Amphibians in the Region of Murcia (SE Iberian peninsula): conservation status and priority areas

A. Egea–Serrano, F. J. Oliva–Paterna & M. Torralva

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Abstract

Amphibians in the Region of Murcia (SE Iberian peninsula): conservation status and priority areas.— The conservation status of amphibian species was studied in the Region of Murcia, taking into consideration 10 variables concerning their biology and distribution. The results obtained show that the amphibian species exposed to the highest risk of extinction in the study area are those with long larval development and a restricted distribution range. According to this species classification, an index is proposed for assessing areas whose conservation is of the highest priority. In the Region of Murcia, most of these areas are located in the main mountain systems, primarily confined to the northwest. Regional Parks and proposed priority conservation areas overlap by only about 12%. The current isolation of these areas makes it necessary to undertake habitat restoration programmes to ensure their interconnection.

Key words: Amphibians, Region of Murcia, Species conservation, Priority areas.

Resumen

Anfibios en la Región de Murcia (SE península ibérica): estatus de conservación y áreas prioritarias.— Se ha analizado el estado de conservación de las especies de anfibios presentes en la región de Murcia en función de 10 variables relacionadas con la biología y distribución de dichas especies. Los resultados obtenidos muestran que las especies de anfibios expuestas al mayor riesgo de extinción en el área de estudio son aquéllas que presentan un desarrollo larvario prolongado y una distribución restringida. En función de esta clasificación de las especies, se propone un índice que permita evaluar las áreas cuya conservación es prioritaria. En la Región de Murcia, la mayor parte de estas áreas están localizadas en los principales sistemas montañosos y limitadas principalmente a la comarca nordoccidental del área de estudio. El solapamiento entre los Parques Regionales y las áreas propuestas de conservación prioritaria es sólo del 12%. El aislamiento actual de estas áreas hace necesario emprender programas de restauración del hábitat para garantizar su conexión.

Palabras clave: Anfibios, Región de Murcia, Conservación de especies, Áreas prioritarias.

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A. Egea–Serrano, F. J. Oliva–Paterna & M. Torralva, Dept. de Zoología y Antropología Física, Fac. de Biología, Univ. de Murcia, 30100 Murcia, España (Spain).

Corresponding author: A. Egea–Serrano. E–mail: aegea@um.es

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Introduction

Environmental alteration as a consequence of anthropic activity is considered to have contributed to the decline of numerous amphibian populations throughout the world (Wake, 1991; Galán, 1997; Pechman & Wake, 1997; Marco, 2002a, 2002b). A complete inventory of amphibian species present in a determined territory, as well as its distribution range, is of priority interest. Such information would provide a basic tool to establish the regional conservation status of the different species (UICN, 2003) and consequently, to develop management programmes to ensure their conservation (Palomo & Antúnez, 1992). Monitoring efforts have enabled conservation status to be established on wide spatial scales (Pleguezuelos et al., 2002). Nevertheless, determining distribution and conservation status at a regional scale is also necessary since these parameters can vary greatly for a given species from one region to another (Gärdenfors et al., 1999, 2001).

In addition to species conservation, another target in conservation biology is to prioritize areas on the basis of their biological value (Sutherland, 2000), selecting those which show the highest priority. Such areas could represent a valuable tool for establishing conservation and management programmes. As regards amphibians, some studies have established important areas for herpetofauna conservation in the Iberian peninsula (Santos et al., 1998; Mateo, 2002). These studies include the Region of Murcia consider amphibian and reptile species together, and no such studies establish priority areas in this territory as a function of amphibian species present alone.

The Region of Murcia in the southern Iberian peninsula is considered one of the most important areas in the Mediterranean region for its amphibian species diversity and/or endemic amphibians (Borkin, 1999). It is characterized by an arid climate (Vidal–Abarca et al., 1992), which makes it unfavorable for amphibians due to hydrological stress and lack of breeding habitats that such climatic conditions represent. Moreover, these factors make the amphibian species present in the Region of Murcia more vulnerable to land use changes affecting this area (Martínez & Esteve, 2003) as they involve a severe habitat degradation process. Several studies dealing with amphibian biology and distribution (Miñano et al., 2003; Egea–Serrano, 2005; Egea–Serrano et al., 2005a, 2005b, 2005c, 2005d, 2005e, 2005f) have been performed. Nevertheless, to date, there has been no study concerning the risk of extinction of amphibians in the Region of Murcia.

The objectives of the present study were to develop a methodology based on the biological and ecological constraints and distributions of amphibian species to evaluate the risk of extinction of the species present in the Region of Murcia and to establish areas whose conservation should be considered priority.

Material and methods

The study area is restricted to the Region of Murcia (SE Iberian peninsula). This territory includes most of the Segura River basin, one of the most arid of the Iberian peninsula (Vidal–Abarca et al., 1987) and, probably, of Europe (Geiger, 1973). Eleven ecological sectors have been recognised in this basin (Vidal–Abarca et al., 1990), most of them exposed to a dry, hot and arid climate. However, during the last three decades land uses in the study area have been increasingly devoted to extensive agricultural irrigation practices (Martínez & Esteve, 2003), while traditional land uses (non–irrigated agricultural farms) are restricted to the northwestern region of the study area (Pérez & Lemeunier, 2003).

Following Andreone & Luiselli (2000) and Filippi & Luiselli (2000), 10 biological and ecological variables were analysed. These variables include aspects dealing with the distribution, demography, ecology and taxonomy of the species present in the study area. Data for these variables were obtained from the bibliography, as well as from the experience of the authors (table 1). Independent variables were categorised, ranging from the lowest (category 0) to the highest (categories 2, 3, 4, 10, depending on the variable) risk of extinction. The variables considered in this study are related as follows, as well as their categories and the rationale for the choice of these scores.

Species presence in the Region of Murcia, based on data presented by Egea–Serrano et al. (2005b, 2005c): 0. Present in >50% of the study area surface; 1. Present in 10–50%; 2. Present in 5–10%; 3. Present in <5% of the study area surface.

Reproductive strategy: 0. Taxon with several reproductive periods throughout the active season; 1. Taxon with 2–3 reproductive periods during active season; 2. Taxon with a single reproductive event each year; 3. Ovoviviparous taxon or showing parental care. It is assumed that species that breed more frequently can recover faster when their habitat is altered. Furthermore, an ovoviviparous taxon (or showing parental care) is expected to be exposed to a higher risk of extinction than an oviparous one in altered habitats. This is because adult individuals carry their embryos for a long period of time and, as a consequence, the probability of some sort of alteration or even death of adults involving the loss of offspring is higher.

Eggs (offspring) number: 0. >200 eggs/newborns; 1. 50–200; 2. 10–50; 3. <10. Species showing a higher fertility can recover more easily in the face of habitat alteration.

Habitat breadth: based on data presented by Egea–Serrano et al. (2005b, 2005c) and on 11 ecological sectors described by Vidal–Abarca et al. (1990): 0. Species present in all sectors; 1. Species present in 10 sectors; 2. Species present in nine sectors; 3. Species present in eight sectors; 4. Species present in seven sectors; 5. Species present in six sectors; 6. Species present in five sectors; 7. Species present in four sectors; 8. Spe-

Table 1. Bibliographic references used to define scores for studied species for each threatening factor: RS. Reproductive strategy; EN. Egg (offspring) number; H. Habits; MA. Maximum age; BH. Breeding habitat; TU. Taxonomic uniqueness; 1. Alcobendas & Buckley, 2002; 2. Arntzen & García–París, 1995; 3. Barbadillo et al., 1999; 4. Bosch, 2003; 5. Busack, 1986; 6. Díaz–Paniagua, 1986; 7. Egea–Serrano et al., 2005e; 8. Egea–Serrano et al., 2005f; 9. Esteban et al., 2004; 10. García–París et al., 2003; 11. García–París, 2004; 12. Guyétant et al., 1999; 13. Lizana et al., 1994; 14. Martínez–Solano & García–París, 2002; 15. Martínez–Solano et al., 2003; 16. Montori & Herrero, 2004; 17. Nöllert & Nöllert, 1995; 18. Rebelo & Caetano, 1995; 19. Salvador & García–París, 2001; 20. Salvador, 2005; 21. Toxopeus et al., 1993; * Experience of the authors.

*Tabla 1. Referencias bibliográficas utilizadas para definir las puntuaciones de las especies de anfibios estudiadas para cada factor de riesgo: RS. Estrategia reproductiva; EN. Número de huevos (descendientes); H. Hábitos; MA. Edad máxima; BH. Hábitat reproductor; TU. Exclusividad taxonómica; * Experiencia de los autores. (Para las otras abreviaturas ver arriba.)*

Species	RS	EN	H	MA	BH	TU
Salamandra salamandra	10	*	16	18	7	1, 10, 16
Rana perezi	6	19	11, *	19	8, *	19
Alytes dickhilleni	15, 20	4	20, 11	4	19, *	2, 11
Alytes obstetricans	4	4	4, 11	4	11, *	2, 11
Bufo calamita	6	19	3, 19	19	19, *	19
Bufo bufo	6	19	3, 19	19	11, *	19
Pelodytes punctatus	6	12, 21	12, 21	9	3, 19, *	19
Discoglossus jeanneae	19	19	19	19	14	5, 11
Pelobates cultripes	6, 13	19	11	17, 3	13, 19, *	19

cies present in three sectors; 9. Species present in two sectors; 10. Species present in one sector. This variable reflects species tolerance for environmental variables.

Habits of adult phase: 0. Nocturnal fossorial species or with aquatic activity; 1. Nocturnal species; 2. Diurnal species with cryptic habits; 3. Diurnal species with obvious habits. It is assumed that obvious species are more exposed to man and predator persecution.

Maximum age: 0. > 15 years; 1. 11–15 years; 2. 6–10 years; 3. 1–5 years.

Adaptability to altered environments: based on the experience of the authors: 0. Species extremely adaptable (found even in urban parks); 1. Adaptable species (found in suburbia intermingled with small natural fields); 2. Species scarcely adaptable (found in medium sized natural habitat); 3. Unadaptable species (found only in large patches of natural habitat).

Altitudinal distribution: based on data presented by Egea–Serrano et al. (2005d). 0. Ubiquitous; 1. Present at high elevations (> 900 m); 2. Species present at a wide range of medium altitudes; 3. Estenohypse species found at medium altitudes; 4. Estenohypse species found at medium altitudes, but restricted to high plateaus. In the study area, sites located at high altitudes are more mountainous than the rest, which makes them inaccessible for most human activies. Species present at high altitudes are therefore more protected from habitat degradation resulting from anthropic activities than those inhabiting less mountainous localities.

Breeding habitat: 0. Taxon which breeds in temporal and permanent water bodies; 1. Taxon which breeds in temporal water bodies; 2. Taxon which breeds in permanent water bodies. It is assumed that species that breed in both permanent and temporal water bodies can better face the pressure resulting from anthropogenic activities than species that only breed in permanent water bodies, most of which in the study area are dedicated to farming activities.

Taxonomic uniqueness: 0. Species of a polytypic genus with more than three recognised subspecies; 1. Species of a polytypic genus with 1–3 recognised subspecies; 2. Monotypic species of a polytypic genus; 3. Species of a monotypic genus. It is assumed that a species recognised as representing a monotypic genus has more importance from a conservation point of view.

All environmental variables were submitted to a multifactorial analysis to classify different amphibian species depending on their similarities in relation to their risk of extinction, a methodology successfully used in previous studies on amphibians and reptiles (Andreone & Luiselli, 2000; Filippi &

Luiselli, 2000). According to these authors, this statistical approach allows studied species to be grouped in a more suitable way than univariate techniques since relations between variables can be established. Anuran and urodele species were analysed together because no information is available concerning the main differences between these two groups in relation to their biology and sensitivity to habitat degradation. The multifactorial analysis used was a multiple correspondence analysis (MCA). This statistical technique allows information provided by original data to be reduced to two dimensions which explain most data variance, and assigns a new coordinate to each case for each dimension extracted by the analysis (Visauta, 1998). According to the values obtained for each dimension, species have been assigned to one of the following categories, ranging from low to high risk of extinction: 1. Species showing positive values for both dimensions (low risk of extinction); 2. Species showing positive values for dimension 1 and negative values for dimension 2 (low–medium risk of extinction); 3. Species showing negative values for dimension 1 and positive values for dimension 2 (medium–high risk of extinction); 4. Species showing negative values for both dimensions (high risk of extinction).

To establish priority conservation areas from the point of view of the amphibian species present, the surface area of the Region of Murcia was divided into a 5 x 5 km UTM grid. The number of amphibian species present for each square was determined according to information presented by Egea–Serrano et al. (2005b, 2005c). Additionally, the proportion of squares occupied by each species was calculated in relation to the number of 5 x 5 UTM squares into which the study area was divided. This procedure allowed to estimate species extension in the study area, establishing an index of area occupation in Murcia (D) with five categories ranging from high to low presence: 1. Species present in > 30% of the surface of the region. This area corresponds to the area of occupancy of a species considered as Near Threatened or Least Concern according to UICN categories (UICN, 2001). 2. Species present in 10–30% of the surface of the region. This area corresponds to the area of occupancy of a species whose risk of extinction can be considered intermediate between Near Threatened or Lleast Concern and Vulnerable categories, according to UICN criteria (UICN, 2001). 3. Species present in 5–10% of the surface of the region. This area corresponds to the area of occupancy of a species considered Vulnerable according to UICN categories (UICN, 2001). 4. Species present in 1–5% of the surface of the region. This area corresponds to the area of occupancy of a species whose risk of extinction can be considered intermediate between Vulnerable and Endangered categories, according to UICN criteria (UICN, 2001). 5. Species present in < 1% of the surface of the region. This area corresponds to the area of occupancy of a species considered Endangered according to UICN categories (UICN, 2001).

Considering the calculated amphibian distribution data, number of species per square and the previously calculated risk of extinction for each species, a biological value was calculated for each 5 x 5 km square through the expression:

$$\Sigma(MCA_i+D_i)+Spp_j$$

where MCA_i is the risk of extinction for species i, D_i is the distribution of species i in the Region of Murcia, and Spp_j the number of amphibian species for j square.

Squares showing values higher than the 75th percentile for this index were selected as priority conservation squares.

Statistical analysis were performed with the SPSS® statistical package.

Results

The scores for the independent variables for the amphibian species in the Region of Murcia are presented in table 2. The results provided by multiple correspondence analysis have enabled identification of three groups of species (fig. 1). Table 3 shows the scores for each variable in each dimension extracted by the MCA. Breeding habitat combined the highest value for dimension 1 (0.770) and the lowest for dimension 2 (0.067), whereas species presence presented the lowest value for dimension 1 (0.682) and the highest for dimension 2 (0.911). This implies that the main variables arranging species through dimension 1 and dimension 2 in the Region of Murcia are, respectively, breeding habitat and species presence.

Table 4 shows the values obtained for variables risk of extinction and extension in the study area for each amphibian species.

The 5 x 5 km UTM squares showing biological value indices higher than the 75th percentile were considered as priority conservation areas. The total number of such areas added up to 103 (fig. 2) and represented 16% of the surface of the Region of Murcia.

Discussion

Although Andreone & Luiselli (2000) indicate that both univariate and multivariate methodology sufficiently characterise the conservation status of a species group, multivariate analysis alone was used in the present study as univariate analysis is considered to have the disadvantage of not establishing relationships between variables and therefore not realistically ranking the studied species according to their risk of extinction.

The results obtained show that the species exposed to higher risk of extinction are those which depend on the presence of permanent water bodies to complete their larval development and which, in addition, show a restricted distribution

Table 2. Scores for the independent variables considered to affect survival of amphibian species in the region of Murcia: P. Presence in the region of Murcia; RS. Reproductive strategy; EN. Egg (offspring) number; HB. Habitat breadth; H. Habits; MA. Maximum age; AE. Adaptability to altered environments; AD. Altitudinal distribution; BH. Breeding habitat; TU. Taxonomic uniqueness.

Tabla 2. Puntuaciones para las variables independientes que se considera que afectan a la supervivencia de las especies de anfibios en la región de Murcia: P. Presencia en la región de Murcia; RS. Estrategia reproductora; EN. Número de huevos (descendientes); HB. Amplitud de hábitat; H. Hábitos; MA. Edad máxima; AE. Adaptabilidad a ambientes alterados; AD. Dsitribución altitudinal; BH. Hábitat reproductor; TU. Exclusividad taxonómica.

Species	P	RS	EN	HB	H	MA	AE	AD	BH	TU
S. salamandra	3	3	2	9	1	0	2	1	2	0
R. perezi	1	2	0	1	3	2	0	0	0	2
A. dickhilleni	3	2	2	9	1	2	2	1	2	2
A. obstetricans	3	2	2	10	1	2	2	4	2	0
B. calamita	1	2	0	1	1	1	1	0	1	2
B. bufo	2	2	0	4	1	0	1	2	2	1
P. punctatus	2	2	0	4	1	2	1	2	0	2
D. jeanneae	3	1	0	10	1	2	3	1	2	2
P. cultripes	3	2	0	5	1	1	1	3	0	2

range in the study area. On the other hand, species showing higher plasticity in relation to breeding habitat and a widespread distribution range are less threatened.

The studied species can be classified into three groups according to their risk of extinction, as seen from our results. Species facing the highest risk of extinction in the Region of Murcia included *S.*

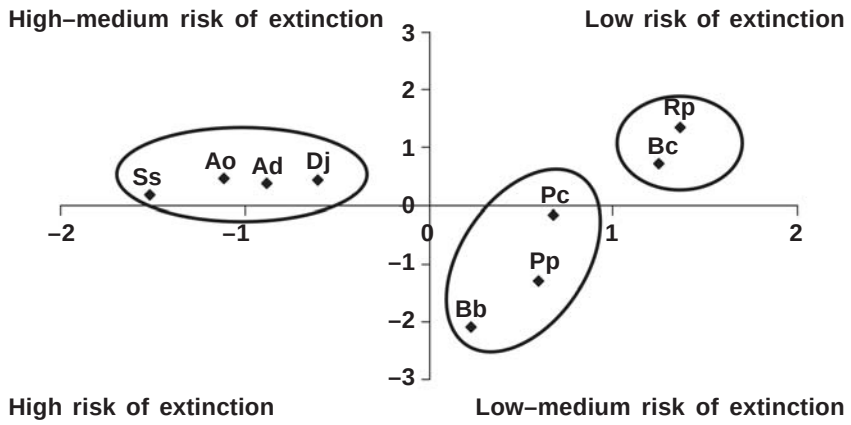

Fig. 1. Bidimensional plot of scores for each studied species in the dimensions extracted by multiple correspondence analysis. Amphibian species groups according to their risk of extinction are identified. Ss. *Salamandra salamandra*; Rp. *R. perezi*; Ad. *A. dickhilleni*; Ao. *A. obstetricans*; Bc. *B. calamita*; Bb. *B. bufo*; Pp. *P. punctatus*; Dj. *D. jeanneae*; Pc. *P. cultripes*.

Fig. 1. Representación bidimensional de las puntuaciones de cada especie estudiada para las dimensiones extraídas por el análisis de correspondencias múltiple. Los grupos de especies de anfibios se identifican en función de su riesgo de extinción. (Para las abreviaturas, ver arriba.)

Table 3. Scores for two dimensions extracted by multiple correspondence analysis for independent variables: E. Eigenvalue. (For abbreviations see table 2.)

Tabla 3. Puntuaciones para las dos dimensiones extraídas por el análisis de correspondencia múltiple para las variables independientes. (Para las abreviaturas ver tabla 2.)

Variable	Dimension 1 (E = 0.63)	Dimension 2 (E = 0.44)
P	0.682	0.911
RS	0.369	0.031
EN	0.687	0.059
HB	0.954	0.939
H	0.234	0.229
MA	0.308	0.260
AE	0.917	0.485
AD	0.943	0.937
BH	0.770	0.067
TU	0.499	0.551

Table 4. Scores for amphibian species existing in the region of Murcia for the variables risk of extinction (RE) and extension of distributiion (E).

Tabla 4. Puntuaciones de las especies de anfibios presentes en la región de Murcia para las variables riesgo de extinción (RE) y extensión de distribución (E).

Species	RE	E
S. salamandra	3	4
A. dickhilleni	3	4
A. obstetricans	3	4
D. jeanneae	3	5
B. calamita	1	2
B. bufo	2	3
P. punctatus	2	3
P. cultripes	2	4
R. perezi	1	1

salamandra, *A. dickhilleni*, *A. obstetricans* and *D. jeanneae*. However, when the IUCN Red List Criteria are applied to these species at a worldwide level (UICN, 2001), only *A. dickhhilleni* is described as vulnerable (IUCN, 2004). Nevertheless, the group formed by the above species shows a higher risk of extinction than the other studied species when the IUCN Red List Criteria at country level (UICN, 2003) are applied (Pleguezuelos et al., 2002).The degree of agreement between this classification and our results was good. In relation to the remaining species studied, although they have not been evaluated at a worldwide level (IUCN, 2004), when the IUCN Red List Criteria are applied at country level (UICN, 2003) they are not classified separately (Pleguezuelos et al., 2002); they all show a low risk of extinction (Least Concern). In contrast with this classification, the index applied at a regional level in the present study identified a group of species exposed to a low–medium risk of extinction (*B. bufo*, *P. punctatus* and *P. cultripes*) and another group with a low risk of extinction (*R. perezi* and *B. calamita*). This difference demonstrates the importance of a spatial scale in evaluating a taxon´s risk of extinction.

If a species in a region is considered threatened (as is the case of *S. salamandra*, *A. dickhilleni*, *A. obstetricans* and *D. jeanneae* in Murcia) measures must be taken to ensure the conservation of these populations in this territory. Such measures should include the conservation of traditional farming practices because these would contribute to preserving terrestrial habitats suitable for the adult individuals of many species, as well as water bodies where many species can finish their larval development, as suggested by several authors (París et al., 2002; Martínez–Solano et al., 2004; unpublished data).

The importance of mountain systems in amphibian conservation in the Region of Murcia is clear. Most areas whose conservation has been considered priority in the present study (80%) are located in the main mountains of the study area, and have been proposed as Sites of Community Interest (Baraza, 1999). However, only 12% of the proposed priority conservation areas are included within Regional Parks (Baraza, 2003), the current legally protected areas.

Mateo (2002) showed some of these mountains were valuable areas for herpetofauna conservation, although amphibian and reptile species were considered together. These areas are characterized by habitats of community interest, such as *Tetraclinis articulata*, *Quercus ilex*, *Quercus rotundifolia*, *Juniperus phoenicea*, or *Juniperus thurifera* forests (Baraza, 1999), whose distribution range in the study area is restricted. According to our results, the area showing the most noticeable lack of protection is the north eastern part of the study area, a territory where only three out of the 12 squares established as priority conservation areas are included in Sites of Communitary Interest or Regional Parks.

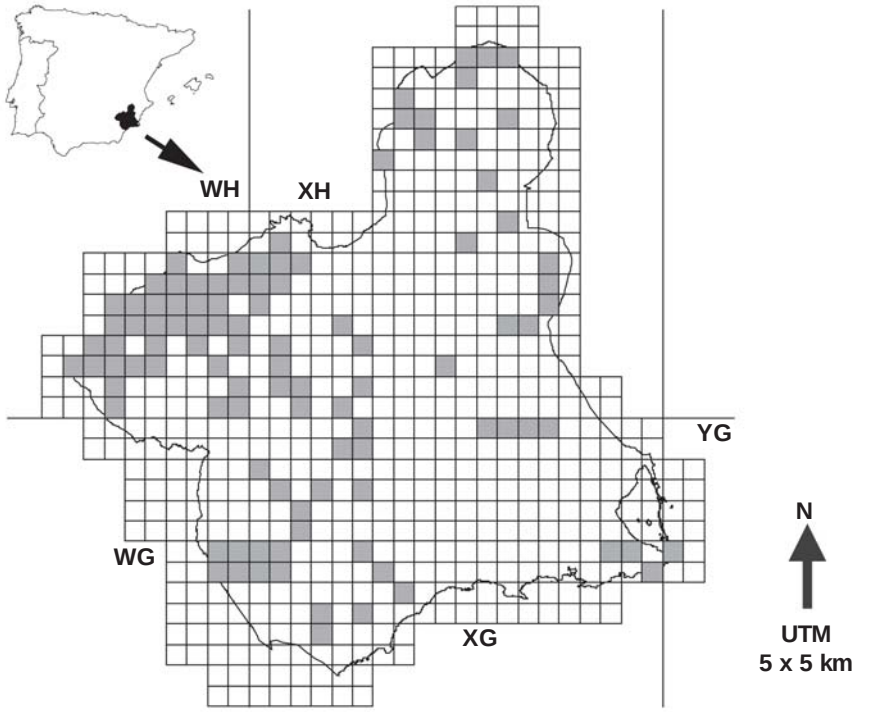

Fig. 2. Distribution of areas of the highest conservation priority in the Region of Murcia.

Fig. 2. Distribución de las áreas prioritarias de conservación en la Región de Murcia.

The fact that most priority squares are concentrated in the northwestern area of the region, where they coincide with different protected areas, emphasises the biological value of this territory. In addition, the value of this area increases because of its cultural importance from the point of view of traditional land use conservation (Pérez & Lemeunier, 2003).

Finally, it should be mentioned that most of the priority conservation areas suggested in this work are isolated as a consequence of the severe habitat destruction that the Region of Murcia has undergone, and continues to undergo, as a consequence of irrigation crop expansion (Martínez & Esteve, 2003). Such severe environmental degradation means that only species showing low ecological requirements, such as *R. perezi*, can survive, and it implies that most of the amphibian populations present in the study area will remain isolated. Since ensuring colonization and genetic flow from nearby populations is an essential measure in amphibian conservation (Semlitsch, 2002), habitat restoration programmes need to be undertaken to provide suitable habitats for different amphibian species. This would form biological corridors that make individual migrations feasible. These aspects should be taken into consideration when amphibian populations in the Region of Murcia are subjected to management and/or recovery programmes.

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