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Diversity of Water Beetles in Picos de Europa National Park, Spain: Inventory Completeness and Conservation Assessment

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Abstract

The diversity of true water beetles (Coleoptera: Gyrinidae, Haliplidae, Dytiscidae, Helophoridae, Hydrochidae, Hydrophilidae, Hydraenidae, Elmidae, and Dryopidae) in Picos de Europa National Park (Cantabrian Mountains, Spain) was examined. Taking into account historic long-term sampling (all collections from 1882 to the present), a total of 117 species are recorded. Species accumulation models and non-parametric estimators were used to estimate the actual species richness of aquatic Coleoptera occurring in Picos de Europa National Park. Estimates were generated by analyzing both the collector's curve from the long-term sampling and the historic cumulative curve of species recorded from the park since 1882. Values of species richness estimated by different methods range from 127 to 170 species (mean = 148 ± 15 SD). Therefore, it seems that the current inventory has reached a reasonably good level of completeness as estimates indicate that about 80% of the water beetle fauna has already been recorded. The inventory is used to analyze the biological uniqueness of the park and its outstanding level of species richness and endemism (33 Iberian endemic species). Richness and endemism of water beetles in Picos de Europa National Park is compared to those of other national parks in Spain. Finally, the conservation status and threat level is assessed for two Cantabrian endemic species, *Deronectes costipennis gignouxi* Fery and Brancucci and *Ochthebius* (*Asiobates*) *cantabricus* Balfour-Browne.

Key Words: aquatic Coleoptera, cumulative species curves, Cantabrian endemism, species richness, vulnerability assessment

Continental aquatic ecosystems are among the most threatened ecosystems on the planet, particularly within the context of global change (Carpenter *et al.* 1992). These changes obviously affect aquatic biota, so groups of organisms that act as biodiversity indicators are of great importance as they enable these changes to be monitored. Within the group of freshwater invertebrates, aquatic Coleoptera have the highest richness, with 18,000 species throughout the world (Jäch and Balke 2008). Approximately 1,000 species of water beetles have been recorded in Europe, over 500 of which are found in the Iberian Peninsula (Ribera 2000). Besides this high species richness, the Iberian Peninsula is also of particular interest due to its unique fauna with a high percentage of endemic species, especially in the families Dytiscidae and Hydraenidae. Species richness and rarity of water beetles have been used as indicators of ecological diversity and habitat conservation, both inside and outside the Iberian Peninsula (Eyre and Foster 1989; Foster *et al.* 1990; Ribera and Foster 1993; Sánchez-Fernández *et al.* 2004). The conservation status of several Iberian water beetles was studied after developing a methodology for assigning conservation priorities (Abellán *et al.* 2005; Sánchez-Fernández *et al.* 2008a).

A step prior to the assessment of biodiversity patterns or the diagnosis of the conservation status of an area is to analyze the quality of our biological

inventories (Lobo 2008b). When describing biodiversity patterns, it is crucial to analyze whether available data reflect real biological patterns, or whether they are affected by taxonomic (Cabrero-Sañudo and Lobo 2003; Baselga *et al.* 2007; Baselga *et al.* 2010), geographic (Lobo *et al.* 2007), or ecological biases (Hortal *et al.* 2008). When assessing the relevance of a single area in terms of species richness, endemism, or conservation status, measuring the degree of completeness of the biological inventory is the safest approach for dealing with the aforementioned sampling biases (Colwell and Coddington 1994). This is especially important when inventories are derived from heterogeneous sources such as non-standardized samplings, bibliographic references, and one's own data (Hortal *et al.* 2004; Baselga and Novoa 2006; Hortal *et al.* 2007; Baselga and Novoa 2008).

Picos de Europa National Park, located in the Cantabrian Mountains (northern Spain) is one of the natural areas of greatest conservation value in the Iberian Peninsula. Due to its biological importance, the Picos de Europa area has been the object of numerous entomological investigations, with records of water beetles dating from Sharp (1882) to the authors' present records (2005 sampling), which complete previous successive and extensive samplings by the same authors (L. Valladares in 1984–85 and J. Garrido in 1986–1988).

The aims of this paper are (i) to present an updated inventory of species of true water beetles (Jäch 1998; Jäch and Balke 2008) in Picos de Europa National Park, (ii) to analyze how knowledge of these species has advanced historically, (iii) to assess the degree of completeness of the species inventory, and (iv) to review the conservation status of this unique water beetle fauna.

Material and Methods

Study Area. Picos de Europa National Park (hereafter PENP) currently comprises the Montaña de Covadonga National Park, the oldest protected natural area in Spain, created in 1918. It is situated in the center of the Cantabrian Mountains (northern Spain) on the confluence between Asturias, Cantabria, and León provinces (Fig. 1). It is a geomorphological unit within the Cantabrian mountain range, formed by three mountainous massifs (Western, Central, and Eastern) and separated by the headwaters of the Sella, Cares, Duje, and Deva Rivers. It is the largest limestone formation in Atlantic Europe, with altitudes reaching 2,646 m, an Atlantic or Atlantic Continental climate (2,000 mm rainfall/year) and Mediterranean microclimates at lower altitudes. Its 64,660 ha are a very well conserved representation of the high Cantabrian Mountains.

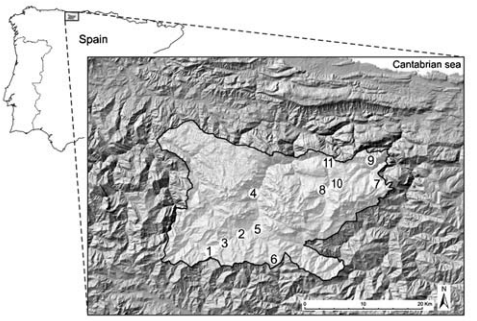

Fig. 1. Location of Picos de Europa National Park in northern Spain. Numbers indicate locations of 2005 sampling sites: 1 = Puerto de Panderrueda (León province); 2 = Soto de Valdeón (León province); 3 = Brañarredonda (León province); 4 = Caín (León province); 5 = Posada de Valdeón (León province); 6 = Puerto de Pandetrave (León province); 7 = Begés (Cantabria province); 8 = Invernal del Texu (Asturias province); 9 = Tresviso (Cantabria province); 10 = Sotres (Asturias province); 11 = Valfrío-Tielve (Asturias province).

Water beetles were collected in the following aquatic habitat types within the PENP: headwater streams, montane rivers, lakes, pools, ponds, springs, and peat bogs.

Record Data. This study is based on an exhaustive bibliographic review to compile records from 1882 to the present day, including data from sampling carried out by the authors during 1984–1988 (Valladares 1988a; Garrido 1990). The records are for species found within a distance of 5 km around the legal limits of the PENP.

Using this information, a database of water beetle records for the PENP was created, containing 915 records of localities and corresponding data on sampling dates, number of specimens collected, and bibliographical references for each record.

To complete the study, additional sampling was carried out in July 2005. A number of sites were selected and visited in the different areas and aquatic habitats of the PENP (Fig. 1 and Appendix 2). Water beetles were sampled using a 250 μm mesh D-framed pond net. A fine mesh strainer was used to collect the specimens floating on the surface after sweeping the bottom and macrophytes of edges with the net. After all the microhabitats had been prospected, the samplings were considered finished when sweeps provided no new species. Each collection generally took an hour and a half per site.

Assessment of Inventory Completeness. Two complementary methods, asymptotic models and non-parametric estimators, were used to assess the completeness of the inventory (Colwell and Coddington 1994). Estimations were produced by

two different approaches that analyzed the accumulation of species as a function of sampling effort and time (Baselga and Novoa 2006), respectively: (1) the collector's curve derived from pooling all samplings performed in the area; and (2) the historic curve plotting the accumulation of species from the first records made to the present as a function of time.

The collector's curve and the non-parametric estimators were generated with Estimate S 6.0 software (Colwell 2005), randomizing the sample order 100 times. Database records were used as a sampling-effort surrogate (Lobo 2008a). Our database comprised 915 records for 7,426 specimens and included all the collections conducted in the area, mainly derived from samplings by Valladares (1988a) and Garrido (1990). Each record was comprised of the following fields: species name, locality, date, and number of specimens. Any difference in any database field value gave rise to a new database record, so increments in the number of records provided correlative increments in the sampling effort (Martín-Piera and Lobo 2003). The collector's curve was used to compute a parametric estimator (Clench function) and four non-parametric estimators. The asymptotic Clench function was fitted to the collector's curve (Soberón and Llorente 1993; Hortal *et al*. 2006; Lobo 2008a) by means of a Simplex and Quasi Newton method (StatSoft 2004). The asymptote of the Clench curve is the estimated species richness. Among the existing non-parametric estimators, ICE, Chao 2, Jackknife 1, and Jackknife 2 were selected, following Hortal *et al.* (2006).

The second approach for estimating the degree of completeness of the PENP water beetle inventory was to fit the Clench function to the historic cumulative curve (Cabrero-Sañudo and Lobo 2003; Baselga and Novoa 2006; González *et al.* 2007). This historic curve was generated taking into account the year of published papers or the year of collection if known. The final section (1981–2005) of the curve seemed to acquire an asymptotic shape due to the increase in sampling effort and thus only this period was selected to fit the Clench function.

Assessing Conservation Status. The biogeographical categories proposed by Ribera *et al.* (1998) for Iberian water beetles were used, together with some comments provided by Fery and Fresneda (2007). Only three of the five categories inhabit the PENP: Northern species (N: species present in Europe north to the Pyrenees and some areas of the Iberian Peninsula, but not in North Africa); Trans-Iberian species (T: species present in Europe and North Africa); Iberian endemic species (X: species exclusive of the Iberian Peninsula, including the north face of the Pyrenees in some cases). Conservation priorities were assigned using the methodology by Abellán *et al.* (2005) and the modifications by Sánchez-Fernández *et al.* (2008a). This proposal classifies species in four vulnerability categories (low, moderate, high, and very high).

To compare the water beetle fauna of PENP with that of other Spanish national parks, data corresponding to Doñana National Park in the study by Millán *et al.* (2005) were used. These data are based on their own sampling and an exhaustive bibliographical compilation (Soler and Montes 1980; Montes *et al.* 1982; Garrido *et al.* 1996, 1997; Castro *et al.* 2003). Also used were data from Sierra Nevada National Park obtained from a study by Millán *et al.* (2010), which, apart from containing records of their own sampling, compiles information given by Sáinz-Cantero (1989).

Results and Discussion

The current water beetle inventory of Picos de Europa National Park consists of 117 species (six subspecies) belonging to the families Gyrinidae (three species), Haliplidae (four species), Dytiscidae (51 species), Helophoridae (six species), Hydrochidae (two species), Hydrophilidae (13 species), Hydraenidae (22 species), Elmidae (14 species), and Dryopidae (two species) (Appendix 1). In the 2005 sampling, 57 species (49% of the total number) were collected, and provided 10 new records for the national park: *Hydroglyphus geminus* (F.), *Hydroporus brancuccii* Fery, *Helophorus obscurus* Mulsant, *Enochrus fuscipennis* (Thomson), *Laccobius bipunctatus* (F.), *Laccobius ytenensis* Sharp, *Coleostoma orbiculare* (F.), *Hydraena testacea* Curtis, *Dryops luridus* (Erichson), and *Pomatinus substriatus* (Müller) (see Appendix 2). Of the 117 recorded species, 33 are Iberian endemic species and two of them, *Deronectes costipennis gignouxi* Fery and Brancucci and *Ochthebius* (*Asiobates*) *cantabricus* Balfour-Browne, are endemic species from the Cantabrian mountains, the latter species only being found in PENP.

From the biogeographical point of view, the greatest proportion of species (43%) belong to the Trans-Iberian category, with very similar percentages pertaining to the Northern category (29%) and Iberian endemics category (28%). The fact that PENP is situated in the northern Iberian Peninsula, in the Eurosiberian phytogeographical region, accounts for these percentages, particularly in the case of the Northern species. The fact that no southern species (species present in North Africa and some areas of the Iberian Peninsula) are present in PENP is noteworthy considering that the area has valley bottoms with a suitable climate and Mediterranean vegetation for species with this type of distribution. The observed high level of endemism, particularly

in rheophilic water beetles including many species of Hydraenidae and some genera of Dytiscidae, could be attributed to the characteristic isolation of mountainous regions and numerous running water habitats (mainly headwater streams) as well as to the role of the Iberian Peninsula as faunal refugium during glaciations, particularly for Dytiscidae (Ribera *et al.* 2003; Ribera and Vogler 2004).

Completeness Analysis. Two types of analysis were made. The first one used database records as a sampling effort surrogate and two types of estimators: parametric and non-parametric. The parametric estimator, the asymptote of the Clench function (Fig. 2), predicted the presence of 136 species, which indicated quite a complete inventory of water beetles in the PENP (86% of the estimated species were already inventoried). The non-parametric estimators (ICE, Chao-2, Jack-1, and Jack-2) predicted a somewhat higher number of 147–170 species (Table 1), which implies a lower level of completeness.

The second type of analysis was based on the historic cumulative curve of first species records (Fig. 3). The graph shows a low initial number of records as none were made during the 54-year interval between the first record by Sharp (1882) and the second by d'Orchymont (1936). From the second half of the twentieth century, records increased noticeably, especially with important contributions by Bertrand (1954–1965) for aquatic Adephaga, Valladares (1988a) for Hydraenidae and Hydrophilidae, and Garrido (1990) for aquatic Adephaga and Elmidae. Data obtained from the historic curve show that the number of contributions has become stable, thus suggesting a very high level of inventory completeness. Additional sampling carried out in 2005 showed that the number of species in PENP has increased steadily.

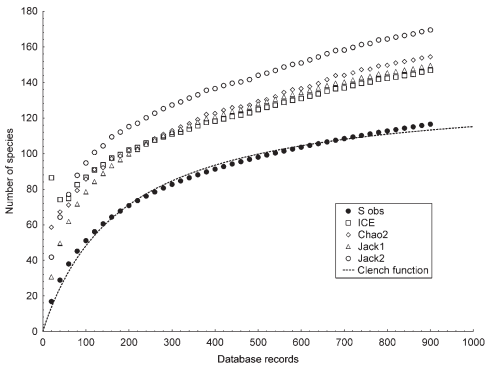

Fig. 2. Species accumulation curves generated from the database with the fitted Clench function and the non-parametric estimators. Only one of each 20 points is shown for clarity.

Table 1. Estimates of water beetle species richness in Picos de Europa National Park by four non-parametric estimators. Number of species observed is 117.

Estimator	Richness estimate	Completeness (%)
ICE	147	79
Chao 2	155	76
Jack 1	150	78
Jack 2	179	69

However, a detailed analysis of these new records revealed that most of them were for less studied species of Polyphaga, especially Hydrophilidae and Dryopidae. Also, except for *H. brancuccii*, the other new records for 2005 are fairly common, widely distributed species that can nearly always be found in favorable habitats, as is the case of PENP. So, increasing the sampling effort in such an extensively studied area is not likely to provide new records of rare or endemic species. The curve seems to become asymptotic from 1981, so by fitting the Clench function to that period (Fig. 4) an asymptote of 127 species is obtained, which indicates a very high level of 92% completeness.

The number of samplings, size, and the quite small variety of habitats in PENP suggest that a high number of species have been inventoried and that the inventory has almost reached completeness. This can be seen by estimates obtained using the Clench function for the entire period when records were made (86% completeness) or for the final period (92% completeness). The number of species could perhaps be increased in some of the less studied groups (*e.g.*, Hydrophilidae) or in groups of less abundant species characteristic of rare habitats in PENP (*e.g.*, Dytiscidae commonly found in pools or ponds). There are data for species not recorded in PENP, but which have been collected in nearby areas and could be found within the confines of the national park. This is the case of *Agabus brunneus* (F.) and *Deronectes moestus inconspectus* (Leprieur) recorded by Bertrand (1957), *Brychius elevatus* (Panzer) and *Riolus illiesi* Steffan recorded by Garrido (1990), *Deronectes ferrugineus* Fery and Brancucci recorded by Fery and Fresneda (2007), and *Berosus signaticollis* (Charpentier) recorded by Schödl (1993).

Conservation. A considerable number of water beetle species have been recorded in the PENP. The richness values and, particularly, the number of endemic species have led to the area being identified as having the highest conservation value for Iberian aquatic Coleoptera (Ribera 2000; Sánchez-Fernández *et al.* 2008b) and as a crucial target site and habitat for protection (hotspot), particularly representative of freshwater stream habitats (Sánchez-Fernández *et al.* 2008a).

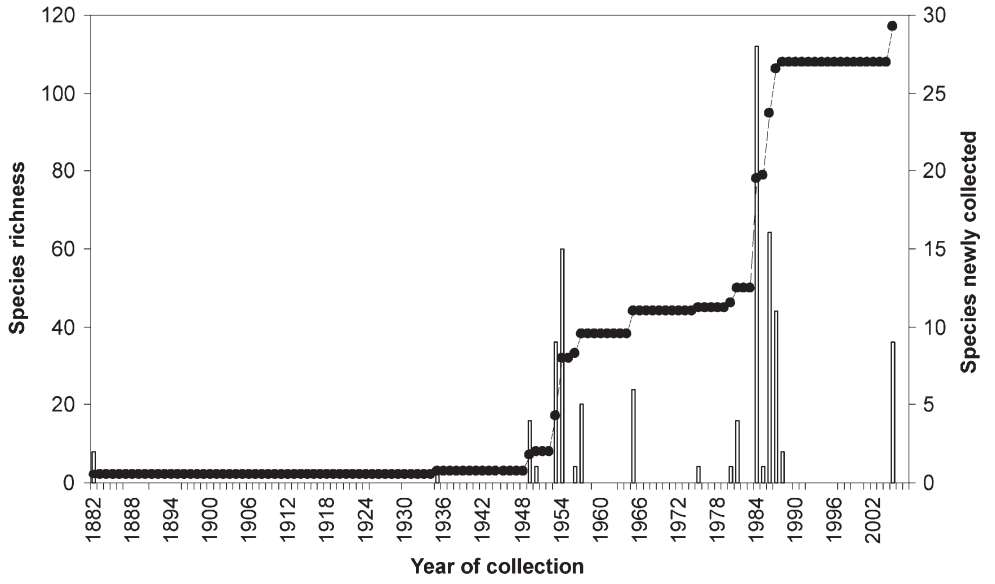

Fig. 3. Historic species richness curve (1882–2005) (dots) together with the number of species collected for the first time each year (bars).

Species richness in PENP is much higher than other Spanish national parks where the Coleoptera fauna has been studied in detail (Table 2). Richness is noticeably lower in the Doñana and Sierra Nevada National Parks, situated in the southern Iberian Peninsula and of similar size. Water beetle species richness in Doñana National Park (Millán *et al.* 2005) is lower than in PENP, but still quite considerable with 101 species recorded (Scirtidae, Limnichidae, Heteroceridae, and Curculionidae excluded). However, the number of endemic water beetles in Doñana National Park is very low, with only two Iberian endemic species (*Helophorus seillitzii* Kuwert and *Hydraena corrrugis* d'Orchymont), both widely distributed in the Iberian Peninsula. This would largely be explained by the fact that the park's marshlands are not geographically isolated and by the absence of running headwaters, one of the two habitat types where most Iberian endemics in this group occur (Sánchez-Fernández *et al.* 2008a). Low endemicity in Doñana National Park could be due to the fact that most of its surface was under marine water during the recent Holocene (Ruiz *et al.* 2004).

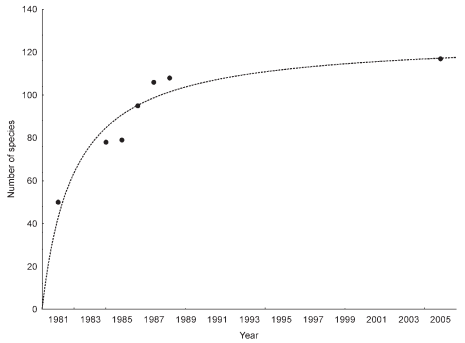

Fig. 4. Species accumulation curve during final sampling period (1981–2005) and fitted Clench function.

Values of richness and number of Iberian endemic species for PENP are considerably higher than those reported by Millán *et al.* (2010) for Sierra Nevada National Park (117 species and subespecies in PENP versus 88 in Sierra Nevada National Park, and 33 versus 16 Iberian endemic species, respectively; see Table 2). According to Millán *et al.* (2010), the low number of species in Sierra Nevada National Park is due to the rigorous climate and geological homogenicity of the area. However, there are clearly more endemic species exclusive to Sierra Nevada than to PENP, which underlines the unique biological nature and high conservation value of this natural area situated in the south of the Iberian Peninsula.

Besides its richness, the most relevant aspect of the biological uniqueness of PENP is the number of Iberian endemic species found there. The 33 recorded Iberian endemic species in PENP

Table 2. Comparative richness and endemicity of the water beetle fauna in three well studied Spanish national parks.

National park	Ecosystem	Area (ha)	Species richness (S)	Iberian endemics (% of S)	Number of Iberian endemic species						Exclusively park endemic species
					Dytiscidae	Helophoridae	Hydrochidae	Hydrophilidae	Hydraenidae	Elmidae	
Picos de Europa	High Atlantic mountains	64,660	117	33 (28%)	14	1	1	0	14	2	1
Sierra Nevada	High Mediterranean mountains	86,210	88	16 (18%)	7	1	1	1	5	0	4
Doñana	Mediterranean coastal wetlands	54,251	101	2 (2%)	0	1	0	0	1	0	0

account for approximately 27.5% of the total number of endemic water beetle species existing in the Iberian Peninsula, making PENP a very representative area of the Iberian endemic fauna of water beetles and confirming its status as a hotspot for this group (Sánchez-Fernández *et al.* 2008a, b). This fact may be true for Iberian freshwater biodiversity in general.

Sánchez-Fernández *et al.* (2008a) analyzed the Iberian vulnerability level of 19 endemic species present in PENP. Most of these species show moderate vulnerability, but five are in the "high" threat range (according to their vulnerability score): *D. costipennis gignouxi*, *O. cantabricus*, *Deronectes aubei sanfilippoi* Fety and Brancucci, *Hydrochus angusi* Valladares, and *Rhithrodytes bimaculatus* (Dufour). An exhaustive compilation of records for the first two species, exclusive to the Cantabrian mountain range, was made (Table 3) and used to reassess their threat level following the criteria of Sánchez-Fernández *et al.* (2008a).

Ochthebius cantabricus (Tables 3 and 4), a Cantabrian endemic species, is known only from the type locality (Valle de Valdeón, León province) located in PENP. The species was recorded from Turkey (Kasapoglu and Erman 2002), but this record should be considered invalid (M. A. Jäch, personal communication), as it refers to a different species, but very close to *O. cantabricus*. *Ochthebius cantabricus* was collected in the gravel of a fast-running stream at 1,300 m elevation. Two of us (LFV and JG) returned to the type locality several times to capture more specimens, but were unsuccessful. As is the case for other very rare species in the subgenus *Asiobates* Thomson (*e.g.*, the Pyrenean endemic *Ochthebius* (*Asiobates*) *ferroi* Fresneda, Lagar and Hernando, 1993), it probably inhabits a microhabitat of sand, gravel, and damp stones adjacent to mountain streams and is very difficult to find. Due to geographical rarity and lack of recaptures, this species is classified as "highly" threatened (12 vulnerability score).

Deronectes costipennis gignouxi (Tables 3 and 4) is endemic to the central and western Cantabrian Mountains. It is found in small mountain streams up to 1,650 m elevation. These streams are shallow and well oxygenated, the substrate is gravel and plant debris, and their bank vegetation is well conserved (Fery and Brancucci 1989; Garrido 1990; González and Novoa 1995; Fernández-Díaz *et al.* 2008). It occasionally occurs in ponds. Using current data to reassess species vulnerability, slight changes can be seen in the variable scores (Table 4) in comparison with those proposed by Sánchez-Fernández *et al.* (2008a). The result is a vulnerability score of nine points and the species remains in the "high" category, very close to the "moderate" category. It will probably be placed in the "moderate" category

Table 3. Compilation of records of two threatened Cantabrian endemic water beetle species present in Picos de Europa National Park. The PENP column indicates whether the locality is located within Picos de Europa National Park or not (Yes or No, respectively).

Ochthebius cantabricus

Locality	Province	UTM coordinates	PENP	Reference	Record date	Number of individuals
Puerto de Pandetrave	León	30TUN4973	Yes	Balfour-Browne 1978	05/07/1965	33

Deronectes costipennis gignouxi

Locality	Province	UTM coordinates	PENP	Reference	Date record	Number of individuals
Posada de Valdeón	León	30TUN4579	Yes	Fery and Brancucci 1989	20/03/1989	52
Aira da Pedra	León	29TPH8139	No	Garrido 1990	18/04/1987	7
Bezanes	Asturias	30TUN1480	No	Garrido 1990	26/06/1988	2
Caboalles de Abajo	León	29TQH1459	No	Garrido 1990	13/07/1987	2
Cofiñal	León	30TUN1668	No	Garrido 1990	03/06/1986	1
Folledo	León	30TTN7753	No	Garrido 1990	23/09/1986	6
Geras	León	30TTN7354	No	Garrido 1990	27/07/1987	8
La Aldea	Asturias	30TUN2382	No	Garrido 1990	16/10/1988	7
Morgovejo	León	30TUN4047	No	Garrido 1990	03/06/1987	1
Peranzanes	León	29TPH9350	No	Garrido 1990	10/10/1987	5
Prioro	León	30TUN3950	No	Garrido 1990	14/07/1986	3
Puerto de Leitariegos	León	29TQH1063	No	Garrido 1990	30/07/1986	1
Puerto de Tarna	Asturias	30TUN1973	No	Garrido 1990	26/06/1988	2
Puerto de las Señales	León	30TUN1871	No	Garrido 1990	29/07/1986	35
Redipollos	León	30TUN1663	No	Garrido 1990	13/09/1986	1
Tarna	Asturias	30TUN1976	No	Garrido 1990	26/06/1988	2
Valle de Lago	Asturias	29TQH2872	No	Garrido 1990	09/07/1988	4
Brego	Lugo	29TPH7339	No	González and Novoa 1995	26/09/1984	2
Vegacervera	León	30TTN9151	No	Fery and Fresneda 2007	11/08/1990	>1
Cofiñal	León	30TUN1668	No	Fery and Fresneda 2007	11/08/1990	>1
Puerto de las Señales	León	30TUN1871	No	Fery and Fresneda 2007	29/07/1986	>1
Puerto del Pontón	León	30TUN3575	Yes	Fery and Fresneda 2007	15/06/1991	>1
Posada de Valdeón	León	30TUN4579	Yes	Fery and Fresneda 2007	07/07/1995	>1
Torga	Asturias	29TPH8050	No	Fery and Fresneda 2007	20/08/1989	>1
Cerredo	Asturias	29TQH0050	No	Fery and Fresneda 2007	20/08/1989	>1
El Río	Ourense	29TNH8505	No	Fernández-Díaz *et al.* 2008	14/05/1999	1
Posada de Valdeón	León	30TUN4579	Yes	Present study	12/07/2005	2

in future studies as the number of 10×10 km UTM squares in which it has been detected is close to 20 (see Table 3).

Most of the species under some degree of threat occur in ecosystems with sufficient conservation measures, both in PENP and other protected mountain spaces. Beyond the effect that tourism or livestock can have on aquatic environments, the main impacts on these species are derived from climate change in mountainous regions. In principle, the most threatened species is *O. cantabricus*, but as it is so difficult to find and capture, the real level of threat and possible factors affecting this species cannot be ascertained.

The main conclusions of our study are that: (1) based on successive faunistic studies of aquatic

Table 4. Vulnerability scores of variables used in vulnerability assessment (Sánchez-Fernández *et al.* 2008a) for two threatened Cantabrian endemic species present in Picos de Europa National Park. GD = general distribution; ID = Iberian distribution; gr = geographic rarity; dr = demographic rarity; hs = habitat specificity; R = rarity, gr+dr+hs; P = persistence; HR = habitat rarity; HL = habitat loss; VS = vulnerability score; CAT = category.

Species	GD	ID	dr	gr	hs	R	P	HR	HL	VS	CAT
Ochthebius cantabricus	3	3	0	1	1	2	3	0	1	12	High
Deronectes costipennis gignouxi	3	3	0	1	1	2	0	0	1	9	High

Coleoptera in PENP covering a period of 123 years, 117 species are known in this area; (2) the exhaustiveness of this inventory is relatively high, and few species are expected to be added in the future; (3) the biological uniqueness of PENP is characterized by high species richness and particularly by a large number of Iberian endemic species which are not exclusive to the national park or even the Cantabrian Mountains; and (4) from the conservation perspective, most of the endemic species have a moderate level of vulnerability.

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Appendix 1. Revised checklist of the water beetles of Picos de Europa National Park water beetles with the first and following records. See Material and Methods for explanation of distribution (*i.e.*, biogeographical categories).

Species	First record	Published records	Remarks	Distribution
Gyrinidae				
Gyrinus (*Gyrinus*) *dejeani* Brullé	1957	Bertrand (1957)		T
Gyrinus (*Gyrinus*) *substriatus* Stephens	1957	Bertrand (1957), Garrido (1990), Garrido *et al.* (1994), Fery and Fresneda (2007)		T
Orectochilus villosus (Müller)	1954	Bertrand (1954), Garrido (1990), Garrido *et al.* (1994)		T
Haliplidae				
Haliplus (*Haliplidius*) *obliquus* (F.)	1954	Bertrand (1954), Garrido (1990), Garrido *et al.* (1994)		T
Haliplus (*Haliplus*) *heydeni* Wehncke	1990	Garrido (1990), Garrido *et al.* (1994)	Recorded as *Haliplus immaculatus* (Gerhardt)	N
Haliplus (*Liaphlus*) *mucronatus* Stephens	1990	Garrido (1990), Garrido *et al.* (1994)		T
Haliplus (*Neohaliplus*) *lineatocollis* (Marsham)	1954	Bertrand (1954, 1956), Garrido (1990), Garrido *et al.* (1994), present study 2005		T
Dytiscidae				
Agabus (*Acatodes*) *lapponicus* (Thomson)	1990	Garrido (1990), Garrido *et al.* (1994)	Recorded as *Agabus congener* (Thunberg)	N
Agabus (*Gaurodytes*) *biguttatus* (Olivier)	1950	Margalef (1950), Bertrand (1954, 1957), Garrido (1990), Garrido *et al.* (1994), Fery and Fresneda (2007)	Recorded as *Agabus nitidus* (F.)	T
Agabus (*Gaurodytes*) *bipustulatus* (L.)	1950	Margalef (1950), Bertrand (1954, 1956), Garrido (1990), Garrido *et al.* (1994), present study 2005, Fery and Fresneda (2007)		T
Agabus (*Gaurodytes*) *didymus* (Olivier)	1957	Bertrand (1957)		T
Agabus (*Gaurodytes*) *guttatus guttatus* (Paykull)	1990	Garrido (1990), Garrido *et al.* (1994), Fery and Fresneda (2007)		N
Agabus (*Gaurodytes*) *nebulosus* (Förster)	1990	Garrido (1990), Garrido *et al.* (1994)		T
Agabus (*Gaurodytes*) *paludosus* (F.)	1954	Bertrand (1954)		T
Ilybius albarracinensis (Fery)	1990	Garrido (1990), Garrido *et al.* (1994)	Recorded as *Agabus neglectus* Erichson	X
Ilybius chalconatus (Panzer)	1950	Margalef (1950), Bertrand (1954), Régil (1982), Garrido (1990), Garrido *et al.* (1994)	Recorded as *Agabus chalconatus* (Panzer)	T

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Appendix 1. Continued.

Species	First record	Published records	Remarks	Distribution
Dytiscidae				
Ilybius meridionalis Aubé	1954	Bertrand (1954)	Recorded as *Ilybius fuliginosus* (F.)	T
Platambus (*Platambus*) *maculatus* (L.)	1990	Garrido (1990), Garrido *et al.* (1994), present study 2005		N
Colymbetes fuscus (L.)	1990	Garrido (1990), Garrido *et al.* (1994)		T
Acilius (*Acilius*) *sulcatus* (L.)	1950	Margalef (1950), Garrido (1990), Garrido *et al.* (1994)		T
Dytiscus circumflexus F.	1954	Bertrand (1954)		T
Dytiscus marginalis L.	1982	Régil (1982), Garrido (1990), Garrido *et al.* (1994)		T
Dytiscus semisulcatus, O. F. Müller	1954	Bertrand (1954), Garrido (1990), Garrido *et al.* (1994)		T
Bidesssus coxalis Sharp	2007	Fery and Fresneda (2007)		T
Bidessus minutissimus (Germar)	1990	Garrido (1990), Garrido *et al.* (1994)		T
Hydroglyphus geminus (F.)	2005	Present study 2005		T
Deronectes angusi Fery and Brancucci	1990	Garrido (1990), Garrido *et al.* (1994)	Recorded as *Deronectes latus* (Stephens)	X
Deronectes aubei sanfilippoi Fery and Brancucci	1957	Bertrand (1957), Régil (1982), Garrido (1990), Garrido *et al.* (1994), present study 2005, Fery and Fresneda (2007)	Recorded as *Deronectes aubei* (Mulsant) and *D. delarouzei* (Du Val).	X
Deronectes costipennis gignouxi Fery and Brancucci	1989	Fery and Brancucci (1989), present study 2005, Fery and Fresneda (2007)		X
Graptodytes flavipes (Olivier)	1990	Garrido (1990), Garrido *et al.* (1994)		T
Graptodytes fractus (Sharp)	1990	Garrido (1990), Garrido *et al.* (1994)		T
Hydroporus brancucii Fery	2005	Present study 2005		X
Hydroporus decipiens Sharp	1990	Garrido (1990), Garrido and Régil (1994), Garrido *et al.* (1994)	Recorded as *Hydroporus analis* Aubé	X
Hydroporus discretus discretus Fairmaire and Brisout de Barneville	1954	Bertrand (1954, 1956)		T
Hydroporus foveolatus Heer	1954	Bertrand (1954, 1956), Garrido (1990), Garrido and Régil (1994), Garrido *et al.* (1994)		N
Hydroporus marginatus (Duftschmid)	1957	Bertrand (1957), Garrido and Régil (1994), present study 2005		T
Hydroporus nevadensis Sharp	1990	Garrido (1990), Garrido and Régil (1994), Garrido *et al.* (1994), present study 2005, Fery and Fresneda (2007)	Recorded as *Hydroporus longulus* Mulsant	X

Appendix 1. Continued.

Species	First record	Published records	Remarks	Distribution
Dytiscidae				
Hydroporus nigrita (F.)	1954	Bertrand (1954), Régil (1982), Garrido (1990), Garrido and Régil (1994), Garrido *et al.* (1994), present study 2005		N
Hydroporus planus (F.)	1990	Garrido (1990), Garrido and Régil (1994), Garrido *et al.* (1994)	Recorded as *H. lucasi* Reiche (see Fery and Fresneda 2007)	T
Hydroporus pubescens (Gyllenhal)	1990	Garrido (1990), Garrido and Régil (1994), Garrido *et al.* (1994), present study 2005		T
Hydroporus tessellatus (Drapiez)	1990	Garrido (1990), Garrido and Régil (1994), Garrido *et al.* (1994), present study 2005		T
Hydroporus vagepictus Fairmaire and Laboulbéne	1954	Bertrand (1954), Garrido (1990), Garrido and Régil (1994), Garrido *et al.* (1994), Fery and Fresneda (2007)	Recorded as *Hydroporus palustris* (L.)	X
Nebrioporus (*Nebrioporus*) *carinatus* (Aubé)	1954	Bertrand (1954), Régil (1982), Garrido (1990), Garrido *et al.* (1994), present study 2005, Fery and Fresneda (2007)		X
Nebrioporus (*Nebrioporus*) *elegans* (Panzer)	1954	Bertrand (1954), Garrido (1990), Garrido *et al.* (1994), Fery and Fresneda (2007)	Recorded as *Potamonectes elegans* (Panzer) and *P. depressus elegans* (Panzer)	T
Nebrioporus (*Zimmermannius*) *canaliculatus* (Lacordaire)	1982	Régil (1982), Garrido (1990), Garrido *et al.* (1994), present study 2005		N
Oreodytes davisii rhianae (Carr)	1954	Bertrand (1954), Fery and Fresneda (2007)	Recorded as *Oreodytes borealis* (Gyllenhal)	X
Oreodytes sanmarkii alienus (Sharp)	1956	Bertrand (1956), Régil (1982), Garrido (1990), Garrido *et al.* (1994), present study 2005, Fery and Fresneda (2007)	Recorded as *O. rivalis* (Gyllenhal), *Oreodytes rivalis* ab. *sanmarki* (Sahlberg), and *O. sanmarki* (Sahlberg)	X
Oreodytes septentrionalis (Gyllenhal)	1882	Sharp (1882), Bertrand (1956, 1957), Garrido (1990), Garrido *et al.* (1994)		N

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Appendix 1. Continued.

Species	First record	Published records	Remarks	Distribution
Dytiscidae				
Rhythrodytes bimaculatus (Dufour)	1989	Bameul (1989), Garrido (1990), Garrido *et al.* (1994), Bilton and Fery (1996), present study 2005, Fery and Fresneda (2007)		X
Scarodytes halensis (F.)	1990	Garrido (1990), Garrido *et al.*, (1994)		T
Stictonectes epipleuricus (Seidlitz)	1956	Bertrand (1956, 1957), Garrido (1990), Garrido *et al.* (1994), present study 2005, Fery and Fresneda (2007)		X
Stictotarsus bertrandi (Legros)	1990	Garrido (1990), Garrido *et al.* (1994), Fery and Fresneda (2007)		X
Stictotarsus duodecimpustulatus (F.)	1990	Garrido (1990), Garrido *et al.* (1994)		N
Stictotarsus ibericus Dutton and Angus	1954	Bertrand (1954, 1956), Garrido (1990), Garrido *et al.* (1994)	Recorded as *Potamonectes griseostriatus* (De Geer)	T
Hygrotus (*Coelambus*) *confluens* (F.)	1954	Bertrand (1954)		T
Hygrotus (*Coelambus*) *marklini* (Gyllenhal)	1882	Sharp (1882), Bertrand (1954), Garrido (1990), Garrido *et al.* (1994)	Recorded as *Hydroporus astur* (Sharp)	N
Laccophilus hyalinus (De Geer)	1990	Garrido (1990), Garrido *et al.* (1994)		T
Laccophylus minutus (L.)	1990	Garrido (1990), Garrido *et al.* (1994)		T
Helophoridae				
Helophorus (*Rhopalohelophorus*) *brevipalpis* Bedel	1950	Margalef (1950), present study 2005		N
Helophorus (*Rhopalohelophorus*) *discrepans* Rey	1988	Valladares (1988a), present study 2005		T
Helophorus (*Rhopalohelophorus*) *flavipes* F.	1988	Valladares (1988a), present study 2005		N
Helophorus (*Rhopalohelophorus*) *glacialis* Villa and Villa	1988	Valladares (1988a)		N
Helophorus (*Rhopalohelophorus*) *obscurus* Mulsant	2005	Present study 2005		N
Helophorus (*Rhopalohelophorus*) *seidlitzii* Kuwert	1988	Valladares (1988a), present study 2005		X
Hydrochidae				
Hydrochus angusi Valladares	1988	Valladares (1988a, b), present study 2005		X
Hydrochus nitidicollis Mulsant	1988	Valladares (1988a)		T
Hydrophilidae				
Anacaena globulus (Paykull)	1986	Berge Henegouwen (1986), Valladares (1988a), present study 2005		T
Paracymus scutellaris (Rosenhauer)	1988	Valladares (1988a), present study 2005		T
Enochrus (*Lumetus*) *fuscipennis* (Thomson)	2005	Present study 2005		T

Appendix 1. Continued.

Species	First record	Published records	Remarks	Distribution
Hydrophilidae				
Enochrus (*Methydrus*) *nigritus* (Sharp)	1988	Valladares (1988a)		T
Helochares (*Helochares*) *lividus* (Förster)	1988	Valladares (1988a)		T
Helochares (*Helochares*) *punctatus* Sharp	1988	Valladares (1988a)		N
Laccobius (*Dimorpholaccobius*) *atratus* Rottenberg	1988	Valladares (1988a), present study 2005		N
Laccobius (*Dimorpholaccobius*) *bipunctatus* (F.)	2005	Present study 2005		T
Laccobius (*Dimorpholaccobius*) *obscuratus* Rottenberg	1975	Gentili and Chiesa (1975), Valladares (1988a), present study 2005		N
Laccobius (*Dimorpholaccobius*) *sinuatus* Motschulsky	1988	Valladares (1988a), present study 2005		T
Laccobius (*Dimorpholaccobius*) *striatulus* (F.)	1988	Valladares (1988a)		N
Laccobius (*Dimorpholaccobius*) *ytenensis* Sharp	2005	Present study 2005		T
Coelostoma orbiculare (F.)	2005	Present study 2005		N
Hydraenidae				
Hydraena (*Hydraena*) *affusa* d'Orchymont	1988	Valladares (1988a)		X
Hydraena (*Hydraena*) *barrosi* d'Orchymont	1988	Valladares (1988a)		X
Hydraena (*Hydraena*) *brachymera* d'Orchymont	1978	Balfour-Browne (1978), Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		X
Hydraena (*Hydraena*) *corinna* d'Orchymont	1988	Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		X
Hydraena (*Hydraena*) *corrugis* d'Orchymont	1988	Valladares (1988a), Garrido (1990), Garrido *et al.* (1994)		X
Hydraena (*Hydraena*) *emarginata* Rey	1936	d'Orchymont (1936), Balfour-Browne (1978), Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		X
Hydraena (*Hydraena*) *exasperata* d'Orchymont	1988	Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		X
Hydraena (*Hydraena*) *gracilis* Germar	1988	Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		N
Hydraena (*Hydraena*) *inapicipalpis* Pic	1988	Valladares (1988a), Garrido (1990), Garrido *et al.* (1994)		X
Hydraena (*Hydraena*) *minutissima* Stephens	1990	Garrido (1990), Garrido *et al.* (1994), present study 2005		N

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Appendix 1. Continued.

Species	First record	Published records	Remarks	Distribution
Hydraenidae				
Hydraena (*Hydraena*) *nigrita* Germar	1985	Valladares (1985), Valladares (1988a), Garrido (1990), Garrido *et al.* (1994)		N
Hydraena (*Hydraena*) *stussineri* Kuwert	1978	Balfour-Browne (1978), Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		X
Hydraena (*Hydraena*) *testacea* Curtis	2005	Present study 2005		T
Hydraena (*Hydraena*) *truncata* Rey	1988	Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		N
Limnebius gerhardti Heyden	1978	Balfour-Browne (1978), Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		X
Limnebius lusitanus Balfour-Browne	1988	Valladares (1988a)		X
Limnebius myrmidon Rey	1988	Valladares (1988a)		N
Limnebius truncatellus (Thunberg)	1978	Balfour-Browne (1978), Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		N
Ochthebius (*Asiobates*) *cantabricus* J. Balfour-Browne	1978	Balfour-Browne (1978)		X
Ochthebius (*Asiobates*) *heydeni* Kuwert	1985	Valladares (1985), Valladares (1988a), Garrido (1990), Jäch (1990), Garrido *et al.* (1994), present study 2005		X
Ochthebius (*Enicocerus*) *exsculptus* Germar	1985	Valladares (1985), Valladares (1988a), Garrido (1990), Garrido *et al.* (1994)		T
Ochthebius (*Enicocerus*) *legionensis* Hebauer and Valladares	1985	Hebauer and Valladares (1985). Valladares (1988a), Garrido (1990), Garrido *et al.* (1994), present study 2005		X
Elmidae				
Dupophilus brevis Mulsant and Rey	1965	Bertrand (1965), Garrido (1990), Garrido *et al.* (1994), Rico (1996, 1998), Present study 2005		N
Elmis aenea (Müller)	1965	Bertrand (1965), Garrido (1990), Garrido *et al.* (1994), Rico (1996), present study 2005		N

Appendix 1. Continued.

Species	First record	Published records	Remarks	Distribution
Elmidae				
Elmis maugetii maugetii Latreille	1965	Bertrand (1965), Garrido (1990), Garrido *et al.* (1994), Rico (1996), present study 2005		N
Elmis perezi Heyden	1990	Garrido (1990), Garrido *et al.*, (1994)		X
Elmis rioloides (Kuwert)	1990	Garrido (1990), Garrido *et al.* (1994), Rico (1996, 1998), present study 2005		N
Esolus angustatus (Müller)	1965	Bertrand (1965), Garrido (1990), Garrido *et al.* (1994), Rico (1996, 1998), present study 2005		N
Esolus parallelepipedus (Müller)	1965	Bertrand (1965), Garrido (1990), Garrido *et al.* (1994), Rico (1996, 1998), present study 2005		T
Limnius opacus Müller	1965	Bertrand (1965), Garrido (1990), Garrido *et al.*, (1994), Rico (1996), present study 2005		T
Limnius perrisi carinatus (Pérez-Arcas)	1990	Garrido (1990), Garrido *et al.* (1994), Rico (1996, 1998), present study 2005		X
Limnius volckmari (Panzer)	1965	Bertrand (1965), Garrido (1990), Garrido *et al.* (1994), Rico (1996), present study 2005		N
Oulimnius troglodytes (Gyllenhal)	1872	Sharp (1872), Bertrand (1965), Garrido (1990), Garrido *et al.* (1994), Rico (1998), present study 2005		N
Oulimnius tuberculatus perezi (Sharp)	1990	Garrido (1990), Garrido *et al.* (1994), Rico (1996)		X
Riolus subviolaceus (Müller)	1965	Bertrand (1965)		N
Stenelmis canaliculata (Gyllenhal)	1990	Garrido (1990), Garrido *et al.* (1994)		N
Dryopidae				
Dryops luridus (Erichson)	2005	Present study 2005		T
Pomatinus substriatus (Müller)	2005	Present study 2005		T

Appendix 2. Records of water beetles in Picos de Europa National Park taken between 12 and 14 July 2005. St. 1: Puerto de Panderrueda (León province). St. 2: Soto de Valdeón (León province). St. 3: Brañarredonda (León province). St. 4: Caín (León province). St. 5: Posada de Valdeón (León province). St. 6: Puerto de Pandetrave (León province). St. 7: Begés (Cantabria province). St. 8: Invernal del Texu (Asturias province). St. 9: Tresviso (Cantabria province). St. 10: Sotres (Asturias province). St. 11: Valfrío-Tielve (Asturias province).

Species	Sampling sites
Haliplidae	
Haliplus (*Neohaliplus*) *lineatocollis* (Marsham)	St. 5
Dytiscidae	
Agabus (*Gaurodytes*) *bipustulatus* (L.)	St. 5, St. 11
Platambus (*Platambus*) *maculatus* (L.)	St. 2
Hydroglyphus geminus (F.)	St. 5
Deronectes aubei sanfilippoi Fery and Brancucci	St. 7, St. 10, St. 11
Deronectes costipennis gignouxi Fery and Brancucci	St. 5
Hydroporus brancucii Fery	St. 2
Hydroporus marginatus (Duftschmid)	St. 5
Hydroporus nevadensis Sharp	St. 8, St. 11
Hydroporus nigrita (F.)	St. 1
Hydroporus pubescens (Gyllenhal)	St. 5, St. 10
Hydroporus tessellatus (Drapiez)	St. 7, St. 11
Nebrioporus (*Nebrioporus*) *carinatus* (Aubé)	St. 11
Nebrioporus (*Zimmermannius*) *canaliculatus* (Lacordaire)	St. 7
Oreodytes sanmarkii alienus (Sharp)	St. 2, St. 8
Rithrodytes bimaculatus (Dufour)	St. 3, St. 5
Stictonectes epipleuricus (Seidlitz)	St. 7, St. 11
Helophoridae	
Helophorus (*Rhopalohelophorus*) *brevipalpis* Bedel	St. 3, St.7, St.8, St.10, St. 11
Helophorus (*Rhopalohelophorus*) *discrepans* Rey	St. 1
Helophorus (*Rhopalohelophorus*) *flavipes* F.	St. 1, St. 2, St. 3, St. 4, St.8, St. 9, St.10, St. 11
Helophorus (*Rhopalohelophorus*) *obscurus* Mulsant	St. 2, St. 4, St. 5, St.9, St.10
Helophorus (*Rhopalohelophorus*) *seidlitzii* Kuwert	St. 1, St. 2, St. 5, St.7
Hydrochidae	
Hydrochus angusi Valladares	St. 3
Hydrophilidae	
Anacaena globulus (Paykull)	St. 3, St. 6, St. 9, St. 10
Paracymus scutellaris (Rosenhauer)	St. 9
Enochrus (Lumetus) fuscipennis (Thomson)	St. 5, St. 11
Laccobius (Dimorpholaccobius) atratus Rottenberg	St. 1, St. 9, St. 11
Laccobius (Dimorpholaccobius) bipunctatus (F.)	St. 6, St. 11
Laccobius (Dimorpholaccobius) obscuratus Rottenberg	St. 2, St. 4, St. 5, St.7, St. 8, St. 9, St. 10, St. 11
Laccobius (Dimorpholaccobius) sinuatus Motschulsky	St. 5
Laccobius (Dimorpholaccobius) ytenensis Sharp	St. 5
Coelostoma orbiculare (F.)	St. 9, St. 11
Hydraenidae	
Hydraena (*Hydraena*) *brachymera* d'Orchymont	St. 3, St. 5
Hydraena (*Hydraena*) *corinna* d'Orchymont	St. 5, St. 6, St. 11
Hydraena (*Hydraena*) *emarginata* Rey	St. 1, St. 2, St. 3, St. 4, St. 5, St. 6, St.7, St.8, St.10
Hydraena (*Hydraena*) *exasperata* d'Orchymont	St. 1
Hydraena (*Hydraena*) *gracilis* Germar	St.7, St.8
Hydraena (*Hydraena*) *minutissima* Stephens	St. 3, St. 5, St.7, St.8
Hydraena (*Hydraena*) *stussineri* Kuwert	St. 3, St. 4, St. 5, St.7
Hydraena (*Hydraena*) *testacea* Curtis	St.7
Hydraena (*Hydraena*) *truncata* Rey	St. 2, St. 3, St.7, St.8
Limnebius gerhardti Heyden	St. 1, St. 6, St. 11
Limnebius truncatellus (Thunberg)	St. 1, St. 2, St. 3, St. 5, St. 6, St. 7, St. 9, St. 11
Ochthebius (*Asiobates*) *heydeni* Kuwert	St. 5, St. 7
Ochthebius (*Enicocerus*) *legionensis* Hebauer and Valladares	St. 1, St. 2, St. 7, St. 11

Appendix 2. Continued.

Species	Sampling sites
Elmidae	
Dupophilus brevis Mulsant and Rey	St. 1, St. 2, St. 7
Elmis aenea (Müller)	St. 3, St. 5, St. 6, St.7, St.8, St.9, St.10, St.11
Elmis maugetii maugetii Latreille	St. 3, St. 7, St. 12
Elmis rioloides (Kuwert)	St. 1, St. 2, St. 3, St.4, St.5
Esolus angustatus (Müller)	St. 1, St. 2, St. 3, St. 4, St. 5, St. 6, St.7, St.8, St.10
Esolus parallelepipedus (Müller)	St. 1, St. 2, St.7, St.8
Limnius opacus Müller	St. 4, St. 8
Limnius perrisi carinatus (Pérez-Arcas)	St. 1, St. 2, St. 3, St. 5
Limnius volckmari (Panzer)	St.7, St.8
Oulimnius troglodytes (Gyllenhal)	St.7
Dryopidae	
Dryops luridus (Erichson)	St. 4, St.7, St.10, St.11
Pomatinus substriatus (Müller)	St.7