Identifying conservation priorities when data are scanty: a case study with small mammals in Italy

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ABSTRACT

Species prioritisation is an important component of conservation strategies. However, identifying species that are threatened is not easy for many taxa that lack detailed information on distribution and population trends. We propose a ranking system for small mammals, based on their degree of vulnerability and their conservation value. Scores were derived from data on life history traits and ecological requirements of individual species, with respect to their sensitivity to changes in landscape and the composition and qualities of ecosystems. Twelve variables were considered, related to the distribution, demography, ecological adaptability, and their endemism and taxonomic diversification. Rodents with the highest score values were either characteristic of mountain habitats (*Apodemus alpicola*, *Chionomys nivalis* and *Marmota marmota*), typical of lowlands (*Micromys minutus*) or forest species (dormice), and they were also short living, with few reproduction events. Top ranking Soricomorpha were endemic (*Crocidura sicula*, *C. pachyura*), range restricted (*Sorex alpinus*, *Talpa caeca*) and habitat specialists (*Neomys fodiens, N. anomalus*), and were further characterized by low reproduction, low dispersal ability, and restricted elevation range. The factors used in the score system were able to emphasize localized endemisms that could be recognized in the future whenever subspecies should be promoted to the rank of species. Soricomorpha highlighted in the IUCN national red list as nearly threatened or for the absence of information ranked at the top of our list. The methodological framework proposed here could be used when a pool of species needs to be evaluated for further investigation or conservation actions, helping by focusing on species that are more sensitive to habitat changes or have an intrinsic conservation value.

Key words: Conservation; Erinaceomorpha; Ranking system; Rodentia; Soricomorpha

Introduction

Addressing conservation issues on a regional scale requires strategic planning aimed at identifying species that are threatened, or becoming endangered, and require management intervention to reverse these negative trends. However, this collides with the lack of detailed information on the distribution and population trends for most species, thereby introducing a high level of uncertainty when evaluating the conservation status and priorities of species groups for which little is known.

Listing species on the basis of their level of threat or likelihood of extinction is one of the main tools used in setting priorities for conservation. The IUCN Red List categories have been widely accepted throughout the world as a reference for planning species conservation (Possingham et al., 2002). These lists mainly evaluate the reduction in the geographic range and population size of a set of species (IUCN, 2001). According to the red list criteria, the absence of data should not deter attempts at evaluating the species status, as methods involving inferences and projections are acceptable, as well as indirect information concerning the deterioration of habitats where species live (IUCN, 2001). For example, during the IUCN European Mammal Assessment, demographic trend information was not available for 33% of the species considered (Temple and Terry, 2007).

The loss of range and populations over a threshold are factors that place a species at risk, but these changes are rarely quantified for secretive species. For instance, these data are not available for small mammal species in many countries. Thus, in many cases the conservation ranking for this group of species is mainly based on expert judgment and not on quantitative assessment (Temple and Terry, 2007). When data are scanty there is a risk of considering most species safe, because there is no indication of decline. On the other hand, collecting complete information for many secretive species is difficult and costly. A species ranking system based on relatively few data, that can be easily collected, is thus required.

Categorization systems based on the evaluation of biological, ecological and distributional information have been developed for different taxa (Cofré and Marquet, 1999; Filippi and Luiselli, 2000; Andreone and Luiselli, 2000). These systems are usually based on the scoring of life history traits and the ecological requirements of species with respect to their sensitivity to changes in landscape and ecosystem composition and qualities. The basis for this type of species categorisation is that species with low reproductive potential and restricted tolerance to ecological factors should be less adaptable and more sensitive to habitat degradation than more generalist and adaptable species. Here, a similar system is proposed to rank Italian small mammals according to their degree of vulnerability. In this ranking system the choice was made to use data that well describes the species' biological and ecological constraint, but could be easily derived from the basic knowledge of their natural history. These kinds of data are available for many small mammal species, making this ranking system applicable to many countries or regions of the world.

An increasing number of new species have been described in recent years as a result of the development of DNA techniques. In such a situation, a proposed ranking system has to be flexible for the incorporation of new taxa, when these are described and accepted by the scientific community. To verify whether our ranking system is adaptable to the description of new species, the scoring system was also applied to possible cryptic species.

Material and methods

Species considered

Species present in Italy belonging to the orders Rodentia (rodents), Erinaceomorpha and Soricomorpha were considered (Amori et al., 2008a). *Arvicola scherman* was excluded from this analysis because the species is known from Italy only for few records at the border with Slovenia (Amori et al., 2008a). *Microtus brachycercus* was not considered here because its specific status is still debated (Castiglia et al., 2008). *Sorex arunchi* was not considered as a recent genetic study did not support its specific status (Yannic et al., 2012). As a first step, the subspecies division was not considered, nor were taxa not yet clearly recognised as valid species. The nomenclature follows Wilson and Reeder (2005).

Cryptic species

The increase of nuclear and mitochondrial DNA studies on European mammals have provided more accurate information on the genetic structure of populations. Such information has been used for the reconstruction of the phylogeographic history of many taxa, as well as for the identification of cryptic species (Ferguson, 2002). As a result, more mammal species are now recognised in Europe than a few years ago, and other proposed cryptic species are still waiting for an evaluation. To verify whether this ranking system is adaptable to the description of new species, the scoring system was applied to possible cryptic species. To identify the phylogroups with a high probability of representing true species, a literature search was performed for genetic studies focused on small mammal species present in Italy. In a second step, we used the criteria proposed by Baker and Bradley (2006) to identify new mammal species under a genetic species concept. We considered as cryptic species those taxa that were identified by the authors as having a genetic distance between allopatric or parapatric phylogroups equal or greater to the mean value found for sister species belonging to the same genus or family.

According to these criteria, the Calabrian red squirrel (*Sciurus vulgaris meridionalis* Lucifero 1907) and the Sicilian population of Savi's vole (*Microtus savii nebrodensis* Minà Palumbo 1868) may be considered as endemic cryptic species for Italy. The genetic distance calculated with the entire cytochrome-*b* distance between *M. s. nebrodensis* and the cluster formed by other *Microtus savii* taxa ranged from 7.4 to 7.9% (Castiglia et al., 2008). The genetic lineage of *S. v. meridionalis* was significantly differentiated from the rest of Italy and Europe, providing evidence for distinct histories throughout the Pleistocene era (Grill et al., 2009). Cytochrome-*b* net genetic distance between Calabrian squirrels and red squirrels from the rest of Europe was 2%, and within-group means were 0.3% for the European clade, and 0% for the Calabrian clade.

The use of these taxa as possible cryptic species was an exercise to test the robustness of the scoring system and should not be considered as an endorsement to the hypothesis that the two subspecies should be promoted to the rank of species.

Factors and variables

Italian small mammal species were ranked according to their potential vulnerability and conservation value. Twelve variables related to the distribution, demography, ecological specialisation, and conservation values of each species were considered. Each variable was categorised in four ranks (0-3), ranging from the lowest (0) to the highest (3) risk. The final score for each species was the mean of the scores across all of the variables, with higher values implying a higher priority for conservation. The breath of the categories of a given parameters was not kept constant; instead it was adapted according to our interpretation of the influence the single parameter may have on the species. For instance, the distributional breadth of occupancy was split into four equal ranges of 25% wide, while the home range diameter was split considering 10m, 50m, and 100m as limits to the vagility of different species. We acknowledge that this is a subjective choice, but in our opinion not all the parameters could be split into equal ranges.

By far the most important threat to European terrestrial mammals is habitat loss and degradation, followed by pollution and human disturbance (Temple and Terry, 2007); habitat loss is the most severe threat also at the global level (Vié et al., 2009). Generally, those species that are characterised by a restricted range, low abundance and habitat specificity, are expected to be more vulnerable to habitat disturbance (e.g. habitat loss and degradation) and prone to extinction than species that are widely distributed, habitat generalists and abundant (Rabinowitz et al., 1986; Davidson et al., 2009). A set of variables related to species distribution, demography and ecological adaptability were considered, which were complemented with information on the conservation value of the species based on their level of endemism and taxonomic diversification. The variables are reported below with the ratio for their choice; rank values are explained in Table 1.

Distributional criteria: Italy is a long and narrow peninsula, with a strong north-south gradient in environmental parameters. Thus, species with a large distribution are potentially more adapted to different ecological and climatic condition (Slatyer et al., 2013). Island species are generally more vulnerable to extinction because they have a small geographic range that is limited to the island and may be more easily affected by habitat alteration due to human activities. Short dispersal distances mean that declining populations may not be sustained by immigration, and that recolonisation following local extinction may not occur (Brown and Kodric-Brown, 1977). Considering that dispersal distances are not available for most of the species considered here, the home range diameter was used as a proxy of the vagility of each species (Bright, 1993; Whitmee and Orme, 2013; Santini et al., 2013). This was calculated from the mean home range area by assuming that the range was circular, and for riparian species the total length of the linear range was used (Bright, 1993). The parameters considered for the distributional criteria were: Distributional breadth of occupancy in Italy, Insularity, and Home range diameter. The distributional breadth of occupancy and the insularity of species were evaluated by using the maps published in Amori et al. (2008a).

Demographic parameters: a taxon that breeds several times a year, produces large offspring numbers and lives longer, it may recover more easily from population crashes, and could colonize with success habitats where populations have become extinct. We considered the following parametrs: Frequency of reproduction, Offspring number, Mean life in nature.

Ecological specialisation: species that are less specialised are considered more adaptable and thus more tolerant to anthropogenic disturbance. A group of variables that would capture the degree of ecological specialisation for each species was used: Elevational distribution, Climatic breadth, Habits, Adaptability to altered habitats. Species living at low altitudes are more subject to anthropogenic disturbance, such as pollution, road and railway traffic, habitat degradation and destruction. However, we acknowledge that under the effects of climate change, species restricted to the highest altitude will lose their ranges and will experience a higher extinction risk. This will imply a change in the scoring system in the future. The climatic and habitat specialisation of a species was derived from the known occurrence of the species in four climatic zones of Italy (Mediterranean, mid-elevation Apennine mountains, Po plain, Alpine zone). Habits is related to the ability of species to move and live in one of four main habitats (fossorial, terrestrial, arboreal or aquatic species). Secretive species were assumed to be less subject to direct or indirect disturbances in general, including deforestation or pollution. The Adaptability to altered habitats was evaluated in respect to the possibility for species to live in urban centres and suburban areas.

Conservation value: with this general term we refer to species that have a restricted range (endemism) and represent evolutionary novelties (i.e. genera with one or few species and species with few subspecies). Maximizing the so-called phylogenic diversity should be one of the aims in conservation priority setting (Isaac et al. 2007). Therefore, the extinction of a species in an old, monotypic or species-poor clade would result in a greater loss of biodiversity in respect to a young species with many close relatives (Mace et al., 2003; Isaac et al., 2007). Here we measured the contribution of single species according to the diversification of their relatives. The parameters considered were: Endemism and Taxonomic uniqueness.

Data on the biological and ecological characteristics of species were compiled from different sources. Data collected in Italy was the primary source of information, but when data were not available we used other information sources from Europe. The main sources were Toschi and Lanza (1959), Toschi (1965), Niethammer and Krapp (1978, 1982, 1990), Sarà (2000), MacDonald and Barret (2001), Capizzi and Santini (2007) and Amori et al. (2008a).

The result of our scoring system was compared with the species status reported in the Italian IUCN red list for threatened species (www.iucn.it/liste-rosse-italiane.php). This list is a worldwide reference for conservation policies.

Data analysis

Ordination and clustering methods were employed to summarise the two multivariate datasets and to identify groups of similar species in terms of their habitat, life history and distributional traits. Principal Coordinate Analysis (PCoA) was initially used to summarise the major patterns of variation in the two matrices. A main advantage over this technique is that it can use different dissimilarity matrices from traditional ordination techniques, such as PCA, to calculate scores that can be visualised in two dimensions (Legendre and Legendre 1998). Because the input matrix was composed of categorical variables, the Gower general dissimilarity index (Gower, 1971) was used to construct a distance matrix. A hierarchical cluster analysis was also performed with average linkage on the same dissimilarity matrix. Average linkage was chosen on the basis of assessment of the Gower distance (Borcard et al. 2011). To identify the "optimal" number of clusters, the CH index method proposed by Caliński & Harabasz (1974) was used, which can be used as a stopping rule for identifying the ''optimal'' number of clusters through the calculation of a pseudo-F statistic (Caliński & Harabasz 1974).

Results

Rodentia

The 21 species of rodents native to Italy were ranked in descending order of vulnerability and conservation priority (Table 2). Mean score values (mean 0.96 ± 1.00) ranged from 0.33 for *A. sylvaticus* to 1.50 for *A. alpicola*. Species with the highest score values (>1.2) were habitat and range restricted: *A. alpicola* and *M. marmota* restricted to alpine habitats, *C. nivalis* to alpine and Apennine habitats, *M. minutus* typical of plains and *D. nitedula* and *M. avellanarius* typical of forested habitats. The other two Italian glirids gave score values ≥1 indicating the sensitivity of this family group. According to these results, the variables with the highest mean score for rodents were ML (short living species), CB (climatic specialists), DB (range restricted), and FR (with 1-2 reproduction events). Conservation values and other criteria (i.e. distributional, demographic and ecological specialization) were not correlated ($r_s = 0.11$, NS). Conservation variables alone identified four species as priorities for their taxonomic uniqueness (*M. avellanarius* and *G. glis*), its endemism level (*M. savii*) or both (*A. alpicola*).

The Italian IUCN red list considers *E. quercinus, A. amphibius* and *C. nivalis* as Near Threatened and *A. alpicola* as Data Deficient, while all the other rodents are of Least Concern.

Rank values of species listed as NT and DD did not to differ from rank values of species listed as LC (Mann-Whitney test: U = 15.5, p = 0.1).

Erinaceomorpha and Soricomorpha

The 16 Italian species are reported in Table 3 in descending order of vulnerability and conservation priority. Mean score values (mean 1.27 ± 1.05) ranged from 0.67 for *E. europaeus* to 2.00 for *C. sicula*, and were higher than the scores of rodents ($t_{(35)} = 2.59$, $p < 0.05$). Considering the small mammals altogether, six out of the seven first species are Soricomorpha.

The seven species with the highest score values among Erinaceomorpha and Soricomorpha are characterised by a restricted range (*C. sicula* present only on the island of Sicily and its surrounding small islands, *C. pachyura* endemic to the Mediterranean region, *S. alpinus* to the Alps and *T. caeca* to the Alps and Apennines), are habitat specialists, such as the two aquatic *Neomys,* or are endemic to Central and South Italy (*S. samniticus*). The variables with the highest mean score were ML (short living species), FR (low reproduction), HR (small home range), EL (restricted in elevation) and END (endemic species). Conservation values and other criteria were not correlated ($r = 0.31$, NS). Conservation variables alone highlighted two species for their endemism level and taxonomic uniqueness (*C. sicula* and *T. caeca*).

The IUCN red list considers only *S. alpinus* as NT, but five species (*T. cieca*, *C. pachyura*, *N. fodiens*, *N. anomalus*, *S. antinorii*) are considered Data Deficient.

Rank values of species listed as NT and DD were higher than rank values of species listed as LC (U = 10.5, $p < 0.05$).

Cryptic species

Score values for the two cryptic species are reported in Table 4, together with the score values of the two sister species from which they were separated, after removing the range of the cryptic species. Some biological information was not available for the cryptic species, so the values of the sister species from which they may be separated were used in this case. *Sciurus vulgaris* and *M. savii* maintained the same score values, because removing the range of the two cryptic species does not change their distributional and taxonomic values. *Sciurus meridionalis* would have a mean score value of 1.50 and *M. nebrodensis* of 1.33, indicating that these taxa are vulnerable and of high conservation value. In fact, the two cryptic species would be localised endemisms, and *S. meridionalis* as a taxon would also be less generalist and adaptable than *S. vulgaris*.

Groups of species

Ordination of the rodent life history and distribution traits revealed two gradients of trait variation represented by the PCoA axes, which explained 22.11% and 12.30% of the total variation, respectively (Figure 1). The first axis (Dim1) revealed a gradient from species that breed several times a year, which is typical of open habitats or generalist species (*Apodemus* and *Microtus*), to species that reproduce only once a year and are habitat specialists (Gliridae and *S. vulgaris* in forest habitats, *M. marmota* in alpine meadows). The CH index identified only two clusters, separating the forest species (dormice, *S. vulgaris* and *H. cristata*) and the specialised *M. marmota* from the other species.

For Erinaceomorpha and Soricomorpha the first two axes of the ordination of the life history and distribution traits explained 20.76% and 16.90% of the variance, respectively (Figure 2). The first axis (Dim1) separated island species from mainland species. The second axis (Dim2) distinguished the aquatic species more exposed to direct disturbances, from terrestrial and fossorial species.

The CH index identified five optimal clusters for Erinaceomorpha and Soricomorpha. The first main division separated the subterraneous species of the genus *Talpa* from the other species. In the remaining group of species, a first division separated the two *Crocidura* from the islands (*C. sicula* and *C. pachyura*) from the three clustered groups composed of the two *Erinaceous* species and *S. etruscus*, the two aquatic *Neomys* and the *Sorex* and the remaining *Crocidura* species.

Discussion

Our scoring system allowed us to identify Italian small mammals potentially vulnerable to human pressure and habitat changes, as a result of their restricted range, ecological specialisation and low reproductive rate. This is not equivalent to defining a threatened status, which is what the red lists are normally used for. The IUCN Red List highlights species that are threatened with extinction within a short time span (IUCN, 2001). The basis for listing is rarity or a marked decline in population size and/or geographical range. Among Italian small mammals no species strictly responds to these criteria; however three rodents are considered to be at the edge of a threatened status. Furthermore, five Erinaceomorpha and Soricomorpha and one rodent are considered Data Deficient (DD) because there is inadequate information to make a direct, or indirect, assessment of their risk of extinction based on their distribution and population status. In a similar way, the IUCN Red List considers only 8.2% of European rodents and 8.8% of European Erinaceomorpha and Soricomorpha as threatened and other 9.4% and 5.4% respectively as Near Threatened.
Species conservation policies should not be focused only on species that are already threatened. These are only a fraction of the total species and in most cases their management and recovery is complicated by their small populations. Every-day conservation activity of parks and other nature

conservation institutions needs to consider a wide range of species and a complexity of interactions. Our scoring system ranks the Italian small mammals integrating data on life history traits, ecological requirements and species range, which give a measure of their sensitivity to changes in landscape and ecosystems, with information on the species conservation interest based on their level of endemism and taxonomic uniqueness. The biological and ecological information necessary to implement this scoring system is derived from basic knowledge on the natural history of the species. These kind of data are available for many small mammal species and part of them are usually collected during research expeditions in countries that are poorly studied. For this reason we believe that this scoring system could be applied to the mammal fauna of many regions of the world, allowing a first screening of the species that deserve further conservation attention. On the other hand, our system was not able to catch the vulnerability of some small mammals to the presence of introduced species (e.g. the native red squirrel threatened by the American grey squirrel, Bertolino 2008; Martinoli et al. 2010), probably because this depend on the characteristics of both the native and the introduced species.

A restricted range and reduced habitat niche were the most important factors highlighted by this scoring system for rodent species. Most of the species were characteristic of alpine habitats (*A. alpicola* and *M. marmota*), typical of lowlands (*M. minutus*) or forest species (dormice). While alpine species should be considered less exposed to human pressure, species restricted to the lowlands may suffer from human-induced habitat transformation. *Micromys minutus*, for instance, is thought to be declining in England due to changes in habitat management and agriculture intensification (Perrow and Jowitt, 1995; Trout and Harris, 2008). Forest species are sensitive to changes in woodland management. This is the case of *M. avellanarius*, which is suffering from the loss and fragmentation of ancient woodlands in many European countries (Bright and Morris, 1996; Amori et al., 2008b). Soricomorpha with the highest score values were range restricted. The two island-based *Crocidura* (*C. sicula* and *C. pachyura*) may be more easily affected by habitat alterations and scored at the top of the list generated here. The two *Neomys* are greatly exposed to degradation and the loss of riparian habitats and increase in water pollution, and some studies have suggested that water shrews have decreased in number and occurrence in areas where they were once abundant (Churchfield, 1997).

Providing examples of declining species cases from outside of Italy were primarily used. This is not because Italy is a sort of fortunate peninsula, where small mammal species are in a good conservation condition and well protected in a pristine and preserved landscape. On the contrary, Italy suffers, as do many other western countries, from a high human pressure with an increasing urbanisation, large infrastructure construction, agriculture intensification and widespread habitat erosion. However, if the last and most updated review on Italian small mammals is considered (Amori et al., 2008a), the absence of information on the population trends of most species is embarrassing. In this situation, most of the assessments of the small mammals' status made for the compilation of the national Red List were mainly based on an expert judgment, without the possibility of a quantitative assessment. Nonetheless, five out of sixteen (31.2%) Erinaceomorpha and Soricomorpha were highlighted for the absence of any data useful to infer their status. This generalised lack of information on the distribution and population dynamics of Italian small mammals is a strong indication for the need of urgent and coordinated nationwide surveys on species status. Meanwhile, the scoring system developed here should help conservationists to focus on species that may be considered as prioritary for future surveys and conservation attention as a result of their restricted range, habitat specificity or endemicity.

In some cases two species of the same genera have very similar scores (e.g. *Neomys fodiens* and *N. anomalus*). This is due to the lack of data for single species and the necessity to consider values from the closest species. We are aware that this makes it difficult to assess the real rank position for some species. However, the ranking system is open and can be updated with new information when it becomes available, making the evaluation flexible, easy to computerize and maintain up to date.

Although mammals are well studied in comparison to other taxa, an increasing number of new species have been described in recent years. This is related to the advent of relatively inexpensive DNA-sequencing technologies that enable the recognition of cryptic species previously grouped as a single taxon. The description of new species poses many problems regarding legal issues, as national laws and European Directives protect only taxa that are reported in the provided lists. A recent dispute between mammalogists has debated the conservation issues related to this 'taxonomic inflation', with a dispute between 'lumpers' and 'splitters' (e.g. Gippoliti and Groves, 2012; Gippoliti et al., 2013; Zachos and Lovari, 2013; Zachos et al., 2013). In any way, the necessity to protect new species is often more urgent than for species that have been recognised as such for a long time. The adaptability of our scoring system to future change in small mammal taxonomy was tested using two possible endemic cryptic species. In both cases, the two possible new species (*S. meridionalis* and *M. nebrodensis*) ranked at the top of the score list, while the sister species from which they have been separated (*S. vulgaris* and *M. savii*) were at the bottom. This provided evidence that the pool of factors used in this scoring system is able to highlight localised endemism that derives from the splitting of more broad and generalist species.

The methodological framework used here highlights species that are more sensitive to landscape and ecosystem changes. This is an *'a priori'* evaluation based on bibliographic information and does not reflect the real status of the species. It is, however, interesting to note that most of the Soricomorpha highlighted in the IUCN national red list as nearly threatened or for the absence of information, ranked at the top of our list. In our opinion, the ranking that was obtained here should be considered as a first screening system that can be used when a pool of species needs to be evaluated for further investigation and conservation actions. This can include monitoring activities in protected areas or a large-scale nationwide investigation of species distribution and population dynamics. Given that the resources available for these activities are usually limited, focusing on species that are more sensitive to human pressure or have an intrinsic conservation value is much more cost-effective (Cagnacci et al., 2012).

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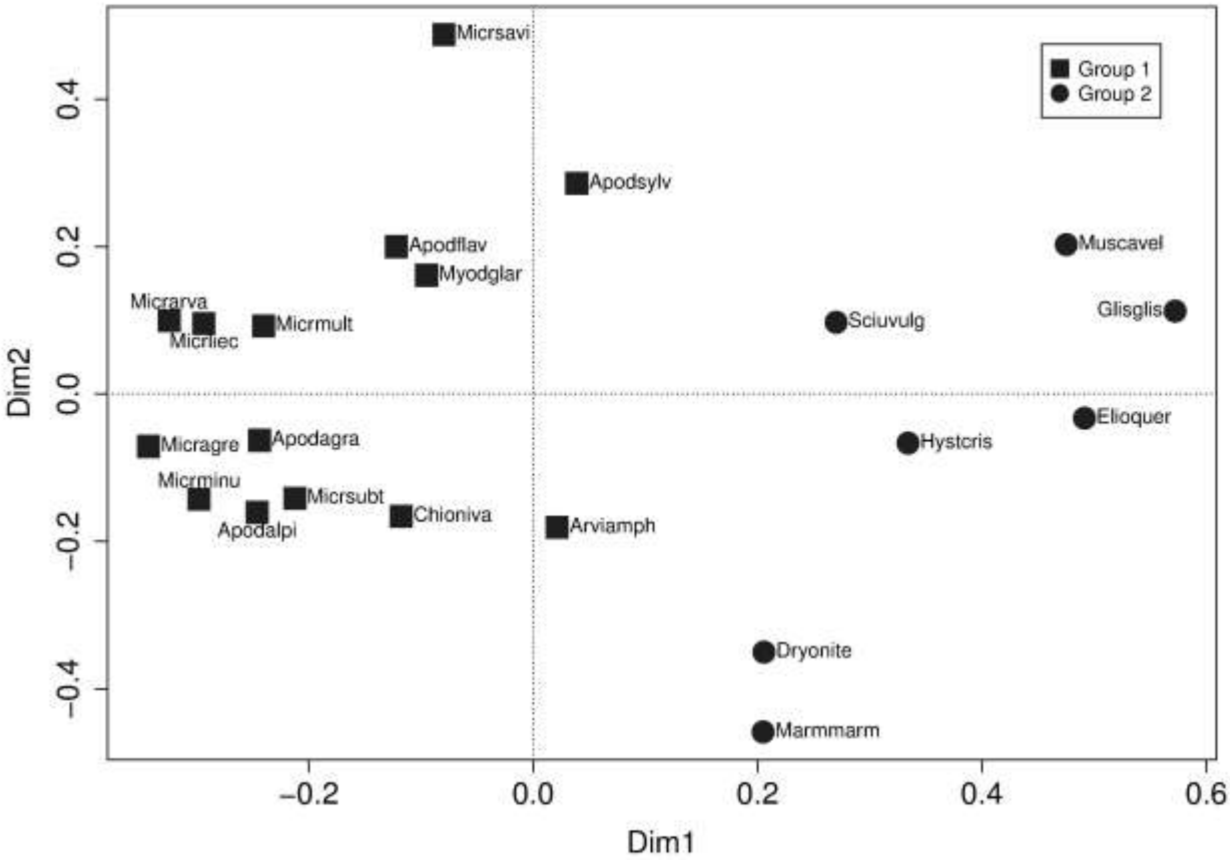

Fig. 1. Principal coordinate analysis plot showing the similarity of composition of 21 Italian rodent species; codes are composed by the first four letters of the genus and the species name. Groups 1-2 refers to the two optimal clusters identified using the CH index method.

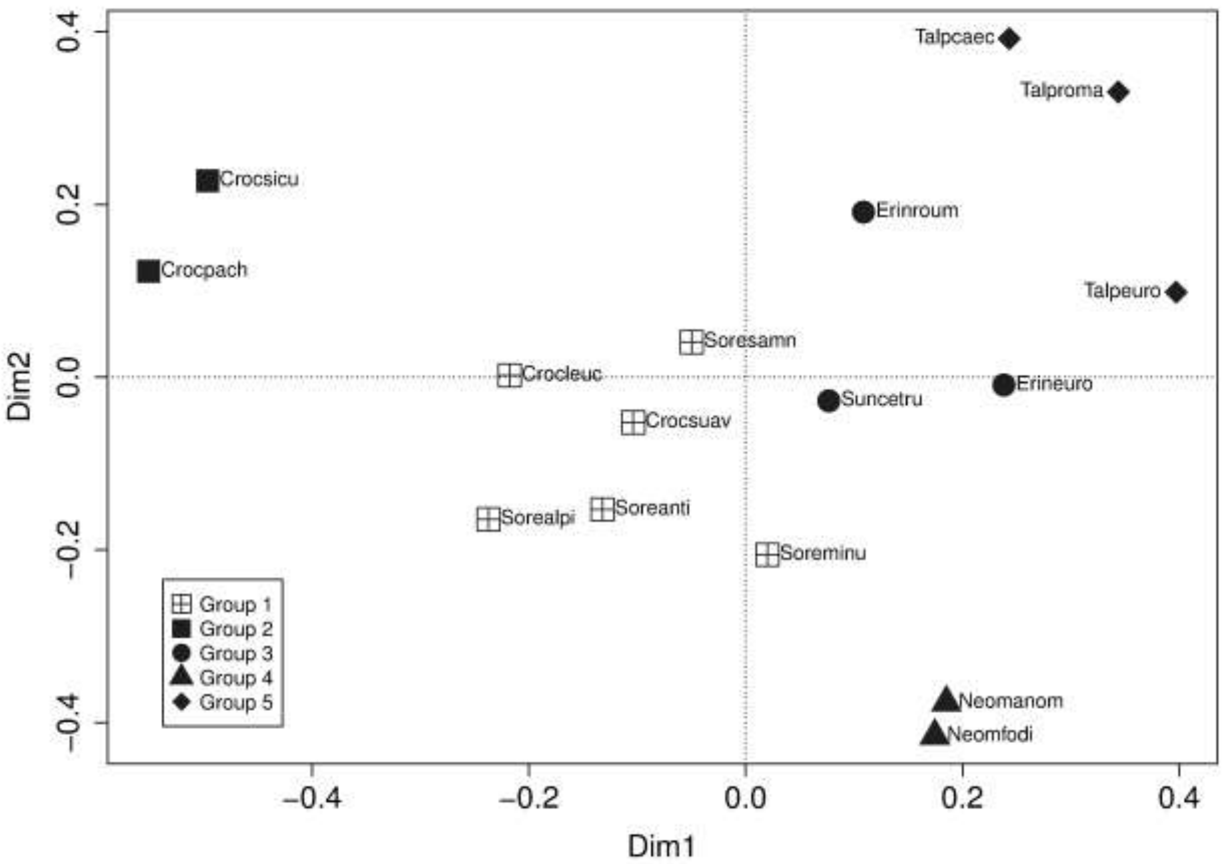

Fig. 2. Principal coordinate analysis plot showing similarity of composition of 16 Italian Erinaceomorpha and Soricomorpha; codes are composed by the first four letters of the genus and the species name. Groups 1-5 refers to the five optimal clusters identified using the CH index method.

Table 1

Variables used in the ranking system, their explanation and rank score values

Variable	Explanation	Abbreviation	Ranks			
			0	1	2	3
Distributional criteria						
Distributional breadth of occupancy in Italy	Percentage of presence in the country	DB	> 75%	51-75%	25-50%	< 25%
Insularity	Distribution of the taxon on mainland and islands	IN	100% on mainland	50-99% on mainland	< 50% on mainland	only on islands
Home range diameter	Assuming a circular range; total length of the linear range for riparian species	HR	HR > 100m	50m < HR ≤ 100m	10m < HR ≤ 50m	HR ≤ 10m
Demographic parameters						
Frequency of reproduction	Number of reproductive events throughout the year	FR	> 3	2-3	1-2 according to year and condition	1
Offspring number	Mean number of offspring per litter	OFF	> 5	4-5	3-4	< 3
Mean life in nature	taxon with a mean life (in months)	ML	≥ 54	36-54	18-36	< 18
Ecological specialisation						
Elevational distribution	Altitudinal limits for the species	EL	ubiquity species	present only at > 1,000m elevation	present on reliefs up to 1,500m	restricted to planes (< 600m elevation)
Climatic breadth	Occurrence of the species in four climatic zones of	CB	found in four habitats	found in three habitats	found in two habitats	found in one habitat

	Italy: Mediterranean, mid-elevation Apennine mountains, Po plain, Alpine zone					
Habits	Species adapted for moving and living in four main habitats	H	mainly with fossorial activity	mainly with above ground activity	mainly with arboreal activity	mainly with aquatic activity
Adaptability to altered habitats	Adaptability of the species to urban habitats	AD	extremely adaptable species (found even in urban centres)	adaptable species (found also in suburbia if small natural patches are present)	scarcely adaptable species (found at best in average sized natural areas)	unadaptable species (found only in large areas of natural habitat)
Conservation value						
Endemism	Percentage of the Italian range related to the whole taxon distribution	END	< 10%	10-50%;	51-75%	> 75%.
Taxonomic uniqueness	Based on the degree of monotypy at the level of genus and family	TU	species of a polytypic genus with > 3 clearly recognised subspecies	species of a polytypic genus with 2-3 clearly recognised subspecies	species monotypic of a polytypic genus	species of a monotypic genus

Table 2
Scores for the variables affecting survival and the conservation value of Italian rodents; codes are explained in Table 1. IUCN indicate the category within the national red list. 'Mean conservation' is the mean between END and TU score values; 'mean others' is the mean between the other score values; 'mean all values' is the mean between the score value of all variables. 'Rank total' is the rank order considering Rodentia, Soricomorpha and Erinaceomorpha all together.

Taxon	END	TU	Conservation Mean	DB	IN	FR	OFF	ML	H	EL	CB	AD	HR	Others Mean	All values Mean	IUCN	Rank total
Apodemus alpicola	2.0	2.0	2.0	3.0	0.0	0.0	0.0	3.0	1.0	1.0	3.0	2.0	1.0	1.4	1.50	DD	4
Chionomys nivalis	1.0	1.0	1.0	2.0	0.0	2.0	1.0	2.0	1.0	1.0	2.0	2.0	2.0	1.5	1.42	NT	8
Micromys minutus	0.0	0.0	0.0	2.0	0.0	1.0	0.0	3.0	1.0	3.0	3.0	2.0	2.0	1.7	1.42	LC	8
Dryomys nitedula	0.0	0.0	0.0	3.0	0.0	3.0	1.0	1.0	2.0	1.0	2.0	3.0	0.0	1.6	1.33	LC	11
Marmota marmota	1.0	0.0	0.5	3.0	0.0	3.0	2.0	0.0	1.0	1.0	3.0	2.0	0.0	1.5	1.33	LC	11
Muscardinus avellanarius	1.0	3.0	2.0	0.0	1.0	3.0	1.0	1.0	2.0	0.0	0.0	2.0	1.0	1.1	1.25	LC	13
Hystrix cristata	1.0	0.0	0.5	0.0	1.0	3.0	3.0	0.0	1.0	2.0	2.0	1.0	0.0	1.3	1.17	LC	15
Glis glis	1.0	3.0	2.0	0.0	1.0	3.0	1.0	0.0	2.0	2.0	0.0	0.0	0.0	0.9	1.08	LC	17
Microtus subterraneus	0.0	0.0	0.0	3.0	0.0	1.0	1.0	2.0	0.0	0.0	2.0	1.0	2.0	1.2	1.00	LC	18
Eliomys quercinus	1.0	0.0	0.5	0.0	1.0	3.0	1.0	1.0	2.0	0.0	1.0	2.0	0.0	1.1	1.00	NT	18
Microtus liechtesteinii	1.0	2.0	1.5	2.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	1.0	2.0	0.9	1.00	LC	18
Arvicola amphibius	0.0	0.0	0.0	1.0	0.0	0.0	0.0	2.0	3.0	2.0	1.0	2.0	0.0	1.1	0.92	NT	25
Microtus agrestis	0.0	0.0	0.0	3.0	0.0	0.0	0.0	2.0	0.0	1.0	2.0	0.0	2.0	1.0	0.83	LC	27
Apodemus agrarius	0.0	0.0	0.0	2.0	0.0	0.0	0.0	2.0	1.0	3.0	2.0	0.0	0.0	1.0	0.83	LC	27
Microtus multiplex	1.0	0.0	0.5	2.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	2.0	0.8	0.75	LC	30
Microtus savii	3.0	1.0	2.0	0.0	1.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.0	0.5	0.75	LC	30
Myodes glareolus	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0	1.0	0.0	0.0	1.0	2.0	0.8	0.67	LC	32
Microtus arvalis	0.0	0.0	0.0	2.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	2.0	0.8	0.67	LC	32
Sciurus vulgaris	0.0	0.0	0.0	0.0	0.0	2.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.6	0.50	LC	35
Apodemus flavicollis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	0.0	0.0	1.0	1.0	0.5	0.42	LC	36
Apodemus sylvaticus	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0	0.4	0.33	LC	37
Mean variable value	0.6	0.6		1.3	0.3	1.2	0.6	1.6	1.0	0.8	1.4	1.0	1.0				

Table 3
Scores for the variables affecting survival and the conservation value of the Italian Soricomorpha and Erinaceomorpha); codes are explained in Table 1. IUCN indicates the category within the national red list. 'Mean conservation' is the mean between END and TU score values; 'mean others' is the mean between the other score values; 'mean all values' is the mean between the score value of all variables. 'Rank total' is the rank order considering Rodentia, Soricomorpha and Erinaceomorpha all together.

Taxon	END	TU	Conservation Mean	DB	IN	FR	OFF	ML	H	EL	CB	AD	HR	Others Mean	All values Mean	IUCN	Rank total
Crocidura sicula	3.0	2.0	2.5	3.0	3.0	2.0	0.0	2.0	1.0	2.0	3.0	1.0	2.0	1.9	2.00	LC	1
Crocidura pachyura	2.0	1.0	1.5	3.0	3.0	2.0	0.0	2.0	1.0	3.0	3.0	1.0	2.0	2.0	1.92	DD	2
Sorex alpinus	1.0	1.0	1.0	3.0	0.0	2.0	1.0	2.0	1.0	1.0	3.0	3.0	2.0	1.8	1.67	NT	3
Talpa caeca	3.0	2.0	2.5	2.0	0.0	1.0	2.0	2.0	0.0	1.0	2.0	2.0	1.0	1.3	1.50	DD	4
Neomys anomalus	1.0	0.0	0.5	0.0	0.0	3.0	1.0	3.0	3.0	1.0	0.0	3.0	3.0	1.7	1.50	DD	4
Neomys fodiens	1.0	0.0	0.5	1.0	0.0	3.0	1.0	3.0	3.0	0.0	0.0	3.0	3.0	1.7	1.50	DD	4
Sorex samniticus	3.0	0.0	1.5	0.0	0.0	2.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	1.4	1.42	LC	8
Talpa romana	3.0	0.0	1.5	2.0	0.0	1.0	2.0	2.0	0.0	2.0	2.0	0.0	1.0	1.2	1.25	LC	13
Suncus etruscus	0.0	0.0	0.0	0.0	1.0	3.0	1.0	3.0	1.0	2.0	1.0	0.0	2.0	1.4	1.17	LC	15
Erinaceus roumanicus	0.0	0.0	0.0	3.0	0.0	0.0	3.0	0.0	1.0	2.0	2.0	1.0	0.0	1.2	1.00	LC	18
Crocidura leucodon	1.0	0.0	0.5	0.0	0.0	2.0	0.0	2.0	1.0	2.0	1.0	1.0	2.0	1.1	1.00	LC	18
Sorex antinorii	3.0	0.0	1.5	0.0	0.0	2.0	1.0	2.0	1.0	0.0	0.0	1.0	2.0	0.9	1.00	DD	18
Sorex minutus	1.0	0.0	0.5	0.0	0.0	3.0	1.0	3.0	1.0	0.0	0.0	1.0	2.0	1.1	1.00	LC	18
Talpa europaea	1.0	0.0	0.5	2.0	0.0	1.0	2.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0	0.92	LC	25
Crocidura suaveolens	1.0	0.0	0.5	0.0	0.0	2.0	0.0	2.0	1.0	2.0	0.0	0.0	2.0	0.9	0.83	LC	27
Erinaceus europaeus	1.0	0.0	0.5	0.0	1.0	0.0	3.0	0.0	1.0	2.0	0.0	0.0	0.0	0.7	0.67	LC	32
Mean variable value	1.6	0.4		1.2	0.5	1.8	1.2	2.0	1.1	1.5	1.2	1.2	1.7				

Table 4

Scores for the variables affecting survival and the conservation value of two cryptic rodent species ([1]) and score values for the two species from which they may be separated ([2]) if the cryptic species are removed from their range; codes are explained in Table 1.

Taxon	END	TU	DB	IN	FR	OFF	ML	H	EL	CB	AD	HR	Mean
Sciurus vulgaris[2]	0.0	0.0	0.0	0.0	2.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.42
Sciurus meridionalis[1]	3.0	0.0	3.0	0.0	2.0*	1.0*	1.0*	2.0	2.0	2.0	2.0	0.0*	1.50
Microtus savii[2]	3.0	1.0	0.0	1.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.0	0.75
Microtus nebrodensis[1]	3.0	1.0	3.0	3.0	0.0*	0.0*	2.0*	0.0	0.0	2.0	0.0	2.0*	1.33

* these values were taken from the sister species because information for the subspecies (i.e. the cryptic species) were not available