2008. The Journal of Arachnology 36:457–463

Assessing the conservation value of the spider fauna across the West Palearctic area

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Abstract. Making use of the recent publication of a catalogue of spider species from Europe and the Mediterranean Basin, we built a computer database which indexes all specific and subspecific taxa reported from countries or islands in Platnick's world catalogue as well as in regional or national catalogues. We used this database to analyze the distribution of conservation values at the West Palearctic scale. Three indices of conservation value were calculated and compared between mainland and island territories: species richness, number of endemic species, and I_c, a "Conservation Value Index." Species richness increases with the size of the area being considered, either in islands or in mainland countries, and is highest in Southern Europe. The number of endemics also increases with area, but only for mainland countries, suggesting that different factors determine endemism on islands and in mainland areas. The conservation index shows that several island territories are of a high conservation interest: the Mediterranean and Atlantic islands clearly exhibit the highest conservation value and some islands (mainly Canary and Balearic islands) can be considered hotspots of biodiversity for the West Palearctic area; other hotspots are some small Mediterranean islands.

Keywords: Species richness, endemic species, island theory, Araneae, Europe

The identification of priority areas for species/habitat conservation should first incorporate an evaluation of narrow range species or endemic species to the total species richness. Concerning spiders, a large number of endemic (rare) species have been described and studied in the famous biodiversity hotspot archipelagoes or islands of the Pacific (see for instance Baert et al. 1991; Gillepsie 2002; Wood et al. 2007). In contrast, very few studies have dealt with spider rarity in northern areas. Distinct centers of endemism have been pointed out in mainland West Palearctic areas (Deltshev 1999; Marusik & Koponen 2002) and in some Atlantic archipelagoes (Borges & Brown 1999; Arnedo et al. 2001) but very few studies have been made to estimate the global rarity of faunas at national (Ruzcika & Bohac 1994; Gadjos & Sloboda 1995) or local scales (e.g., Pétillon et al. 2007). Thus, in spite of the presence of spiders in all biota, we have no overview of the distribution of narrow range spider species in the European fauna, which is needed as basic knowledge for European conservation plans (as for instance the so-called "European framework for environmental protection," Natura 2000). Relatively extensive data on the distribution of spiders in Europe and North Africa are now available and stored in a database (Canard 2005). In this study we propose to use these data to determine the distribution of conservation value across the West Palearctic area at a national scale for both mainland and island territories.

The assessment of conservation value is usually based on species richness and rarity. In Europe, rarity status for spiders is currently unavailable or inaccurately estimated. Instead, we used the number of endemic species and a synthetic index based on the integration of degrees of rarity of all species of a territory (Canard & Ysnel 2002). The distribution of these indices were i) analyzed in relation to area of the territory and its location (i.e., geographical sectors, see Methods for details) and ii) compared between islands and mainland territories. Since species richness and the number of endemic species are expected to increase with the size of the area being sampled (MacArthur & Wilson 1967; Emerson & Kolm 2005), these two parameters were analyzed by accounting for the area effect. That also allows us to explore the robustness of the database.

METHODS

The European reference database is stored on an Access database (not yet available on the Internet, but available from the authors on request). Following Canard (2005), the West Palearctic zone is divided into six different sectors (Table 1): North and Far East Europe, Atlantic Europe, Central Europe, Mediterranean Europe, Mediterranean Middle East, and North Africa and South Atlantic islands. Spider occurrence data for these sectors come from Canard's Catalogue (Canard 2005) updated with Platnick's World Spider Catalog data (Platnick 2007) and with national checklists published or available on the Internet (see Table 2). Before being integrated in the reference base, data from the Internet were critically analyzed and, in case of doubtful mentions, the relevant species were not included in the database. At the moment the database lists 5,603 species (presence /absence data) from 75 territories (49 mainland countries and 26 islands).

For each territory, species richness, number of endemic species, Conservation Value Index (I_c, see details below) and surface area were determined (Table 1). In order to respect normality, the data were log(x + 1)-transformed. ANCOVAs were carried-out on species richness and number of endemic species with "insularity factor" (island vs. mainland) as categorical fixed factor and territory area as continuous covariate (Model 1; García-Berthou 2001). If the covariate-by-factor interaction was not significant (homogeneity of slopes), a Model 2 (standard ANCOVA) was performed. If the interaction was significant, the data from both types of territories (island and mainland) were separately analyzed with respect to their area (standard linear regression analysis: Model 3).

Evaluating conservation value through the global range of rarity of spider faunas makes sense because a country colonized mainly by ubiquitous species (with high dispersal abilities and a broad ecological spectrum) has a low arachnological conservation value. On the other hand, a country having many rare specialized species (endemic and/or stenotopic species, with a narrow geographical and/or ecological spectrum) may have a high conservation value. Referring to this idea, a "Conservation Value Index" (I_c) based on the relative rarity of spider species was elaborated to estimate the conservation value of the different communities of each territory (islands and mainland countries) of the West Palearctic area. This index is the same that we have earlier described under the name of "patrimonial index" (Canard & Ysnel 2002). Fig. 1 gives a theoretical example showing how I_c is calculated. The calculation consists of ordering the number of species collected for all the spiders of West Palaearctic (Z1) and in the territory tested (Z2) according to the different numbers of stations known for each species. These numbers are calculated as percentages

Table 1.—Biogeographic sector, name of the country/island, code (C), insularity factor (I, Ma = Mainland, Is = Island, area (A, km^2), number of endemic species (Ne), species richness (S), and Conservation Value Index (I_c). Countries are coded according to the ISO 3166-1-alpha-2 A norm except for United Kingdom which was divided into Great Britain (GB) and Ireland s.l. (including Northern Ireland, coded IR). All islands, constituting a country or not, were coded separately by the first two letters of their names (as far as possible). x: Ic not calculated.

Sector	Name	C	I	A	Ne	S	I_c
North and Far East Europe							
1	Estonia	EE	Ma	45226	3	514	−55.70
1	External Hebrides	HE	Is	3071	0	147	−56.80
1	Finland	FI	Ma	338145	6	629	−52.30
1	Iceland	IS	Is	103125	2	111	−51.80
1	Jan Mayen	JA	Is	377	0	5	x
1	Latvia	LV	Ma	64589	0	439	−56.90
1	Lithuania	LT	Ma	65303	1	48	−57.40
1	Norway	NO	Ma	324220	3	558	−54.40
1	Russia	RU	Ma	17075400	90	1247	−37.40
1	Svalbard	SV	Is	61606	1	20	x
1	Sweden	SE	Ma	449964	2	702	−53.08
Atlantic Europe							
2	Belgium	BE	Ma	30528	1	702	−55.20
2	Faroe Islands	FE	Is	1399	0	39	−56.00
2	France	FR	Ma	675417	190	1507	−36.34
2	Great Britain	GB	Is	229850	2	636	−55.10
2	Ireland	IR	Is	84431	0	415	−56.40
2	Isle of Man	IM	Is	572	0	194	−57.20
2	Netherlands	NL	Ma	41526	0	623	−55.07
2	Orkney Islands	OR	Is	990	0	130	−56.80
2	Shetlands Islands	SH	Is	1426	0	81	−56.70
Central Europe							
3	Austria	AT	Ma	83858	14	982	−49.50
3	Belarus	BY	Ma	207600	0	387	−57.10
3	Bulgaria	BG	Ma	110910	37	981	−48.30
3	Czech Republic	CZ	Ma	78866	1	841	−53.87
3	Denmark	DK	Ma	43094	1	530	−56.40
3	Germany	DE	Ma	357027	3	1005	−51.80
3	Hungary	HU	Ma	93030	6	726	−54.60
3	Luxembourg	LU	Ma	2586	0	48	−57.40
3	Macedonia	MK	Ma	25713	10	440	−52.03
3	Moldavia	MD	Ma	33843	0	291	−55.90
3	Poland	PL	Ma	312685	1	774	−54.35
3	Romania	RO	Ma	238391	53	960	−48.06
3	Serbia	RS	Ma	88361	31	623	−54.50
3	Slovakia	SK	Ma	48845	4	902	−53.10
3	Switzerland	CH	Ma	41285	4	944	−52.06
3	Ukraine	UA	Ma	603700	28	833	−50.11
Mediterranean Europe							
4	Aegean Islands	IE	Is	4395	7	97	−45.10
4	Albania	AL	Ma	28748	2	29	−44.80
4	Balearic Isles	BL	Is	4992	31	59	3.90
4	Bosnia	BA	Ma	51130	23	65	−14.41
4	Corsica	CO	Is	8569	35	512	−43.50
4	Crete	CR	Is	8336	58	284	−30.17
4	Croatia	HR	Ma	56542	36	630	−47.50
4	Cyclad Islands	CC	Is	2630	8	148	−45.50
4	Dodecanese Islands	DO	Is	2564	15	284	−45.80
4	Greece	GR	Ma	131940	61	629	−40.70
4	Ionian Islands	IO	Is	2370	19	227	−43.44
4	Italy	IT	Ma	301230	149	1183	−39.70
4	Malta	MT	Is	316	7	11	x
4	Montenegro	ME	Ma	13812	0	11	x
4	Portugal	PT	Ma	88800	24	702	−43.60
4	Sardinia	SR	Is	3	1	205	−42.90
4	Sicily	SC	Is	25700	26	242	−42.02
4	Slovenia	SI	Ma	20270	15	514	−53.10

Table 1.—Continued.

Sector	Name	C	I	A	Ne	S	I_c
4	Spain	ES	Ma	504782	122	1177	−37.86
4	Sporad Islands	SP	Is	414	0	25	−55.11
Mediterranean Middle East							
5	Armenia	AM	Ma	29800	0	149	−47.90
5	Azerbaijan	AZ	Ma	86100	55	624	−38.26
5	Cyprus	CY	Is	9251	9	47	−24.60
5	Georgia	GE	Ma	69700	48	493	−40.06
5	Israel	IL	Ma	20770	134	459	−12.70
5	Jordan	JO	Ma	92300	0	6	
5	Lebanon	LB	Ma	10452	16	186	−50.40
5	Syria	SY	Ma	185180	16	261	−37.31
5	Turkey	TR	Ma	779452	99	528	−38.10
North Africa and South Atlantic Islands							
6	Algeria	DZ	Ma	2381741	243	717	−12.47
6	Azores	AC	Is	2333	17	89	−30.60
6	Canary Islands	CA	Is	7447	299	411	19.50
6	Egypt	EG	Ma	1001449	19	365	−25.27
6	Libya	LY	Ma	1759540	55	451	−56.70
6	Madeira	MR	Is	779	54	171	−14.50
6	Salvage Islands	SA	Is	24090	31	4	x
6	Tunisia	TN	Ma	163610	33	351	−35.14
6	Morocco	MA	Ma	446550	112	321	−11.03

relative to the total numbers. The Conservation Value Index sums these values over the occurrence classes as:

$$I_c = \sum (Z2 - Z1)/Q$$

where Q is the mean number of stations for the class being considered (i.e., midpoint of the interval).

The index is calculated in an Access program. Referring to the actual database, the Conservation Value Index may vary from a strong negative value when there are only very common species in the country investigated (I_c min) to a high positive value when there are only rare species in the fauna investigated (I_c max). We calculated the upper and the lowest values of Ic by testing lists of species all of which were known from only one country (I_c max = +39.6) or all known from more than 40 countries in the database (I_c min = −58.0). Another noticeable value is « zero » which corresponds to a theoretical community composed of all the species of the reference base or a smaller number of species distributed in the same way over the occurrence classes. It must be underlined that the index is very sensitive to the presence/absence, and to the number of species collected (Canard & Ysnel 2002). Thus, comparisons have to be made for communities or faunas of similar specific richness, especially for assemblages composed of less than 50 species. No species is found in all the 75 territories investigated and the reference curve shows that almost 50% of the species in the database are found in only one country or island (Fig. 1).

RESULTS

The size of the area has a significant positive effect on species richness for both island and mainland territories (Fig. 2) and insularity does not influence this relationship (Table 3). Area as well as the interaction area × insularity factor has a significant effect on the number of endemic species per territory. When considering islands and mainland areas separately, the number of endemic species is positively and significantly influenced by the area only for mainland areas (Fig. 3), whereas the number of endemic species does not vary significantly with the size of the area for islands (Table 3).

Fig. 4 shows the different values of the Conservation Value Index according to the specific richness of the different biogeographic sectors. I_c was calculated for the summed lists for islands/mainland countries of each sector. The differences observed between the I_c values of each sector reflect a difference in spider distribution between sectors and clearly separate the six sectors according to their conservation values. Low conservation values concern continental territories of Central Europe (Ma3: I_c = −41.2; 1583 spp.), islands territories of both North and Far Eastern Europe (Is1: I_c = −52.2; 212 spp.), and Atlantic Europe (Is2: I_c = −54.8; 647 spp.). The highest conservation value for continental areas is from North Africa (I_c = −6.4; 1292 spp.) and for the South Atlantic islands (I_c = +7.3; 846 spp.). The species richness of Mediterranean Europe (Sector 4) is high, and its I_c value is higher than those of Central or Northern mainland sectors. Within this sector, Bosnia exhibits a high conservation value. Several mainland countries of sectors 5 (Israel and Lebanon) and 6 (Algeria, Egypt, Morocco as well as Madera Islands to a lesser extent) are of particular interest in term of global rarity of the spider fauna. Canary Islands and Madeira Islands exhibit the highest level of endemic species across the West Palearctic, contributing to the high percentage of species known from only one territory (see I_c values in Table 1).

DISCUSSION

By using the available data on spider distribution, the relationship between area and species richness is shown for both islands and mainland countries. This result is consistent with several previous studies and the Island theory, therefore, applies for spiders at the West Palearctic scale. The number of endemic species increases with the size of the area only for mainland countries. That may reflect the fact that the larger the country is, the higher the number of habitats, each one being likely to produce specialized endemic species. Surprisingly, we did not find this relationship for islands. Thus, other parameters – such as temporal and/or spatial isolation – could determine the high insular endemic rates in some Southern-European islands (Emerson & Kolm 2005).

Table 2.—National checklists integrated to the database for updating Canard (2005) and Platnick (2007) catalogues.

Sector	References
North and Far East Europe	Aakra & Hauge 2003 Agnarsson 1996 Koponen 2005 Kronestedt 2001 Logunov & Marusik 2003 Mikhailov 1997, 1998a,b,c. Relys & Spungis 2004 Scharff & Gudik-Sørensen 2006 Tanasevitch 2004 Vilkas 2004
Atlantic Europe	Bosmans& Vanuytven 2004 Le Péru 2007 Merrett & Murphy 2000 Van Helsdingen 2006 Vanuytven 2006
Central Europe	Blagoev 2002, 2005 Blagoev et al. 2005 Blick et al. 2004 Buchar & Ruzicka 2002 Deltshev et al. 2003 Gajdos et al. 1999 Klimeš 2006 Kritscher 1996 Samu & Szinetár 1999 Weiss & Urák 2000
Mediterranean Europe	Alicata & Cantarella 2004 Bosmans & Chatzaki 2005 Cantarella 1982 Cardoso 2005 Milosevic 2002 Morano 2007 Pesarini 1995, 2003 Van Helsdingen 2005
Mediterranean Middle East	Amr 2003 Topcu et al. 2005 Varol 2003
North Africa and South Atlantic Islands	El-Hennawy 2006

The index of conservation value has been previously used to compare the conservation value of different habitats at a regional scale (Canard et al. 1998; Canard & Ysnel 2002). When comparing the global rarity of spider faunas at the European level using numerous datasets, this calculation helps to quickly focus on specific biogeographic or political areas. As shown by increasing I_c values from the northern to the southern areas, narrow-range spiders are more likely to be found in the south of the West Palearctic area. Due to the increasing number of new species descriptions during the last decades, the present study reveals a particularly high level of endemism in the Canary Islands compared to other sectors. Although the spider fauna of Madeira Islands is still poorly described, we also found an unexpected high level of endemism. The Mediterranean basin - including the Atlantic islands - is home to numerous endemic plants, insects, or reptiles and no less than ten specific regional hotspots have been identified in North African territories and Mediterranean or Atlantic islands (Medail & Quezel 1999). Considering this first approach to examine the conservation values of various European spider faunas, it may be assumed that these hotspots are likely to be priority sites for spider conservation. In the future, special attention must be paid to the spider fauna of the southern islands,

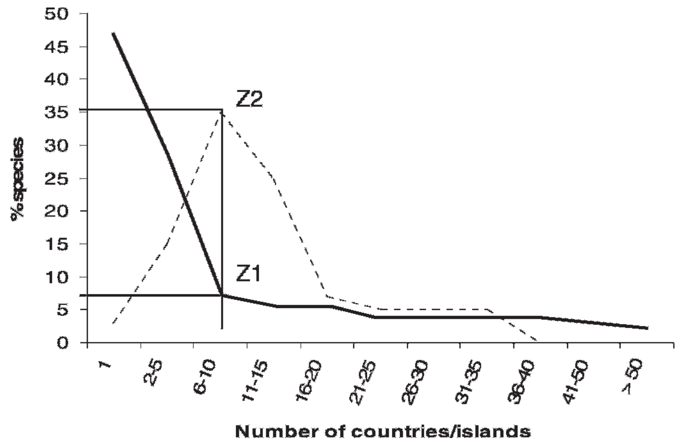

Figure 1.—Comparison between the curve based on the reference data base (solid line) and a curve based on an investigated territory (dotted line). At point Z1 there are 6% of the total species of the reference base known from 6 to 10 countries. At point Z2, there are 35% of the species in the territory investigated known from 6 to 10 countries in the reference base. The conservation value index (I_c) is calculated by summing up the differences between Z1 and Z2 over all x-axis groups.

especially to mini-hotspots as for instance Madeira, Salvage, and Balearic islands, which are notably under-sampled.

The proportion of endemic species is low in Central European countries, indicating that these countries are dominated by widespread species. Particularly high conservation indices in mainland countries such as Bosnia and to a lesser extent Russia reflect the occurrence of specialized species associated with particular relatively isolated habitats (e.g., caves or high mountains, Deltshev 1999), or reflect their glaciation history (Marusik & Koponen 2002). Furthermore, at the scale we investigated, the presence of biogeographic crossroads (sensu Spector 2002) for spiders may also lead to low I_c values by increasing the number of species shared with other countries. Further studies should thus analyze the contribution of different climatic regions or eco-regions within countries, notably large and recognized biogeographic crossroad areas such as Russia, France, or Spain. Such large-scale data have inherent shortcomings due to possible variation in sampling intensity between territories Therefore, though large differences between I_c values may indicate

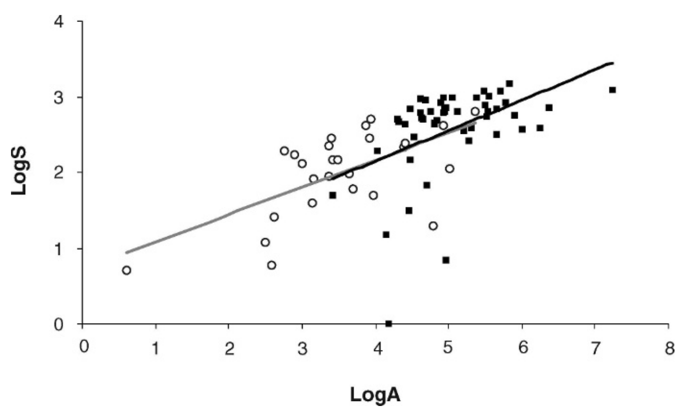

Figure 2.—Relationship between species richness (logS) and the size of the area (logA, km^2) in mainland (black squares) and island (open circles) territories. Black and grey lines: linear regressions for mainland countries (LogS = 0.539 + 0.403 LogA) and islands (LogS = 0.723 + 0.360 LogA).

Table 3.—Influence of the size of the area (continuous predictor, logA) and insularity (discontinuous factor, Is: island, Ma: mainland) on species richness and the number of endemic species. For details on statistical analysis, see Methods.

		d.f.	*F*-ratio	R^2 adjust.	*P*
Species Richness					
Model 1	Whole	71	15.52	0.371	**<0.0001**
	Insularity	1	0.07		0.7873
	LogA	1	25.42		**<0.0001**
	Insularity *LogA	1	0.08		0.7772
Model 2	Whole	72	23.54	0.387	**<0.0001**
	Insularity	1	<0.01		0.9870
	LogA	1	25.68		**<0.0001**
Number of endemic species					
Model 1	Whole	71	6.65	0.186	**<0.0001**
	Insularity	1	6.33		**0.0141**
	LogA	1	13.67		**<0.0001**
	Insularity *LogA	1	4.98		**0.0288**
Model 3	LogA(Is)	24	0.97	−0.001	0.3334
Model 3′	LogA(Ma)	47	18.31	0.265	**<0.0001**

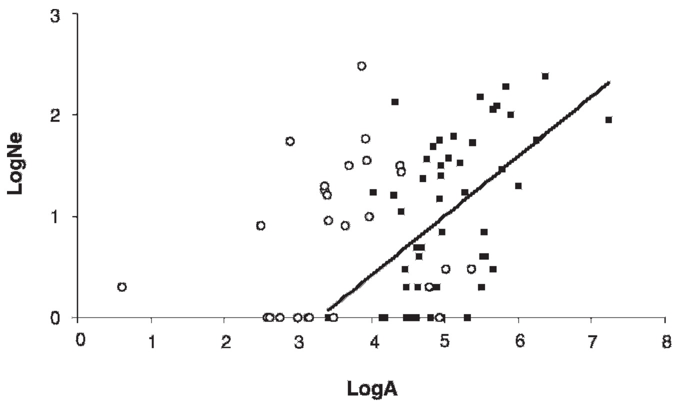

Figure 3.—Relationship between number of endemic species (logNe) and the size of the area (logA, km^2) in mainland (black squares) and island (open circles) territories. Black line: linear regression for mainland countries (LogNe = 0.588 LogA − 1.94).

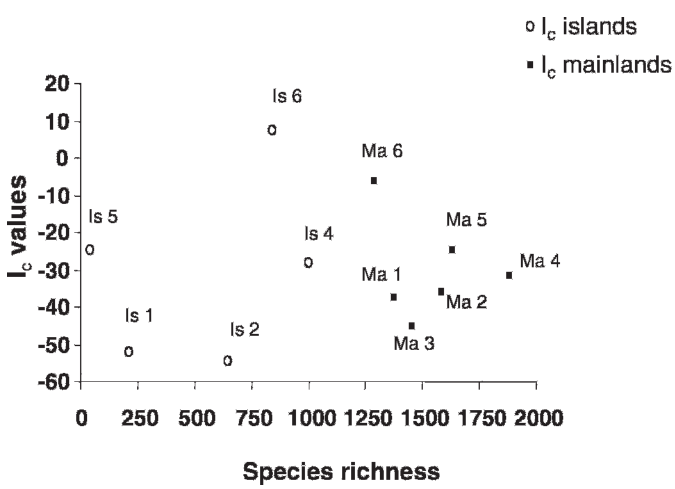

Figure 4.—Species richness and conservation value index of islands (Is, open circles) and mainland countries (Ma, black squares) belonging to the different biogeographic sectors of the West Palearctic area (Sector codes: see the Table 1).

real differences in originality of spider faunas, small differences cannot at the moment be reliably interpreted.

ACKNOWLEDGMENTS

Søren Toft and two anonymous reviewers provided very useful and relevant comments on an earlier draft. We would like to thank Denis Poinsot for English improvement.

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Manuscript received 14 December 2007, revised 13 August 2008.