

A PRELIMINARY STUDY OF BIODIVERSITY HOTSPOTS FOR ODONATES IN GALICIA, NW SPAIN

M. AZPILICUETA AMORÍN¹, C. REY RAÑÓ², F. DOCAMPO BARRUECO²,
X.C. REY MUÑIZ² and A. CORDERO RIVERA^{1*}

¹Grupo de Ecología Evolutiva e da Conservación, Departamento de Ecología e Bioloxía Animal,
Universidade de Vigo, E.U.E.T. Forestal, Campus Universitario,
ES-36005 Pontevedra, Galicia, Spain

²Sociedade Galega de Historia Natural, Sección de Entomoloxía, Apdo. de Correos nº 303,
ES-36600 Vilagarcía de Arousa, Galicia, Spain

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The analysis of distribution data of odon. in NW Spain indicates the presence of 49 spp. *Macromia splendens*, *Oxygastra curtisii*, *Gomphus graslini* and *Coenagrion mercuriale* are protected under the European Habitats Directive and Spanish Law. Localities of specimens collected between 1978 and 2004 were situated in UTM squares of 10×10 km to produce a map of species richness for the region. Additionally, all localities (UTM 1×1 km) where protected and rare spp. were found are introduced in a GIS system, on a map of the Natura 2000 network of the region. The results indicate that *O. curtisii* and *C. mercuriale* are common in NW Spain. As local rare taxa are identified *Brachytron pratense*, *Aeshna affinis* and *Erythromma viridulum*, because they were found in less than 10 squares, and are also relatively rare in the Iberian peninsula. As areas of special interest are selected those that include all known populations of *M. splendens*, *G. graslini*, and *B. pratense*, all localities with at least 2 of the 4 protected spp., and areas with more than 20 spp. This gives a list of 24 hotspots, most of them (15) at least partially included in the Natura 2000 network. Unfortunately the analysis also reveals that the knowledge of this group is clearly fragmentary, with most records concentrated on the coastal region, and very few squares sampled more than 20 times, the minimum to obtain reliable data. Therefore a systematic sampling of the region is needed to properly identify areas with high species richness.

INTRODUCTION

The current rate of biodiversity loss is mainly due to overexploitation, habitat destruction and introduction of exotic species (HUNTER, 1996). All these causes

* Corresponding author: adolfo.cordero@uvigo.es

are in fact different sides of the same problem, the fact that human population is growing at an exponential rate, and demanding a huge quantity of resources (EHRlich & EHRlich, 1993; HALL et al., 2000). Given the social, demographic and economic pressures on land, setting aside large areas for biodiversity preservation is an unrealistic scenario. Therefore conservationists have tried to identify areas of special concern, where a large fraction of biodiversity is concentrated, known as “biodiversity hotspots” (BIBBY et al., 1992; BIBBY, 1998; REID, 1998; MYERS et al., 2000). These hotspots are concentrated in tropical and subtropical areas, where paradoxically human population is growing faster than in temperate areas (CINCOTTA et al., 2000), a fact that does not allow optimism on the conservation of these areas.

Using the former concept of global hotspots for regional conservation is unrealistic, as it leaves a great part of Earth’s biodiversity outside of protection goals. We give a practical sense to this concept to include areas of special relevance due to the presence of a number of species higher than regional average, or to the presence of endangered and rare species. Under this approach the identification of local hotspots might be of special relevance for regional conservation planning (REY BENAYAS & DE LA MONTAÑA, 2003). There is evidence that biodiversity hotspots are not geographically concordant among taxonomic groups (PRENDERGAST et al., 1993). This fact indicates that no single group can be used as an indicator of overall diversity. Therefore we should detect and propose areas of special relevance for important taxonomic groups.

In this paper our aim is to use all available information to detect hotspots for Odonata in NW Spain. We have selected this group because odonates are large and conspicuous animals with complex life-histories (CORBET, 1999), that are good indicators of the situation of riverine and wetland ecosystems (CORBET, 1995; EDA, 1995; SAMWAYS & STEYTLER, 1996; CHOVANEC & RAAB, 1997; CHOVANEC & WARINGER, 2001). Furthermore, these animals are taxonomically rather well-known in Europe (ASKEW, 1988), and previous accounts of faunistic studies have been published in the studied region (OCHARÁN, 1988; CORDERO, 1996). Finally, odonates are “umbrella” species for freshwater invertebrate conservation and are emblematic, probably as charismatic as butterflies (NEW et al., 1995), and several taxa are included in European lists of endangered species (VAN TOL & VERDONK, 1988).

METHODS

This study is a summary of the available data on Odonate distribution in NW Spain. We identified all the specimens ($N = 3,085$) preserved in the Laboratory of Ecology of the Forestry School of Pontevedra (University of Vigo, Spain), Natural History Museum of Ferrol and private collections of authors, that have been collected between 1978 and 2004, although most of them were collected between 1995 and 2004. Furthermore, we also included in the analysis 723 personal sightings of common species, without voucher specimens, and 272 bibliographic records (mainly based on

OCHARÁN, 1987; JÖDICKE, 1996). Species identification follows ASKEW (1988). Localities of collection were found in 245 UTM squares of 10×10 km (of a total of 365), and distribution maps were produced with ArcMap 9.1 (www.esri.com). These maps reflect the presence of species but cannot easily give an impression of sampling bias, which is a problem in most biological databases. The number of records per square clearly depends on sampling intensity (DENNIS, 2001; WILLOTT, 2001; MORENO & HALFFTER, 2001a, 2001b), which in turn might depend simply on distance to universities and other research centres (DENNIS & THOMAS, 2000). Therefore we estimated the minimum number of samples needed to obtain reliable estimates of odonate richness by a species rarefaction curve based on the number of samplings made in each square. Given the limited geographical extent of this study, and specially the scarcity of records, we have assumed that all squares may have a similar number of species, which is incorrect at larger scales, but a good approximation when data are limited (HORTAL et al., 2001; LOBO & MARTIN-PIERA, 2002).

Localities (UTM 1×1 km when possible) where protected species were found were included in a GIS system based on ArcMap 9.1, and then overlaid on a map of the Natura 2000 network of the region. Boundaries of Natura 2000 areas were obtained from the regional government web site (www.xunta.es/conselle/cmala05elCMA05eh/p05eh01.htm). This methodology is equivalent to preliminary GAP analysis (SCOTT et al., 1993; JENNINGS, 1995; PRENDERGAST et al., 1999). The proportion of habitats that is protected was estimated by overlaying the boundaries of the Galician Inventory of Wetlands (RAMIL REGO et al., 2003) with the boundaries of Natura 2000 habitats using ArcView.

RESULTS

We collected a total of 46 species (see Tab. I), and found published records of three additional species not recorded in our survey. Species richness in squares of 10×10 km oscillates between 1 and 31 (Fig. 1). Most records lie on coastal areas, but we have some information on only 67% of squares. The relationship between the number of samplings and species richness in the visited squares (Fig. 2) suggests that most squares are poorly studied, and about 20 samplings are needed to obtain a good representation of the local fauna.

Table II shows the relative importance of dif-

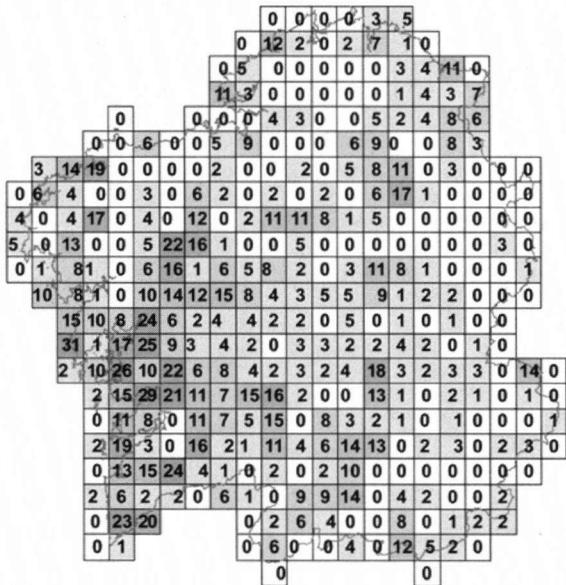


Fig. 1. The number of species found in the squares (UTM 10×10 km) sampled during this study and bibliographic records.

Table I

List of species found in Galicia, with their abundance. Species protected under Spanish law are shown in bold. Number of habitats is based only on personal records

Species	Number habitats	UTM squares	Number of records
<i>Calopteryx haemorrhoidalis</i>	10	29	82
<i>Calopteryx virgo</i>	14	150	336
<i>Calopteryx xanthostoma</i>	6	58	118
<i>Lestes barbarus</i>	6	13	29
<i>Lestes dryas</i>	11	17	39
<i>Lestes virens</i>	10	32	76
<i>Chalcolestes viridis</i>	11	41	86
<i>Sympecma fusca</i>	5	9	23
<i>Platynemis acutipennis</i>	9	45	105
<i>Platynemis latipes</i>	7	46	90
<i>Pyrrosoma nymphula</i>	15	124	248
<i>Erythromma lindenii</i>	6	27	62
<i>Erythromma viridulum</i>	3	8	17
<i>Coenagrion mercuriale</i>	9	41	105
<i>Coenagrion puella</i>	10	36	90
<i>Coenagrion scitulum</i>	7	24	118
<i>Enallagma cyathigerum</i>	10	38	108
<i>Ischnura elegans</i>	6	18	155
<i>Ischnura graellsii</i>	13	64	432
<i>Ischnura pumilio</i>	6	11	24
<i>Ceriagrion tenellum</i>	16	54	281
<i>Aeshna affinis</i>	3	2	5
<i>Aeshna cyanea</i>	14	22	33
<i>Aeshna mixta</i>	6	10	23
<i>Anax imperator</i>	14	65	120
<i>Hemianax ephippiger</i>	3	4	4
<i>Brachytron pratense</i>	4	3	9
<i>Boyeria irene</i>	9	79	140
<i>Gomphus graslini</i>	2	2	18
<i>Gomphus pulchellus</i>	8	30	66
<i>Gomphus simillimus</i>	4	12	22
<i>Gomphus vulgatissimus</i>		1	1
<i>Onychogomphus forcipatus</i>	2	5	5
<i>Onychogomphus uncatus</i>	7	68	126
<i>Cordulegaster boltonii</i>	17	114	186
<i>Oxygastra curtisii</i>	9	44	129
<i>Macromia splendens</i>	4	13	35
<i>Libellula depressa</i>	9	27	37
<i>Libellula quadrimaculata</i>	15	39	64
<i>Orthetrum brunneum</i>		2	2
<i>Orthetrum cancellatum</i>	9	27	43
<i>Orthetrum coerulescens</i>	16	63	115
<i>Crocothemis erythraea</i>	6	22	43
<i>Sympetrum fonscolombei</i>	8	26	45
<i>Sympetrum meridionale</i>	2	8	14
<i>Sympetrum pedemontanum</i>		2	2
<i>Sympetrum sanguineum</i>	13	49	94
<i>Sympetrum striolatum</i>	11	35	70
<i>Trithemis annulata</i>	1	1	1

ferent habitats for odonates, calculated from the number of species that were collected at each habitat. The absence of true lakes in this region, clearly dominated by a dense river system (MARTÍNEZ ANSEMIL & MEMBIELA, 1992) explains the dominance of lotic species.

The most common lentic habitat is constituted by small to medium ponds, many of them in coastal dunes (coastal lagoons; 21 out of 58 ponds sampled during this study). The majority of these coastal

lagoons are formally protected under the Natura 2000 network (53% of 72 lagoons and temporary ponds on coastal sand dunes; Tab. II and Fig. 3). We found 33 odonates in these ponds, but only one is considered as endangered under the Spanish law (*C. mercuriale*, that is actually not breeding in the lagoons but in small irrigation channels; see below).

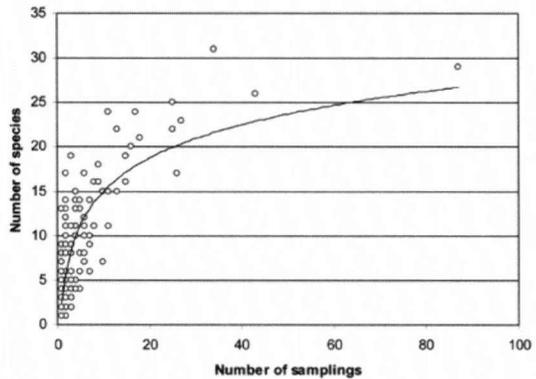


Fig. 2. The relationship between sampling intensity (number of visits) and species richness in the UTM squares sampled during this study. The rarefaction curve suggests that most areas are poorly studied.

RARE AND PROTECTED SPECIES

Twelve species were found in less than 10 squares (Tab. I). Some are migrant species (*H. ephippiger*) and others have been captured a long time ago (*G. vulgatis-simus*, *O. brunneum*, *S. pedemontanum*), suggesting they do not have stable populations in the area. Most of the remaining species are common elsewhere in Spain (*Onychogomphus forcipatus*, *Sympecma fusca*, *Gomphus simillimus*, *Sympetrum meridionale*) but *Brachytron pratense*, *Aeshna affinis* and *Erythromma viridulum* are rather rare in the Iberian peninsula (OCHARÁN, 1987). These three species are considered here as important target species. Also, we found four species, namely *Coenagion mercuriale*, *Macromia splendens*, *Oxygastra curtisii* and *Gomphus graslini*, that are included in the Spanish list of Endangered Species, and also in the Habitats Directive of the European Community, and therefore are also part of the target group of species. The status of all these species is as follows:

- *E. viridulum* – There are 17 records of this species, all of them in large ponds with floating vegetation (Fig. 3). It usually flights far from the shore, and this makes it not easily detectable.
- *C. mercuriale* – Widespread in coastal areas (found in 41 squares; Fig. 3). This species appears in small irrigation channels and rivulets with dense veg-

Table II

The rank-order of habitats for odonates in NW Spain. The percentage indicates the proportion of species recorded at each type of habitat (out of a total of 46 species). There are no true lakes in this region. The proportion of each habitat that is protected indicates habitats that are at least partially included in the Natura 2000 network (see Fig. 3)

Habitat	Number of species (%)	Number of records	Habitat Protection	
Rivers	39	84.8	1297	<50%
Permanent and temporary ponds (natural and man-made)	38	82.6	1101	29%
Coastal lagoons	33	71.7	443	53%
Streams and rivulets	29	63.0	345	<25%
Man-made reservoirs	28	60.9	171	28%
Acid bogs	20	43.5	110	37%
Salt marshes	13	28.3	68	49%
Others (springs, irrigation channels and ponds, forest roads, etc)	32	69.6	206	-

etation, where usually is the dominant damselfly.

- *A. affinnis* – Very rare. Only found as isolated specimens in two coastal lagoons, and apparently does not have permanent populations in the region (Fig. 3).
- *B. pratense* – Very rare. It has been found breeding in three localities, two of them included in legally protected areas (Fig. 3).
- *G. graslini* – Rare, only known from two rivers and at low densities (Fig. 3), in both cases together with *M. splendens* and in one case also with *O. curtisii*.
- *M. splendens* – Known from 13 squares (Fig. 3), it lives in medium to large rivers, where the species might be locally common, especially in lentic areas (CORDERO RIVERA et al., 1999; CORDERO RIVERA, 2000).
- *O. curtisii* – Widespread and with dense populations in the region (44 squares, Fig. 3). Larvae are common in most rivers. Males are territorial in the same rivers, but occasionally can be found in ponds patrolling the shore.

Most of the localities where these target species have been found are included in protected areas. The proportion of localities at least partially included in the Natura 2000 network is 54% (7/13) in *M. splendens*, 59% (26/44) in *O. curtisii*, 66% (27/41) in *C. mercuriale*, 50% (1/2) in *G. graslini*, 67% (2/3), in *B. pratense*, 100% (3/3), in *A. affinnis* and 63% (5/8) in *E. viridulum*. Of the four protected species, *C. mercuriale* has a different distribution (due to its habitat requirements) and usually does not coincide with the other species (Fig. 3). *M. splendens* and *O. curtisii* are found together in eight localities, and a single locality has *M. splendens*, *O. curtisii* and *G. graslini*.

HOTSPOTS

We tentatively selected as areas of special interest those that include all known populations of *M. splendens*, *G. graslini*, and *B. pratense*, all localities with at least two of the four protected species, and areas with more than 20 species. We do not use the presence of *O. curtisii* and *C. mercuriale* as a selection criterion, because both are very common in the region. *A. affinis* is probably not a breeding species, and *E. viridulum* is likely more common than appears, due to its flying behaviour far from the shore. Using these criteria gives a list of 24 hotspots, most of them (15) included in the Natura 2000 network (Tab. III).

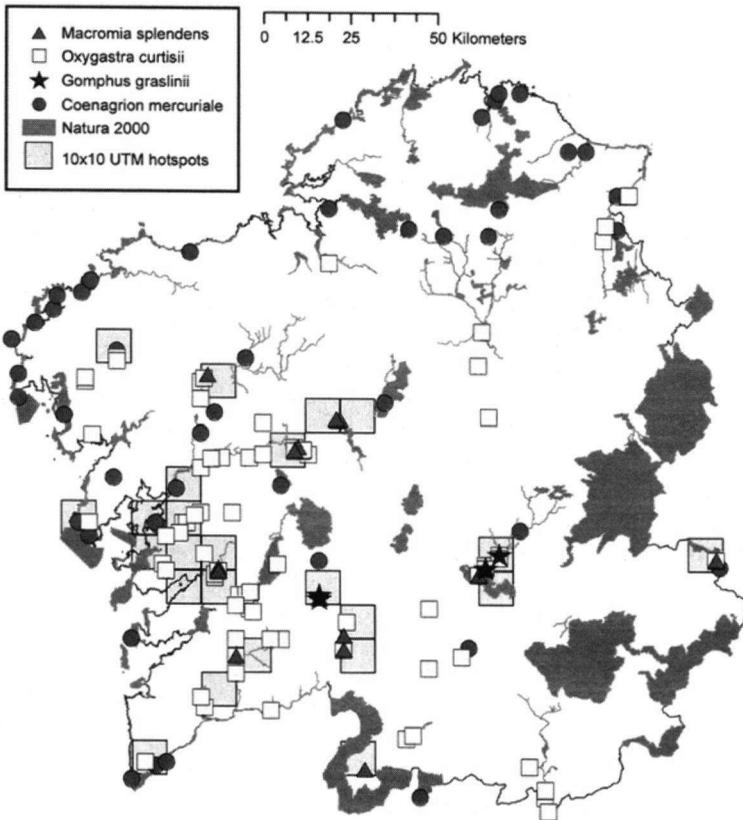


Fig. 3. The geographical distribution of the four species included in Spanish List of Endangered Species that were found in Galicia. Shaded areas are those protected under the Natura 2000 network. Grey squares indicate our proposed hotspots for odonates in this region.

Table III
 Areas of special interest (hotspots) for the protection of odonates in Galicia. These areas include all known populations of *M. splendens*, *G. grasilinii*, and *B. pratense*, all localities with at least two protected species, and areas with more than 20 species. Squares in bold are at least partially included in the Natura 2000 network

Main Locality	Province	UTM square	n° sp	Type habitat	Focal species
Corrubedo	A Coruña	MH91	31	Coastal lagoons, streams, ponds	<i>O. curtisii</i> <i>C. mercuriale</i> <i>S. fusca</i> <i>B. pratense</i>
Pontevedra	Pontevedra	NG29	29	Ponds, streams, rivers, acid bogs, salt marshes	<i>T. annulata</i> <i>O. curtisii</i> <i>E. viridulum</i>
O Porriño	Pontevedra	NG36	29	Ponds	<i>A. affinis</i> <i>O. curtisii</i> <i>B. pratense</i>
Illa de Arousa-O Grove	Pontevedra	NH10	26	Streams, rivers, ponds, coastal lagoons	<i>O. curtisii</i> <i>G. simillimus</i>
river Umia	Pontevedra	NH21	25	Streams, rivers, man-made reservoirs	<i>C. mercuriale</i> <i>O. curtisii</i> <i>E. viridulum</i>
Goñán (Tomoiño)	Pontevedra	NG14	25	Ponds, streams, rivers	<i>C. mercuriale</i> <i>S. fusca</i> <i>E. viridulum</i>
river Ulla	Pontevedra	NH22	24	Ponds, acid bogs, rivers	<i>C. mercuriale</i>
river Lérez	Pontevedra	NH30	22	Ponds, man-made reservoirs, streams, river	<i>M. splendens</i> <i>O. curtisii</i> <i>G. simillimus</i>
river Tambre	A Coruña	NH35	22	Streams, rivers, ponds	<i>O. curtisii</i> <i>G. simillimus</i>
river Lérez	Pontevedra	NG39	21	Ponds, rivers	<i>O. curtisii</i> <i>G. simillimus</i>
river Cabe	Lugo	PH10	18	Streams, rivers, ponds	<i>M. splendens</i> <i>G. grasilinii</i> <i>O. curtisii</i>
Vilagarcía de Arousa	Pontevedra	NH11	17	Acid bogs, rivers, coastal lagoons, ponds	<i>B. pratense</i> <i>C. mercuriale</i>
river Xallas	A Coruña	NH06	17	Acid bogs, streams, rivers, man-made reservoirs	<i>O. curtisii</i> <i>C. mercuriale</i> <i>G. simillimus</i>
River Tea	Pontevedra	NG47	16	Ponds, rivers	<i>M. splendens</i> <i>O. curtisii</i> <i>G. simillimus</i>
river Deza	Pontevedra	NH53	15	Streams, rivers	<i>M. splendens</i> <i>O. curtisii</i> <i>C. mercuriale</i> <i>G. simillimus</i>
Albarellos reservoir	Ourense	NG69	15	Ponds, rivers, Man-made reservoirs	<i>M. splendens</i> <i>O. forcipatus</i>
Ribadavia	Ourense	NG78	15	Rivers	<i>M. splendens</i> <i>O. curtisii</i>
Rubiá	Ourense	PH70	14	Man-made reservoirs, rivers, streams	<i>M. splendens</i> <i>O. curtisii</i> <i>C. mercuriale</i> <i>G. simillimus</i>
river Cabe	Lugo	PG19	13	Ponds, rivers	<i>M. splendens</i> <i>O. curtisii</i> <i>C. mercuriale</i> <i>G. simillimus</i>
river Arnoia	Ourense	NG77	11	Rivers	<i>M. splendens</i> <i>O. curtisii</i>
river Umia	Pontevedra	NH20	10	Ponds, streams, rivers	<i>O. curtisii</i> <i>C. mercuriale</i>
Portodemouros	Pont.-A Coruña	NH74	8	Man-made reservoirs, rivers	<i>M. splendens</i>
Portodemouros	Pont.-A Coruña	NH64	5	Man-made reservoirs	<i>M. splendens</i>
Lobos	Ourense	NG74	2	Man-made reservoirs	<i>M. splendens</i>

DISCUSSION

“RARE” SPECIES

Rarity is a relative concept in conservation: one species might be rare in a global scale but very common in a particular area. Therefore we need to approach this question from different scales (GÄRDENFORS, 2001). We refer here to rarity in extension and abundance of populations. We have gathered records of 49 species from Galicia (including species not found in this survey), that constitute 71% of the species found in Spain (OCHARÁN, 1988). Among them, four species are included in the National Red List, in three categories: “Endangered” (*M. splendens*), “Sensible to Habitat Alteration” (*O. curtisii*) and “Of Special Interest” (*C. mercuriale* and *G. graslini*).

Our analysis clearly suggests that *O. curtisii* and *C. mercuriale* are not rare at the regional scale, and we are optimistic about their conservation. The situation of *M. splendens* is especially interesting because this species is a taxonomic rarity in Europe (DOMMANGET & GRAND, 1996). Previous studies (CORDERO RIVERA et al., 1999; CORDERO RIVERA, 2000) indicate that NW Spain might have the best populations of the species. Recent studies in France (LEIPELT et al., 1999; DOMMANGET, 2001) and Portugal (MALKMUS, 2002b) indicate that this species is not endangered at the global scale.

Very different is the situation for *G. graslini*. We were able to find only two populations of this species in NW Spain, and the low number of records in other areas of the Iberian Peninsula (a total of 18 records) (OCHARÁN, 1987; Florian Weihrauch, pers. comm.; JÖDICKE, 1996; MALKMUS, 2002a) and France (DOMMANGET et al., 2002), do not allow optimism about its conservation. We think that this species should be included in the “Endangered” category in the Spanish Red List.

Our review of the literature and collections has identified three rare taxa at the regional scale (*B. pratense*, *A. affinis* and *E. viridulum*) that are also rare in the Iberian peninsula. We propose that these species should be included in the future Galician Red list as species of “special interest”.

HABITATS OF SPECIAL INTEREST

Given the results of Table I, the most important habitats for odonate conservation are large rivers with populations of *M. splendens*, *O. curtisii* and *G. graslini*. These rivers are common in the region and are in good conditions for odonate survival, but many will be heavily transformed by hydro-electric dams in the near future. From this point of view, only the river Tea (Tab. II) will probably be free of dams because it has been included in the Natura 2000 network (but this is not guarantee!).

The second most relevant habitat type is represented by ponds and coastal lagoons, that are common in the region and include the breeding area of at least 38 species. Coastal lagoons are reasonably well represented in the Natura 2000 network of the region (Tab. II). The most interesting species in this habitat is *C. scitulum*. Furthermore, all localities where *B. pratense* and *A. affinis* were found in this region are coastal lagoons and ponds.

LOCALITIES OF SPECIAL INTEREST (HOTSPOTS)

We have identified 24 UTM squares (10×10 km) of special relevance for odonate conservation in NW Spain. Fortunately, many of the habitats included in these hotspots are formally protected. We have also found that our knowledge of the biodiversity of odonates is rather poor in most areas: only 19 squares have been sampled more than 10 times, and Figure 2 suggests that at least 20 samplings are needed to have a good estimation of odonate richness. From this point of view the UTM square 29TNG29 that has 29 species is probably simply the result of the vicinity of this area to our laboratory (87 samplings), and suggests that many areas should be of similar importance when our knowledge of odonate distribution improves. For instance the square 29TMH91 has 31 species with 34 samplings. A program to map odonate diversity, similar to the INVOD project in France (DOMMANGET et al., 2002), is clearly necessary and it is being developed by a local Natural History Association (SGHN).

The final part of river Cabe (29TPH10) is the most important hotspot for odonates in NW Spain. This place has a Mediterranean climate (CARBALLEIRA et al., 1983) that explains the presence of large populations of *M. splendens* and *O. curtisii*. Furthermore, in 2002 we found also two specimens of *G. graslini*. This is therefore the only river that has all three protected anisopterans. This area is included in the Natura 2000 network and is also interesting from a botanical point of view, due to the confluence of Atlantic and Mediterranean species (ROMERO BUJÁN, 1993).

Future work should concentrate in a planned sampling of habitats, and the recently published Inventory of the Wetlands of Galicia (RAMIL REGO et al., 2003) is a very useful tool for the selection of habitats by type and geographical distribution. The aim is to produce a Geographical Information System that will help in conservation planning.

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