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Biodiversity and conservation of Iberian spiders: past, present and future

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Abstract: The knowledge of Iberian spider species and their distributions has undergone several development stages. The accumulation of knowledge, reinforced by the emergence on the last years of several associations devoted to the study of arachnids, allowed us to currently register more than 1300 species in the Iberian Peninsula. In a project started by Eduardo Morano and now with my cooperation, the new Iberian spider catalogue is being developed and is partly available online.

However, even if all existing data are compiled, they still present two main problems. Firstly, they are incomplete for the vast majority of the species. Secondly, the heterogeneity of the studies that recorded the data does not allow direct or reliable comparisons between areas. Both the reasonable completeness of the data and its comparability are essential for, among others, biogeography and conservation studies. These two targets can only be guaranteed by the use of optimized and standardized sampling protocols. Based on intensive fieldwork made in different areas and habitats in Portugal, a flexible sampling protocol has been developed which, will allow different teams with multiple objectives to compare results among each other, a procedure not possible until the present.

The Iberian Peninsula has, from now on, a set of tools that will allow the efficient accumulation of reliable and comparable data. Only with these data, it is possible to think on the effective protection of our species, many of which are endemic, with data as much or more robust than the ones existing for vertebrates and vascular plants.
Keywords: Araneae, biodiversity assessment, catalogue, checklist, inventory, monitoring, Portugal, sampling protocol, Spain.

The past

As with most arthropod taxa, the knowledge of Iberian spiders has undergone distinct development stages, although is far from complete. Actually, even recognizing that the number is constantly changing, we still do not know how many species currently live in the Iberian Peninsula. And even for most of the species recognized to be present, little is known regarding their distribution. Several reasons may be pointed for this outcome, likely related in higher or lower degree to: the inexistence of optimized and standardized sampling protocols (at least until now); the lack of taxonomy experts that are able to correctly identify specimens; the poor knowledge on the influence of habitat or climate change to different species; the widespread belief that spiders are "nasty" and "dangerous"; and finally, the unawareness that most politicians (including from nature protection agencies) have of this taxon (see also New, 1999).

Until the present, 1378 species have been recorded for the Iberian Peninsula (fig. 1). This number excludes the recognized synonyms, *nomina dubia* and *nomina nuda* (mostly following Platnick, 2008). But it still includes many misidentifications which are hard to determine, especially for old records for which the individuals are commonly unavailable. The accumulation of the Iberian spider species along decades (fig. 1) is almost linear, with no sign of an asymptote. Inclusively during the later decade, more than 100 species were added, many of them new to science. Some families have received more attention than others since the 1980's, when a new generation of arachnologists started working with the group: Agelenidae (J.A. Barrientos), Araneidae (E. Morano), Dysderidae (M.A. Ferrández), Nemesiidae (A. Decae), Thomisidae (C. Urones, which also studied other smaller families) and Zodariidae (R. Bosmans and S. Pekár). The increasing interest in spider studies has inclusively led to the association of many arachnologists in the Iberian Group of Arachnology (GIA) and the Spider Study and Conservation Society (SECA).

The growing interest on the Iberian spiders is also evident on the number of spider records observed along decades (fig. 2). This trend seems to follow an exponential curve and there are at the present nearly 20,000 records compiled in the literature. The curve can also be explained by the current use of sampling protocols intended to sample many groups of spiders simultaneously. This allows capturing many species from each sampled site, common and rare, when in former decades most of the sampling protocols were not standardized and were focused on few species at a given time, providing then a poor number of records.

Despite the increase in the number of records per species through time, the knowledge on the different species is very unbalanced in the sense that most species contribute with a very low proportion of data, while a few species contribute with a large proportion (fig. 3). This is a typical scenario for many arthropod taxa. With such an unbalanced knowledge among species, it is difficult to perceive general trends, either in space or in time, when analyzing data that include all spiders. Even more worrying is the fact that more than 300 species only have one record and nearly 300 species only have two or three records. These two classes together represent half of the known species in the region. Even taking into account that many of these could be misidentifications, the numbers are clear.

Also informative of the lack of knowledge we face, is the recent discovery in Portugal of two emblematic species. Coincidentally, these are the smallest and largest known

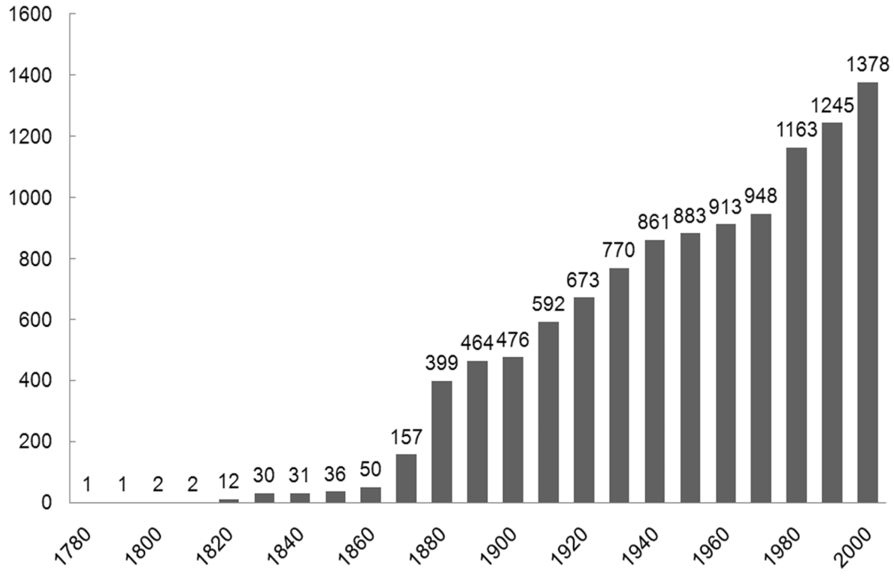

Fig. 1. Cumulative number of species recorded for the Iberian Peninsula per decade.

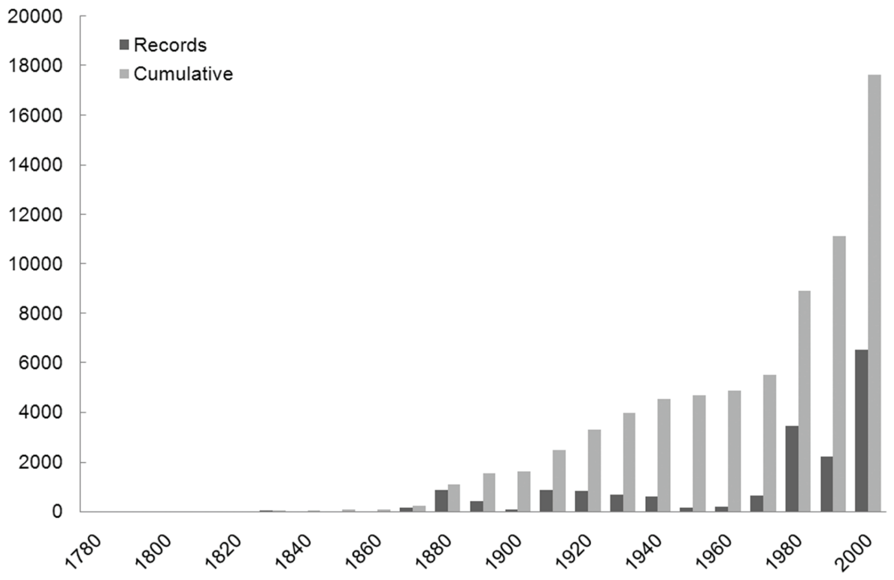

Fig. 2. Number of records for the Iberian Peninsula per decade. Each record is a citation of a species from a site; repeated citations in time by the same author (e.g. due to long-term or multiple-sample studies) are counted as a single record.

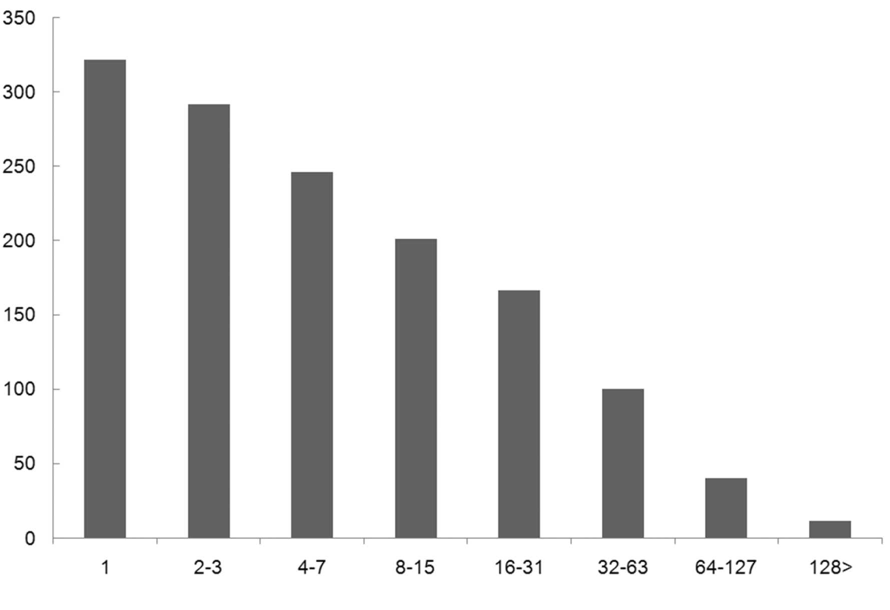

Fig. 3. Number of records per species, divided by the respective octaves.

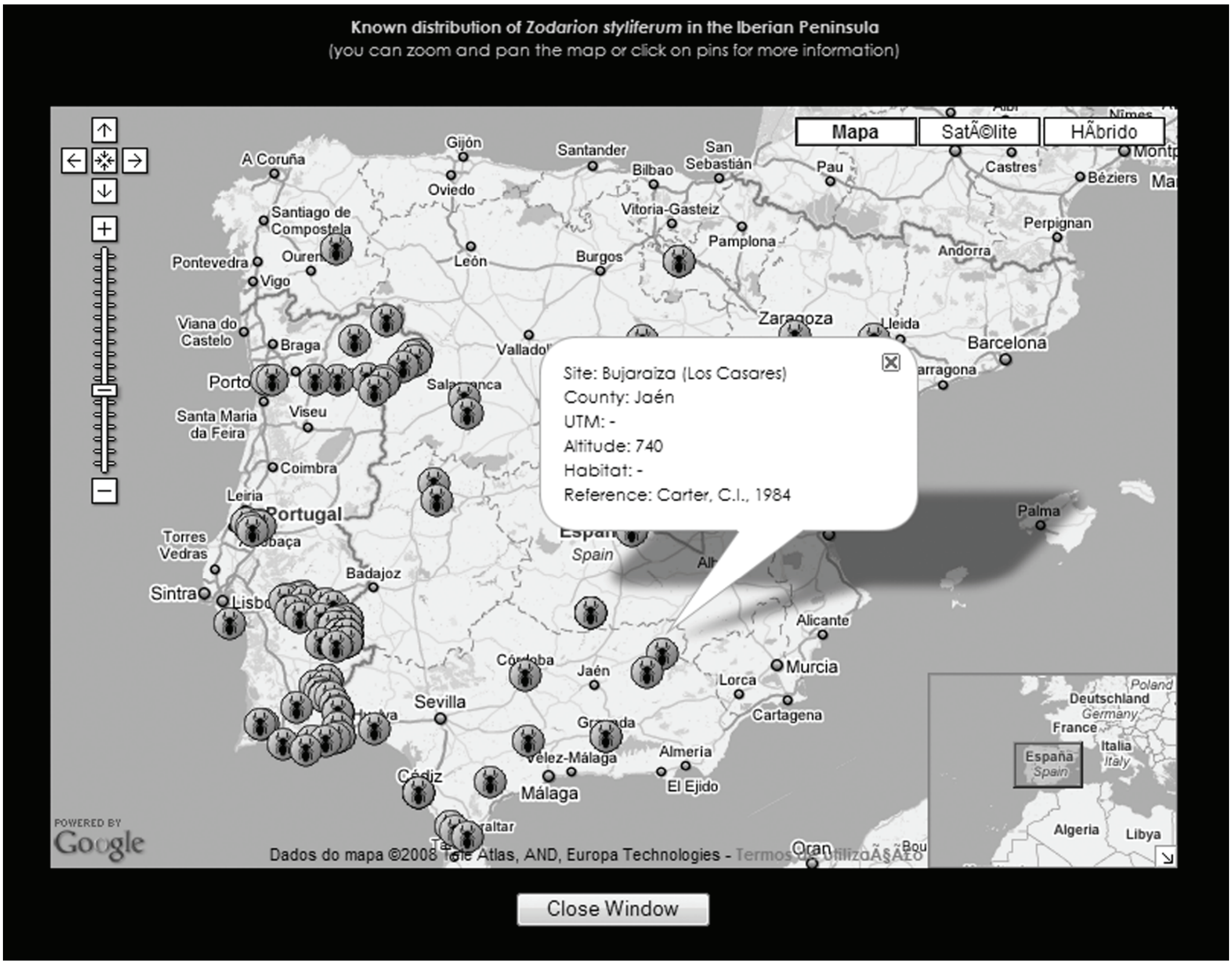

Fig. 4. Example output from the Iberian spider catalogue (Morano & Cardoso 2008).

species in Europe. The first, from which only females are known with 0.5mm, is the only known representative of the family Symphytognathidae in Europe, of the genus Anapistula. Being a troglobiont species, it is restricted to a single cave system in Arrábida Nature Park and was found by a team belonging to the Costa Azul Speleology Nucleus in February 2005. Its habitat area is rapidly diminishing due to limestone quarries that operate in the area and the species risks extinction. Not even António de Barros Machado, the last and most recognized Portuguese arachnologist and biospeleologist, found this small species, possibly because of its restricted distribution. The second species, *Macrothele calpeiana* (Walckenaer, 1805), was only known from Spain and Ceuta and some females can have up to 3 or 4 cm of body size. It was only recently found by chance in Portugal by Siegfried Huber, a German arachnologist during his vacations, in March 2007, at Rocha da Pena and Fonte Benémola, in Algarve. How has such a large species gone unnoticed for so long, even to Amélia Bacelar, a specialist on mygalomorphs that visited the region a number of times, is revealing of how little we know about the group.

Even though the available data on Iberian spiders are incomplete, they can still be very useful. To compile all the information on species distribution and make it available is one of the objectives of the recently announced Iberian Spider Catalogue (Morano & Cardoso, 2008). This project, besides guaranteeing the availability of significant data, intends to be a catalyst of new projects to be developed in the future on the fields of biogeography and conservation, since anyone can easily know what was recorded at a given site (fig. 4). Biodiversity data sharing is, in fact, the rationale of many projects that are currently compiling information on the distribution of species. GBIF (www.gbif.org) and Fauna Europaea (www.faunaeur.org) are two of them, experiencing a variable degree of success depending on the taxon.

The present

Biodiversity and conservation studies of Iberian species of spiders, particularly endemics, require knowledge on many characteristics of each species, namely, their distribution in space and time. However, as already seen, even if everything known so far, regarding all species, would become available in a single database, it would still be poor. Without new field data, even the Iberian Spider Catalogue (or any other) is certainly incomplete and risks inadequacy (e.g. Hortal *et al.*, 2007). Firstly, because distribution data are very incomplete for the vast majority of species. Secondly, because the heterogeneity of the studies that provided the data does not allow direct or reliable comparisons between areas. Both the reasonable completeness of the data and their comparability need to be essential targets, and these two targets can only be guaranteed by the use of optimized and standardized sampling protocols.

In the last years, intensive fieldwork was made in distinct Portuguese natural areas (table I; see Cardoso *et al.*, 2008, in press a, b). With the resulting data, a flexible sampling protocol was developed to allow different teams with diverse objectives to compare results among each other, a comparison that, until recently, was not possible. This protocol has been nicknamed as COBRA – Conservation Oriented Biodiversity Rapid Assessment.

A COBRA cookbook

At each site to be studied, a sampling plot with one hectare should be delimited. All the sampling methods will be made inside this plot and collectors are allowed to freely roam inside it. This can be a square (100x100m) area or an adapted shape for linear habitats (e.g. river margins).

A semi-quantitative sampling design, with a sampling unit defined as one person-hour of effective fieldwork, is to be followed. For the purpose, collectors should use a stopwatch to control the time that is spent collecting, and to be able to stop the counter when occupied with other activities (e.g. photography, maintenance of tools, eating, etc.; one hour of collecting can take up to 10 or 20 minutes more).

Previous work (see Cardoso *et al.*, 2008, in press a, b) has demonstrated that each combination of method and time of the day can be considered as a different method itself. For example, sweeping low vegetation during the day samples a different fraction of the spider community than sweeping that same vegetation during the night. Therefore, these should be regarded as different methods.

The proposed methods were chosen due to their proved efficiency to sample spiders, and also because they target different fractions of the sampled community, even if with some overlap in a few cases (fig. 5):

Aerial – this method consists in collecting all spiders found above knee-level by hand, forceps, pooter or brush and immediately transferring them into alcohol. All the time spent searching is to be accounted for.

Ground – Similar to the aerial method, but directed towards spiders seen below knee-level, including species in hidden sites such as below stones or inside hollow trunks.

Beating – A one by one meter square sheet with a frame should be used as a drop-cloth and a wooden pole used to beat tree branches, as high as possible. The effective time includes all the time spent in the activity, like beating, searching for fallen spiders on the sheet and transferring them to alcohol.

Sweeping – A round sweep net with an opening diameter of 40 cm is used to sweep bushes and tall herbs. All time spent sweeping or searching for dislodged spiders is accounted for.

Pitfall – Pitfall traps are placed next to the delimited plot (not inside to avoid interference with collectors). Each trap is placed 5 meters apart from the nearest traps. A sample is a group of 4 contiguous pooled traps. The clumping of traps makes individual sampling effort reasonably comparable with time-based samples, as the effort applied to rig and collect four traps is calculated to be roughly equivalent to one person-hour of work. Traps should be left in the field for two weeks. Preference should be given to standard 33 cl plastic cups, 8 cm wide at the top and 12 cm high. Two-thirds of each cup is filled with a preservative liquid containing 50% of ethylene glycol and a drop of detergent to break surface tension, covered with a square wooden plate placed about 2 cm above the ground.

Table I. Comparison of all semi-quantitative sampling studies in Portugal that followed a similar strategy and that were used to delineate the COBRA protocol. Each sample corresponds to one person-hour of fieldwork. Sampling intensity is the number of individuals divided by the number of species. Inventory completeness is the proportion between observed and estimated richness.

Site	Gerês	Arrábida	Guadiana
Samples	320	320	192
Individuals	7516	5548	2675
Species richness	185	150	110
Sampling intensity	41	37	24
Singletons	21%	17%	29%
Estimated richness (Chao 1)	213	162	155
Inventory completeness	87%	92%	71%

Other factors like collector experience have been tested and only occasionally found to influence the results (Coddington *et al.*, 1991, 1996; Scharff *et al.*, 2003). It is therefore unnecessary to strictly control the experience of collectors, although I recommend that at least one of the collectors is experienced in this type of sampling and proficient with all the methods, so that consistency between different teams is maximized.

With these methods, and using an iterative optimization procedure explained elsewhere (Cardoso, subm.), three nested (sub-)protocols were reached (table II). The low-effort protocol is intended to capture around 50% of the existing species, regardless of the habitat type, and is part of the medium-effort protocol, which requires four times more effort to capture 70% of the richness. Concurrently, this medium-effort protocol is part of the high-effort protocol. This way, the flexibility is guaranteed, as different sampling teams may have different objectives and resources, but at the same time all sites are comparable, even if sampled with different effort.

It has been suggested that it is more efficient to concentrate most effort during a single sampling season than to spread the effort during an entire year (Cardoso *et al.*, 2007). Therefore, if a single season is to be chosen for sampling, it should be during May and June, when richness is highest (table III; Cardoso *et al.*, 2007). If the objectives require that the sampling is done along the year, I propose a "96 + 24 + 24" or a "320 + 96 + 96" strategy (table II), with the lower effort sampling seasons being done during January/February and September/October (Cardoso, subm.).

The protocol now proposed only optimizes the effort spent in the field. This is probably the most critical stage, given the remote location of many sampling sites and the logistics involved. Moreover, fieldwork is the only part of any project that is often impossible to repeat. In contrast, it is possible to (re-)identify some species if collections are available or to rerun statistic analyses afterwards. However, several ways for optimizing the identification process have been proposed for Iberian spiders. Among these are the identification of individuals only to genus level which will act as higher taxa surrogates (Cardoso *et al.*, 2004a) or the identification of gnaphosids and theridiids which were proved to be good indicator taxa of the overall spider diversity (Cardoso *et al.*, 2004b). With these options, the total number of species may be estimated with reasonable confidence and results remain comparable between areas, even if at different taxonomic resolution.

Fig. 5. Illustration of four of the methods found to be the most efficient to collect spiders in Iberian habitats. Aerial search, ground search, beating tray and sweep net.

Table II. Proposed nested (sub-)protocols. Ad/An – Aerial searching day/night; Bd/Bn – Beating day/night; Gd/Gn – Ground searching day/night; Sd/Sn – Sweep day/night; Pf – Pitfall trapping (each sample being comprised by four pitfall traps as explained in text). Numbers of samples in parenthesis refer to alternative protocols when sites do not have arboreal cover. %S - expected % of species captured.

Samples	%S	Ad	An	Bd	Bn	Gd	Gn	Sd	Sn	Pf
24	50	0	4 (0)	2 (0)	2 (0)	0	0 (4)	2 (4)	2 (4)	12
96	70	0	16 (0)	8 (0)	8 (0)	0	0 (16)	8 (16)	8 (16)	48
320	90	32 (0)	32 (0)	32 (0)	32 (0)	32 (64)	32 (64)	32 (64)	32 (64)	64

Table III. Adequacy of periods of the year to sample according to geographical area in Portugal and habitat (tree cover density) characteristics (see Cardoso *et al.*, 2007). Notation as follows: (-) Avoid; (o) Good; (+) Optimum.

		April		May		June		July	
		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
North	Dense	-	-	o	+	+	+	o	-
	Sparse	-	-	-	o	+	o	-	-
	Open	-	-	-	o	+	o	-	-
Centre	Dense	-	o	+	+	+	+	o	-
	Sparse	-	-	o	+	+	o	-	-
	Open	-	-	o	+	+	o	-	-
South	Dense	-	o	+	+	+	o	-	-
	Sparse	-	-	o	+	o	-	-	-
	Open	-	-	o	+	o	-	-	-

The future

In his work devoted to the Iberian endemisms, Melic (2001) listed 223 endemic species and subspecies (the validity of subspecies in spiders was long abandoned by most authors). The same author had also estimated 1600 spider species occurring in the Iberian Peninsula, based on extrapolations comparing the Iberian and Italian faunas. If we assume that 1300 species are currently known and confirmed, the gap would be of 300 species remaining to be found in the region. But even more difficult than filling this gap is to gather enough information that will allow us to know with reasonable confidence the distribution of all the different species.

The sampling protocol that is now proposed can be one of the ways to rapidly fill the existing gaps. As an example of its efficiency, the intensive protocol that was used in Gerês (Cardoso *et al.*, in press b) provided remarkable results. With two weeks of sampling it was possible to capture 26 new species for Portugal and four new genera for the Iberian Peninsula - *Bassaniana* (Thomisidae), *Callobius* (Amaurobiidae), *Echemus* (Gnaphosidae) and *Peponocra-*

nium (Linyphiidae). Several sampling trips are now planned to the country by different teams with diverse objectives (inventory, monitoring, ecology), following the COBRA guidelines.

Applying this type of protocol, the large number of specimens collected in a short period of time shows one of the main problems of dealing with arthropods: the taxonomic impediment. The specimens must be translated into data and this implies their identification to the lowest taxonomic level possible, preferentially to species. A useful tool is already available, an illustrated key of the Iberian spider genera (Barrientos *et al.*, unpublished document). As already shown elsewhere (Cardoso *et al*., 2004a), genera are excellent surrogates of species for spider taxa. They are not, however, perfect substitutes, as conservation measures usually require the knowledge of named species.

In any case, the Iberian Peninsula has, from now on, a set of tools that will allow the efficient accumulation of reliable and comparable data. Only with these data it is possible to think on the effective protection of our spider species, including many endemic, with data as much or more robust than the ones existing for vertebrates and vascular plants. But even the best of data do not guarantee their use in conservation management.

The only spider protected in the Iberian Peninsula, due to the adoption of the EU Habitats Directive, is *Macrothele calpeiana*. Although it has been classified as Vulnerable in the Redbooks of invertebrates of Spain and Andalucia (Ferrández, 2006, in press), and being its inclusion in the IUCN redlist (www.redlist.org) recently submitted for the 2009 edition (Ferrández & Cardoso, subm.), it is not the only or most threatened spider in the region. Unfortunately, the Natura 2000 network process is in a stall and it is apparently impossible to add species to the Habitats directive lists. The possibility to update the species listed in the Directive is an essential task if we want to protect what should effectively be protected and not only what some anonymous politician felt right a number of years ago. Environmental impact studies, for example, never consider spiders in their designs. One of the ways of lobbying is to take advantage of the open process, similar to most refereed journals, that the IUCN implements for the inclusion of species in its listings. Although these lists do not have legal binding, they are certainly useful for future lobbying.

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