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Regional endemic species in conservation planning: a multi-taxon assessment of spatial priorities and protected-area gaps

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Abstract

Endemic species represent a distinctive component of biodiversity because their known distributions are geographically restricted. When endemicity is defined at the scale of an administrative territory with direct responsibilities for biodiversity conservation, identifying and conserving these species becomes particularly relevant for regional conservation planning. However, endemic species are often assessed within individual taxonomic groups, limiting the extent to which their overall contribution to regional biodiversity can be evaluated. Here, we provide a multi-taxon assessment of the endemic biota of the Region of Murcia, southeastern Spain, and evaluate its representation within the regional protected-area network. We compiled information for 47 taxa considered endemic to Murcia and retained 34 consolidated endemic taxa representing different taxonomic groups. Using a 5 × 5 km grid, we quantified endemic species richness and spatial rarity, identified the upper 5% of grid cells as endemism hotspots, and assessed their representation within protected areas. Endemic richness was strongly concentrated in southeastern Murcia, particularly in coastal and pre-coastal sectors. Twenty-six endemism hotspots were identified, six of which had less than 10% protected-area coverage. At the species level, nine endemic taxa had none of their known localities within protected areas, whereas eight were represented at all known localities. Our results show that even relatively small Mediterranean regions can harbour a spatially concentrated diversity of endemic taxa across multiple taxonomic groups, while important gaps remain in their representation within existing protected-area networks. Aligning the biogeographical scale at which endemicity is assessed with the governance scale at which conservation is implemented can therefore help translate geographical restriction into concrete conservation priorities and strengthen the capacity of biodiversity planning to safeguard geographically restricted taxa.

Keywords: endemicity hotspots; spatial rarity; protected areas; conservation planning; regional biodiversity; Mediterranean region; Region of Murcia

Introduction

Biodiversity loss is one of the major environmental challenges of the 21st century, driven by habitat transformation and fragmentation, land-use intensification, pollution, invasive species and climate change (Dirzo et al., 2014; Ceballos et al., 2017; Cowie et al., 2022). These pressures are reshaping biological communities and threatening species, ecosystems and the ecological processes on which human societies depend (Cardinale et al., 2012; Costanza et al., 2014; Marselle et al., 2021). In this context, conservation planning increasingly relies on spatial approaches capable of identifying areas where conservation action can provide the greatest benefits.

Protected areas are among the main instruments available for biodiversity conservation, but their contribution depends not only on the amount of land under protection but also on which components of biodiversity they represent (Margules & Pressey, 2000; Gaston et al., 2008; Watson et al., 2014). The global expansion of protected areas under the Kunming–Montreal Global Biodiversity Framework has further increased the need to evaluate whether conservation networks adequately represent geographically restricted and biologically distinctive elements of biodiversity (CBD, 2022; Watson et al., 2023). This is particularly relevant for species with restricted distributions, for which spatially targeted conservation can be critical.

Endemic species are a particularly distinctive component of biodiversity because their known distributions are restricted to specific geographical areas. Their restricted ranges may also be associated with ecological specialization, dependence on particular substrates or microhabitats, and limited opportunities for geographical redistribution under environmental change (Işik, 2011; Manes et al., 2021). Consequently, endemic taxa have long been considered relevant targets for conservation prioritization, particularly in regions characterized by high levels of geographical and environmental heterogeneity (Sánchez-Fernández et al., 2008; Bacchetta et al., 2012).

The spatial scale at which endemicity is assessed, however, has important implications for conservation planning. Administrative boundaries rarely coincide with biogeographical distributions, and species ranges may extend beyond political borders. Nevertheless, conservation policies and management actions are implemented by institutions operating within defined jurisdictions. In Spain, autonomous communities have major responsibilities for biodiversity conservation within their respective competences (Law 42/2007 of 13

December on Natural Heritage and Biodiversity). Consequently, when the known distribution of a species is confined to a single autonomous community, conservation actions undertaken by that administration become directly relevant to the persistence of the species. Endemicity at the appropriate governance scale can therefore translate geographical restriction into an operational conservation responsibility.

This perspective does not imply that administrative boundaries represent natural biogeographical units. Rather, it highlights their practical relevance for conservation planning. A species whose known distribution is restricted to a particular jurisdiction may require explicit consideration within that jurisdiction's biodiversity policies (Schmeller et al., 2008; 2014). This governance perspective has also been incorporated into broader approaches to conservation responsibility, which emphasize the role of jurisdictions responsible for substantial portions of species' distributions (Kraus et al., 2023).

Despite the importance of endemic species for conservation, assessments of endemic biodiversity have often been conducted separately within individual taxonomic groups, particularly vascular plants and vertebrates, and at broad spatial scales (Sánchez-Fernández et al., 2008; López-López et al., 2011; Romeiras et al., 2016; Orsenigo et al., 2018). Such approaches provide valuable information but may overlook patterns shared among taxonomic groups and, when conducted across broad spatial scales, may encompass multiple administrative jurisdictions with different responsibilities for environmental management, potentially limiting their direct applicability to regional conservation planning. Multi-taxon assessments can therefore provide a broader perspective by identifying areas where endemic taxa from different groups converge and by revealing conservation gaps that may not be apparent from single-taxon analyses.

Assessing the representation of endemic taxa within existing protected-area networks is a further step towards translating spatial patterns of endemic biodiversity into conservation planning (Delso et al., 2021). Protected areas may adequately represent the distribution of some endemic taxa while providing little or no spatial representation for others. This is particularly relevant for geographically restricted taxa, for which insufficient representation within the study region cannot be compensated for through conservation measures elsewhere. Evaluating both taxon-level representation and the coverage of areas with high concentrations of endemic species can therefore reveal complementary dimensions of conservation gaps.

The Region of Murcia, in southeastern Iberia, provides an appropriate case study for developing this approach. Despite its relatively small geographical extent, the region encompasses substantial environmental heterogeneity and supports a diverse assemblage of taxa with restricted distributions. Previous studies have documented the quality of multi-taxon inventories (Bruno et al., 2012) in the study area. Also, the important patterns of endemic biodiversity in southeastern Iberia, particularly among vascular plants (Sánchez-Gómez et al., 2002; Buira et al., 2017, 2020), and insects (Sánchez-Fernández et al., 2004). However, a comprehensive multi-taxon assessment of the endemic biota of Murcia and its representation within the regional protected-area network is still lacking.

Here, we compile and analyse available distributional information for the endemic taxa known from the Region of Murcia, encompassing multiple taxonomic groups. Specifically, we aim to: i) compile and validate a database of taxa whose known distributions are restricted to the study area; ii) characterize the spatial distribution of endemic taxa using endemic richness and spatial rarity; iii) identify endemism hotspots within a common spatial framework; and iv) evaluate the representation of both endemic taxa and endemism hotspots within the existing protected-area network. More broadly, we use the Region of Murcia as a case study to explore how endemic biodiversity can be explicitly incorporated into regional conservation planning, particularly in territories where a single regional administration has direct responsibility for conserving geographically restricted biodiversity.

Materials and methods

Study area

The Region of Murcia is located in the southeastern Iberian Peninsula, within the Betic mountain system, and covers approximately 11,137 km² (Fig. 1). Despite its relatively small area, the region encompasses marked environmental heterogeneity resulting from the interaction of climate, topography, geology and soils. Its landscapes include mountain ranges, inland depressions, plains, coastal and pre-coastal environments, and extensive semi-arid areas. The climate is predominantly Mediterranean semi-arid, with low and irregular precipitation and a marked gradient from relatively cooler and wetter northwestern areas to warmer and drier southern and coastal sectors, being one of the most semiarid areas of Europe. Geological and edaphic heterogeneity is also high, including calcareous, marly and gypsum substrates and localized volcanic outcrops. This combination of climatic, geological

and topographical variation generates a diverse mosaic of habitats and microhabitats and contributes to the occurrence of taxa with restricted geographical distributions (Esteve-Selma, 2013).

Compilation and validation of endemic taxa

We compiled information on taxa whose known distribution is restricted to the Region of Murcia. The initial inventory was based on published literature, including regional red lists and associated references, and was subsequently reviewed using information provided by taxonomic and regional experts working on different taxonomic groups (Mace, 2004). The initial database comprised 567 occurrence records for 47 taxa identified as endemic to Murcia, with each record georeferenced to one of the 531 cells 5 × 5 km MGRS grid cell covering the Region of Murcia (Fig. 1).

We then applied conservative criteria to determine which taxa could be reliably included in subsequent spatial analyses. Three taxa were excluded because their available occurrence records did not provide sufficient spatial resolution to be reliably assigned to the 5 × 5 km grid used in the study. A further 10 taxa were classified as non-consolidated endemics because their endemic status could not be considered sufficiently certain. These included recently described taxa for which the geographical extent of their distributions remains poorly known, as well as taxa belonging to groups that have not been sufficiently surveyed in neighboring regions. Thus, although these taxa are currently known only from Murcia, their occurrence outside the region cannot be confidently excluded. The remaining 34 taxa were classified as consolidated endemic taxa and retained for all subsequent spatial analyses (551 records). This conservative approach restricted the analyses to taxa for which both distributional information and endemic status were considered sufficiently reliable (i.e., a very high probability of being exclusive of Murcia Region). This distinction is important because apparent endemism may reflect limited knowledge of distributions outside Murcia, particularly for recently described or poorly surveyed taxa. The filtering procedure therefore reduces the risk of interpreting incomplete distributional knowledge as definitive geographical endemism.

Spatial distribution of endemic taxa

Endemic-species richness (S) was calculated as the number of endemic species recorded in each 5 × 5 km grid cell.

Species rarity was calculated as:

$R_i = 1 / N_i$

where N_i is the number of grid cells in which species i was recorded. For each grid cell, a rarity score was then calculated as the sum of the rarity values of all endemic species occurring in that cell.

This approach gives greater weight to species with highly restricted distributions and allows areas containing both several endemic species and particularly range-restricted species to be distinguished. Cell-level spatial rarity (R) was then calculated as the sum of the rarity values of all consolidated endemic taxa occurring in each cell. Thus, cells containing taxa with more spatially restricted distributions received higher rarity values.

These metrics were used to characterize two aspects of the distribution of the regional endemic biota: endemic richness described the spatial concentration of endemic taxa, whereas spatial rarity described the occurrence of taxa with relatively restricted distributions within Murcia.

Spatial analyses and cartographic outputs were produced using QGIS (QGIS Development Team, 2024). The 5 × 5 km grid provided a common spatial framework for integrating occurrence records and protected-area information while maintaining an appropriate level of spatial resolution for the available data.

Identification of endemism hotspots

Endemism hotspots were identified by ranking the 531 grid cells according to endemic species richness, from highest to lowest. When two or more cells had the same richness value, spatial rarity was used as a secondary criterion to resolve ties. The upper 5% of ranked cells were classified as endemism hotspots, resulting in 26 hotspots.

Protected-area representation

We considered two main categories of protected areas in the Region of Murcia: Protected Natural Areas (ENP) and the Natura 2000 network (Fig. 1). ENP comprise areas designated under regional or national protection categories, including regional parks, nature reserves, protected landscapes and natural monuments, aimed at conserving ecological, geological and landscape values under the Spanish Natural Heritage and Biodiversity Act (Law 42/2007). The Natura 2000 network comprises Special Areas of Conservation (SACs) designated under the EU Habitats Directive (92/43/EEC) and Special Protection Areas for Birds (SPAs) designated under the Birds Directive (2009/147/EC) (Evans, 2012). Together, these

designations constitute the main framework for biodiversity protection in the Region of Murcia and were considered when assessing the representation of endemic taxa and endemism hotspots.

At the taxon level, we quantified the number and proportion of known localities overlapping protected areas. Consolidated endemic taxa for which none of the known localities overlapped the protected-area network were classified as gap species, indicating a complete absence of spatial representation in the current network.

At the spatial level, we calculated the proportion of each endemism hotspot covered by protected areas. Endemism hotspots with less than 10% protected-area coverage were classified as gap areas, representing hotspots with particularly limited spatial representation within the protected-area network.

These analyses assess the spatial representation of endemic taxa and endemism hotspots within protected areas, rather than the effectiveness of protected-area management.

Results

Composition and distribution of the endemic biota

The initial inventory included 47 taxa considered endemic to the Region of Murcia. Of these, 34 were classified as consolidated endemic taxa and were retained for subsequent spatial analyses, while 13 were excluded because of insufficient spatial resolution or uncertainty regarding their geographical restriction to Murcia. The consolidated list of endemic taxa was dominated by invertebrates (25 taxa), particularly Coleoptera (16 taxa) and molluscs (8), followed by vascular plants (9 taxa) (Table 1).

The spatial extent of individual taxa also varied considerably. Seven consolidated endemic taxa occurred in only one 5 × 5 km grid cell, whereas some taxa occupied a substantially larger number of cells. The widest distributions were recorded for *Sideritis pusilla* subsp. *carthaginensis* (24 cells), *Teucrium carthaginense* (18 cells) and *Moricandia moricandioides* subsp. *pseudo-foetida* (16 cells) (Table 1).

Spatial patterns of endemic richness and rarity

Endemic species richness showed a pronounced concentration in southeastern Murcia, particularly across coastal and pre-coastal sectors, specifically in Campo de Cartagena, Sierra Minera and areas surrounding the Mar Menor (Fig. 2A). The highest value was seven

consolidated endemic taxa recorded in a single grid cell (Calblanque). Several additional areas showed relatively high endemic richness, whereas substantially lower values predominated across much of the region.

In contrast, the spatial pattern of rarity was more heterogeneous (Fig. 2B). High cell-level rarity values occurred in both coastal and inland sectors, reflecting the presence of taxa with highly restricted distributions that were not necessarily concentrated in the areas with the highest endemic richness.

Endemism hotspots

Most 26 of the endemism hotspots (Fig. 2C) were concentrated in the southern and southeastern parts of the region, although a few were also located inland. The identified hotspots included areas characterized by high concentrations of endemic taxa across coastal, and pre-coastal environments (Campo de Cartagena, Calblanque, Sierra de la Muela–Cabo Tiñoso). Their distribution therefore extended beyond a single landscape type, although the greatest concentration of hotspots occurred in southeastern Murcia.

Representation in protected areas

Representation of consolidated endemic taxa within protected areas was highly heterogeneous. Eight taxa had all their known localities within protected areas, whereas nine taxa had none of their known localities represented within the protected-area network and were therefore classified as gap species: *Alphasida (Elongasida) levantina, Alphasida (s.str.) lorcana, Alphasida (s.str.) sanchezgomezi, Asida (Globasida) curvatipennis mateui, Asida (Gracilasida) ricoi oertzeni, Larca fortunata, Lusitanopsis lencinai, Paratyphlus lencinai* and *Robustiella incantata.* (Table 1, Fig. 3A).

At the spatial level, six of the 26 endemism hotspots were classified as gap areas (Fig. 3B). These gap areas occurred in both southeastern and inland sectors of the region, and their protected-area coverage ranged from 0 to 9%.

Discussion

Our study provides a multi-taxon assessment of endemic biodiversity at the regional scale, integrating taxonomic validation, spatial patterns and representation within the protected-area network. Of the 47 taxa initially identified as endemic to the Region of Murcia, 34 were retained as consolidated endemic taxa, encompassing a taxonomically heterogeneous biota

dominated by invertebrates, particularly Coleoptera and molluscs, followed by vascular plants, with no endemic vertebrates identified. Endemic biodiversity showed marked spatial structuring, with richness concentrated mainly in southeastern Murcia, while its representation within protected areas was highly uneven. These findings highlight the value of assessing endemicity across taxonomic groups within a common spatial framework, as single-taxon approaches may provide only a partial representation of regional endemic biodiversity. More broadly, they emphasize the importance of aligning the scale at which endemicity is assessed with the scale at which conservation decisions are made, so that geographical restriction can be translated into concrete conservation priorities.

Why the regional administrative scale matters

A central contribution of this study is to frame regional endemicity not only as a biogeographical property but also as a potentially useful criterion for conservation planning. Administrative boundaries do not necessarily coincide with biogeographical units, and species distributions may extend beyond them. Nevertheless, conservation planning and management are implemented through institutions operating within defined administrative jurisdictions (Schmeller et al., 2014). In Spain, autonomous communities have substantial responsibilities for biodiversity conservation within their respective competences. Thus, when the known distribution of a taxon is confined to a single autonomous community, conservation measures implemented within that territory become directly relevant to its persistence.

This provides a practical rationale for assessing endemicity at the regional administrative scale. Rather than treating administrative boundaries as ecological limits, our approach recognizes them as a scale at which conservation decisions can be implemented. This distinction between biogeographical and administrative scales is increasingly relevant in conservation planning, where conservation decisions are often made within administrative regions that do not coincide with natural biogeographical boundaries (Moilanen & Arponen, 2011).

The framework is therefore potentially transferable to other administrative territories with substantial endemic biodiversity. By compiling endemic taxa, mapping their distributions and evaluating their representation within existing conservation networks, regional assessments can provide a direct link between biogeographical information and the institutions responsible for biodiversity planning and management.

Spatial structure of endemicity

Endemic richness was strongly concentrated in southeastern Murcia, particularly in coastal and pre-coastal sectors. This pattern is consistent with the environmental heterogeneity and biogeographical singularity previously documented for southeastern Iberia and the Region of Murcia (Buira et al., 2017, 2020). The concentration of endemic taxa in this area may reflect the combined effects of environmental heterogeneity, current and past climatic conditions, geological complexity and localized habitats, which can promote geographical isolation and differentiation (Abellán & Svenning, 2014).

Importantly, endemic richness should not be interpreted as a proxy for overall biodiversity, as areas with high endemic richness do not necessarily coincide with areas of high species richness or rarity (Stohlgren et al., 2005; Kier et al., 2009). Indeed, the areas with high values of biodiversity in the Region of Murcia are located in the Northwest area (Calvo-Sendín et al., 2000). Endemic richness should therefore be considered a complementary dimension of biodiversity, particularly when the conservation objective is to safeguard geographically restricted taxa. The 26 endemism hotspots identified here provide a spatially explicit representation of this component of regional biodiversity, identifying cells where multiple consolidated endemic taxa converge. Because hotspots were defined primarily by endemic richness, spatial rarity was used only to resolve ties between cells with equal richness, providing complementary information on the degree of distributional restriction of the taxa represented. The contrasting spatial patterns of endemic richness and spatial rarity further illustrate that these metrics capture different properties (Abellán et al., 2005). Whereas endemic richness was concentrated mainly in southeastern Murcia, high rarity also occurred in inland areas. Nevertheless, identifying highly range-restricted taxa remains relevant for conservation because their restricted distributions can make them particularly vulnerable to habitat loss and other environmental pressures affecting a large proportion of their known range simultaneously (Guo et al., 2023).

Gaps in the representation of endemic biodiversity

Protected-area representation showed substantial gaps at both the taxon and spatial levels. Nine consolidated endemic taxa had none of their known localities within protected areas, whereas eight were fully represented. Even relatively widespread endemic taxa had only part of their known distribution covered, highlighting that overall protected-area coverage does not necessarily ensure adequate representation of individual endemic taxa.

Similar gaps emerged at the spatial level, with six of the 26 endemism hotspots having less than 10% protected-area coverage. Taxon-level and spatial gaps provide complementary information: protected areas may represent several endemic taxa individually while failing to cover areas where multiple endemic taxa converge, whereas protecting endemic-rich areas does not necessarily ensure representation of every taxon (Araújo et al., 2007; Kier et al., 2009). The occurrence of gap areas across coastal environments also suggests that endemic biodiversity may occur in landscapes that are poorly represented within conventional protected-area networks. Globally, protected areas tend to be biased towards locations less exposed to land conversion, such as higher-elevation and steeper terrain (Joppa & Pfaff, 2009), potentially leaving some localized endemic taxa in agricultural, urban or otherwise modified landscapes less represented.

These gaps should not be interpreted as evidence of ineffective protected areas, as our analysis assesses spatial representation rather than conservation effectiveness. Noticeably, they identify components of endemic biodiversity with limited or no overlap with the current protected-area network and provide a spatial basis for considering complementary conservation actions. Notably, most of the endemic taxa identified as gap species also lack specific legal protection, further highlighting the need to consider conservation measures beyond their inclusion within the existing protected-area network.

Implications for biodiversity policy

Our results indicate that endemicity can complement existing criteria used in regional biodiversity planning, particularly where the entire known distribution of a taxon falls within a single administrative territory. Identifying endemic taxa and hotspots outside the existing protected-area network can provide a spatial basis for proposing new protected areas or other conservation instruments, including small-scale approaches that may be particularly suitable for localized taxa and habitats (Laguna et al., 2004; Sánchez-Gómez et al., 2005). At the same time, endemic taxa and hotspots already encompassed by protected areas should not be considered adequately conserved simply because of their spatial overlap; their presence should be explicitly incorporated into management planning through targeted measures addressing their specific ecological requirements and threats. Thus, endemicity can serve as an initial spatial prioritization criterion that is subsequently combined with information on threat status, population trends, habitat condition, land-use pressure and management effectiveness (Kier et al., 2009). More broadly, this framework provides a practical link between biogeographical patterns and regional conservation planning by identifying both

where new protection may be needed and where existing protected areas require more targeted management for endemic biodiversity.

Limitations and future directions

Several limitations should be considered. First, endemicity was assessed from currently available distributional knowledge. Future surveys or taxonomic revisions may reveal occurrences outside Murcia, particularly for the non-consolidated taxa excluded from the spatial analyses. Although our conservative filtering reduces the risk of interpreting incomplete knowledge as definitive endemism, it may also exclude taxa that are genuinely restricted to the region. Occurrence data were also heterogeneous among taxa and across the region, meaning that some spatial patterns may partly reflect differences in sampling effort, particularly among poorly known invertebrates (Hopkins & Freckleton, 2002). Further surveys in under-sampled areas would help distinguish biological patterns from sampling effects.

Second, the 5 × 5 km grid provides a consistent spatial framework but may obscure fine-scale distributions and habitat associations. Finer-resolution analyses would require more precise and homogeneous occurrence data. Finally, protected-area representation was assessed spatially rather than functionally: overlap between known localities and protected areas does not necessarily imply effective conservation, which also depends on management, habitat condition, threats and population dynamics. Future assessments should therefore integrate endemicity with population status, habitat quality, threats and management effectiveness.

Extending the analysis beyond Murcia to the wider southeastern Iberian region would provide a complementary biogeographical perspective and help distinguish taxa genuinely restricted to the region from those whose distributions extend into neighbouring territories. Genetic and phylogeographic studies could further clarify the evolutionary origins and historical processes underlying regional endemicity.

Conclusions

Our study highlights the value of explicitly incorporating endemicity into regional biodiversity planning and, importantly, of assessing it at a spatial scale that is consistent with the scale at which conservation decisions are made. When the geographical extent used to identify endemic taxa aligns with the administrative territory responsible for biodiversity conservation, patterns of geographical restriction can be translated more directly into concrete conservation priorities. This scale matching can reveal conservation gaps that may be

overlooked in broader assessments spanning multiple jurisdictions, while providing a practical framework for integrating endemic biodiversity into regional conservation policies. More broadly, our findings show that aligning the biogeographical scale at which endemicity is assessed with the governance scale at which conservation is implemented can strengthen the capacity of biodiversity planning to safeguard geographically restricted taxa.

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References

Abellán, P., Sánchez-Fernández, D., Velasco, J., & Millán, A. (2007). Effectiveness of protected area networks in representing freshwater biodiversity: The case of a Mediterranean river basin (south-eastern Spain). *Aquatic Conservation: Marine and Freshwater Ecosystems,* 17, 361–374. https://doi.org/10.1002/aqc.778

Abellán, P., Sánchez-Fernández, D., Velasco, J., & Millán, A. (2005). Conservation of Freshwater Biodiversity: a Comparison of Different Area Selection Methods. *Biodiversity & Conservation*, 14(14), 3457-3474. https://doi.org/10.1007/s10531-004-0550-1

Abellán, P., & Svenning, J. C. (2014). Refugia within refugia–patterns in endemism and genetic divergence are linked to Late Quaternary climate stability in the Iberian Peninsula. *Biological journal of the Linnean Society*, 113(1), 13-28. https://doi.org/10.1111/bij.12309

Araújo, M. B., Lobo, J. M., & Moreno, J. C. (2007). The effectiveness of Iberian protected areas in conserving terrestrial biodiversity. *Conservation Biology*, 21(6), 1423-1432. DOI: 10.1111/j.1523-1739.2007.00827.x

Bacchetta, G., Farris, E., & Pontecorvo, C. (2012). A new method to set conservation priorities in biodiversity hotspots. *Plant Biosystems,* 146, 638–648. https://doi.org/10.1080/11263504.2011.642417

Bruno, D., Sánchez-Fernández, D., Millán, A., Ros, R. M., Sánchez-Gómez, P., & Velasco, J. (2012). Assessing the quality and usefulness of different taxonomic groups inventories in a semiarid Mediterranean region. *Biodiversity and Conservation*, 21(6), 1561-1575.

Buira, A., Aedo, C., & Medina, L. (2017). Spatial patterns of the Iberian and Balearic endemic vascular flora. *Biodiversity and Conservation,* 26, 479–508. https://doi.org/10.1007/s10531-016-1254-z

Buira, A., Cabezas, F., & Aedo, C. (2020). Disentangling ecological traits related to plant endemism, rarity and conservation status in the Iberian Peninsula. *Biodiversity and Conservation,* 29, 1937–1958. https://doi.org/10.1007/s10531-020-01957-z

Calvo-Sendín, J. F., Esteve-Selma, M. A., & López-Bermúdez, F. (2000). *Biodiversidad: contribución a su conocimiento y conservación en la Región de Murcia*. Universidad de Murcia.

Convention on Biological Diversity. Kunming-Montreal Global Biodiversity Framework; CBD/COP/DEC/14/5; United Nations Environment Programme: Montreal, QC, Canada, 2022. Available online: https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf (accessed on 5 October 2026).

CBD (2022). Kunming-Montreal Global Biodiversity Framework. Convention on Biological Diversity, Montreal, Canada.

Ceballos, G., Ehrlich, P. R., & Dirzo, R. (2017). Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences, 114*, E6089–E6096. https://doi.org/10.1073/pnas.1704949114

Cowie, R. H., Bouchet, P., & Fontaine, B. (2022). The sixth mass extinction: Fact, fiction or speculation? *Biological Reviews, 97*, 640–663. https://doi.org/10.1111/brv.12816

Dirzo, R., Young, H. S., Galetti, M., Ceballos, G., Isaac, N. J. B., & Collen, B. (2014). Defaunation in the Anthropocene. *Science, 345*, 401–406. https://doi.org/10.1126/science.1251817

Esteve-Selma, M. A. (2013). Análisis ecológico, económico y jurídico de la red de espacios naturales de la Región de Murcia. Editum, Ediciones de la Universidad de Murcia. https://publicaciones.um.es/publicaciones/public/obras/ficha.seam?numero=111&edicion=1

Evans, D. (2012). Building the European Union's Natura 2000 network. *Nature Conservation, 1*, 11–26. https://doi.org/10.3897/natureconservation.1.1808

Gaston, K. J., Jackson, S. F., Cantú-Salazar, L., & Cruz-Piñón, G. (2008). The ecological performance of protected areas. *Annual Review of Ecology, Evolution, and Systematics, 39*, 93–113. https://doi.org/10.1146/annurev.ecolsys.39.110707.173529

Guo, W. Y., Serra-Diaz, J. M., Eiserhardt, W. L., Maitner, B. S., Merow, C., Violle, C., ... & Svenning, J. C. (2023). Climate change and land use threaten global hotspots of phylogenetic endemism for trees. *Nature Communications*, 14(1), 6950. https://doi.org/10.1038/s41467-023-42671-y

Hopkins, G. W., & Freckleton, R. P. (2002). Declines in the numbers of amateur and professional taxonomists: implications for conservation. *Animal Conservation,* 5, 245–249. https://doi.org/10.1017/S1367943002002299

Joppa, L. N., & Pfaff, A. (2009). High and far: biases in the location of protected areas. *PLoS ONE,* 4, e8273. https://doi.org/10.1371/journal.pone.0008273

Kraus, D., Enns, A., Hebb, A., Murphy, S., Drake, D. A. R., & Bennett, B. (2023). Prioritizing nationally endemic species for conservation. *Conservation Science and Practice,* 5, e12845. https://doi.org/10.1111/csp2.12845

Laguna, E., Deltoro, V. I., Pérez-Botella, J., Pérez-Rovira, P., Serra, L., Olivares, A., & Fabregat, C. (2004). The role of small reserves in plant conservation in a region of high diversity in eastern Spain. *Biological Conservation,* 119, 421–426. https://doi.org/10.1016/j.biocon.2004.01.001

Law 42/2007 of 13 December on Natural Heritage and Biodiversity (2007). BOE-A-2007-21490. Ley 42/2007, de 13 de diciembre, del Patrimonio Natural y de la Biodiversidad. Boletín Oficial del Estado. https://www.boe.es/buscar/doc.php?id=BOE-A-2007-21490.

López-López, P., Luigi, M., Alessandra, F., Emilio, B., & Luigi, B. (2011). Hotspots of species richness, threat and endemism for terrestrial vertebrates in SW Europe. *Acta Oecologica*, 37(5), 399-412.

Mace, G. M. (2004). The role of taxonomy in species conservation. *Philosophical Transactions of the Royal Society B,* 359, 711–719. https://doi.org/10.1098/rstb.2003.1454

Margules, C. R., & Pressey, R. L. (2000). Systematic conservation planning. *Nature,* 405, 243–253. https://doi.org/10.1038/35012251

Moilanen, A., & Arponen, A. (2011). Administrative regions in conservation: Balancing local priorities with regional to global preferences in spatial planning. *Biological Conservation*, 144, 1719–1725. https://doi.org/10.1016/j.biocon.2011.03.007

Orsenigo, S., Montagnani, C., Fenu, G., Gargano, D., Peruzzi, L., Abeli, T., ... & Rossi, G. (2018). Red Listing plants under full national responsibility: Extinction risk and threats in the vascular flora endemic to Italy. Biological Conservation, 224, 213-222.

QGIS Development Team (2024). QGIS Geographic Information System. QGIS Association. https://www.qgis.org

Romeiras, M. M., Catarino, S., Gomes, I., Fernandes, C., Costa, J. C., Caujapé-Castells, J., & Duarte, M. C. (2016). IUCN Red List assessment of the Cape Verde endemic flora: towards a global strategy for plant conservation in Macaronesia. *Botanical Journal of the Linnean Society*, 180(3), 413-425.

Sánchez-Fernández, D., Abellán, P., Velasco, J., & Millán, A. (2004). Selecting areas to protect the biodiversity of aquatic ecosystems in a semiarid Mediterranean region using water beetles. *Aquatic Conservation*: Marine and Freshwater Ecosystems, 14(5), 465–479. https://doi.org/10.1002/aqc.633

Sánchez-Fernández, D., Bilton, D. T., Abellán, P., Ribera, I., Velasco, J., & Millán, A. (2008). Are the endemic water beetles of the Iberian Peninsula and the Balearic Islands effectively protected?. *Biological Conservation*, *141*(6), 1612-1627. https://doi.org/10.1016/j.biocon.2008.04.005

Sánchez-Gómez, P. (2002). Libro rojo de la flora silvestre protegida de la Región de Murcia. Consejería de Agricultura, Agua y Medio Ambiente.

Sánchez-Gómez, P., Guerra, J., Rodríguez, E., Vera, J. B., López, J. A., Jiménez, J. F., ... & Hernández, A. (2005). Lugares de interés botánico de la Región de Murcia. *Murcia: Consejería de Agricultura, Agua y Medio Ambiente, Dirección General del Medio Natural, Comunidad Autónoma de la Región de Murcia*.

Schmeller, D. S., Gruber, B., Budrys, E., Dziock, F., & Henle, K. (2008). Determination of national responsibilities for species conservation in regions with multiple political jurisdictions. *Biodiversity and Conservation,* 17, 3603–3618. https://doi.org/10.1007/s10531-008-9439-8

Schmeller, D. S., et al. (2014). The national responsibility approach to setting conservation priorities—Recommendations for its use. *Journal for Nature Conservation,* 22, 457–465. https://doi.org/10.1016/j.jnc.2014.03.002

Watson, J. E. M., Dudley, N., Segan, D. B., & Hockings, M. (2014). The performance and potential of protected areas. *Nature,* 515, 67–73. https://doi.org/10.1038/nature13947

Watson, J. E. M., Venegas-Li, R., Grantham, H., Dudley, N., Stolton, S., Rao, M., ... & Ward, M. (2023). Priorities for protected area expansion so nations can meet their Kunming-Montreal Global Biodiversity Framework commitments. Integrative Conservation, 2(3), 140-155. https://doi.org/10.1002/inc3.24

Table 1. Taxonomic identity and distributional characteristics of the taxa considered endemic to the Region of Murcia. Group (I: Invertebrates; P: Plants); ES: Endemicity Status: (consolidated species: 1, non consolidated: 0); NC: Number of cells occupied by each endemic taxa; r: rarity value for each endemic taxa.

Group	**Order**	**Family**	**Taxon**	**ES**	**NC**	**r**
I	Coleoptera	Staphylinidae	*Alevonota alboculata*	1	1	1.00
I	Coleoptera	Tenebrionidae	*Alphasida (Elongasida) levantina*	1	2	0.50
I	Coleoptera	Tenebrionidae	*Alphasida (s.str.) lorcana*	1	3	0.33
I	Coleoptera	Tenebrionidae	*Alphasida (s.str.) sanchezgomezi*	1	1	1.00
I	Coleoptera	Staphylinidae	*Amauronyx andujari*	0	-	-
I	Diptera	Therevidae	*Ammothereva biflava*	0	-	-
I	Coleoptera	Rhadalidae	*Aplocnemus lencinai*	0	-	-
I	Stylommatophora	Arionidae	*Arion espini*	1	1	1.00
I	Coleoptera	Tenebrionidae	*Asida (Globasida) curvatipennis curvatipennis*	1	6	0.17
I	Coleoptera	Tenebrionidae	*Asida (Globasida) curvatipennis mateui*	1	1	1.00

I	Coleoptera	Tenebrionidae	*Asida (Globasida) curvatipennis schrammi*	1	1	1.00
I	Coleoptera	Tenebrionidae	*Asida (Gracilasida) brucki brucki*	1	2	0.50
I	Coleoptera	Tenebrionidae	*Asida (Gracilasida) fallax*	1	3	0.33
I	Coleoptera	Tenebrionidae	*Asida (Gracilasida) ricoi oertzeni*	1	1	1.00
P	Asparagales	Asparagaceae	*Asparagus macrorrhizus*	1	11	0.09
P	Fabales	Fabaceae	*Astragalus nitidiflorus*	1	5	0.20
I	Hemiptera	Cicadellidae	*Biluscelis hardei*	0	-	-
I	Coleoptera	Elateridae	*Cardiophorus lencinai*	0	-	-
I	Coleoptera	Elateridae	*Cebrio (Tibesia) joseluislencinai*	0	-	-
I	Stylommatophora	Chondrinidae	*Chondrina escutiai*	1	5	0.20
I	Stylommatophora	Chondrinidae	*Chondrina murcica*	1	8	0.13
I	Stylommatophora	Chondrinidae	*Chondrina ricotensis*	1	1	1.00
I	Coleoptera	Chrysomelidae	*Cryptocephalus (Heterichnus) gallegoi*	0	-	-
I	Coleoptera	Melyridae	*Dasytes (Dasytes) murcianus*	0	-	-
P	Caryophyllales	Caryophyllaceae	*Dianthus anticarius saorinii*	1	3	0.33
I	Stylommatophora	Helicidae	*Iberus carthaginiensis*	1	14	0.07
I	Stylommatophora	Helicidae	*Iberus punicus*	1	14	0.07
I	Pseudoscorpionida	Larcidae	*Larca fortunata*	1	1	1.00
P	Caryophyllales	Plumbaginaceae	*Limonium album*	1	11	0.09
P	Caryophyllales	Plumbaginaceae	*Limonium carthaginense*	1	8	0.13
I	Coleoptera	Staphylinidae	*Lusitanopsis lencinai*	1	1	1.00
P	Brassicales	Brassicaceae	*Moricandia moricandioides pseudo-foetida*	1	16	0.06
I	Coleoptera	Staphylinidae	*Oxypoda (Deropoda) lencinai*	1		
I	Coleoptera	Staphylinidae	*Paratyphlus carmeloi*	1	1	1.00
I	Coleoptera	Staphylinidae	*Paratyphlus deformis*	1	1	1.00
I	Coleoptera	Staphylinidae	*Paratyphlus espunae*	1	1	1.00
I	Coleoptera	Staphylinidae	*Paratyphlus lencinai*	1	1	1.00
I	Coleoptera	Curculionidae	*Pentatemnus ochotorenai*	0	-	-
I	Hemiptera	Miridae	*Phytocoris pseudobscuratus*	0	-	-
I	Hemiptera	Rhyparochromidae	*Plinthisus jordiribesi*	0	-	-
I	Coleoptera	Leiodidae	*Pseudotriarthron hispanicum*	0	-	-
I	Littorinimorpha	Hydrobiidae	*Robustiella incantata*	1	1	1.00
P	Lamiales	Lamiaceae	*Sideritis pusilla subsp. carthaginensis*	1	24	0.04
P	Lamiales	Lamiaceae	*Teucrium carthaginense*	1	18	0.06
P	Lamiales	Lamiaceae	*Teucrium terciae*	1	14	0.07
I	Diptera	Bombyliidae	*Usia pterosaurioides*	0	-	-
I	Stylommatophora	Geomitridae	*Xerocrassa penalveri*	1	1	1.00

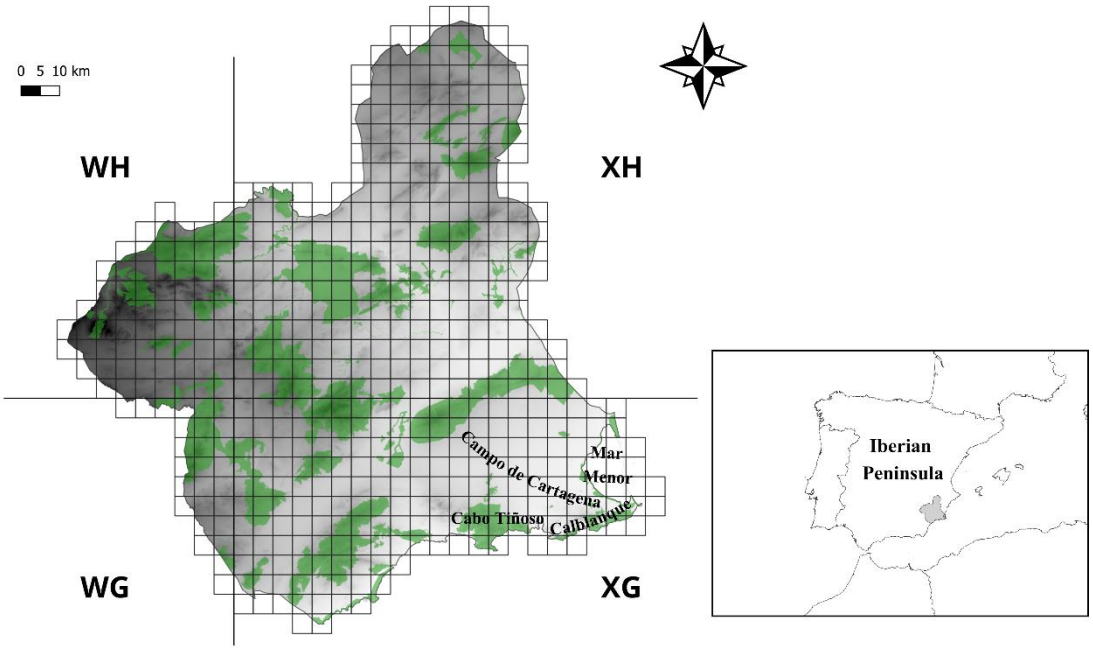


Figure 1. Study area. The Region of Murcia divided into 5 × 5 km MGRS grid cells (UTM projection). Green areas represent protected areas.

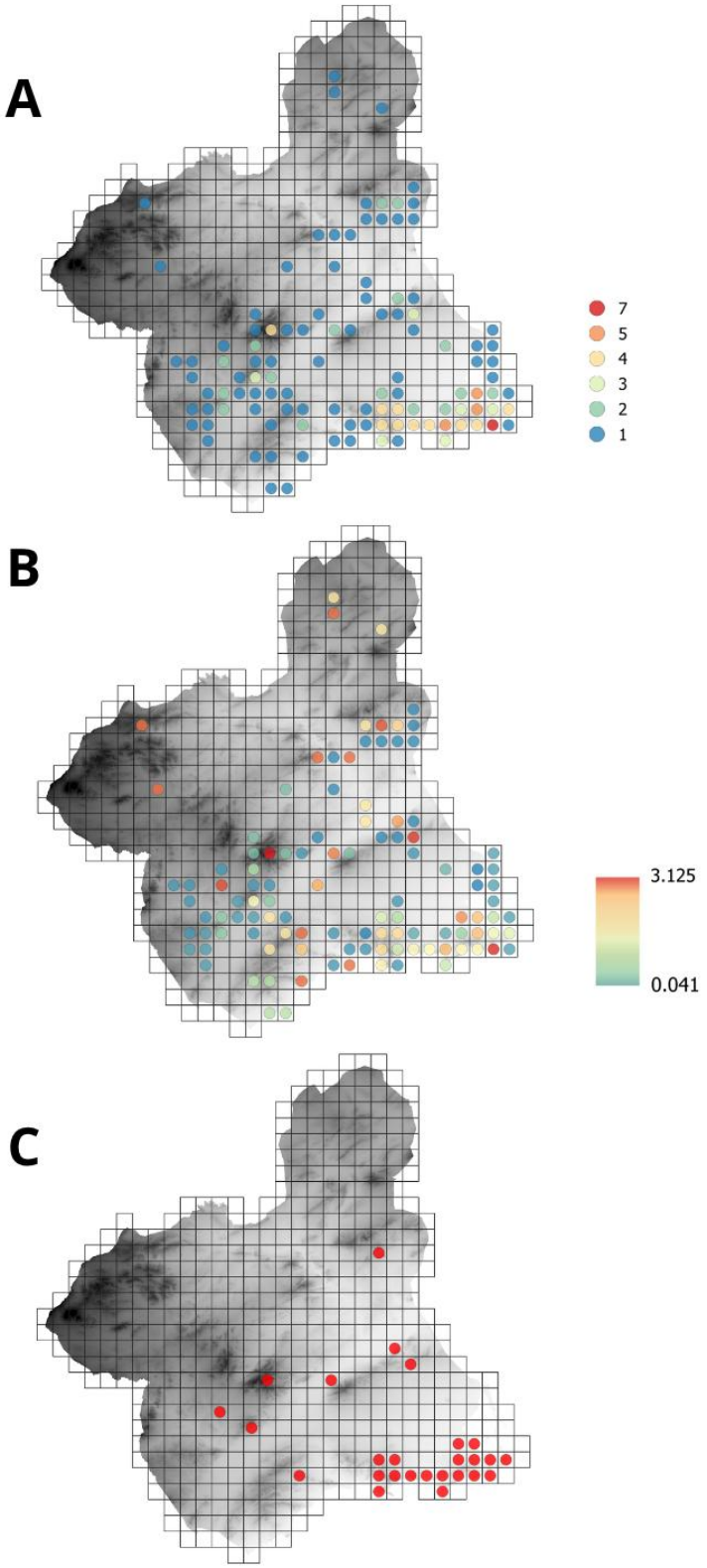


Figure 2. Spatial distribution patterns of endemic taxa in the Region of Murcia. Endemic species richness (A) and endemic species rarity (B). Endemicity hotspots in the Region of Murcia (C).

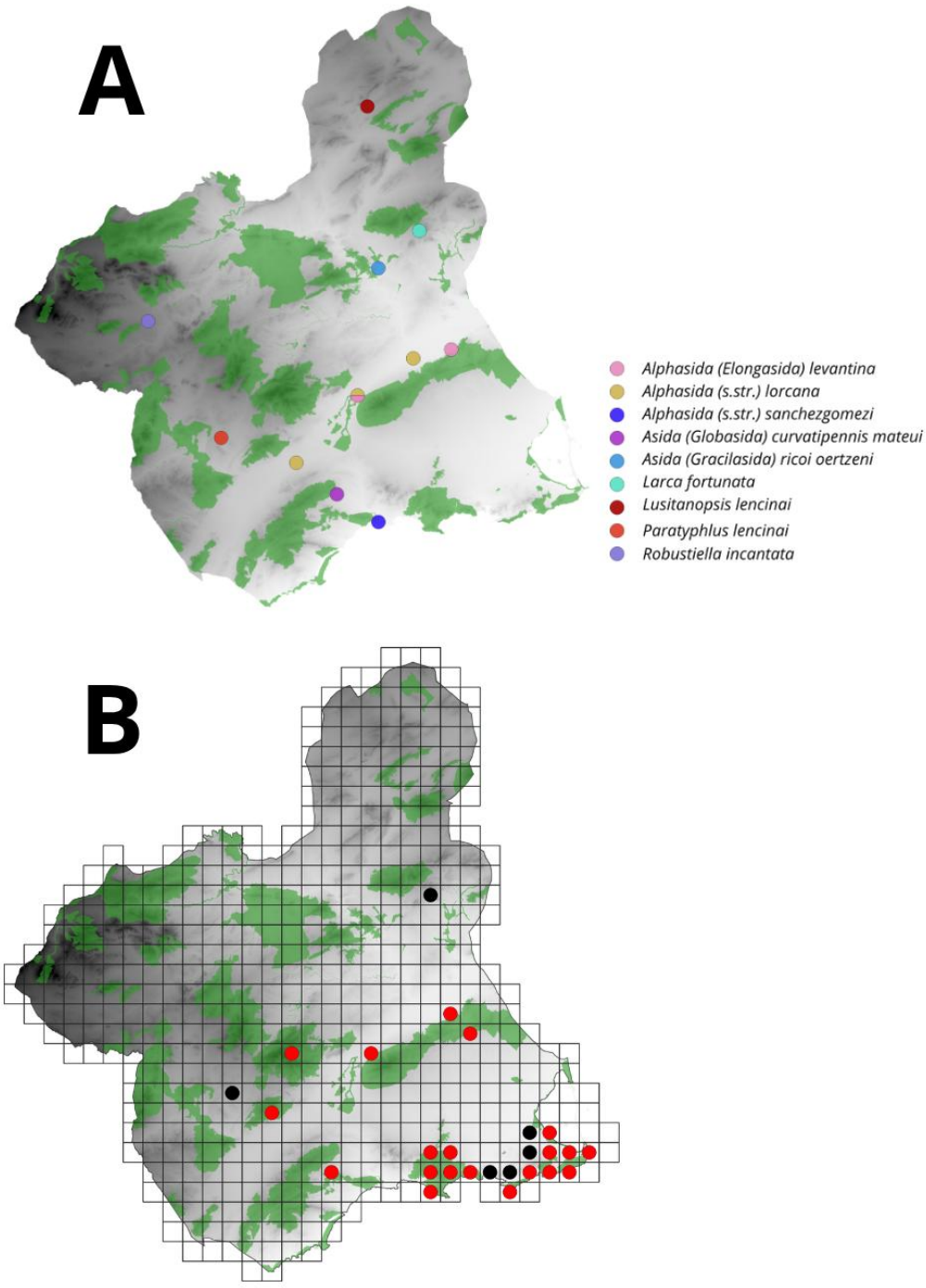


Figure 3. Representation within protected areas. Overlap between the localities of the nine unprotected endemic taxa (A) and endemicity hotspots (B) and protected areas (green areas). Endemicity hotspots are shown in red, except those with less than 10% overlap with protected areas which are shown in black.