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Leptocerus interruptus (Fabricius, 1775) (Trichoptera: Leptoceridae) in Poland: a Case Study of Distribution, Conservation Status and Potential Monitoring Value of a Rare European Caddisfly Species

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Abstract: *Leptocerus interruptus* is a rare caddis species in Europe, including Poland – where so far it has been recorded only at 17 sites. We present 18 further sites and confirm the occurrence of the species in one previously known site. These new records extend greatly species distribution data to many regions, especially outside the lake district of Northern Poland. Based on the available habitat data, we define its typical habitat and identify some literature inaccuracies. Our results indicate that *L. interruptus* is mainly associated with a natural medium-sized river habitats of width 4-20 m, located at 101-150 m a.s.l., in open landscapes (meadows and croplands), with well-developed aquatic vegetation and water of good to satisfactory quality. For the use of monitoring and nature conservation, we propose it as an indicator species for lowland rivers representing reference types nos. 20 and 19 (as defined by the abiotic factors) as well as an umbrella species for such habitats. We also provide a critical analysis of its status in the Polish Red List, since the species has been included in category "EX?" (probably extinct) since 2002, which is in contradiction with the present results.

Key words: Trichoptera, *Leptocerus interruptus*, distribution, habitat preferences, water monitoring, red list

Introduction

Anthropogenic pollution and environment transformations result in shrinkage of distribution ranges, and could potentially lead to the extinction of species (Goudie 2013). The quality of the natural environment is closely related to biodiversity, therefore certain species may be, and actually are, used as bioindicators of ecosystem status (Noss 1990). As regards aquatic ecosystems, the establishment of the Water Framework Directive (Directive 2000) has intensified and directed researchers' efforts to develop better and more accurate methods for monitoring water bodies and, on a wider scale, the landscape, which is recognised as "the health of the ecosystem" (Balian *et al.* 2008). It appears that this is no easy task, as seen from difficulties in the determination of reference types of particular water habitats. This is the reason why insufficiently precise synthetic indices at the family level (e.g., BMWP) are being abandoned (Hewitt 1991). These are considerably erroneous, e.g., the largest European family of caddisflies, Limnephilidae, includes so many species with various preferences that it does not, by itself, provide any uniform information on the water purity status (Hawkins *et al.* 2000, Lenat, Resh 2001, King,

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Richardson 2002). Therefore, species-level identification tools and autecological data on habitat preferences are crucial and are currently re-evaluated. According to the Water Framework Directive, an assessment of aquatic ecosystems is primarily based on both the identification of types in all categories of waters and the determination of reference conditions for them. Those are defined by, *inter alia*, biological elements of quality, which include the composition and abundance of invertebrates, including caddisflies. For Polish watercourses, 27 types have been identified so far (Czoch, Kulesza 2006, Bis, Mikulec 2013), according to catchment size, altitude and chemical composition of geological substrates. However, invertebrate data, including those on Trichoptera, are not available for all of them due to the insufficient faunal studies within certain regions. Therefore, there is still a real and fundamental need to identify potential indicators for specific water habitat types.

The condition of the environment (the health of the ecosystem) is also associated with risks to aquatic biocoenoses. Assessment of the actual degree of risk for a species is, in case of numerous invertebrates, a very difficult task, principally due to the small amount of available data. Even in a relatively well-known group such as caddisflies (Trichoptera), there are numerous species with poorly known ecology, habitats and geographical distribution. This remark is especially sound for rare species, information about which is extremely scarce. Therefore, the published Red Lists often fail to include all endangered species, and the status of the species included happens to be disputable, since it is formulated on the basis of scarce and random data. Occasionally, the discovery of a relatively few new sites may change the distribution and the assessment of potential threats, and even habitat preferences of a particular species (Pietrzak, Czachorowski 2004, Buczyńska *et al.* 2015).

In Europe, the genus *Leptocerus* Leach, 1815 contains six species (Graf *et al*. 2008, Malicky 2005), of which two are found in Poland. *Leptocerus tineiformis* Curtis, 1834 is a very common species in stagnant waters, occurring in large numbers in the elodeid zone of lakes, while *L. interruptus* (Fabricius, 1775) is a river species being rarely found (Szczęsny, Majecki 2007), which is included in the Red List of Animals in a high-risk zone (Szczęsny 1992, Szczęsny, Majecki 2002).

The aim of this paper is to provide new data on the occurrence of *L. interruptus* in Poland, and to analyse the geographical distribution and preference for selected habitat parameters of this particular species based on all available data. Since this species is rarely found, habitat preference data in the literature are incomplete and partially contradictory. Considering that *L. interruptus* is regarded as a habitat-specific widely distributed European species (Graf *et al*. 2008), relatively easy to identify, we analysed it as a potential indicator and umbrella species for running waters. These results may be useful in a wider, European context of the Water Framework Directive and attempts to identify reference rivers and invertebrate macrofauna assemblages for Central Uplands and Lowlands as well as for the Carpathian Mountains.

Material and Methods

We based our study on all data on the occurrence of *L. interruptus* available in entomological and hydrobiological literature, as well as new data collected in 2006-2014. The data obtained by the authors were gathered as part of the monitoring of the water quality in rivers performed by Provincial Inspectorates for Environmental Protection (WIOŚ) in all regions of Poland and as part of various faunal projects carried out by the authors in north-eastern Poland. Benthos samples were taken using a Surber net and hydrobiological scoop according to the instructions of WFD, while imagines were caught using entomological net or hand-picking. A total of 183 larvae, one larval case, ten pupae, and two imagines of *L. interruptus* were collected.

The habitat information for particular sites, such as the width of the watercourse, altitude (m a.s.l.), presence/absence of watercourse transformation (regulation), and the type of catchment basin was obtained from data gathered in the field, or by using internet application tools (Geoportal (http://geoportal.gov.pl), Google Earth Pro). In addition, for 16 of the sites, data from WIOŚ reports on the condition of the environment from seven provinces, concerning the water purity status (purity classes) and potential declassing factors were analysed. The sites were assigned to particular abiotic types of reference watercourses in Poland, based on two ministerial reports to the European Commission (MŚ 2005a, 2005b). The sites were arranged according to their locations in geographical macro-regions, based on a uniform decimal classification of physicogeographical regions (Kondracki 2000). Their distribution within the UTM grid 10x10 km is provided in Fig. 1. Abbreviations and symbols: * – literature data, # – own data, ~ – approximate data (without precise location, in such case the centre of the nearest locality was given), L – larva/larvae, LC – larval case/larval cases, P – pupa/pupae, Im – imago/imagines, WIOŚ – Provincial Inspectorate for Environmental Protection.

Results

Distribution of *Leptocerus interruptus* in Poland

The species was found at 35 sites: 17 historical sites extracted from literature and 18 novel sites based on new observations. At one historical site, the species was rediscovered. "R" letter means that the river stretch is regulated.

313.4 Koszalin Coastland

#Dąbki, 54º21' N, 16º18' E, UTM: WA82, 1 m a.s.l. *Ad lucem*, 14.07.2014, 1 Im, leg. P. Żurawlew, det. et coll. S. Czachorowski.

313.5 Gdańsk Coastland

#Nowa Pasłęka, 54º25' N, 19º46' E, DF23, -2 m a.s.l. Pasłęka River n. road bridge, R, 19.06.2006, 17 L, 10 P, leg. P. Buczyński, det. et coll. E. Buczyńska.

314.4 West Pomerania Lakeland

*Złocieniec, 53º32' N, 16º00' E, WV63, 121 m a.s.l. Drawa River, 21.05.1998 – 5.10.2002, 924 L, 2 LC (Pietrzak 2001, Pietrzak, Czachorowski 2004).

*Złocieniec, 53º32' N, 16º00' E, WV63, 127 m a.s.l. Wąsawa River, R, 22.05.1999, 1 L (Pietrzak, Czachorowski 2004).

314.5 East Pomerania Lakeland

*Ostrzyce, 53º36' N, 18º16' E, CF11, 167 m a.s.l. Radunia River, 5.06.2008, 2 L (Krejckant, Liśniański 2008).

314.6-7 South Pomerania Lakeland

*Tleń, 53º32' N, 18º29' E, CE14, 80 m a.s.l. Prusina River, 7.06.1996, 1 LC (Pietrzak, Czachorowski 2004).

#Krasne, 53º51' N, 17º17' E, XV57, 140 m a.s.l. Krasne Lake, 15.07.2009, 1 Im, leg. et det. et coll. S. Czachorowski.

315.3 Toruń-Eberswalde Ice-Marginal Valley

#Skwierzyna, 53º35' N, 15º29' E, WU32, 26 m a.s.l. Obra River, 18.06.2007, 3 L, leg. WIOŚ Zielona Góra, det. et coll. S. Czachorowski.

315.4 Lubuskie Lakeland

#Trzciel, 52º22' N, 15º52' E, WU50, 54 m a.s.l. Obra River, R, 22.05.2009, 1 L, leg. WIOŚ Zielona Góra (regional office in Gorzów Wielkopolski), det. et coll. S. Czachorowski.

318.1 South Greater Poland Lowland

*Marzenin, 51º33' N, 19º02' E, CC61, 155 m a.s.l. Grabia oxbow, autumn of 1999, 3 L (Majecki 2006, Nijboer *et al.* 2006).

318.5 Silesian Lowland

*Wrocław (surroundings), 51º06' N, 17º01' E, XS46, ~120 m a.s.l. (Schneider 1885).

318.6 North Mazovia Lowland

*Sochocin Settlement, 51º41' N, 20º27' E, DD63, 85 m a.s.l. Raciążnica River, 4.05.2009, 13 L (Czachorowski 2012).

318.7 Central Mazovia Lowland

#Otwock (Młądz), 52º08' N, 21º17' E, EC17, 98 m a.s.l. Świder River, 10.06.2009, 16 L, leg. WIOŚ Warszawa, det. et coll. S. Czachorowski.

318.9 South Podlasie Lowland

#Paplin, 52º28' N, 21º52' E, ED51, 109 m a.s.l. Liwiec River, 20.05.2009, 1 L, leg. WIOŚ Warszawa, det. et coll. S. Czachorowski.

342.1 Przedborska Upland

*Sulejów, 51°21' N, 19°52' E, DB28, 166 m a.s.l. Pilica River, autumn of 1998 and 1999, and spring of 1999 and 2000, 6 L (uncertain determination) (Majecki 2006, Nijboer *et al.* 2006).

513.3 West Beskids Foothills

#Czasław (Myto), 49º50' N, 20º07' E, DA32, 275 m a.s.l. Krzyworzeka River, 21.05.2009, 1 L, leg. WIOŚ Kraków (regional office in Tarnów), det. et coll. S. Czachorowski.

#Łąkta Górna, 49º49' N, 20º25' E, DA52, 276 m a.s.l. Potok Sanecka River, 12.05.2009, 2 L, leg. WIOŚ Kraków (regional office in Tarnów), det. et coll. S. Czachorowski.

841.5 Old Prussian Lowland

#Łozy, 54º11' N, 19º57' E, DF30, 29 m a.s.l. Pasłęka River n. road bridge, 19.06.2006, 1 L, leg. P. Buczyński, det. et coll. E. Buczyńska.

*Bartoszyce, 53°14' N, 20°46' E, DF81, 47 m a.s.l. Łyna River above the urbanized areas, years 1972-1974, L, quite numerous (accounting for 5.5% individuals of the macrozoobenthos at this site) (Wielgosz 1979a).

848.2 Mazury Lakeland

#Wojciechy, 53º58' N 20º10' E, DE48, 74 m a.s.l. Pasłęka River, 9.06.2005, 15 L, leg. et det. et coll. S. Czachorowski.

*Kurki, 53°32' N, 20°20' E, DE63, 129 m a.s.l. Łyna River, 8.06.1998, 1 L, 12 X 1998, 4 L (Pietrzak, Czachorowski 2004).

*Nature Reserve "Las Warmiński" ad Łańsk, 53°37' N, 20°29' E, DE64, 143 m a.s.l. Łyna River n. Ustrych Lake, 8.05.1998, 30 L, 26.06.1998, 1 L (Czachorowski *et al.* 1998).

*#Ruś, 53°41' N, 20°29' E, DE65, 113 m a.s.l. Łyna River, 26.06.1998, 6 L (Pietrzak, Czachorowski 2004), 5.05.2008, leg. M. Krejckant, det. et coll. S. Czachorowski, 8 L, 10.05.2010, 64 L, leg. WIOŚ Olsztyn, det. et coll. S. Czachorowski, 8.06.2010, 3 L, leg. P. Stępnowska, det. et coll. S. Czachorowski.

*Bartąg, 53°43' N, 20°28' E, DE65, 107 m a.s.l. Łyna River, 8.05.1998, 1 L, 26.06.1998, 21 L (Pietrzak, Czachorowski 2004).

*Olsztyn, 53°44' N, 20°28' E, DE65, 104 m a.s.l. Łyna River n. road bridge between the districts of Jaroty and Kortowo, years 1974-1975, 4 L (0.1 ind.·m^{-2}) (Wielgosz 1979b).

#Olsztyn (Brzeziny), 53°45' N, 20°28' E, DE65, 103 m a.s.l. Łyna River, 30.05.2011, 27 L, leg. WIOŚ Olsztyn, det. et coll. S. Czachorowski.

*Knopin ad Dobre Miasto, 53°44' N, 20°28' E, DE68, 77 m a.s.l. Łyna River n. road bridge, years 1974-1975, 1 L (Wielgosz 1979b).

#Mikosze, 53°48' N, 21°55' E, EE66, 119 m a.s.l. Orzysza River, 12.05.2009, 6 L, leg. WIOŚ Olsztyn (regional office in Giżycko), det. et coll. S. Czachorowski.

#Połom, 53°38' N, 22º6' E, EE88, 131 m a.s.l. Połomska Młynówka River, 2007 1 L, leg. WIOŚ Olsztyn (regional office in Giżycko), det. et coll. S. Czachorowski.

#Lipińskie Małe, 53°44' N, 22°24' E, EE95, 117 m a.s.l. Ełk River, 18.05.2009, 4 L, 26.05.2010, 2 L, leg. WIOŚ Olsztyn (regional office in Giżycko), det. et coll. S. Czachorowski.

#Sędki, 53°50' N, 22°28' E, EE96, 122 m a.s.l. Jegrznia River (=Lega), 24.05.2010, 8 L, leg. WIOŚ Olsztyn (regional office in Giżycko), det. et coll. S. Czachorowski.

*Gołdap, 54°18' N, 22°18'E, EF81, ~150 m a.s.l. (Riedel 1961).

843.3 North Podlasie Lowland

#Tworkowice, 52º38' N, 22º27'E, ED93, 110 m a.s.l. Nurzec River, 23.06.2009, 2 L, leg. WIOŚ Białystok (regional office in Łomża), det. et coll. S. Czachorowski.

#Strękowa Góra, 53º12' N, 22º33'E, FD09, 101 m a.s.l. Narew River, 23.09.2010, 1 L, leg. WIOŚ Białystok, det. et coll. S. Czachorowski.

Data without location

*East Prussia (Ostpreußen) (Ulmer 1912).

General information on the occurrence of *L. interruptus* in this former province of Germany (existing until 1945), which included numerous macro-regions belonging to two subprovinces: East Baltic Coastland and East Baltic Lakeland. Currently, the area in question is part of Poland, Russia, and Lithuania. Thus, the specific geographical macro-region in which the species was found cannot be indicated, and the current national affiliation of its site cannot be identified with certainty either.

Habitat preferences of *Leptocerus interruptus* in Poland

We have examined the following environmental variables for all sites representing running waters: width of the stream/river, altitude, watershed type, water quality classes, type of a course (natural or regulated) and abiotic type of a river. We have not used standard statistical tests since the material was collected by different persons, using different methods and in different time periods. Moreover, the material cannot be analysed within sample (or any sensible unit) level because for historical sites we can use maximum values of individual numbers only.

Leptocerus interruptus inhabits courses of width ranging from 4 to 50 m. Five classes were distinguished for this variable (Table 1). Fig. 2 provides relative proportion of habitat classes, together with their maximum and cumulative maximum for the number of sites and individuals. For the number of individuals the highest mean was obtained for class 3 (21-30 m), however, these results were disturbed by the enormously huge number of specimens caught at site 3. This comment is also valid for the remaining factors. For the number of sites the highest means were obtained for the range of classes 1-2 (4-20 m).

For the second parameter taken into consideration – the altitude – five habitat classes were distinguished within the range between -2 and 276 m a.s.l. (Table 1, Fig. 3). Both individual numbers and the occurrence sites reached the highest means between 101-150 m a.s.l. Worth mentioning is the rapid decrease of both values above 150 m a.s.l. Below 100 m a.s.l., the number of sites in the two lowest ranges was almost similar, however, the number of individuals was very low.

The examined sites were situated in different landscapes; however, five dominating types could be distinguished: F – forests, FM – mosaic of forests and meadows, M – meadows, MC – meadows and croplands, C – croplands (Table 1, Fig. 4). The most important either in case of percentage number of sites or individuals were the meadows, as well as mosaics of meadows and croplands. Together with crops they constituted over 80% of all sites which indicated strong preferences of the species towards pure open landscapes.

Data about water quality was available for 16 stations. The relative proportion of particular water quality classes of sites and individuals is given in Table 1 and Fig. 5. Classes 2 (good quality of water) and 3 (satisfactory quality of water) ratings covered as many as 81% of all sites. *Leptocerus interruptus* was never found in water of Class 5 (bad quality). As for role declassifying factors, for most cases chemical factors were used (e.g., NO_3, Hg, PO_4), while microbiological factors (e.g., *E. coli*) were very scarce. An additional interesting issue is associated with the findings of larvae in the River Pasłęka, which is one of the two rivers supplying the Vistula Lagoon. Its waters are brackish, with average total salt content of 3.3 ‰ ± 0.86 (2.15-4.89‰ Renk *et al.* 2001). Site 2 in this paper was situated only within 450 m from the Baltic Sea.

Leptocerus interruptus was found in seven abiotic types of watercourses out of 27 distinguished types in Poland. Most sites represented types 20, 19 and 25 (80% in total; Table 1, Fig. 6). These were respectively: 20 – lowland river with gravel bottom,

Table. 1. Number of sites (N_S) and individuals (N_I) of *Leptocerus interruptus* in particular habitat classes and types

	Width classes					Altitude classes					
range [m]	≤10	11-20	21-30	31-40	>40	≤50	51-100	101-150	151-200	201-250	251-300
N_S [%]	10 [34.4]	10 [34.5]	6 [20.6]	1 [3.4]	2 [6.9]	5 [14.7]	6 [17.6]	18 [52.9]	3 [8.8]	0 [0.0]	2 [5.9]
N_i [%]	47 [3.9]	194 [16.0]	934 [77.3]	1 [0.1]	33 [2.7]	32 [2.6]	47 [3.9]	1121 [92.3]	11 [0.9]	0 [0.0]	3 [0.2]

	Water quality classes					Catchment type classes				
class	1	2	3	4	5	1	2	3	4	5
N_S [%]	1 [6.3]	8 [50.0]	5 [31.3]	2 [12.5]	0 [0.0]	1 [6.3]	8 [50.0]	5 [31.3]	2 [12.5]	0 [0.0]
N_i [%]	13 [1.2]	1070 [95.2]	11 [1.0]	30 [2.7]	0 [0.0]	13 [1.2]	1070 [95.2]	11 [1.0]	30 [2.7]	0 [0.0]

	Abiotic type of a course						
type	12	16	18	19	20	24	25
N_S [%]	2 [6.7]	1 [3.3]	1 [3.3]	6 [20.0]	12 [40.0]	2 [6.7]	6 [20.0]
N_i [%]	3 [0.2]	3 [0.2]	1 [0.1]	44 [3.6]	1111 [91.7]	2 [0.2]	48 [4.0]

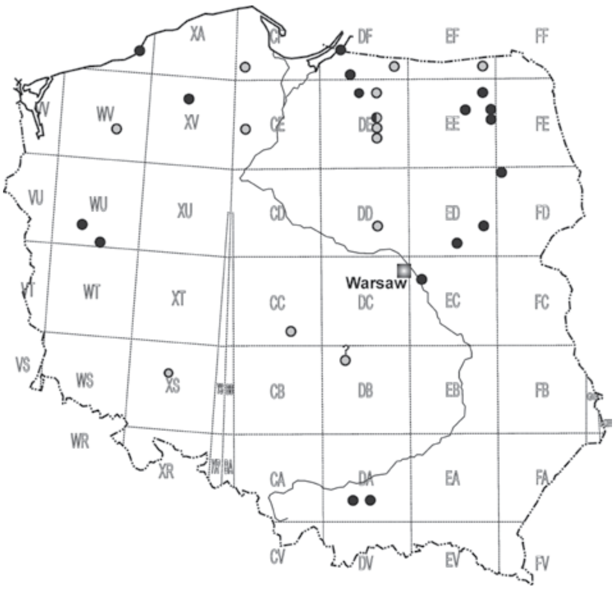

Fig. 1. Distribution of known sites of *L. interruptus* throughout Poland. Gray circles: UTM grid 10x10 km with literature data; black circles: new data. The boundaries of the UTM squares of 100x100 km are marked with a dotted-dashed line

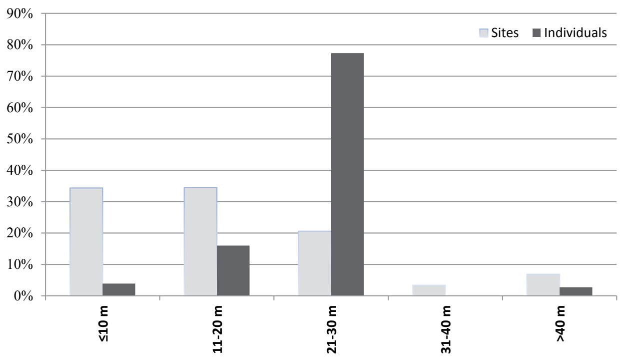

Fig. 2. Relative proportions of sites and individuals of *L. interruptus* in river width classes in Poland

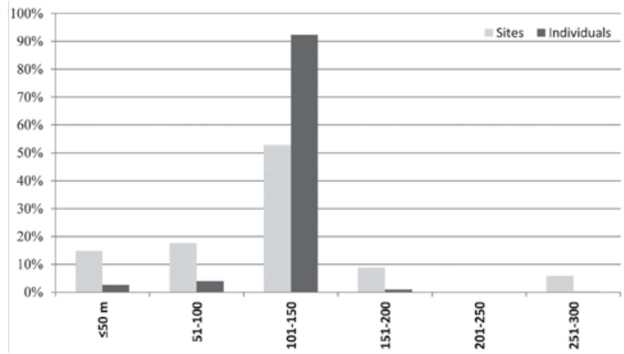

Fig. 3. Relative proportions of sites and individuals of *L. interruptus* in altitude classes in Poland

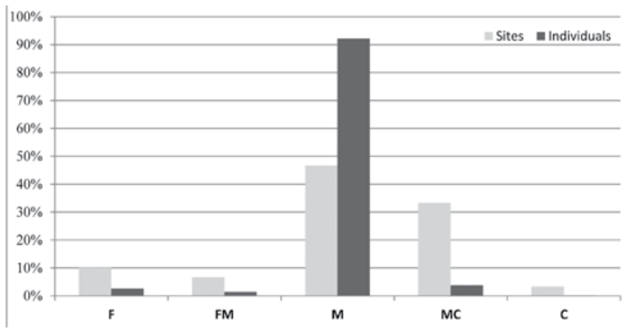

Fig. 4. Relative proportions of sites and individuals of *L. interruptus* in watershed classes in Poland. F – forests, FM – mosaic of forests and meadows, M – meadows, MC – meadows and croplands, C – croplands

19 – lowland river with sand-clay bottom, and 25 – stretches between lakes. Worth mentioning is the fact that the sites representing the most preferred type 20 were more habitually varied than in the descriptions in the literature (Czoch, Kulesza 2006, Bis, Mikulec 2013). It refers to courses with a bottom composed of gravel, however, our sites had mainly sandy, muddy and clay bottoms. This resulted from the mosaic patterns (riffle and pool areas) of the course. As well, *L. interruptus* showed preferences towards pool areas – slowly flowing and overgrown – which would be more in accordance with the description of type 19. Therefore, types 20 and 19 may be considered as the most representative for this species.

Two more parameters were also considered: transformations of the riverbeds and the presence of aquatic vegetation. The species showed strong preferences towards natural rivers: only three from all analysed sites were regulated. Some sites (the Łyna and Pasłęka Rivers) were regulated long ago; however, nowadays the processes of strong re-naturalisation are so advanced that we can assume that during our studies these stretches were of almost natural character. The presence of aquatic plants can be given only in case of novel sites since literature data does not provide such information. The densities of particular aquatic species and their coverage areas were different but plants were always present. We were not able to compare any numbers describing this factor since material was collected in different months, and, above all, it differred greatly during the whole vegetation season.

Taking into consideration all parameters given above we assigned a typical habitat for *L. interruptus* in Poland (Fig. 7). It is a natural (unregulated) medium-sized river of 4-20 m width, located at 101-150 m a.s.l. in open landscape, with well-developed aquatic vegetation and water of good to satisfactory quality. This habitat may be included to types 20, 19 and 25.

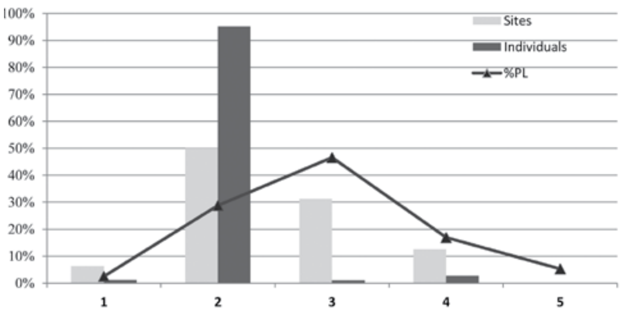

Fig. 5. Relative proportions of sites and individuals of *L. interruptus* in water quality classes in Poland. 1 – waters of very good quality, 2 – waters of good quality, 3 – waters of satisfactory quality, 4 – waters of unsatisfactory quality (in total, a five-class system adopted by Poland in 2005). % PL – body of water in Poland

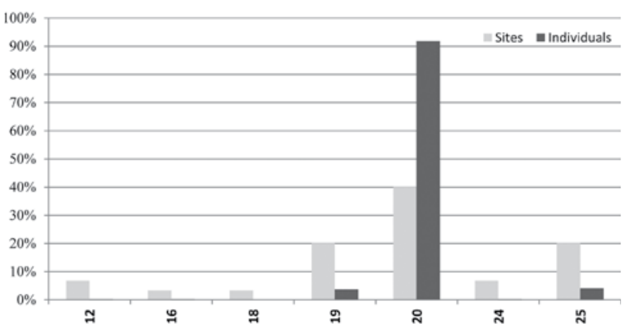

Fig. 6. Relative proportions of sites and individuals of *L. interruptus* in abiotic types of rivers in Poland

Discussion

Distribution and geographical range: Poland and the European background

Until 2004, *L. interruptus* was known from 14 sites in Poland, located almost exclusively in the north of the country, and there, with one exception, within the belt of lakelands (Pietrzak, Czachorowski 2004). Outside of northern Poland, only one historical site from Lower Silesia was known (Schneider 1885). In the checklist of Trichoptera of Poland, the species was considered to be associated only with the western and northern part of the country (Szczęsny, Majecki 2007). New data clearly expands the range of this species to almost all of Poland, namely Mazovia, Greater Poland, Lesser Poland, and up to the Western Carpathian Mts (Fig. 1). Sites within the latter region are currently the highest located known sites of the species. On the other hand, it is currently not recorded from south-eastern Poland, even though numerous studies have been conducted on the caddisflies in these areas, including watercourses meeting its environmental requirements. Current distribution data of *L. interruptus* indicates that it could be expected in other regions, considering habitat requirements as presented in this contribution. This also applies to the Carpathian and Sudetes Foothills.

On the European scale, this species is widespread: it is only absent in the far north (Iceland, Fennoscandia and Borealic Uplands), and in the Iberian Peninsula and Western Balkans (Graf *et al.* 2008). A wide range of occurrence is one of the significant criteria for a good indicator (bioindicator) in the monitoring of water bodies and watercourses. Therefore, *L. interruptus* may be of greatest significance for flowing waters in Europe. In this regard, *L. savur* Sipahiler, 2001 and *L. aksu* Sipahiler, 2003 are of marginal significance as endemic species with narrow ranges, practically outside Europe. *L. lusitanicus* (McLachlan, 1884) occurs in similar habitats but the ranges of these species are different. The ranges of *L. interruptus* and *L. tineiformis* overlap the most but are separated in terms of the habitats, which is outlined below.

Habitat preferences

General habitat preferences of the discussed species in Europe are given as follows: Botosaneanu, Malicky (1978) describe it as typical of rhitral and potamal, while Graf *et al.* (2008) are more specific: metharhitral, epi- and metapotamal; Reusch, Brinkmann (1998) indicate hyporhitral, epi- and metapotamal. In Britain and Ireland, Wallace (1991) gives roots of marginal vegetation in rivers as habitat preferences; Wallace *et al.* (2003) mention slow-flowing regions of rivers, and Barnard, Ross (2012) give rivers in general. In Poland Szczęsny, Majecki (2007) indicate running waters as habitat preferences, and namely the potamal zone. Our findings are similar to European information while the current category for Poland is too narrow. As for the altitude, European monographs describe the species as a lowland-specific (Botosaneanu, Malicky 1978) and Graf *et al.* (2008) and Graf, Schmidt-Kloiber (2011) provide two ranges of the occurrence of the species: below 200 m a.s.l. and 200-800 m a.s.l. Malicky (2014) give four sites of this species with 0, 20, 30 and 300 m a.s.l., respectively. This data is compatible with ours, even the lowest values (site 2 in the paper).

One ecological parameter given by Graf *et al.* (2008) is in contradiction to our results: these authors describe this species as limnophilous, i.e. a species that prefers standing waters and rarely occurs in slowly flowing streams. Our results indicate that this category is not appropriate for Poland since its presence in standing waters is sporadic (e.g., site 10 in the paper – an oxbow). We suggest that this species should be considered as a rheophil, typical of riv-

Fig. 7. An example of typical habitat of *L. interruptus* in Poland (site 2 in the text)

ers with slow current, but not standing waters. The similar situation is the case of *L. lusitanicus*. In literature, its habitats are: rivers, streams and waterbodies (Wallace 1991), large rivers and ponds (Hickin 1967), slowly flowing waters (Wallace *et al.* 2003), large rivers and gravel pits (Barnard, Ross 2012). It should be described as a rheo- to limnophil, not a limnophil. Only the third species: *L. tineiformis* shows strong and clear preferences towards standing waters (limnobiont). Both Polish species: *L. interruptus* and *L. tineiformis* inhabit waters with aquatic vegetation but are habitually separated (rivers vs. lakes), probably to avoid competition. Moreover, they are also separated by the preferences towards microhabitats (phytal vs. organic), as is the case of *L. lusitanicus* and *L. interruptus* (xylal vs. phytal) who share similar habitats in Western Europe (Graf *et al.* 2008). The mentioned microhabitat selection of *L. interruptus* (Graf *et al.* 2008) is also in accordance with our data. Other elements of its habitats given by us can be also included as specific, at least in Poland: this refers to open landscape and quality (purity) of waters. The parameters referring to waters (classes of quality) obtained by us are also similar to those given by Graf *et al.* (2008), which indicate the presence of this species in α-saprobic and β-saprobic zones.

Most caddisfly species live in freshwater, only a few inhabit brackish waters (Graf *et al.* 2008). Among new sites of *L. interruptus*, the waters of Pasłęka River (site 2) are supplied with salt from tidal seawater, which results in an average salt content of ca. 3 ‰. This indicates the possibility that the discussed species can tolerate brackish conditions. Malicky (2014) also gave *L. interruptus* from brackish stream in Greece (together with four other leptocerids), however, the values of salinity found there were lower than ours (below 1‰). Other representatives of the family Leptoceridae may also inhabit brackish waters, such as *Ylodes* (*Triaenodes*) Milne, 1934 (Wallace *et al.* 2003), or *Oecetis* McLachlan, 1877 (Waringer, Graf 2014). Barnes (1994) gave *Mystacides longicornis* (Linnaeus, 1758) and *Oecetis ochracea* (Curtis, 1834) as occasionally recorded at salinities of up to 10 ‰ in North-western Europe. However, in the checklist of Baltic Sea macro-species (Kontula, Haldin 2012), seven Trichoptera species are provided but from Phryganeidae and Hydroptilidae only. Gerecke's (1991) find in saline waters in Sicily also *Hydroptila maclachlani* Klapalek, 1891 and rare representatives of the genus *Limnephilus* Leach, 1815. Our results could be an important supplement to the data about this relatively rare phenomenon among caddisflies.

Protection and management of *L. interruptus* in Poland

The rarity of *L. interruptus* on the European scale is demonstrated by the fact that it was listed in as

Table 2. *Leptocerus interruptus* in the European Red lists. EX?, V – probably extinct, CR – critically endangered, EN – endangered, VU – vulnerable, DD – data deficient, RDB 3 – rare, not endangered or vulnerable but at risk

Country	Category	References
Austria	DD, V	Malicky (2009)
Czech Republic	CR	Chvojka *et al.* (2005)
Netherlands	VU	MLNV (2004)
Latvia	–	ESL (2013)
Germany	EN	Klima (1998)
Poland	EX?	Szczęsny (2002)
Slovenia	–	Krušnik (1992)
Switzerland	–	Lubini *et al.* (2012)
Hungary	EN	Nógrádi, Uherkovich (1999)
UK	RDB 3	Wallace (1991)

many as ten Red Lists of countries of this continent (Table 2), including Poland. The categories of risks to this species are very diverse, from “rare” to “probably extinct”.

In Poland, until the first edition of the Red List of Threatened and Endangered Animals (Szczęsny 1992), the species status was “vulnerable” (V), i.e., prone to extinction. Ten years later, it was considered to be “probably extinct” (EX?; Szczęsny 2002). In the latest checklist for Poland (Szczęsny, Majecki 2007) the status EX? was maintained, which is surprising in the light of literature data from Poland. If the faunal synthesis by Tomaszewski (1965) were to be considered the starting point, the species was recorded several times after that date, including three papers after 1992, i.e., following the first edition of the Red List (Wielgosz 1979a, 1979b, Czachorowski *et al.* 1998, Pietrzak 2001, Pietrzak, Czachorowski 2004). Considering the specific habitat requirements of the species, its rarity and potential modifications of rivers in Poland, it would explain why *L. interruptus* is still regarded as probably extinct. In this paper, the authors present further, current sites, which indicate the status of the species to be certainly not probably extinct (EX?) but still rare in potentially threatened habitats.

As indicated by Buczyńska *et al*. (2015), using *Erotesis baltica* as an example, the application of strict criteria of IUCN (2014) to caddisflies is problematic due to the lack of current data. Criteria to be applied in such a situation were suggested by Głowaciński, Nowacki (2002). In the light of that and based on data presented in this paper, *L. interruptus* in Poland certainly does not belong to a high-risk species, i.e., the category of VU (vulnerable) or higher. It may be included in the category of NT (lower risk – nearly threatened) for two reasons: (1) its habitats are potentially at risk of degradation, and (2) the situation of the species is bad in neighbouring countries, including in a large part of Central Europe (Table 2).

Additionally, *L. interruptus* could be used as an umbrella species for flowing waters for which five caddisfly species have been provided so far (Czachorowski *et al.* 2000). This is justified by the following factors: well-recognised habitat requirements and development cycle, the ease of identification (even for very typical empty cases), and the restrictedness to waters of good and satisfactory quality. The latter guarantees the occurrence of valuable plant and animal species at the same sites, which is the essence of the application of umbrella species in the environmental protection. Their task is to identify and protect particularly valuable biotopes along with their biocoenoses. As regards the species in question, the first aspect is of particular significance: even though Poland has a rather well-developed river network, it has been incessantly subjected to human pressure. *L. interruptus*, as a species attached to natural and relatively clean rivers, may be a good indicator of such waters and of the general good condition (health) of an ecosystem.

Conclusions

The new data on the distribution and habitat requirements of *L. interruptus* may indicate the suitability of this species for monitoring and protective purposes. This caddisfly has a relatively wide range of occurrence, a long duration of the aquatic development stage, a rather high tolerance for temperature and even salinity, and relatively specific and well-defined habitat preferences as specified in this paper. It is also worth considering, in addition to changing the status of the species in the future Red List for Poland, to change the European scaliest category as regards the water current from “limnophil” to (phytophilous) “rheophil”. This species, preferring clean and relatively clean natural watercourses, may be used as an indicator of the following: (1) specified abiotic types of rivers in the light of the Water Framework Directive; (2) good quality of waters; (3) “the health of ecosystem” *sensu lato*. Our results demonstrate that data from the national monitoring of the environment may provide significant content: they are random (screening) in nature, yet they are abundant and include the entire country. It is also more and more noticeable that the continuation of or return to the methods based on invertebrate families is a mistake, at least in the case of caddisflies. Much better results are obtained through methods applying references to specific species, for example, the determination of reference assemblages of invertebrate macrofauna for certain reference watercourses or umbrella species. Such methods are worth improving in the future.

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