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Are the IUCN standard home-range thresholds for species a good indicator to prioritise conservation urgency in small islands? A case study in the Canary Islands (Spain)

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Summary

The lists of threatened species provide a partial basis from which many governments and NGOs responsible for the recovery of endangered species can draw up conservation priorities. Such lists should therefore, be unambiguous, both in terms of taxonomic diagnosis and the degree to which the species listed are threatened. The importance of establishing from a credible, rational and legally defensible point of view when exactly a certain species is to be considered threatened has led the IUCN to formulate a set of criteria in order to ensure the objectivity of the application of threat levels, based on thresholds which are absolute in some cases and relative in others. This paper will debate the extent to which the absolute thresholds can act as a valid reference for all taxonomic groups in the context of small geographical regions such as the Canary Islands, which are inhabited by a multitude of endemic species, the delimitation of which is not restricted by the consideration of geopolitical state borders. The study concludes that it is not possible to fix valid thresholds for all groups owing to their scarcity and fragmentation as this would risk overestimating the danger faced by the less-vagile species at the expense of the more widely dispersed ones.

The paper also examines how scarcity in the islands constitutes a natural pattern of the distribution of many species. If this factor is not taken into account when selecting absolute thresholds for the areas of occupation or fragmentation, the result is bound to be an overestimation of the threat. That will lead to the creation of overly long Red Lists of threatened species which do not clarify sufficiently well which species deserve priority attention in terms of conservation and which do not. This impediment to ordering the different species in a scale of priority according to

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real urgency in terms of conservation makes the B and D criteria of the IUCN less consistent when using them as benchmarks to help establish conservation priorities in oceanic archipelagos such as the Canary Islands.

Introduction

The lists of species which have been legally declared to be under threat reflect one of the main conservation concerns of many governments. In such lists taxonomic ambiguities and uncertainty regarding threat levels should be minimal in order to avoid distortions in terms of the validity of the taxa (Daugherty et al., 1990; O'Brien & Mayr, 1991). Moreover, since the lists are legally enforceable, they frequently result in regulations being drawn up which involve restrictions to options and civil liberties in terms of the exploitation of the species in question and their natural habitats (Geist, 1992). Furthermore, a species which has been listed officially endangered means that there is a population in crisis which ought to be the subject of an action plan for recovery, with the aim of removing the species in question from the list (Linklater, 2003; Machado, 1997; Wyse-Jackson & Akeroyd, 1994).

Usually, all of the species which are officially declared to be threatened become protected species, but not all protected species are necessarily threatened. In officially protected, but not threatened species, the urgency of conservation is less, since such protection is designed to preserve natural populations which are not in serious decline. With threatened species, and particularly with endangered, conservation urgency is greater and can be so critical that it requires immediate action to avoid extinction. Ranking conservation urgency in different threat categories provides a set of reference points for establishing conservation priorities which should be complemented with the application of criteria related to the foreseen consequences of extinction (Bañares, 1994; Millsap et al., 1990) and the real chances of recovering the species (Mace et al., 2006; Marsh et al., 2007).

The importance of establishing in a credible, rational and legally defensible manner when a certain species should be considered to be threatened and the degree of the threat facing it has led several governmental organisations and NGOs to develop criteria in order to ensure that the application of categories of threat is as objective as possible (Scarpace & Schimpff, 2001; Shelden & DeMaster, 2004; Shelden et al., 2001). The most widely used criteria on a global level are the IUCN standards, originally drawn up in 1994 (IUCN, 1994) and later updated in 2001 (IUCN, 2001) in an attempt to make them applicable to all groups of organisms, regardless of scale and geographical habitat (Mace, 1999). These criteria enable species to be classified into three threat categories (critically endangered, endangered and vulnerable), according to the application of a set of decision guidelines relating to the size of populations, distribution and probability of continued decline.

While it has been claimed that the IUCN criteria can be used as a reference for establishing conservation priorities (Avery et al., 1995; Dunn et al., 1999; Schnittler & Günther, 1999), several authors have criticised this usage (Keller & Bollmann, 2004; Master, 1991; Possingham et al., 2002) and have pointed out certain drawbacks in its application which call its effectiveness into question (Mrosovsky, 2003; Webb & Carrillo, 2000). This has led to the appearance of alternative (Martín et al., 2005b; Molloy et al., 2002) and complementary criteria (Báldi et al., 2001; Zulka et al., 2003) adapted to specific regions or biological groups.

The five essential criteria drawn up by IUCN (2001) can be based on relative or absolute thresholds (Table 1). The former (A and E) reflect the variation of a population deduced by measuring the number of adult individuals at different given times, and the latter the number of mature individuals (C and D1), distribution area (B and D2) or number of locations (B and D2) at a given time, which tends to be the most recent.

Criterion B is based on species distribution values, measured from the extent of occurrence or the area of occupancy (Gaston, 1994). According to this criterion any species or sub-species with an extent of occurrence of 20,000 km^2 or less, and which furthermore satisfies two of the three additional requirements of occupying less than 11 locations, suffering extreme fluctuations or being in continuing decline, should be considered to be threatened. The same thing occurs when the reference parameter is the area of occupancy; this should be 2000 km^2 or less and two of the three above-mentioned requirements should be satisfied. In contrast, criterion D2 states specifically that any

Table 1. Simplified overview of threshold for the IUCN Red List criteria after Butchart et al. (2005).

Criterion	Critically endangered	Endangered	Vulnerable	Qualifiers and notes
A1: reduction in population size	⩾90%	⩾70%	⩾50%	Over 10 years/three generations in the past, where causes are reversible, understood and have ceased.
A2-4: reduction in population size	⩾80%	⩾50%	⩾30%	Over 10 years/three generations in past, future or combination
B1: small range (extent of occurrence)	<100 km^2	<5000 km^2	<20,000 km^2	Plus two of: (a) severe fragmentation/ few localities (1, ⩽5, ⩽10); (b) continuing decline; and (c) extreme fluctuation
B2: small range (area of occupancy)	<10 km^2	<500 km^2	<2000 km^2	Plus two of: (a) severe fragmentation/ few localities (1, ⩽5, ⩽10); (b) continuing decline; and (c) extreme fluctuation
C: small and declining population	<250	<2500	<10,000	Mature individuals. Continuing decline either (1) over specified rates and time periods or (2) with (a) specified population structure or (b) extreme fluctuation
D1: very small population	<50	<250	<1000	Mature individuals
D2: very small range	N/A	N/A	<20 km^2 or ⩽5 locations	Capable of becoming critically endangered or extinct within a very short time
E: quantitative analysis	⩾50% in 10 years/three generations	⩾20% in 20 years/five generations	⩾10% in 100 years	Estimated extinction-risk using quantitative models, e.g. population viability analyses

species or sub-species with five or less known locations or with an area of occupancy of less than 20 km^2 is to be considered threatened.

IUCN defines "location" as "the particular geographical or ecological area in which a single threatening event could have a rapid effect on all of the members of the taxon". This is a highly ambiguous definition if we bear in mind the great variety of factors which could constitute a threat. From the practical point of view, the location may be assimilated to a cell or a group of cells, provided that represents a continuous distribution. In this way there will be as many locations as non-joined cells, and rules for the distances between groups of cells to separate locations could be drawn up.

The criteria based on relative thresholds can only be assessed by comparing the current situation with others in the past. They are independent of the size of the population or its distribution, as the really important factor is the magnitude and trend of the change, not the value of the size of the population or its distribution at a given moment in time. In contrast, criteria based on absolute thresholds do not take into consideration how the size of the population or its distribution evolves over time, but merely focus on the value of such parameters at the present moment in time. These latter criteria have been the subject of criticism because they do not constitute a reliable reflection of the real state of conservation, since they enable an uncommon species with a stable population to be mistakenly classified as threatened (de Lange & Norton, 1998; Sapir et al., 2003).

The adaptation at the regional level of the IUCN criteria had led to guidelines being drawn up to evaluate sub-populations which inhabit territories whose artificial borders do not coincide with the natural limits of the ecosystems (Gardenfors et al., 2001; IUCN, 2003). However, not enough research has been carried out into the extent to which global criteria are applicable to small geographical regions such as islands, mountain regions or lacustrine ecosystems inhabited by a multitude of endemic species, the borders of which are natural and bear no relation to geopolitical state borders.

The aim of this paper is to show the difficulties of applying IUCN distributional criteria (B1, B2 and D2) in the Canary Islands, especially when absolute thresholds are applied to the species of different groups. For this purpose, the potential occupancy areas of all endemic species have been obtained (on the basis of presence registered at any time), and the results have been used for analysing the consistence of establishing conservation priorities from an IUCN point of view.

Methodology

The study area

The Canary Islands are an oceanic archipelago to the north-west of Africa made up of seven main islands and several smaller islands covering a total land surface area of 7447 km^2. The largest of the main islands is Tenerife (2034 km^2) and the smallest is El Hierro (269 km^2). The easternmost island is Fuerteventura which is separated from continental Africa by a stretch of ocean 100 km wide (see Figure 1), while El Hierro is the most westerly island and is 380 km from the African mainland.

The eastern islands are lower in terms of altitude and they are ecologically less diverse than the central-western islands. Tenerife is the highest island, reaching 3718 m above sea level, and the most diverse. The age of the islands varies longitudinally from 20.6 million years for the island of Fuerteventura, to the east of the archipelago, to 1.12 million years in the case of El Hierro to the west. The geological structure of the archipelago is fairly complex, and on the surface of the islands there is a mixture of geological materials derived from volcanic eruptions in different eras, sometimes several millions of years apart. This volcanic dynamism together with that of morphogenetic processes have formed an extremely heterogeneous environment which has favoured reiterated speciation (Fernández-Palacios & Martín Esquivel, 2001).

The Canary Islands currently support 13,333 recognised species and 965 sub-species of fungi, plants and land animals, not including microorganisms and anchialine species (Izquierdo et al., 2004). About 27.5% of all species are endemic to the archipelago and 64.4% of these are found exclusively on a single island (Figure 2). In the past these percentages were even greater, since the progressive appearance of introduced species and movements between one island and another have led to a decrease in the percentage of endemic species.

Source of data

The reference information for this study comes from a large data base belonging to the Canary Islands Government which stores the information about species and their distribution contained in all scientific publications and reports regardless of source (Martín et al., 2005a). All point occurrence data were evaluated according to (1) the information provided by the author at the time of publishing and (2) the degree of validity awarded to such data by an outside expert led the production of a distribution map, based on presences for a given species to be obtained in accordance with different degrees of ambiguity and accuracy, making it

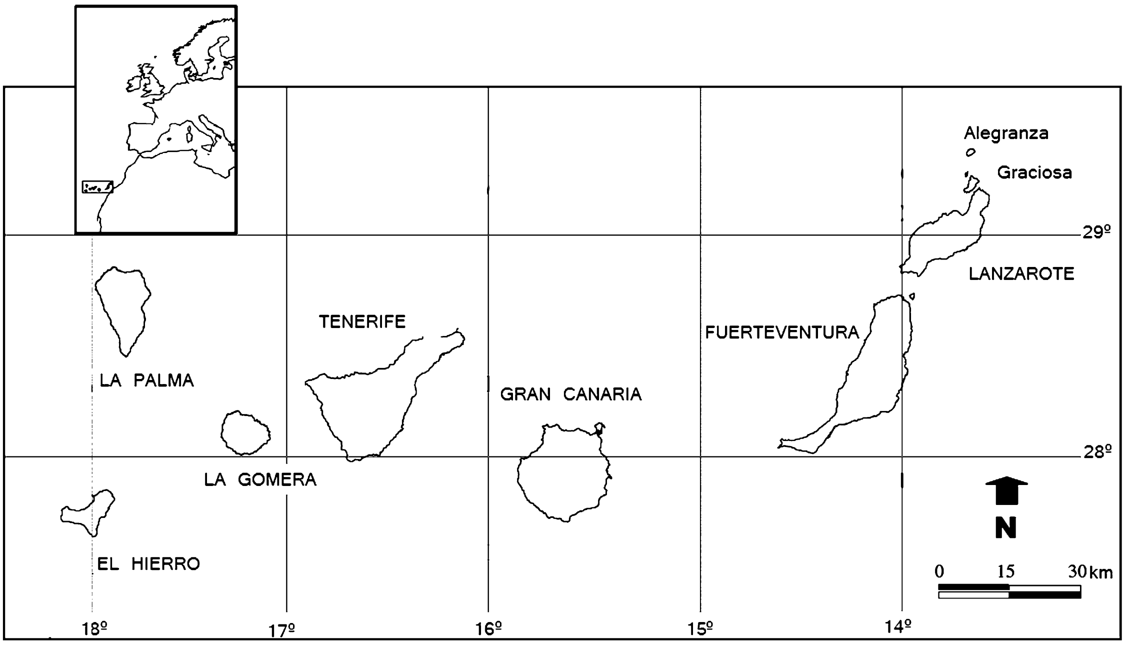

Figure 1. Location and distribution of the different islands which together form the Canary Islands.

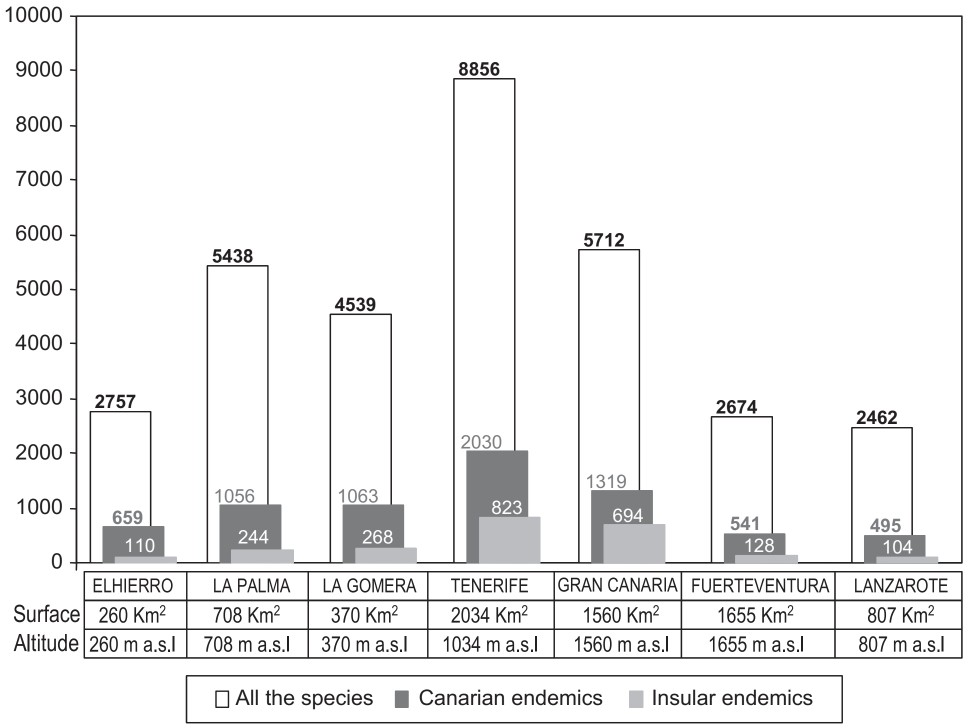

Figure 2. Number of terrestrial species in each one of the seven Canary Islands, with indication of surface, altitude and endemicity.

possible to quantify the extent of occurrence and the area of occupancy.

In any case, the gross information from the data bank mixes such a wide variety of different data that it was necessary to screen it for consultation or the analysis required. For the purpose of this study only the least ambiguous information was used, limited to citations that were either accompanied by a geo-referenced UTM coordinate or which referred to a readily assimilated toponym for each specific location. The original information featuring these accuracy criteria was registered simultaneously in two resolutions: 0.5 km-long cells; and 5 km-long cells.

Analysis

We applied the IUCN criteria (version 3.1) to almost all the Canarian endemic species and subspecies (see the complete list in Izquierdo et al., 2004). Non-endemic species were not considered as they constitute a lesser priority and it has been pointed out on several occasions that the IUCN criteria should be applied at the global level to cover the entire distribution of the species, bearing in mind that at the regional level subjective considerations can often exert a negative influence on effectiveness (Gärdenfors, 2001; Gärdenfors et al., 2001; Eaton et al., 2005). In this way, an assessment made of an endemic species of a given region carried out in the region would be the equivalent of a global assessment (Gärdenfors et al., 2001).

All the species distributions were analysed at the same resolution, in order to guarantee equivalency in the comparisons between the different groups and also in order to avoid biases in the interpretation of the degree of scarcity and the diagnosis of the threat due to the scale of the work (Hartley & Kunin, 2003; Quinn et al., 2004). The resolution chosen was that of 2 km-long cells as recommended by the IUCN as the most suitable for its reference thresholds (IUCN, 2005). Therefore, the data which were registered in 500 m or 5 km-long cells were transformed into 2 km-long cells using the method of Kunin (1998).

The number of 2 km-long cells in which a species is distributed depends on its vagility, so different taxonomic groups can have different average sizes for geographic ranges (Gaston et al., 1998). For this reason, we divided the biota into four groups in order to calculate their distribution patterns: vertebrates; plants; arthropods; and molluscs.

The sizes of the geographical ranges obtained from the areas of occupancy were displayed by means of distribution frequencies in order to obtain the classic right skewed representation (Brown et al., 1996; Gaston, 2003), and thus calculate the proportion of species in each category of range and the average size of the different ranges.

We used summary statistics (Gini coefficient) to test the general patterns of the distribution of range size within and among the four taxonomic groups. The Gini coefficient is a summary statistic that computes the deviation of Lorenz curves from the line of equality in economics. Applied to the biota, the Gini coefficient varies from 0, when the biota is characterised by the same size of range for all species; to close to 1, when only one or a few species occupy the bigger ranges.

The number of locations of a species depends on the minimum distance which we consider separates two groups of cells. For example, if the minimum separation distance were 2.5 linear kilometres the data from Figure 3 would enable us to identify three locations, while if this distance were to be 5 linear kilometres we would only compute two locations and with 10 linear kilometres or more there would only be one location. However, since IUCN has not provided any general rules about what the appropriate distance is, we calculated the number of locations for four cases of minimum location separation: 2.5–5–10–20 km. The analyses were made on a cell resolution of 500×500 m grid, which overestimates the numbers of locations with respect to a $2 \times 2\,km^2$-long cell resolution.

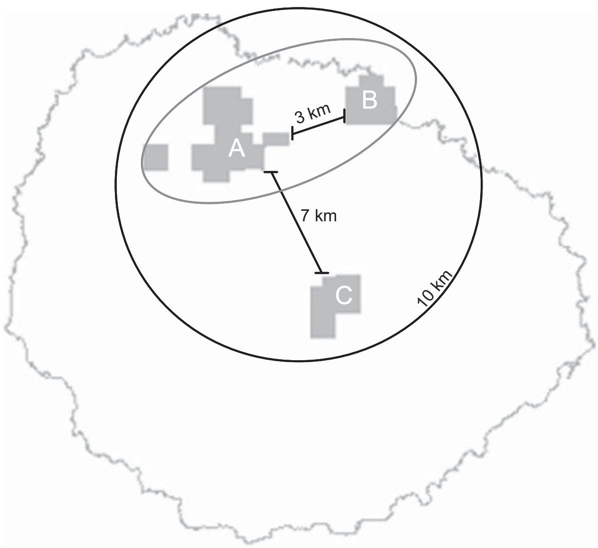

Figure 3. The number of locations of a species depends on the minimum distance which we consider separates two groups of cells. If the minimum separation distance was 2.5 linear kilometres, we would be able identify three locations in the image; while if this distance was to be 5 linear kilometres, we would only compute two locations and with 10 linear kilometres or more there would only be one location.

In order to discover how the surface of the island affects the size of the geographical range of the species we compared the area of occupancy of each species with the size of the island or islands where it is present. When we displayed on the *x*-axis the surfaces of the islands and on the *y*-axis the area of occupancy of all Canarian endemics, we obtained a cloud of points which we then adjusted into a curve (Figure 6).

Results

Owing to the small surface area of the islands, the 3672 recognised Canarian endemics have an area of occupancy which must necessarily be less than the $20{,}000\,km^2$ threshold for the extent of occurence of IUCN criteria B. Similarly, the 2371 species which are endemic to only one island occupy a surface of less than the $2000\,km^2$ threshold for the area of occupancy of IUCN criteria B, practically the same size as the largest island (Tenerife) (Figure 2.).

The species-range size distribution for 70 vertebrates endemic to the Canary Islands shows a marked right-skewed pattern (Figure 4A), in spite of the fact that the categories established for the geographical ranges are fairly small ($100\,km^2$). Of the 70 species and subspecies of endemic vertebrates present in the Canary Islands, only one has a geographical range of $20\,km^2$ or less: the endemic lizard *Gallotia galloti insulanagae*, whose population remains stable on a small islet to the north of Tenerife, where it possibly originated. About 54.3% of the species occupy a surface of $500\,km^2$ or less and 95.7% a surface of less than $2000\,km^2$. The average range of distribution was $716.9\,km^2$ ($\pm$10.551, level of reliability: 0.099). The Gini index of the accumulated curve was 0.519.

The same graph in the case of the 645 species and subspecies of endemic plants displays a much more markedly right-skewed curve (Figure 4B). As many as 49 species have a range of $20\,km^2$ or less, almost all of these being endemic to a single island. About 79.1% of the species have a geographical range of $500\,km^2$ or less, and practically all of the species (98.0%) have a range of less than $2000\,km^2$. The mean species range size was $374.1\,km^2$ ($\pm$2.638, level of reliability: 0.099). The Gini index of the accumulated curve was 0.612.

The species-range size of the 3019 species and subspecies of endemic arthropods is still much more markedly right-skewed (Figure 4C), with a mean species range size of $98.8\,km^2$ ($\pm$0.362, level of reliability: 0.099). In this case, there are 874

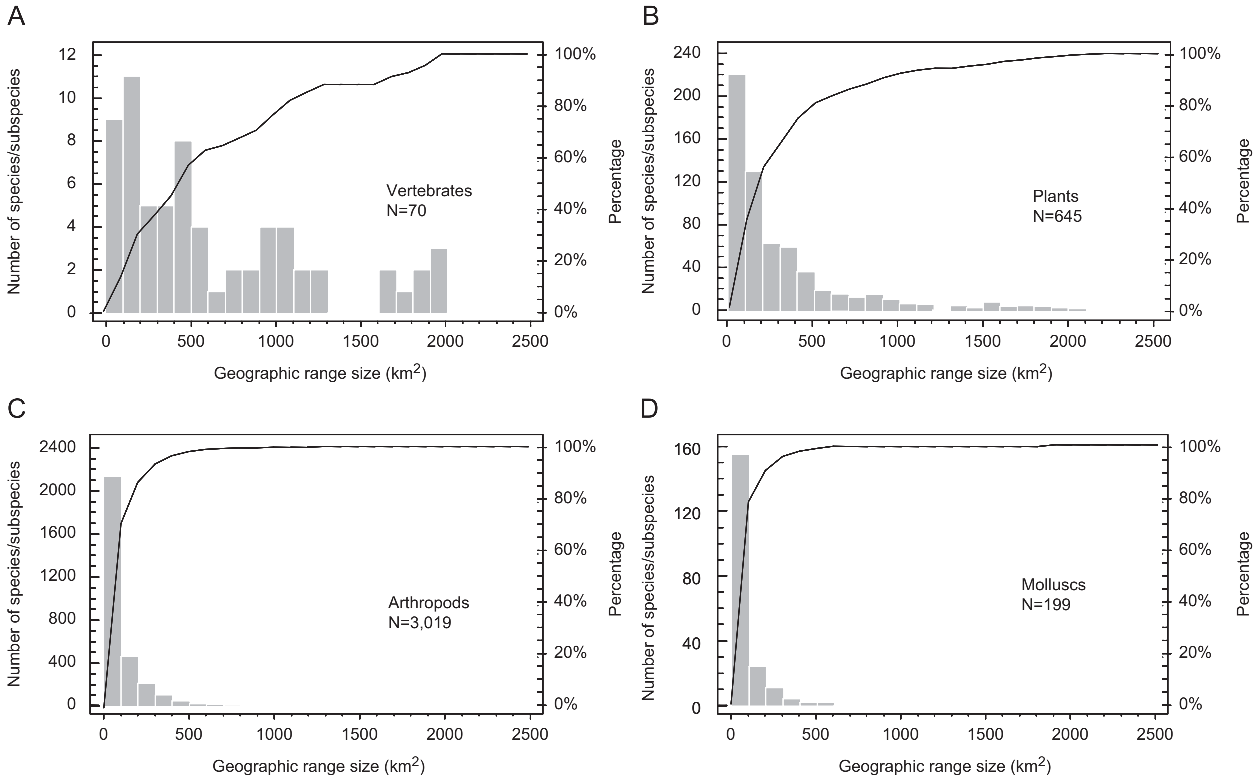

Figure 4. Species/subspecies range size distribution of: (A) endemic vertebrates; (B) endemic plants; (C) endemic arthropods; and (D) endemic molluscs, and accumulated curves. The mean range sizes were 716.9; 374.1; 98.8 and 85.9 km^2, in the respective cases.

taxa with a range of 20 km^2 or less (29% of the total), and practically all of them – 98.0% – have a range of less than 500 km^2. The Gini index of the accumulated curve was 0.548.

The situation with the 199 species and subspecies of molluscs is similar to that of the arthropods. The representation is markedly right-skewed (Figure 4D), with 27.6% of the total of the species having a range size of 20 km^2 or less, and practically all of the species (98.5%) have a geographic range of 500 km^2 or less. The mean size range was 85.9 km^2 ($\pm$1.387, level of reliability: 0.099). The Gini index of the accumulated curve was 0.603.

Figure 5 shows the number of locations calculated for 284 species of plants and 1206 species of arthropods endemic to a single island, and for which sufficient accurate information is available about their distribution (4 plants and 330 arthropods were excluded due to lack of accurate data). In spite of the fact that the resolution of the study was far more precise than recommended by the IUCN, this did not result in a large number of locations. The bigger the distance separating the groups of cells, the lower the number of locations computed. In very few cases were more than five locations recorded and the average values for each minimum separation distance between cell groups was always below three.

A comparison of the geographic ranges of endemic plants with the surface of the island or islands where they are located reflects a polynomial relationship which is statistically significant to a reliability level of 99%, where the adjusted statistic R^2 accounted for up to 40.58% of the variability in the area of occupancy (Figure 6).

Discussion

The comparative analysis of the structure of the geographic ranges of the different groups studied suggests that the majority of the species should be considered as priorities given their reduced area of occupancy. As many as 3704 taxa of the four groups considered (38 vertebrates, 510 plants, 2960 arthropods and 196 molluscs) have a range of less than 500 km^2. An extreme fluctuation or a continuous decrease in their populations would, thus, be sufficient for them to be considered threatened, but since in reality the majority are to be found in less than five locations, the classification of threatened, without any further requirements,

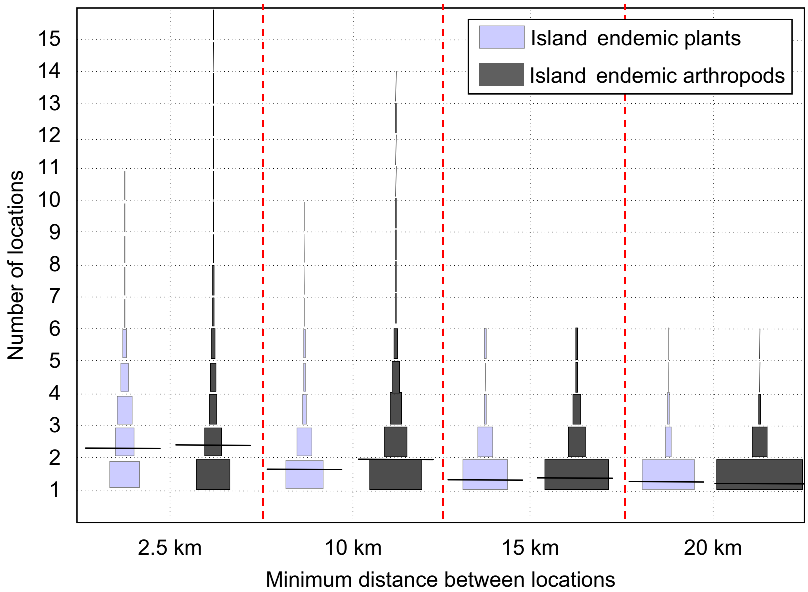

Figure 5. Locations in plants and arthropods for four cases of minimum separation distance: 2.5–5–10–20 km. The width of the column is proportional to the number of species and the horizontal lines represent the average number of locations.

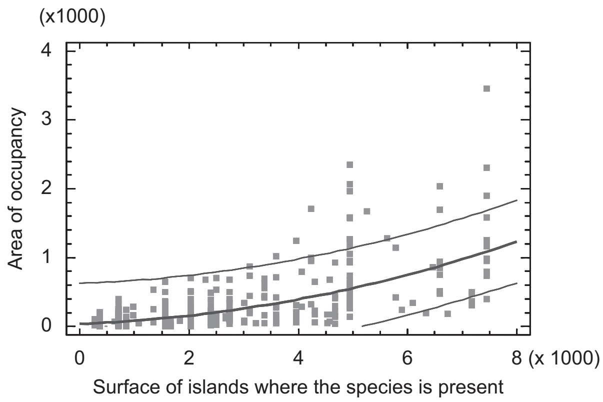

Figure 6. Polynomial relationship between the surfaces of the islands (*x*-axis) and the area of occupancy (*y*-axis) of the Canarian endemic species.

would be applicable according to the IUCN D2 criterion. This same criterion is also directly applicable to the 979 taxa (1 vertebrate, 49 plants, 874 arthropods and 55 molluscs) whose area of occupancy is 20 km^2 or less, regardless of whether their populations are stable or not.

The concept of rarity has been given several different meanings from the point of view of conservation urgency, on the one hand as a symptom of excessive concern when it is associated with a supposed risk of extinction, and on the other hand as an expression of a natural phenomenon where the risk of extinction is relative (Gaston, 1994). The fact that an endemic island species is rare does not necessarily mean that it is more vulnerable to extinction than an equally rare mainland species (Manne et al., 1999), and indeed, the same speciation which could lead to the extinction of new taxons could finally be biased towards having relatively stable population levels (Glazier, 1987).

The presence of rare species is a factor which is common to all ecosystems (Gaston, 1994; Gaston et al., 1998; Rabinowitz, 1981; Rabinowitz et al., 1986; Willis, 1922) and focuses on specific groups of plants (Domínguez & Schwartz, 2005; Schwartz & Simberloff, 2001), in fragmented territories where there is a high degree of environmental heterogeneity, such as archipelagos (Hanski & Ovaskainen, 2002; Rogers & Overton, 2000), and in locations where the local speciation has a marked effect on diversity, as is the case in the islands (Gaston et al., 2005). Orme et al. (2006) pointed out that the ranges of island species are less than those of continental ones, which suggests the possibility of a relationship between the size of geographic ranges and the size of habitats, similar to that obtained in the Canary Islands with the surface of the islands (Figure 6).

If rarity does not always equate with a situation of decline or involve the equivalent risk of extinction, the use of absolute thresholds as a reference to be applied to all regions is not advisable, since this can lead to an overestimation of the threat in small regions, while it may underestimate the danger in larger territories. In contrast, relative thresholds which are variable, proportional to the size of the regional environment under study and based on trends, adjust better to different geographical situations.This is what happens when the criterion of rarity is considered as a relative attribute which depends on the size of the environment being studied. For example, Sapir et al. (2003) consider a species to be rare if it occupies at most 0.5% of the surface area of the state of Israel – their research area – and higher points are scored on the priorities scale as the percentage decreases.

An additional derived problem with respect to absolute thresholds is that they do not allow us to separate species in decline due to human activities from species of naturally restricted distribution, thus making it harder to establish conservation priorities (McIntyre, 1992; Robbirt et al., 2006). Take, for example, any two endemic Canary Islands species with a similar distribution and an area of occupancy of 20 km^2 or less, one naturally restricted and the other in decline due to human action. Both fall into the same threat category according to the IUCN criteria, but the second should be considered a higher priority since if we do not take action about it, it will become extinct in the short or long term. Similarly, let us imagine one species with an area of occupancy of just over 20 km^2, and another with an area of occupancy of 400 km^2. If both species are in decline at the same speed, it would seem logical to give priority to the former, yet in IUCN terms both would be placed in the same threatened category. Moreover, from the management point of view, it is difficult to increase the populations of species which are rare for natural reasons.

The situation is similar with respect to fragmentation, which can be either natural or induced (anthropogenic). If the threat criterion is based on a specific number of locations, it is impossible to separate the decline situations, where fragmentation is growing, from the stable situations. That interpretation of the consequences of fragmentation is more arguable in archipelagos where a single species can be present on several islands, without this necessarily meaning that it is threatened. For example, a species of expansive ecology, colonizing all the islands of an archipelago, would be progressively increasing its fragmentation, without, paradoxically, this meaning any increase in the risk of extinction.

An added drawback to absolute thresholds is that they do not turn out to be equally valid for all taxonomic groups. Figure 4 shows how the size of the average geographic distribution range of vertebrates endemic to the Canary Islands is over eight times greater than that of endemic molluscs, and the Gini index values reveal a very different structuring of the sizes of the ranges within each group. Gaston (2003) has also documented marked differences in the sizes of the geographic ranges of different taxonomic groups.

The last consequence of excessive concern about rarity is the over-listing of threatened species, particularly in certain groups of low vagility. According to the economic theory, the exaggerated valuation of rarity could be prejudicial to some species since it provokes the unexpected appearance of an Allee anthropogenic effect which could drag them towards extinction (Brook & Sodhi, 2006; Courchamp et al., 2006). The over-valuing of rarity is noticeable especially in the invertebrates, whose threat valuation according to the IUCN criteria disproportionately increases the lists, regardless of whether the regions in question belong to continental land masses or islands. For example, the application of the IUCN criteria in Greece revealed that 10% of known invertebrate species (2000–3000) could be endangered (Legakis, 2003), and the same thing occurred in Sweden with 21% of the invertebrates (19756 species) (Gärdenfors, 2003), in Poland with 7.7% (2618 species) (Witkowski, 2003), in the Nordic countries with 46.6% (2330) (Agarrad, 2003) and in Germany with 40% (6000 species) (Gruttke & Haupt, 2003).

Such substantial figures could be an indicator of the state of conservation of the species of invertebrates, but they do not help in terms of management, since they do not differentiate between those which are doomed to extinction unless urgent measures are taken and those which are simply vulnerable to risk due to their rarity, but are not actually in decline. State of conservation and conservation priorities are different concepts which are commonly confused (de Grammont & Cuaron, 2006; Munton, 1987). The IUCN criteria are designed to identify global states of conservation (Butchart et al., 2005), but when it comes to considering distributional ranges they are based on absolute thresholds which are not equally applicable to all taxonomic groups, and neither are they consistent with the size of the distribution ranges of the species in smaller islands. This impedes the classification of the species in a priority scale which reflects the real urgency for conservation.

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