A higher–taxon approach to rodent conservation priorities for the 21st century

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Abstract

A higher–taxon approach to rodent conservation priorities for the 21st century.— Although rodents are not considered among the most threatened mammals, there is ample historical evidence concerning the vulnerability to extinction of several rodent phylogenetic lineages. Owing to the high number of species, poor taxonomy and the lack of detailed information on population status, the assessment of threat status according to IUCN criteria has still to be considered arbitrary in some cases. Public appreciation is scarce and tends to overlook the ecological role and conservation problems of an order representing about 41 percent of mammalian species. We provide an overview of the most relevant information concerning the conservation status of rodents at the genus, subfamily, and family level. For species–poor taxa, the importance of distinct populations is highlighted and a splitter approach in taxonomy is adopted. Considering present constraints, strategies for the conservation of rodent diversity must rely mainly on higher taxon and hot–spot approaches. A clear understanding of phyletic relationships among difficult groups —such as *Rattus*, for instance— is an urgent goal. Even if rodent taxonomy is still unstable, high taxon approach is amply justified from a conservation standpoint as it offers a more subtle overview of the world terrestrial biodiversity than that offered by large mammals. Of the circa 451 living rodent genera, 126 (27,9 %), representing 168 living species, deserve conservation attention according to the present study. About 76 % of genera at risk are monotypic, confirming the danger of losing a considerable amount of phylogenetic distinctiveness.

Key words: Mammals, Rodents, Conservation priorities, Phylogenetic distance.

Resumen

Aproximación a nivel de supratаxón de las prioridades de conservación de roedores en el siglo XXI.— Aunque los roedores no figuren entre los mamíferos con mayor amenaza de extinción, existen pruebas históricas que demuestran la vulnerabilidad de diversos linajes filogenéticos de roedores. Debido al gran número de especies existentes, la taxonomía deficiente y la falta de información detallada sobre el estado de las poblaciones, en determinados casos es arbitrario determinar hasta qué punto algunas especies se encuentran en peligro de extinción de acuerdo con los criterios de la UICN. Además, si a ello se une el escaso aprecio que el público en general siente por los roedores, la situación explica que se pase por alto tanto el papel ecológico como los problemas de conservación de un orden al que pertenecen aproximadamente el 40% de todas las especies de mamíferos. Se proporciona información exhaustiva y relevante sobre el estado de conservación de los roedores, a nivel de género, familia y subfamilia. Para aquellas especies cuya taxonomía sigue estando incompleta, se destaca la importancia de las distintas poblaciones y su taxonomía se analiza por separado. A causa de las limitaciones actuales, las diferentes estrategias para la conservación de la diversidad de roedores deben basarse fundamentalmente en un mayor análisis del taxón y de los lugares de mayor concentración de poblaciones. Asimismo, una clara comprensión de las relaciones filéticas entre grupos difíciles (como por ejemplo *Rattus*) constituye un objetivo apremiante. Pese a que la taxonomía de los roedores no sea aún definitiva, desde un punto de vista conservacionista sigue siendo absolutamente justificable analizar el taxón con mayor detenimiento, ya que ofrece una visión general más precisa de la biodiversidad en zonas continentales que la que ofrecen los grandes mamíferos. De los aproximadamente 451 géneros de roedores existentes, 126 (el 27,9 %), que engloban a 168 especies, merecen una especial atención conservacionista según los datos de este estudio. Entre los

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géneros que se encuentran en peligro de extinción, un 76 % son monotípicos, lo que confirma el peligro de perder una cantidad considerable de singularidades filogenéticas.

Palabras clave: Mamíferos, Roedores, Prioridades de conservación, Distancia filogenética.

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Introduction

More than 10 years later, the papers collected by LIDICKER (1989) after the 1985 meeting at the Third International Theriological Congress still provide the most recent global overview of rodent conservation status. Comprehensive synthesis and Action Plans are available for North America and Australia only (HAFNER et al., 1998; LEE, 1995), although more preliminary contributions at national or regional level have also been compiled (e.g. AMORI & ZIMA, 1994; HEANEY et al., 1998). National Red Lists are not included. The high number of species and lack of experts, especially in relation to tropical faunas, impede significant progress with rodent conservation. Current emphasis on biodiversity mapping and identification of conservation priorities which are not species–specific, highlight the importance of rodents (almost cosmopolitan in distribution, more than 2000 recognised species globally, more than 40 species and at least twelve new genera discovered since 1992 in the Neotropics alone (PATTERSON, 2000, MARES et al. 2000) as a biodiversity indicator group to use in setting world–wide conservation priorities. Furthermore, the vulnerability of this order is demonstrated by the fact that Rodent species represent 51–52 % of mammalian extinctions in the last 500 years (CEBALLOS & BROWN, 1995; MACPHEE & FLEMMING, 1999). In Australia, native rodents suffer a 19 % extinction rate in contrast with 6.3 % of the total mammalian fauna (SMITH & QUIN, 1996). On the contrary, conservation initiatives will continue to be biased towards the most studied and attractive mammal groups and species (AMORI & GIPPOLITI, 2000) or on an opportunistic basis, despite increasing evidence of many rodent species sustaining ecosystems structures and functions. There are many examples of rodents performing critical and non–ecologically redundant roles in communities. Praire dogs *Cynomys* spp. are known to alter prairie landscape in a way which is beneficial to a number of other species, providing foraging, shelter and nesting sites. Declining species such as the black–footed ferret *Mustela nigripes*, burrowing owl *Athene cunicularia* and ferruginous hawks *Buteo regalis* depend in some way on prairie dogs to hasten their population demise (KOTLIAR, 2000). Other rodents suspected to have a key role in ecosystems include subterranean pocket gophers like *Geomys bursarius* and *Thomomys bottae* and the desert–adapted kangaroo rats *Dipodomys* spp. (POWER et al., 1996). The pocket gopher *Tomomys bottae* has been demonstrated to limit the establishment of the exotic and invasive barbed goatgrass *Aegilops triuncialis* through the control of a fungus (EVINER & CHAPIN, 2003). In general, pocket gophers have positive effects on ecosystems creating patterns of disturbance and promoting diversity (REICHMAN & SEABLOOM, 2002), a finding which could probably be generalised to most subterranean rodents. Beavers *Castor* spp. are well known "ecosystem engineers", physically modifying river courses through the building of dams and creating the ideal habitats for a variety of species linked to wetlands (POLLOCK et al., 1995). Particular attention has also been attracted by the role of rodents in forest fragmentation dynamics (KOLLMANN & BUSCHOR, 2003; SANTOS & TELLERÍA, 1997). Finally, the importance of maintaining overall rodent species' diversity is illustrated by OSTFIELD & KEESING (2000). These authors found that exposure risk to Lyme disease in humans —a spirochetal disease transmitted by an ixodid tick— increases with reduction of small mammal species richness owing to dominance of a single common, most competent reservoir host, *Peromyscus leucopus*.

With the aim of providing governments, conservation organisations, and the captive–breeding community with some easy references to global rodent conservation priorities and to highlight the gaps in our understanding of rodent diversity, we undertook the task of reviewing, family by family, the conservation status of Rodentia, as it emerges from the most recently available Red List (IUCN, 2002) and other published information. In particular, given the size of the task —329 species and 61 subspecies are considered threatened to date (IUCN, 2002)— limited knowledge and interest, we feel it is appropriate to convey resources toward "higher" taxa (genus, subfamily or family) of conservation concern. However, we discuss conservation priorities at an intraspecific level in the case of species–poor lineages. Concentrating on threatened genera may result in a bias of interest towards those genera that have one or a few species as well as limited distribution, and which are probably locally rare (cf. SMITH & PATTON, 1993). However, these are clearly at greatest risk of disappearing (RUSSELL et al., 1998) and are most in need of urgent conservation measures. Furthermore, the presence of such relict taxa may underline areas of refuge and endemism for many other little–known organisms and provide an opportunity to detect and protect otherwise neglected habitats which lack more attractive vertebrates. MACE & BALMFORD's (2000) analysis of Red List Mammals confirms the risk of losing a considerable amount of phylogenetic information because most species–poor orders and families are threatened.

Methods

Systematic order follows WILSON & REEDER (1993) if not otherwise stated. This basic work has been updated using NOWAK (1999) as the main source together with other papers which appeared later. Genera of conservation concern were divided into three categories. The first (threatened genera) in-

cludes all genera with all species included in the IUCN category of threat (Critically Endangered, Endangered and Vulnerable) or extinct (AMORI & GIPPOLITI, 2001). The second (potentially–threatened genera) includes those having all species in the threatened and near–threatened categories (i.e. Lower Risk: Conservation Dependent; Lower Risk: Near Threatened; Data Deficient). While based primarily on the 2002 IUCN Red list (IUCN, 2002), a few genera were also included as threatened even if they are not yet included in the IUCN Red List; these are *Cansumys, Abditomys, Limnomys, Microhydromys,* and *Paulamys*. Finally, a number of genera (genera of concern) are also briefly discussed as, owing to small ranges and ecological characteristics, they seem vulnerable to further habitat degradation in spite of the fact that they do not qualify for inclusion in the two above categories.

Systematic account

Aplodontidae

Monotypic primitive family restricted to the wet forest of north west United States, not threatened globally, but two subspecies, *Aplodontia rufa nigra* and *A. rufa phaea,* are considered vulnerable because of small geographic ranges (62 and 175 km^2 respectively), habitat encroachment and predation from feral cats and dogs (STEELE, 1998).

Sciuridae

All continents except Australia and Madagascar. Threatened genera include *Myosciurus* – coastal central Africa including Bioko Island (GHARAIBEH & JONES, 1996); *Eupetaurus* – North–western Himalaya, where a population size of 1000–3000 is estimated (ZAHLER & WOODS, 1997) and Yunnan, *Hyosciurus* (two species) – Sulawesi; *Biswamoyopterus* – North–eastern India and only known from the type specimen (CORBET & HILL, 1992); *Trogopterus* – apparently widely distributed in mountain forests of Central and Southern China and Tibet between 1360–2750 m a.s.l. but might be less threatened than thought given the wide use of this species'dung in traditional Chinese medicine (SUNG, 1998); the several taxa described by Thomas are all included in *T. xanthipes* (HOFFMANN et al., 1993). If *Allosciurus* is accepted as a valid monotypic genus separated from *Protoxerus*, it may warrant inclusion here, as *A. aubinni* is rare and restricted to high forest from Liberia to Ghana (GRUBB et al., 1998; KINGDON, 1997). Several other genera are potentially threatened. These are *Aeretes*, only known from two isolated populations in Hebei / Gansu and Sichuan in China (SUNG, 1998); *Belomys* of South–eastern Asia; *Epixerus* of Central–western Africa, but at least *E. ebii* could be only apparently rare owing to its extreme shyness (EMMONS, 1980); *Euglacomys* of North–western Himalaya – whose generic status has recently been confirmed (THORINGTON et al., 1996), although the only species, *fimbriatus*, appears to be common in various Pakistan habitats (ZAHLER & KARIM, 1998); *Pteromyscus* of South–eastern Asia and *Syntheosciurus*, known only from four montane forest localities in Costa Rica and Panama (WELLS & GIACALONE, 1985). The Oriental Region, particularly the Sunda shelf, appears as the centre of endemism for Petauristini and Sciurini (MOORE & TATE, 1965), but deforestation and recent fires in the region may have negatively affected the status of an unknown number of taxa, especially endemics of small areas such as *Hylopotes bartelsi* from Western Java and *Glyphotes simus* and *Dremomys everetti*, both restricted to North–western Borneo. The maintenance of Sciuridae diversity is probably dependent on primary forest conservation (JOSHUA & JOHNSINGH, 1994) even though some species may take advantage of forest disturbance and fragmentation (UMAPATHY & KUMAR, 2000); these should benefit from programmes for primate habitat conservation. As the introduction of non–native squirrels may be a serious threat to native species (GURNELL & LURZ, 1997), trade in living squirrels should at least be carefully monitored.

Castoridae

Holarctic, two species usually recognised (but see LAVROV, 1983), neither of which globally threatened. *Castor fiber* is being reintroduced in its former European range (NOLET & ROSELL, 1998), but several Asian subspecies – the Siberian, the Mongolian (STUBBE et al., 1991) and especially the Tuvinian subspecies *Castor fiber tuvinicus*, which was reduced to 40–50 individuals in the upper reaches of the Yenisei River (LAVROV, 1983), may be at serious risk and some of them have recently been added to the Red List (IUCN, 2002). *Castor canadensis* has been introduced in southern South America (EISENBERG, 1989), where it may constitute a severe ecological problem.

Geomyidae

Canada to North–western Colombia. The monotypic *Zygogeomys* of Sierra Madre of Michoan (South–western Mexico) is threatened owing to competition with gophers of the genus *Cratogeomys* which penetrated into *Zygogeomys* range as the result of agricultural encroachment and deforestation (HAFNER & BARKLEY, 1984). Five threatened pocket gopher species are found in Mexico, and one in Costa Rica. Although locally common, most Central American species have restricted ranges which pose some conservation problems if agricultural encroachment continues.

Heteromyidae

Mainly North America, but reaching North–western South America. No threatened genus but many declining taxa owing to restricted range (e.g. *Dipodomys elator*), deforestation (ANDERSON & JARRÍN, 2002), and urban development in South-western United States, especially California, which represents the centre of endemism for the kangaroo–rat genus *Dipodomys* (PRICE & ENDO, 1989; BOLGER et al., 1997).

Dipodidae

Desert and steppe of central Asia and North–western Africa except Sicistinae which occurs in Europe and Northern central Asia. *Euchoreutes* (subfamily Euchoreutinae) of North–west China and Mongolia is listed as endangered. The only member of the subfamily Cardiocraniinae, *Cardiocranius paradoxus* (China, Mongolia and Eastern Kazahhstan) is considered vulnerable. IUCN (2002) designates as vulnerable the monotypic *Eozapus setchuanus*, a species restricted to Central China and apparently poorly collected (SUNG, 1998). However, the species seems to adapt to secondary shrubland and was regularly collected inside its range (GIRAUDOUX et al., 1998).

Muridae

Distributed world–wide in all terrestrial habitats. Subfamily arrangement follow MUSSER & CARLETON (1993) and NOWAK (1999), but there is controversy about the taxonomic status and composition of many of them. CHALINE et al. (1977) argued for a different system, raising the following subfamilies to the family level: Sigmodontidae (called Cricetidae) and including Cricetinae, Spalacinae, Myospalacinae, Lophiomyinae and Platacanthomyinae; Nesomyidae including Otomyinae, Rhizomyidae, Gerbillidae, Arvicolidae, Dendromuridae including Petromyscinae, Cricetomyidae and Muridae including Hydromyinae. Although such an arrangement more properly highlights the affinities between the different taxa, and probably does more justice to the extreme diversity of "Muridae", for the sake of consistency the "classic" treatment proposed in the last compendiums on mammalian taxonomy is followed (WILSON & REEDER, 1993; NOWAK, 1999).

Sigmodontinae (93 genera, 7 threatened)

New World.

Three threatened monotypic and little–known genera (*Abrawayaomys, Phaenomys, Rhagamys*) occur in the Atlantic Forest Region of Eastern Brazil and, possibly, in the Misiones Province of Argentina (for *Abrawayaomys*, MASSOIA et al., 1991); *Kunsia* in the Pantanal; *Anotomys* is only recorded in two regions of Northern Ecuador between 2890–4000 m (VOSS, 1988); and one genus —*Nesoryzomys*— is endemic of the Galapagos, where another genus, *Megaoryzomys*, is already extinct (DOWLER et al., 2000). *Podomys floridanus*, a Florida endemics, is threatened by loss of habitat to agriculture and urban development (KIRKLAND, 1998). The recently described *Pearsonomys annectans* (PATTERSON, 1992) as well as *Geoxus*, both of the Valdivian Chilean rainforest, may not be common and may warrant inclusion among the genera of concern owing to continued habitat fragmentation in the region (KELT, 2000). The monotypic *Podoxymys roraime* is known from only six specimens, all originating from Mount Roraima at the border between Guyana, Venezuela and Brazil (PÉREZ–ZAPATA et al., 1992). Its habitat is safe for the time being (Aguilera, pers. com.). Since the description of two new species (EMMONS, 1999b), the akodontine genus *Juscelinomys* appears less threatened even though its cerrado habitat in Brazil and Bolivia is undergoing rapid conversion and thus it deserves conservation attention. Water mice of the genus *Rheomys* and the Yucatan vesper mouse (*Otonyctomys*) may be particularly vulnerable to habitat degradation in Central America (REID, 1997).

Calomyscinae (1 genus)

Middle and Central Asia.

A unique taxonomic entity formerly placed in Cricetinae (MICHAUX et al., 2001), six species of *Calomyscus* presently recognised by MUSSER & CARLETON (1993), three of which are classified lower risk/near threatened and one, *C. hotsoni* of South–western Pakistan, is listed as Endangered (IUCN, 2002).

Cricetinae (7 genera)

Palearctic.

The recently re–evaluated monotypic *Consumys canus* of Gansu and Shaanxi Provinces (China) is only known from three specimens (NOWAK, 1999), and surely deserves inclusion among threatened taxa in need of immediate research.

Spalacinae (2 genera)

Eastern Europe, Ukraine, Middle East, Asia Minor, North–eastern Africa.

No threatened genera (although *Spalax* may qualify for threatened status as only one of the five species, *S. zemni*, is not included in the Red List, perhaps due to an omission), but most of the recognised species are considered vulnerable owing to competition with human activities such as agriculture. To date, over 40 chromosomal forms have been described among *Nannospalax*, 30 of which in Turkey alone (SÖZEN et al., 1999). According to NEVO et al. (1995) all these forms should be treated as full species and an updated conservation assessment would thus be needed.

Myospalacinae (1 genus)

Eastern Asia.

Possibly only a tribe of Cricetinae (MICHAUX & CATZEFLIS, 2000). Alpha–taxonomy is still unstable. Species of subgenus *Eospalax* from China

(NOWAK, 1999); *Myospalax fontanieri* (including *cansus* and *bailey* which are considered distinct species by PANTELEYEV, 1998), *M. smithi* and *M. rothschildi* are considered of conservation concern, even if they may be locally common in cultivated fields (GIRAUDOUX et al., 1998).

Lophiomyinae (1 genus)

East Africa and possibly Arabia.

A distinctive monotypic genus allied to Cricetinae. *Lophiomys imhausi* is not considered threatened at present (IUCN, 2002) but KINGDON (1997) considers it rare and perhaps declining. Known distribution reviewed by KOCK & KÜNZEL (1999). In need of taxonomic revision, as several forms were lumped together by ELLERMAN (1940); some of them may be distinctive and of conservation concern.

Platacanthomyinae (2 genera)

India and Indochina.

Formerly included among Gliridae, the two genera are not recognised as threatened, yet they deserve particular attention owing to their relict distribution and phyletic distinctiveness. One of the three recognised species, *Typlomys chapensis*, is considered Critically Endangered (IUCN, 2002).

Mystromyinae (1genus, threatened)

South–eastern Africa.

The monotypic and distinctive *Mystromys albicaudatus*, formerly placed in the Cricetinae but now considered allied to *Petromyscus* (JANSA et al., 1999), is threatened by the overgrazing of the veld in South–eastern Africa (DEAN, 1978).

Nesomyinae (9 genera, 2 threatened)

Madagascar.

A dubious monophyletic taxon (CARLETON & MUSSER, 1984; JANSA et al., 1999). One monotypic genus, *Hypogeomys antimena* from western sandy forests, is considered threatened. *Hypogeomys* status is of great concern owing to continued degradation of forests inside its small range in the Kirindy Forest and demographic susceptibility to small population size (GANZHORN et al., 1996; SOMMER & HOMMEN, 2000; SOMMER et al., 2002). A captive population originating from five individuals collected by Gerald Durrell in 1990 is managed by the Durrell Wildlife Conservation Trust through an international studbook (COWAN, 2000). The only member of *Gymnuromys*, *G. roberti*, although known from a few sites and classified as Vulnerable (IUCN, 2002), now appears more broadly distributed in the humid eastern forests and less threatened than previously believed (GOODMAN & CARLETON, 1998; Goodman pers. com.). Two genera discovered in recent years, *Monticolomys* and *Voalavo*, seem restricted to upper montane vegetation in Eastern Madagascar (GOODMAN et al., 1999) but do not appear immediately threatened.

Otomyinae (2 genera)

Africa.

A distinct taxonomic entity with unclear affinities (CARLETON & MUSSER, 1984), but likely to be included in Murinae (MICHAUX & CATZEFLIS, 2000). Neither of the two genera threatened, but geographically isolated *Otomys occidentalis* of Mt. Oku in the Guinea highlands (DIETERLEN & VAN DER STRAETEN, 1992) is listed as Endangered (IUCN, 2002).

Rhizomyinae (3 genera)

South–eastern Asia, Eastern Africa.

Alpha taxonomy still unstable. Many taxa of *Tachyoryctes* with restricted distribution in Eastern Africa are included in the IUCN Red List (IUCN, 2002), sometimes supporting charismatic species such as the Ethiopian wolf *Canis simensis* in the Bale region of Ethiopia (SILLERO–ZUBIRI et al., 1995).

Gerbillinae (14 genera, 1 threatened)

Africa.

The monotypic threatened *Ammodillus imbellis* is restricted to the arid zone of Somalia and Eastern Ethiopia, while another monotypic potentially threatened genera, *Microdillus peeli*, occurs in the pre–desertic steppe of North–central Somalia where it is known from only three localities (ROCHE & PETTER, 1968).

Arvicolinae (27 genera)

North America, Europe and Asia.

A very speciose clade with no threatened genus, although *Chionomys* of the Mediterranean region, *Dinaromys* of the Balkans, *Myopus* of Northern–eastern Palearctic and *Proedromys* of Southern China are considered potentially threatened following present IUCN designations (AMORI & GIPPOLITI, 2001). Some other genera have very restricted ranges, such as *Prometheomys* from the Caucasus, *Hyperacrius* from Pakistan and *Blanfordimys* from Afghanistan and Turkmenistan (NOWAK, 1999; PANTELEYEV, 1998).

Dendromurinae (8 genera, 2 threatened)

Africa.

Dubiously monophyletic as here recognized (DENYS et al., 1995; MICHAUX & CATZEFLIS, 2000). *Megadendromus nikolausi* is a little–known endemic of highlands in Eastern Ethiopia. It occurs in the Bale Mountains National Park (YALDEN et al., 1996). The monotypic *Leimacomys buettneri* is only known by two specimens collected in 1890 in Central Togo and is feared to be already extinct. SCHLITTER (1989) and MACPHEE & FLEMMING (1999) correctly include this species among extinct taxa adopting the 50–year rule of record absence, but several authorities pointed out that remaining forests of the region had not been properly sampled in recent decades (GRUBB et al., 1998). The two monotypic and very localised species *Dendroprionomys rousseloti* and *Prionomys batesi* of Central Africa deserve urgent research.

Petromyscinae (2 genera)

Africa.

Two distinctive and monotypic genera (*Petromyscus* and *Delanymys*) with restricted range and unclear affinities. SCHLITTER (1989) and KINGDON (1997) consider *Delanymys brooksi* of the high–altitude marshes of the Albertine Rift threatened by habitat disruption.

Cricetomyinae (3 genera)

Africa.

None of the three genera threatened, but *Beamys* of Eastern Africa is potentially threatened. *Cricetomys emini cosensi* of Zanzibar Island may warrant specific status and its conservation status deserves investigation (KINGDON, 1997).

Murinae (122 genera, 23 threatened)

Most of the threatened murine genera are restricted to islands (AMORI & CLOUT, 2003). They are grouped here according to geographic criteria.

Philippines: *Abditomys latidens* is highly arboreal monotypic rat known from only two specimens collected in Northern and Southern Luzon (MUSSER & HEANEY, 1992). *Anonymomys* is known from only three specimens from North–eastern Mindoro Is. (HEANEY et al., 1998). The two species of *Archboldomys* are only known by the very few specimens collected on Mt. Isarog and Mt. Cetaceo in Luzon (RICKART et al., 1998). Four species of *Crateromys* are presently recognised, all are threatened by hunting and forest degradation and one, *C. paulus* of Ilin Is., is possibly already extinct (PRITCHARD, 1989). Monotypic *Limnomys sibuanus* is only known from seven specimens taken in Mindanao in mountain forest (MUSSER & HEANEY, 1992), even if it is not considered uncommon in high–elevation forest (HEANEY et al., 1998). The monotypic *Tryphomys adustus* is a little known species from three localities of Luzon (HEANEY et al., 1998).

Palawanomys, the single species *P. furvus*, is known from four specimens collected in 1962 on Mt. Mantalingajan, Palawan (MUSSER & NEWCOMB, 1983).

Sunda Islands: *Nesoromys*, monotypic endemic of Seram Is. Not recognised as a distinct genus by MUSSER & CARLETON (1993), apparently only known from the type specimen described by Thomas in 1922 (NOWAK, 1999).

Kadarsanomys, monotypic designated as lower risk/near threatened, but possibly threatened because no specimens has been collected since 1935. Only known from 1000 m high forest in the volcanic massif of Gunang Pangrango–Gede in Western Java (MUSSER, 1982).

Eropeplus, another monotypic genus, is known from only five specimens from mountain forests in Middle Sulawesi (MUSSER, 1970). The genus *Tateomys*, of which two species are known from very few specimens originating from Sulawesi, is sometimes placed in *Melasmothrix* (NOVAK, 1999). *Melasmothrix naso* is restricted to cold and wet moss forests of Central Sulawesi (MUSSER, 1982). A newly described genus and species, *Sommeromys macrorhinos* (MUSSER & DURDEN, 2002), from the mountains of Cerntral Sulawesi must be considered of conservation concern.

The monotypic *Komodomys* is currently known to occur on Rintja and Padar Islands, in the Lesser Sunda, but may possibly also live on other islands, such as Flores where it is known as sub–fossils (MUSSER & CARLETON, 1993). The monotypic *Paulamys naso* was described from sub–fossil material from Flores Is.: a living rat was trapped on Flores and assigned to this species even though KITCHENER et al. (1991) disputed its distinctiveness from *Bunomys*. The only extant species of *Papagomys*, *P. armandvillei* is presently known only from Flores Is. (MUSSER, 1981).

Nansei Shoto arcipelago: two species of *Tokudaia* usually recognised (CORBET & HILL, 1992) even though Japanese mammalogists treat them as subspecies (KAWAMICHI, 1997). A third species occurs on Tokun–oshima Is. but has not yet been described (MUSSER & CARLETON, 1993). Habitat degradation put the survival of endemic species on the Nansei Shoto Archipelago in great danger, with *T. mueninki* of Okinawa considered in a very critical conservation status (ITO et al., 2000).

South–east Asia: the genus *Vernaya* contain one or possibly two little–known species whose known range includes Northern Burma, Northern Sichuan and Yunnan (CORBETT & HILL, 1992; SUNG, 1998).

West–central Africa: the monotypic *Lamottemys okuensis* is only known by four specimens collected on Mt. Oku in South–western Cameroon, an area known as an important centre of endemism for rodents (VERHEYEN et al., 1997).

Ethiopian Highlands: *Muriculus imberbis* represent a monotypic genus endemic to the Ethiopian grassland plateaux, with two well–distinct subspecies, collected only rarely in recent years (YALDEN & LARGEN, 1992). The monotypic *Nilopegamys plumbeus* is known from only one specimen collected in 1927 near the source of the Little Abbai River in Ethiopia, later synonymised with *Colomys* but resurrected by KERBIS PETERHANS & PATTERSON (1995).

Australia: the two species of *Leporillus* were once widespread throughout much of the Southern arid and semi–arid zones of Australia. *Leporillus conditor* survive today only on the two small Franklin Islands of the Nuyts Archipelago, while *L. apicalis* is considered extinct. A captive breeding and translocation program to other off–shore islands is underway (LEE, 1995).

New Guinea: the two little–known species of *Macruromys* occur in the mountain forests of New Guinea where their appearance is both rare and localised (FLANNERY, 1995a). The genus *Solomys* contains more than five species endemic to the Solomons Archipelago, one of which (*Solomys salamonis*) is considered extinct by IUCN but extant by MACPHEE & FLEMMING (1999). All species are threatened by introduced predators and logging of forests (FLANNERY, 1995b).

Hydromyinae (10 genera, 5 threatened)
Australia, New Guinea.

Threatened genera among water rats include the monotypic *Xeromys myoides*, only known from a few specimens from scattered localities in Queensland and the Northern Territory of Australia, and *Pseudohydromys* (2 species), *Neohydromys,* and the distinctive *Mayermys*, all from New Guinea, mostly mountain forests. However, the paucity of available data on New Guinea rodents permit a preliminary conservation assessment only. For instance *Neohydromys* is not considered threatened at all by FLANNERY (1995a). Both species of the genus *Microhydromys* (*M. richardsoni* and *M. musseri*), known from very few specimens (FLANNERY, 1995a), may warrant threatened status.

Anomaluridae

Equatorial Africa, seven species in three genera (DIETERLEN, 1993), but a further genus — *Anomalurops*— and the existence of more species has been suggested (SCHUNKE & HUTTERER, 2000). No species currently considered threatened by IUCN, perhaps for the vast range of the few recognized species and high densities reported in optimal habitats (JULLIOT et al., 1998). Monotypic *Zenkerella insignis* of the Western Equatorial forest block is potentially threatened as it is dependent on conservation of mature forest (KINGDON, 1997). The population recently reported from Bioko Island (VAL et al., 1995) may warrant subspecific status.

Pedetidae

Found in the arid areas of Southern and Eastern Africa. *Pedetes* is considered threatened (listed as vulnerable) because of eradication programs in agriculture areas and habitat loss due to overgrazing, although it may be locally abundant reaching a density of 10 springhares per hectare (BUTYNSKI, 1984). Cytogenetic and molecular data support the elevation of the eastern subspecies *surdaster* to full species status, thus supporting earlier taxonomic arrangements of this peculiar rodent genus (MATTHEE & ROBINSON, 1997).

Ctenodactylidae

Rocky areas in arid regions of Sahara and Northern Afrotropical Region. The monotypic genus *Felovia* of Mali, Mauritania and Senegal is considered threatened by deforestation and desertification (SCHLITTER, 1989) but detailed data are lacking.

Gliridae

Palearctic and African forests and dry–lands (HOLDEN, 1996; NOWAK, 1999). Threatened genera are *Selevinia*, endemic to Kazakhstan and sometimes considered to form its own family, *Glirulus* of Japan, *Myomimus* (three or four species; OBUCH, 2001) of the Balkans and Middle East and *Chaetocauda* of Sichuan, for which we provisionally retain genus status (contra HOLDEN, 1993). Potentially threatened monotypic genera are *Eliomys*, *Muscardinus* and *Glis*, all with a wide but increasingly fragmented distribution in the Western Palearctic. Decline seems associated to intensive management of woodland and/or to a reduction of hedgerows in agro–sylvo–pastoral landscapes (i.e. CAPIZZI et al., 2002).

Bathyergidae

African fossorial family, 14 species recognised by NOWAK (1999), but number of valid species at least among *Cryptomys* in Zambia, is much larger (BURDA et al., 1999). Four species are included in the lower risk category. *Heliophobius* of East Africa is potentially threatened. The genus *Bathyergus* has a very limited range in coastal South–west Africa and is considered vulnerable by KINGDON (1997).

Hystricidae

No threatened or potentially threatened genus for this Old World family. Only *Hystrix brachyura* is listed as Vulnerable (IUCN, 2002). No data are available about the current status of the Palawan endemic *H. pumila* (cf. HEANEY et al., 1998). Some species are of great economical importance as food source (i.e. *Atherurus* in Africa cf. JORI et al., 1998).

Petromuridae

Monotypic, rocky outcrops of South–west Africa, not threatened at the moment but the status of *Petromus typicus* in Namibia need to be properly assessed (cf. GRIFFIN, 1998).

Thryonomyidae

Cane rats are an important food source in Sub-Sahara Africa (AMORI & GIPPOLITI, 2002; JORI et al., 1995).

Erethizontidae

North and South American forests, still unstable alpha taxonomy (BONVICINO et al., 2002; EMMONS & FEER, 1997; NOWAK, 1999; VOSS & DA SILVA, 2001). No threatened or potentially threatened genus. Information is needed on the status of the Andean monotypic endemic *Echinoprocta rufescens*. Only *Sphiggurus vestitus* of Colombia and Venezuela is considered vulnerable. A number of restricted–range and disputed taxa may warrant urgent research, such as *Coendou quichua* of Ecuador Andes, *Sphiggurus sneiderni* of the Colombian western slopes of the Andes and the *S. villosus* complex of Brazilian Atlantic forest (EMMONS & FEER, 1997).

Chinchillidae

South America. Genus *Chinchilla* (two species) is threatened, although a domestic form is widespread in breeding farms around the world. Conservation status of these two species is very confusing, with the Vulnerable *C. lanigera* now considered more at risk than the Critically Endangered *C. brevicaudata* (COFRÉ & MARQUET, 1999) which was recently rediscovered in Northern Chile.

Dinomyidae

Monotypic family found in isolated localities of the eastern foothills of the Andes from Colombia and Venezuela to Bolivia and the Amazon lowlands of W Brazil and Peru (EMMONS & FEER, 1997). *Dynomys branickii* is hunted for food and considered endangered but it occurs at least in one protected areas, the Manu National Park, Perù (VOSS & EMMONS, 1996). A successful breeding program is presently being carried out at Calì Zoo (WHITE & ALBERICO, 1992).

Cavidae

South America. *Dolichotis* (two species), found in scrub and grassland areas from Southern Bolivia to Southern Argentina, is considered potentially threatened, as it is hunted and competes with introduced *Lepus europaeus* (OJEDA & MARES, 1981). *Dolichotis patagonum* is commonly bred in zoos around the world.

Hydrochaeridae

Panama, Northern and Central South America, not threatened. Capybara is harvested for meat and skin and can provide economic benefits to landowners while allowing habitat conservation in the seasonally flooded llanos (OJASTI, 1991). Taxonomic and conservation status of the Capybaras West of the Andes, described as *Hydrochaeris isthmius* (MONES & OJASTI, 1986), should be assessed.

Dasyproctidae

Central and South American forests. Although locally agoutis are extirpated by excessive hunting or owing to excessive habitat fragmentation (i.e. CHIARELLO, 1999) and some taxa may warrant conservation status, no genus appears threatened at this time. The whole genus is in need of taxonomic revision (VOSS & EMMONS, 1996).

Agoutidae

Central and Southern America. *Stictomys taczanowskii* of the Andean region is listed as lower risk —near threatened by the IUCN (2002). The other monotypic genus, *Agouti paca*, is the most prized mammal of the Neotropics for its meat (EMMONS & FEER, 1997) and, although locally extirpated, is not yet considered globally threatened.

Ctenomyidae

Extreme southern part of the Neotropical Region. One genus exhibiting high karyotypic diversity; 48 species recognised by NOWAK (1999), more than 60 according to GIMÉNEZ et al. (1999). Only *Ctenomys magellanicus* is considered threatened (IUCN, 2002).

Octodontidae

Southern South America steppe. The monotypic *Tympanoctomys barrerae* is endemic of salt pan-sand dune habitats of Mendoza and La Pampa provinces of Argentina (OJEDA et al., 1999) and is considered vulnerable by IUCN (2002). The arid region of Northwest Argentina was found to contain two others recently discovered monotypic genera; *Pipanacoctomys* and *Salinoctomys* (MARES et al., 2000) whose conservation status has not yet been assessed.

Abrocomidae

South-western Neotropics, 7 species (BRAUN & MARES, 2001). The status of the recently discovered *Cuscomys ashaninka* (EMMONS, 1999a) from the Northern Vilcabamba Mountains of Cusco, Peru, is undetermined at the moment as is the other species of the genus, *C. oblativa*, known only from remains in Inca tombs, still extant according to EMMONS (1999a).

Echimyidae

New–world arboreal spiny–rats, taxonomy very unstable (NOWAK, 1999). The monotypic *Chaetomys* (formerly in Erethizontidae), endemic to the Atlantic Forest of South–east Brazil, is considered threatened although it has a more extensive range than once believed (OLIVER & SANTOS, 1991). Potentially threatened genera are *Carterodon*, *Olallamys* (2 species) and *Isothrix* (3 species; VIÉ et al., 1996). EMMONS & VUCETICH (1998) establish the new genus *Callistomys* for the little–known *Echimys (Nelomys) pictus* of Bahia, which is known from a very few individuals. The monotypic *Kannabateomys amblonyx* of South–eastern Brazil, Paraguay and Misiones (Argentina) is restricted to dense thickets especially near watersides and may deserve conservation attention (OLMOS et al., 1993). The arboreal spiny rat of the Atlantic region of Eastern Brazil is sometimes separated from *Echimys* and placed in its own genus *Nelomys*. Alpha taxonomy of this group is still unclear, and many taxa are considered threatened owing to small range size, deforestation and hunting pressure (cf. OLMOS, 1997). The terrestrial

spiny rats are now known to be represented by two genera, the more wide–pread *Proechimys* and *Trynomys* (LARA & PATTON, 2000), essentially delimited to the Atlantic Forest domain and of conservation concern as not a single specimen was found even during a long–term study in the Rio Doce State Forestry Park (STALLINGS, 1989). *Proechimys* is an important food source in regions were large game species have been extirpated (SUÁREZ et al., 1995).

Capromyidae

Endemic to the West Indies, more than 30 recognised species in eight genera, at least 19 species and two genera extinct, probably following human settlement there (ALCOVER et al., 1998; CAMACHO et al., 1995; WOODS, 1989). Threatened genera are: *Geocapromys* (two species) from Jamaica and Bahamas, *Mesocapromys* (four species) from Cuba and the monotypic *Plagiodontia* from Hispaniola. The genus *Mysateles* of Cuba is potentially threatened. In Cuba, the four species of *Mesocapromys* are restricted to small islands or tiny ranges and two of them (*M. nanus* and *M. sanfelipensis*) are possibly already extinct. *Isolobodon* is here considered a threatened genus following IUCN (2002) classification of *Isolobodon portoricensis* of Hispaniola as CR although evidence of its survival is very weak (NOWAK, 1999).

Myocastoridae

Freshwater habitats in Southern South America, monospecific, not considered threatened but declining owing to hunting for their pelt, at least in Argentina (OJEDA & MARES, 1981), introduced in many parts of Europe and North America and successfully eradicated in Great Britain (GOSLING & BAKER, 1989).

Discussion

It should be emphasised that biological conservation depends upon and is closely tied to knowledge on the phylogenetic relationships and taxonomy of biological groups. Thus, what we identified as present priorities for rodent conservation should be regularly updated as systematic research refines our understanding of systematic affinities and diversity among rodents (AMORI & GIPPOLITI, 2003). For instance, extinction of two rodent species (*Rattus macleari* and *R. nativitatis*) on Christmas Island in the Indian Ocean at the beginning of the century, may be a negligible loss according to the most prevalent taxonomy, a major loss if the distinctiveness of the two species (MUSSER & CARLETON, 1993) is taken into account and systematically formalised. Furthermore, the result of ecological research may show a brighter status for some endemic taxa which suffer less than thought from habitat disturbance (GIRAUDOUX et al., 1998).

Table 1. Number of living genera (Ng), species (N spp.) and threatened species (NT spp.; IUCN, 2002) of rodents by Family.

Tabla 1. Número de géneros vivos (Ng), de especies (N spp.) y de especies en peligro de extinción (NT spp.; IUCN, 2002) de roedores, agrupados por familias.

Family	Ng	N. spp.	NT spp.
Aplodontidae	1	1	
Sciuridae	51	273	36
Castoridae	1	2	
Geomyidae	6	40	5
Heteromyidae	6	60+	
Dipodidae	17	51	8
Muridae	300+	1,336+	235
Anomaluridae	3	7	
Pedetidae	1	2	2
Ctenodactylidae	4	5	1
Gliridae	10	29	9
Bathyergidae	5	14+	
Hystricidae	3	11	1
Petromuridae	1	1	
Thrynomyidae	1	2	
Erethizontidae	4	17	1
Chinchillidae	3	3	2
Dinomyidae	1	1	1
Cavidae	5	14	
Hydrochaeridae	1	2	
Dasyproctidae	2	13	3
Agoutidae	2	2	
Ctenomyidae	1	60+	1
Octodontidae	6	11	2
Abrocomidae	2	7	
Echimyidae	16+	66+	6
Capromyidae	6	11	10
Myocastoridae	1	1	

Of the 28 rodent families currently recognised, only two, Pedetidae and Dinomydae, are considered threatened at the present time (table 1). Higher rates of endangerment at the generic level are found in the subfamily Euchoreutinae, Mystromyinae, Chaetomyinae, Plagiodontinae and Isolobodontinae —the latter possibly already extinct— all with 100 % of genera threatened, Hydromyinae and Capromyidae (50 %), Cardiocraniinae, Glirinae and Chinchillidae (33 %). According to the present study, 126 of the circa 451 living rodent genera (27,9 %), representing

Table 2. A summary of rodent diversity and conservation status with a list of threatened, potentially threatened and of concern genera by Family and Subfamily. (In brackets, number of living species for each genus other than one.)

Tabla 2. Resumen de la diversidad de roedores y de su estado de conservación con una lista de géneros en peligro de extición, en peligro de extinción potencial y de interés, clasificados por familias y subfamilias. (Entre paréntesis, el número de especies existentes de cada género diferente del indicado.)

Family Subfamily	Threatened	Potentially threatened	Of concern
Sciuridae			
Sciurinae	*Myosciurus*	*Epixerus* (2)	*Allosciurus*
	Hyosciurus (2)	*Syntheosciurus*	*Gliphotes*
Petauristinae	*Biswamoyopterus*	*Aeretes*	*Petaurillus* (2)
	Eupetaurus	*Belomys*	
	Trogopterus	*Euglacomys*	
		Pteromyscus	
Geomyidae	*Zygogeomys*		
Dipodidae			
Cardiocraniinae	*Cardiocranius*		
Euchoreutinae	*Euchoreutes*		
Zapodinae	*Eozaphus*		
Muridae			
Sigmodontinae	*Abrawayaomys*	*Chibchanomys*	*Rheomys* (4)
	Anotomys	*Hodomys*	*Otonyctomys*
	Nesoryzomys (2)	*Lenoxus*	
	Podomys	*Podoxymys*	
	Rhagamys		
	Kunsia (2)		
	Phaenomys		
Cricetinae	*Cansumys*		
Spalacinae			*Spalax*
Lophiomyinae			*Lophiomys*
Mystromyinae	*Mystromys*		
Nesomyinae	*Hypogeomys*	*Brachyuromys*	
	Gymnuromys		
Gerbillinae	*Ammodillus*	*Microdillus*	
Arvicolinae		*Chionomys* (3)	*Blanfordimys*
		Dinaromys	*Hyperacrius*
		Myopus	*Prometheomys*
		Proedromys	
Dendromurinae	*Leimacomys*	*Dendroprionomys*	
	Megadendromus	*Prionomys*	
Petromyscinae			*Delanymys*
Cricetomyinae		*Beamys*	
Murinae	*Abditomys*	*Kadarsanomys*	*Sommeromys*
	Anonymomys	*Stenocephalemys* (2)	
	Archboldomys	*Carpomys* (2)	
	Crateromys (4)	*Celaenomys*	
	Tryphomys	*Hapalomys* (2)	
	Limnomys	*Srilankamys*	
	Palawanomys	*Xenuromys*	

Tabla 2. (Cont.)

Family / Subfamily	Threatened	Potentially–threatened	Of concern
	Eropeplus	*Xenomys*	
	Tateomys (2)	*Diomys*	
	Melasmothrix	*Diplothrix*	
	Komodomys	*Leggadina* (2)	
	Papagomys	*Mesembriomys* (2)	
	Paulamys	*Rhabdomys*	
	Tokudaia		
	Nesoromys		
	Lamottemys		
	Vernaya		
	Muriculus		
	Nilopegamys		
	Leporillus		
	Macruromys (2)		
	Solomys (3)		
Hydromyinae	*Xeromys*		*Microhydromys* (2)
	Pseudohydromys (2)		
	Neohydromys		
	Mayermys		
Anomaluridae			
Zenkerellinae		*Zenkerella*	
Pedetidae	*Pedetes* (2)		
Ctenodactylidae	*Felovia*		
Gliridae			
Glirinae	*Glirulus*	*Glis*	
		Muscardinus	
Leithiinae	*Myomimus* (3)	*Eliomys* (2)	
	Selevinia		
	Chaetocauda		
Bathyergidae		*Heliophobius*	*Bathyergus*
Erethizontidae			*Echinoprocta*
Chinchillidae	*Chinchilla* (2)		
Dinomyidae	*Dinomys*		
Cavidae			
Dolichotinae		*Dolichotis* (2)	
Agoutidae	*Stictomys*		*Agouti*
Octodontidae	*Tympanoctomys*		
Abrocomidae			*Cuscomys*
Echimyidae			
Chaetomyinae	*Chaetomys*		
Dactylomyinae		*Olallamys* (2)	*Kannabateomys*
Echimyinae		*Isothrix* (3)	*Nelomys*
			Callistomys
Eumysopinae		*Carterodon*	
Capromyidae			
Capromyinae	*Geocapromys* (2)	*Mysateles* (5)	
	Mesocapromys (4)		
Isolobodontinae	*Isolobodon*		
Plagiodontinae	*Plagiodontia*		

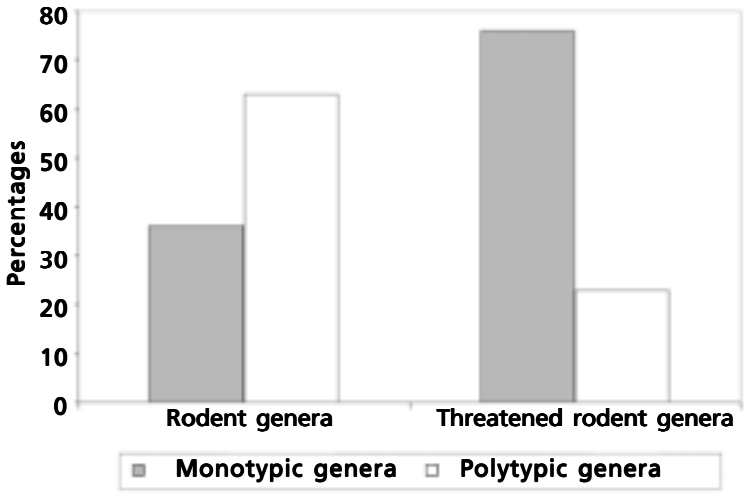

Fig. 1. Percentage of monotypic and polytypic genera in the Order Rodentia and in threatened or potentially threatened genera.

Fig. 1. Porcentaje de géneros monotípicos y politípicos del orden Rodentia y de los géneros en peligro o en peligro de extinción potencial.

168 species, deserve conservation attention (table 2). This is considerably more than the percentage of threat calculated at the species level (16 %) and seems to confirm previous findings on the possible loss of a disproportionate amount of phylogenetic diversity among mammals during the current extinction spasm (PURVIS et al., 2000). There are some indications that there is a high probability that monotypic or species poor lineages are at risk (PURVIS et al., 2000). Of the 106 threatened and potentially threatened genera (thus considering only IUCN 2002 official data), only 25 (23,6 %) are not presently monotypic, while among the whole order Rodentia, polytipic genera represent 63 % circa of living genera (fig. 1). If we consider that even polytypic genera at risk are often represented by only two species, belong to non–speciose clade, and that genetic divergence among currently recognised genera in small mammals is higher than among genera of larger mammals (CASTRESANA, 2001), we may well suppose that there is a risk to lose a considerable amount of genetic diversity among rodents. However, it is unknown to what degree our results are influenced by the high level of threat observed among poor–species lineages restricted to islands.

Conservation of small mammal diversity is low in the environmental agenda (AMORI & GIPPOLITI, 2000; ENTWISTLE & DUNSTONE, 2000) despite increasing evidence of their role in supporting ecosystems and more "attractive" species. To change the popular view that "a rat is a rat" (CEBALLOS & BROWN, 1994) there is the need for refinement of rodent (and especially muroids) systematics and an increase in educational activities focusing on small mammal diversity and ecological roles. Conversely, strategies should be established and financial resources allocated for urgent conservation measures for the most threatened and unique rodent taxa at a global level. This study represents a step forward in the identification of a limited, affordable number of taxa to maintain diversity of the order.

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