dry forest	*Hypogeomys*		Cutting and burning of forests
Madagascar moist forests	*Gymnuromys*	*Brachyuromys*	Deforestation and introduction of exotic rodent species
Nearctic region			
Mexican pine–oak forests	*Zygogeomys*		Deforestation and expansion of the elevational range of the larger and more aggressive *Pappogeomys gymnurus*

Table 4 (Continued).

Ecoregion (by zoogeographical region)	Threatened genera	Potentially threatened genera	Major threats
Florida conifer and broadleaf forests	*Podomys*		Drier upland habitats area is declining for urban and agricultural development
Neotropical region			
Brazil Atlantic forests	*Abrawayaomys* *Phaenomys* *Rhagomys* *Chaetomys*	*Blarinomys*	Urbanization, agricultural and logging expansion
Northern Andean forests and Yungas	*Anotomys* *Dinomys*	*Chibchanomys* *Lenoxus* *Ollallamys*	Agricultural conversion, land clearing and logging
Galápagos Islands	*Nesoryzomys*		Competion with other introduced rodents
Greater Antillean moist forests	*Isolobodon* *Plagiodontia* *Mesocapromys* *Geocapromys*	*Mysateles*	Deforestation and introduction of exotic species (such as domestic cat)
Pantanal flooded savannah and cerrado	*Kunsia*	*Carterodon* *Juscelinomys*	Conversion to pasture and cash crops
Monte Province and Patagonian steppe and grassland	*Tympanoctomys*	*Dolichotis*	Grazing, petroleum and mining activities. Loss of grassland caused by the introduction of non-native species (such as *Lepus europaeus* and *Mustela vison*)
Central Andean region	*Chinchilla*		Overgrazing and uncontrolled hunting
Australian region			
New Guinea forests	*Macruromys* *Mayermys* *Microhydromys* *Neohydromys* *Pseudohydromys*	*Xenuromys*	Introduction of non-native mammals and hunting for food
Solomon moist forests	*Solomys*		Introduction of non-native mammals and hunting for food
Northern Australia and trans-fly savanna	*Xeromys*		Coastal vegetation is under pressure caused by the introduction of ungulates
Sandy Australian deserts	*Leporillus*		Increasing abundance of predators because of the presence of exotic prey species such as rabbits and mice

ecoregions, the Ethiopian highlands hold the greatest number of threatened genera.

As would be expected, most of the recognized crucial areas for rodent diversity conservation are also acknowledged to be of global relevance for biodiversity conservation. The present study, however, identifies some regions which are unrecognized in recent global biodiversity studies (Olson & Dinerstein, 1997; Stattersfield *et al.*, 1998). This is the case of the semidesert regions of central Asia, of the 'western sahel', and of 'central Togo' remnant forests, whereas the Horn of Africa desert is recognized by Olson & Dinerstein (1997) only. These results partly agree with Mares (1992) conclusion for South America that mammal diversity, and thus their conservation importance, has been badly neglected in the drylands. Future research should clarify if these anomalies underline real peculiarities of the Rodentia or, alternatively, real deficiencies in our knowledge of biodiversity patterns in groups other than mammals and birds. Two conservation strategies are required to maintain rodent diversity at the genus level at least. In most of the ecoregions considered, charismatic vertebrates may act as 'umbrella' species for funding active conservation of large tracts of natural habitat (Caro & O'Doherty, 1999) so offering a concrete chance of maintaining entire assemblages of native rodents including threatened endemics (Lynam & Billick, 1999). However, especially in the case of restricted-range or island taxa (i.e. *Nesoryzomys*, *Zygogeomys*, etc.) no alternatives exists to the implementation of species-specific strategies including research, creation of protected areas, control of exotic species, translocation and so on (Dowler *et al.*, 2000). Funding of specific conservation projects for these genera is the first step to maintaining the exceptional diversity of rodents on our planet.

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