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New records of *Psarus abdominalis* (Fabricius) (Diptera: Syrphidae), a threatened species in Europe

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Summary. New records of the endangered European genus and species *Psarus abdominalis* (Diptera, Syrphidae, Rhingiini) are provided together with a list of the Syrphidae collected in the Haut-Rhin Department. Based on these new records, the status of this highly endangered species is discussed. In addition, we give molecular data about *Psarus abdominalis* as part of the German Barcode of Life project, a contribution to a reference DNA library, as well as the detailed distribution of *Psarus*.

Résumé. Nouvelles données de *Psarus abdominalis* (Fabricius) (Diptera: Syrphidae), une espèce menacée en Europe. De nouvelles données concernant le genre monotypique européen *Psarus* et sa seule espèce, *Psarus abdominalis*, en voie de disparition, sont fournies avec une liste des espèces de syrphidés recueillies dans le département du Haut-Rhin. Sur la base de ces nouvelles données, le statut de cette espèce très menacée est discuté. Deplus, des données moléculaires sont présentées pour *Psarus abdominalis* dans le cadre du projet GBOL ayant pour but de construire une banque d'ADN de référence. L'aire de répartition détaillée de *Psarus abdominalis* est donnée.

Keywords: conservation; endangered species; Diptera; Syrphidae; *Psarus*

The Syrphidae (Insecta: Diptera) is one of the most abundant and conspicuous dipteran families, with more than 6000 described species (Brown 2009; Thompson 2013). Commonly known as flower flies and hoverflies, syrphid adults are important pollinators in crops and natural ecosystems (Pérez-Bañón et al. 2003; Ssymank et al. 2008; Ssymank & Kearns 2009), and they are the most significant flower visitors among Diptera (Larson et al. 2001). Syrphidae also play a crucial ecological and economic role in larval stages as biological control agents of plant pests, re-cyclers of dead plant and animal matter, and pests of some ornamental plants (Thompson 1972; Rotheray 1993; Thompson & Rotheray 1998; Rotheray & Gilbert 2011).

Flower flies have been used as bioindicators due to their broad array of larval trophic habits, their abundance and conspicuousness, and their relatively well-known and stable taxonomy, at least in Central Europe (Sommaggio 1999; Dziock 2009; Marcos-García & Ricarte 2009; Sommaggio & Burgio 2014). Syrphid surveys have been useful for the conservation of natural ecosystems in Europe (Speight 1989; Allen 1992; Reemer 2005; Ricarte & Marcos-García 2008; Ricarte 2009; Ricarte et al. 2009; Rotheray 2010; Rotheray et al. 2012; Radenković et al. 2013). Although the Syrphidae are regularly surveyed and have been well studied, only a few European countries have a "Red List" (Andersson et al. 1987; Stoltze & Pihl 1998; Noskov 2002; Wind & Pihl 2004; Farkač et al. 2005; Verdú & Galante 2005; Gammelmo et al. 2006; Cederberg et al. 2010; Rassi et al. 2010; Ssymank et al. 2011; Lutovinovas 2012; Treiber 2014).

The species *Psarus abdominalis* (Fabricius 1794) is listed among the threatened taxa (Ssymank et al. 2011; Treiber 2014). *Psarus* Latreille 1804 is a monotypic genus endemic to Europe and its single species *P. abdominalis* is a highly distinctive insect. *Psarus* flies are almost bare, dark flower flies with a red abdomen and long antenna placed on a short antennifer (Figures 1, 2). The only other European syrphid it resembles even remotely is the male of *Pyrophaena granditarsa* (Forster 1771), which likewise has a bright orange-red abdomen (Speight 2013). The species is so morphologically distinct that previous authors have designated a variety of taxonomic ranks for it: e.g. subtribe Psarina (Shatalkin 1975), tribe Psarini (Peck 1988), subfamily Psariti (Lioy 1864) and Psarinae (Sack 1932; Hull 1949), and even family Psaridae (Bigot 1883).

The German Barcode of Life (GBOL) project aims at capturing the genetic diversity of animals, fungi and plants in Germany using the 5′ gene fragment of the cytochrome c oxidase subunit I (COI) (Pietsch & Rulik 2014), the so-called DNA barcode or Folmer fragment (Hebert et al.

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2003). The final aim of the GBOL project is to build a reference genetic library of national biodiversity. In order to collect *Psarus abdominalis* for GBOL, the authors visited various localities in the "Colmarer Trockeninsel" near Dessenheim in the Alsace (France), not far from the last-known records on the German side of the Rhine, in the vicinity of Grißheim (Baden-Württemberg, Germany), where the last published *Psarus* specimens were collected (Stuke 2000; Ståhls et al. 2004).

The aim of the present work is to report new records of *P. abdominalis* and to discuss the status of this highly endangered species. In addition, we provide a species list of Syrphidae collected in the Haut-Rhin Department.

Material and methods

Most of the known biological information about *Psarus* was compiled by Speight (2013). Based on this information with additional information from Stuke (2000), we selected a few potential areas in the "Colmarer Trockeninsel" and visited several localities in Colmar and Guebwiller districts (Haut-Rhin department, France).

Methods

Sampling localities around Dessenheim, Hirztfelden (Alsace, France) and Grißheim were visited from 7–11.VI.2014 (see Table 1). The fieldwork was planned accordingly with the available data for the flight period of *Psarus*, from late May to late July or early August (Verlinden 1991; Speight 2013). Hand nets were used to collect syrphid adults during the survey, from 8:30 am to 6:00 pm (Central European summer time, CEST).

Table 1. Sampling localities in Alsace (France).

Locality code	Locality	Dates
1	FRANCE: Alsace, Haut-Rhin Dept., Colmar District, Dessenheim, along D1bis, 4th road from round going to Niederhergheim, 198 m, 47°59′21″N, 07°28′01″E.	7.VI.2014
2	FRANCE: Alsace, Haut-Rhin Dept., Colmar District, Dessenheim, along D1bis, 2nd road from round going to Niederhergheim, 199 m, 47°59′24″N, 07°28′22″E.	7.VI.2014 11.VI.2014
3	FRANCE: Alsace, Haut-Rhin Dept., Colmar District, Dessenheim, along D1bis, 3rd road from round going to Niederhergheim, 199 m, 47°59′23″N, 07°28′15.40″E.	8.VI.2014 10.VI.2014 11.VI.2014
4	FRANCE: Alsace, Haut-Rhin Dept., Guebwiller District, CSA Ile du Rhin, 203 m, 47°54′19″N, 07°34′33″E.	8.VI.2014
5	FRANCE: Alsace, Haut-Rhin Dept., Guebwiller District, CSA Hirtzfelden – Rothleible, road D-2, 212 m, 47°53′53″N, 07°25′29″E.	8.VI.2014
6	FRANCE: Alsace, Haut-Rhin Dept., Guebwiller District, CSA Hirtzfelden – Rothleible, road D-2, 214 m, 47°53′28″N, 07°25′04″E.	8.VI.2014

Syrphid identification a number of existing keys were used, mainly Van Veen (2004) but also van der Goot (1981), Verlinden (1991), and Torp (1994). All species were checked against material from the reference collection of the authors.

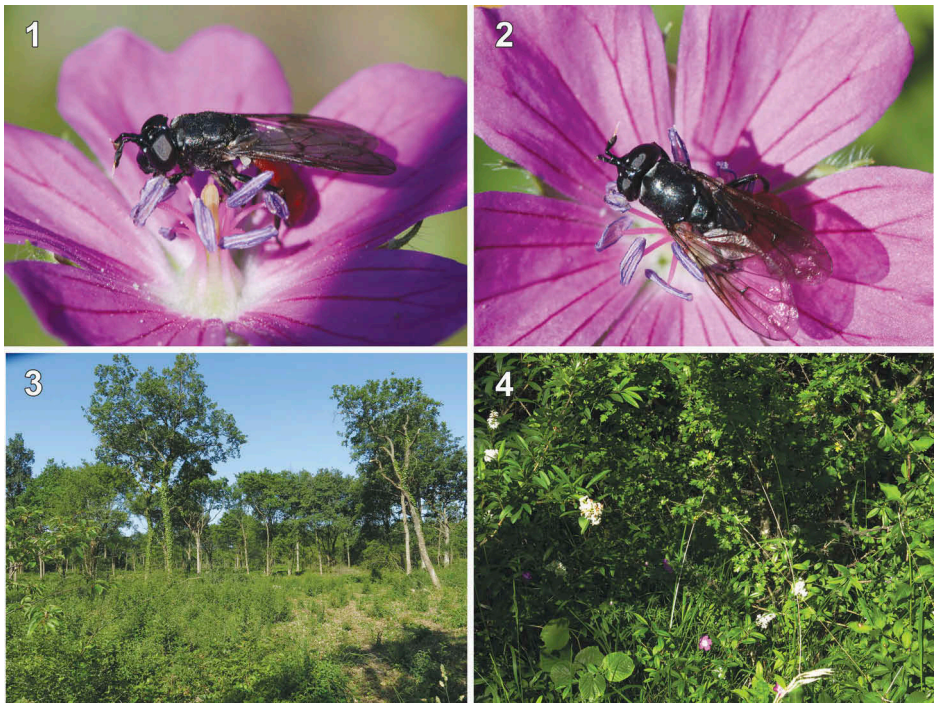
Syrphid nomenclature follows the last German checklist as part of the Red Data book publication (Ssymank et al. 2011). Plant names are used according to the German checklist of the floristic mapping scheme (Wisskirchen & Haeupler 1998).

The study area and its vegetation complexes

The study area is part of the "Colmarer Trockeninsel" (xeric island of Colmar), a region with a very warm and dry climate due to its position in the rain-shadow of the French Vosges mountains, sheltered from prevailing precipitation coming from the west. Annual average temperatures are *c*. 9.5–10°C with annual precipitation between 500 and 650 mm (on the German side near Grißheim). The soils are very shallow, calcareous Rendzina/Pararendzina on pebbles from the Rhine River. The vegetation is a mosaic of dry calcareous oak-forests [*Potentilla albae–Quercetum petraeae* Libbert 1933] in different stages of regrowth mixed with patches of dry calcareous grassland [*Bromion erecti* Koch 1920] (Figure 3) with (in some localities) abundant populations of *Dictamnus albus* L. and dry bushes of the *Berberidion vulgaris*-alliance Braun-Blanquet 1950, mainly *Crataegus monogyna* Jacq., *Ligustrum vulgare* L. and *Sorbus aria* (L.) Crantz. Interfaces between forest or bushes and grassland have fringes of the *Geranion sanguinei*-alliance Tüxen in Theo Müller 1961 (Figure 4), usually with *Geranium sanguineum* L., *Tanacetum corymbosum* (L.) Sch. Bip., *Anthericum liliago* L., *Campanula persicifolia* L. and orchids such as *Plathanthera bifolia* (L.) Rich. The forest-shrub and dry grassland mosaic is the result of and maintained by a traditional method of wood-cutting, known as coppicing (or "Taillis et Taillis sous futaie" in France: Bastien 2002). In this traditional method, young tree stems are repeatedly cut down to near ground level. In subsequent years, many new shoots emerge and after a number of years (20–30) the coppiced tree is ready to be harvested, and the cycle begins again. The coppiced woodland is harvested in very narrow strips, numbered according to the year in which they were harvested. Some oak trees have longer cycles, allowing them to grow longer. As a result, the forest has an oak canopy with low coverage and a small scale mosaic is present with all forest stages on the site. The wood from trees with short cutting cycles is used for making fire, and the wood from trees with longer cycles is used for buildings, barrels, etc.

Results

A total of 288 specimens belonging to 37 species were collected in the sampling localities (Table 1); additionally, 80 observed specimens were also recorded. The main types of the vegetation mosaic clearly had different assemblages of adult syrphids. A detailed species list is given in Table 2. Red-listed species were collected during this survey: two Critically Endangered (including *P. abdominalis*), one Endangered and four Near Threatened (see Table 2).



Figures 1–4. **1**, Female of *Psarus abdominalis* on the flower of *Geranium sanguineum* L. (10.VI.2014, locality 3). **2**, Dorsal view of a female of *P. abdominalis* on *G. sanguineum* (10.VI.2014, locality 3). **3**, General view of the *Quercus* forest of the "Colmarer Trockeninsel", near Dessenheim (locality 2). **4**, Detailed view of the habitat where *Psarus* was collected (locality 3). All photos by A. Ssymank.

Psarus abdominalis was only seen flying along the dry forest fringes or close to bushes where *Geranium sanguineum* was flowering in the calcareous dry grassland. All flower visits observed for *P. abdominalis* were on *Geranium sanguineum*, both males and females, where they were difficult to see among the numerous specimens of *Eumerus ornatus* Meigen 1822, also visiting the same flowers. The authors also observed several *Chrysotoxum* species, *Pipizella viduata* (L. 1758), *Xanthogramma stackelbergi* Violovitsh 1975, *Sphaerophoria chongjini* Bankowska 1964 and *Sphaerophoria scripta* (L. 1758) in the same microhabitat. On the leaves and twigs we also observed the stratiomyid *Chloromyia speciosa* (Macquart 1834) in large numbers, which prefers dry thermophilous vegetation.

All observations of *Psarus abdominalis* were made during a very short time span in the morning, mainly between 08.30 and 09.00 MEST. The latest observations were at 09.30 directly after dew on the flowers had been dried off by the rising sun, when it was already quite hot and dry. At first, *Psarus abdominalis* was seen only on sunny flowers of *Geranium sanguineum*, but later it was also found in partly shady places between bushes. *Ligustrum vulgare* L. was also in flower, but it was visited mainly by *Eristalis tenax* (L. 1758), *E. pertinax* (Scopoli 1763), *Helophilus pendulus* (L. 1758), and *Myathropa florea* (L. 1758). Where the development stages of the forest formed a dense shrub canopy and even the forests paths were shady, *Episyrphus balteatus* (De Geer 1776), *Meliscaeva auricollis* (Meigen 1822), *Volucella pellucens* (L. 1758), *Volucella inflata* (Fabricius 1794), and *Xanthandrus comtus* (Harris 1780) were flying.

Molecular taxonomy

A main goal of this survey was to provide molecular data on *Psarus abdominalis* as part of the GBOL efforts to build a reference library of DNA barcodes. Before this survey, only one barcode of *P. abdominalis* was available in GenBank (accession number AY533318), from a specimen collected in France [France: Elsass, Dessenheim b. Colmar, 3.VI.1999, D. Doczkal]. In BoldSystems (http://www.boldsystems.org/), the online database for DNA barcodes, there is a private record for a *Psarus* specimen from the Zoologische Staatssammlung München (BC-ZSM-DIP-01061), collected on 23.VIII.1997 between Ergersheim and Kehrenberg (Upper Bavaria, Germany).

From the eight specimens we collected, we obtained DNA barcodes for four of them, each of 658 nucleotides (BOLD Process IDs: GBOSY001-15, GBOSY002-15, GBOSY003-15, GBOSY004-15). The sequence in GenBank (AY533318) is the longest at 1182 nucleotides, but misses the first 209 nucleotides of the Folmer fragment, at the 5′ end. Comparisons show three different COI

Table 2. List of species collected in Alsace.

Species	Author	Localities	Number of specimens	Red List category in Alsace
Baccha elongata	(Fabricius, 1775)	1	1♂	LC
Cheilosia soror	(Zetterstedt, 1843)	1	1♂, 1♀	LC
Chrysotoxum bicinctum	(Linnaeus, 1758)	3, 5	2♂♂	LC
Chrysotoxum cautum	(Harris, 1776)	1, 2, 3	5♀♀, 1x	LC
Chrysotoxum elegans	Loew, 1841	3	1♀	EN
Chrysotoxum festivum	(Linnaeus, 1758)	1, 5	2♂♂	LC
Chrysotoxum vernale	Loew, 1841	1	1♂	LC
Chrysotoxum verralli	Collin, 1940	1	1♂	LC
Doros profuges	(Harris, 1780)	3	1♀	CR
Episyrphus balteatus	(De Geer, 1776)	1, 2, 3, 5	9♂♂, 10♀♀, 28x	LC
Eristalis pertinax	(Scopoli, 1763)	1	7♂♂	LC
Eristalis tenax	(Linnaeus, 1758)	2	4♂♂,1♀	LC
Eumerus ornatus	Meigen, 1822	1, 2, 3	88♂♂, 47♀♀, 9x	LC
Eupeodes corollae	(Fabricius, 1794)	1, 3	4♂♂, 2♀♀	LC
Eupeodes luniger	(Meigen, 1822)	2	1♂	LC
Helophilus pendulus	(Linnaeus, 1758)	2, 3, 5	4♂♂, 5♀♀	LC
Melanostoma mellinum	(Linnaeus, 1758)	1, 2, 3, 4, 5	10♂♂, 9♀♀, 40x	LC
Melanostoma scalare	(Fabricius, 1794)	5	1♀	LC
Meliscaeva auricollis	(Meigen, 1822)	1, 2, 6	1♂, 4♀♀	LC
Microdon devius	(Linnaeus, 1761)	4	2♂♂	NT
Microdon mutabilis / M. myrmicae	(Linnaeus, 1758) / Schönrogge et al. 2002	2, 3	2♂♂, 3♀♀	DD
Myatropha florea	(Linnaeus, 1758)	1, 2	1♂,3♀♀	LC
Paragus haemorrhous	Meigen, 1822	1, 5	2♂♂	LC
Pipizella viduata	(Linnaeus, 1758)	5	1♂	LC
Platycheirus occultus	Goeldlin, Maibach & Speight, 1990	5	1♂	NT
Platycheirus scutatus	(Meigen, 1822)	2	1♂	LC
Psarus abdominalis	(Fabricius, 1794)	1, 2, 3	5♂♂, 3♀♀, 1p	CR
Sphaerophoria chongjini	Bankowska, 1964	5	1♂	DD
Sphaerophoria scripta	(Linnaeus, 1758)	1, 3, 4, 5	6♂♂, 2♀♀	LC
Syritta pipiens	(Linnaeus, 1758)	2	1♂, 1♀	LC
Syrphus ribesii	(Linnaeus, 1758)	1, 2, 3, 5	3♂♂, 3♀♀	LC
Syrphus vitripennis	Meigen, 1822	1, 2	2♂♂	LC
Volucella inflata	(Fabricius, 1794)	1, 3	2♂♂, 1♀	NT
Volucella pellucens	(Linnaeus, 1758)	1	5♂♂	LC
Xanthogramma stackelbergi	Violovitsh, 1975	1, 2, 5	4♂♂, 5♀♀	DD
Xanthandrus comtus	(Harris, 1780)	1, 5	2♂♂, 2♀♀	NT
Xylota sylvarum	(Linnaeus, 1758)	5	1p	LC

Red list categories are: CR, Critically Endangered – extremely high risk of extinction in the wild; EN, Endangered – high risk of extinction in the wild; NT, Near Threatened – likely to become endangered in the near future; LC, Least Concern – not threatened category; DD, Data Deficient – not enough data to make an assessment of its risk of extinction. Legend: ♂ = male; ♀ = female; p = only observations, male specimens; x = only observations, without sex.

haplotypes from five *Psarus* specimens: GBOSY003-15 is unique, GBOSY002-15 and GBOSY004-15 share the same nucleotide sequence, and GBOSY001-15 has the same sequence as AY533318 for the overlapping fragment (449 nucleotides). The largest uncorrected pairwise distance among *Psarus* specimens is found between GBOSY003-15 and GBOSY002-15/GBOSY004-15, with a value of 0.304%.

Psarus abdominalis (Fabricius 1794)

Distribution. A total of eight specimens, five males and three females, were collected during the survey, and another male was observed (see Table 2). These are the first specimens of *Psarus abdominalis* collected in Central Europe since 1999 (Ståhls et al. 2004), and in the Haut-Rhin department since 1989 (Dussaix 1999) and 1992 (Stuke 2000).

The first distributional range for *Psarus abdominalis* was provided by Peck (1988). Speight (2013) gives a similar distributional range for this species. Following Speight (2013), *Psarus* can be found from southern Sweden, south through the Netherlands and Belgium to central France; from Brittany eastwards through central Europe (including the Rhine valley in Germany, and Switzerland) to Romania and the European parts of Russia; and in Italy and the former Yugoslavia. Most of the records from these countries are older than 1950, and

Psarus has been declared extinct or "disappeared" in some countries. Below, we present a summary of the records for each country where *P. abdominalis* has been recorded.

Austria. Strobl (1909) mentioned one *Psarus* male from Steiermark (currently Styria). The locality was Lichtenwald, which is now Sevnica in Slovenia (2014 letter from M de Groot to XM; unreferenced). Consequently, the occurrence of *Psarus* in Austria can be considered doubtful.

Belgium. The last record of *P. abdominalis* for Belgium was from 1937. Verlinden & Decleer (1987) stated that this species "has apparently disappeared from all north-west Europe". Verlinden (1991) declared *Psarus* extinct in Belgium, and pointed out that the species has been only recorded in the eastern part of the country (Kempen District). In the last checklist of the Syrphidae for Belgium (Van de Meutter 2011), *Psarus* was not recorded.

Bulgaria. Drensky (1934) listed *Psarus* from Bulgaria. Bańkowska (1967) reported several specimens of *P. abdominalis* collected in 1959 from two localities: Gramatikovo and Petrich. Dirickx (1994) presented a few records from western Bulgaria, but gave no additional information. John Smit (2014 letter from J Smit to XM; unreferenced) collected a female from Krusevetc, 20 km E of Sredec, on 4.V.2006, which is the last known record from this country.

Croatia. Langhoffer (1919) listed *P. abdominalis* from Zagreb. Glumac (1972) cited the species for Croatia. Dirickx (1994, map 423, p. 272) reported a record between Croatia and Slovenia, probably the one from Zagreb by Langhoffer (1919).

Czech Republic. Sack (1930) listed the province of Silesia (Schlesien) for *Psarus*, a region of Central Europe now located mostly in Poland, with smaller parts in the Czech Republic and Germany. Farkač et al. (2005) included *Psarus abdominalis* in their list of threatened species in the Czech Republic. Mazánek (2009) also listed *Psarus* for this country.

England. Walker (1849) listed two specimens of *Psarus* from France and England, one for each country. Verrall (1901) cited *Psarus* for the British Isles based on Walker (1849), but said there was no evidence for any British specimen in the Natural History Museum in London. Speight (1988) thought that *Psarus* may have been in Britain, but may subsequently have become extinct. Since then, no other author has included *Psarus* in any British checklist (Ball et al. 2011).

France. Probably the country in Central Europe where *Psarus* has been recorded most recently. Fabricius (1794) described *Syrphus abdominalis*, citing as the type locality "in Gallia" (France). Speight (1988) mentioned some specimens from the vicinity of Paris. Sarthou et al. (2010) recorded this species in several French departments based on previous publications, mainly Séguy (1961) and Dussaix (1999, 2005, 2013). The species was found in the departments of Allier, Essonne, Eure, Haut-Rhin, Landes, Oise, Sarthe, Seine-et-Marne, Val d'Oise, Var, Vosges, and Yvelines. In GBIF there is a record for *Psarus* from Alsace, Dessenheim (CEUA00018871, University of Alicante, Spain) collected on 15.VI.1988. The last record of *Psarus* in this part of France previous to our survey is the specimen used for molecular analyses by Ståhls et al. (2004), collected in 1999.

Germany. Sack (1908) mentioned two localities (Offenbacher Wald and Enkheimer Wald) for *Psarus*, and later on (Sack 1930) he mentioned several areas in Germany where *Psarus* could be found: Schwarzwald (at low altitudes in the calcareous hilly zone), Taunus, Harz, Rheinebene and Pommern (a former German region, now in Poland). However, no precise localities were given. *Psarus* was listed from Baden-Württemberg (Stuke 1999, 2000), Bavaria, and Saxony, and it is considered extinct in Thuringia, Hesse and Brandenburg (Ssymank et al. 2011). The last published record of *Psarus* for Germany was from the Grißheimer Trockenaue in 1982 (Stuke 2000). Later unpublished records exist from Bavaria near Ergersheim in 1997 (2014 letter from K von der Dunk to AS; unreferenced; BoldSystems, see Molecular taxonomy above).

Greece. Standfuss & Claußen (2007) reported the first record of *Psarus* for Greece, a female from Thessaly collected in a small organic olive plantation. Gerard Pennards (2014 letter from G Pennards to XM; unreferenced) caught a female in Nomos Akhaias (700 m., 37°54.46′N, 22°04.42′E, 22.IV.2005, S. Blank & C. Kutz), the second Greek record known to the authors.

Hungary. Kowarz (1873) listed this species for Hungary and Tóth (1978) recorded it from Szigliget (west Hungary). Tóth (2001) mentioned other specimens, but these were destroyed by a fire in November 1956.

Italy. Rondani (1857) listed *P. abdominalis* for Italy. Dirickx (1994) in his catalog pointed out the absence of this species from peninsular Italy because only records from northern areas were known. Daccordi (1995) listed *Psarus* from northern Italy.

Moldavia. Popov (2009) listed Moldavia in the distributional range of *P. abdominalis*.

Latvia. *Psarus* was listed from Latvia by several authors (Kuznetzov 1993, Kuznetzov & Kuznetzova 1996; Karpa 2008).

Lithuania. Gaidienė (1993) listed one specimen from Lithuania, and Pakalniškis et al. (2006) also included *Psarus* as Lithuanian.

Macedonia. Glumac (1968) reported records from 1958 to 1960, and then (Glumac 1972) listed the species for Macedonia. Dirickx (1994, map 423, p. 272) reported a record from Macedonia, but no additional data was given.

Poland. Sack (1930) listed the province of Silesia (Schlesien) for *Psarus*. Bańkowska (1963) mentioned that *P. abdominalis* may be found in Pomerania and Warsaw area. Bańkowska (1982) reported *Psarus* from the Mazovia region. There is a record in GBIF (CEUA00018870, University of Alicante, Spain) from Nowa Góra, Mts. Pieniny (Małopolskie) collected on 10.VIII.1960.

Romania. Şuster (1959) cited *Psarus* from the Ceahlău Massif, Bacău region. Brădescu (1986) confirmed the presence of *P. abdominalis* from the Domogled-Cerna valley, but Brădescu (1991) outlined a larger distribution in Romania.

Russia. Stackelberg (1989) mentioned several regions of the European part of Russia where *Psarus* was present: northwest, centre and south. Barkalov (2002) cited *Psarus abdominalis* from the Russian plain. Popov (2009) said that *Psarus* could be found in European Russia, from Leningrad southwards to Rostov Oblast, from the Baltic region eastwards to the Volga in the Chuvash Republic and Lower Volga Region. Gerard Pennards (2014 letter from G Pennards to XM; unreferenced) has a recently collected male from near Kasimov, Ryazan region (54°58′8.4″N, 41°19′37.2″ E, 17.VI.2013, N. Vikhrev).

Slovakia. Mazánek (2009) listed *Psarus* for this country.

Slovenia. De Groot & Govedic (2008) reported a mention of *Psarus* from Strobl (1909). Strobl (1909) mentioned Lichtenwald as the locality for the only male he studied in his work "Die Dipteren von Steiermark". Lichtenwald is an old name for Sevnica (2014 letter from M de Groot to XM; unreferenced).

Sweden. *Psarus* was declared "disappeared" in Sweden by Andersson et al. (1987). Bartsch (2009) said that *Psarus* was "formerly known from Skåne (southern Sweden) [latest record from 1913], but it is now considered regionally extinct in Sweden". All Swedish records are from July.

Switzerland. Maibach et al. (1992) reported *Psarus* from Switzerland, based on Schoch (1889). Later, Maibach et al. (1998) affirmed that one of the authors had seen at least one specimen of Swiss provenance.

The Netherlands. Van der Goot (1981) mentioned that most of the Dutch records of *Psarus* are from the early 1900s, when it seems the species was more abundant. It has been declared extinct [disappeared] in Netherlands, since the last record was from 1972 (van Steenis & Barendregt 2002; Reemer et al. 2003, 2009).

Turkey. Bischof (1905) reported two specimens collected in "Erdschias-Dagh", also known as Mount Erciyes, an area close to the city of Kayseri (Kayseri province in the Central Anatolia Region, Turkey). Dirickx (1994) mentioned Bischof (1905) as the sole record for Turkey. Saribiyik (2014) also listed *Psarus* from Kayseri province.

Ukraine. There are many references reporting *P. abdominalis* from Ukraine or as a part of the USSR. Zaika et al. (2011) reported the most recent records from Ukraine (in 2010) and gave its distribution (provinces of Kiev, Luhansk, Donetsk and Kharkiv).

Petersen & Bygebjerg (2001) mentioned that *Psarus* is likely to occur in Denmark based on its distribution, although it has been never collected in this country.

Based on the above information, it seems that *P. abdominalis* is a very rarely collected species in Europe. It seems to have vanished from northwest Europe and to be declining sharply in Central Europe; it is probably more widely distributed in Eastern Europe, although only as scarce, occasional records from what are probably small populations.

Biology. The immature stages of *P. abdominalis* are unknown. Based on current information, the larvae might be related somehow with *Geranium sanguineum*, although *Psarus* has been found in localities where this plant is absent.

Speight et al. (2013) say that *Psarus* is monovoltine, and adults may be found from late May to late July or early August (Verlinden 1991; Popov 2009; Speight 2013). On the other hand, Glumac (1968) reports a female specimen collected on 23–29.VIII.1958, and another male specimen collected on 1.IX.1959. The private record from Ergersheim was also collected in late August.

Behavior. Based on literature and personal experience, the preferred environments for this species are well-drained *Quercus* forest with mature/overmature trees and a diverse ground herb flora. Stuke (2000) observed *Psarus* in dry oak forests with a well-developed shrub layer, and along sunny, sheltered forest edges on calcareous ground. Adults have been seen flying along woodland paths and roads and at forest edges (Stuke 2000; Speight 2013; pers. obs.). Males of *P. abdominalis* have been seen sitting in the sun on the end of dead branches of trackside trees or on the underside of leaves (Sack 1932), returning to particular branches repeatedly (Speight 2013). On hot days, after rain, this species visits temporary puddles of water on forest tracks to drink (Speight 2013).

Glumac (1968) indicated a variety of habitats where *Psarus* had been collected in Macedonia: meadows with *Euphorbia* sp., bushes with flowers of *Crataegus monogyna* Jacq., on flowers of *Malva sylvestris* L., on

Eryngium campestre L., on *Convolvulus arvensis* L., on leaves of *Rubus* sp., riparian meadows with *Heracleum sphondylium* L., and also on flowers of *Anthriscus sylvestris* (L.) Hoffm. Popov (2009) mentioned that adults of *Psarus* visit and feed from flowers of the smoke tree, *Cotinus coggygria* (Scop.). In addition, based on the literature he gives other plants from which adults have been collected: *Berteroa* DC., *Dianthus* L., *Geranium* L., *Potentilla* L., and *Veronica* L. More recently, Dussaix (2013) reported *Psarus* from a flower-rich roadside verge on sandy soil on the border of a *Pinus pinaster* Aiton dominated forest with *Quercus*.

Stuke (2000) mentioned that *Psarus* adults might be found only on flowers of *Geranium sanguineum* L. in Central Europe. Specimens collected in this survey were found on these flowers very early in the morning, only between 8:00 and 9:30 am: syrphid activity lasted until 11:00–11:30 am (but not later) when the temperature was over 30°C. Adults were seen on the flowers, in a perpendicular position to the stem, spinning in circles like a small bee, but also perched on a petal in a more common position.

Mimicry. Adults mimic solitary parasitic bees of the genus *Sphecodes* Latreille 1804 (Hymenoptera: Halictidae). During our survey, we observed and collected several *Sphecodes* specimens at the same collecting points.

Conservation. The conservation status and ranking system of the IUCN Red List of Threatened Species is the best-known worldwide, but its application to Diptera is not straightforward due to the lack of surveys actively looking for potentially threatened species (IUCN 2001). *Psarus abdominalis* has not yet been assessed/evaluated for the IUCN Red List, although Speight (1988) already stated clearly the need to protect this species.

Speight et al. (2013) avoided using the IUCN threat categories due to the heterogeneous nature of existing syrphid data, and so their estimates of threat status were based simply on the best available expert judgment, which is perfectly fine according to the IUCN. Speight et al. (2013) listed *Psarus abdominalis* as threatened, which means that this species is probably threatened with extinction in the geographical area concerned, in all European states where it is present. Contrarily, Vujić et al. (2001) said that *Psarus* is not threatened in the Balkan Peninsula, while Glumac (1968) said that *Psarus* is a usual species in Macedonia, but not in the rest of Europe. However, Glumac (1968) is not a recent work, and Vujić et al. (2001) made a general statement without providing details. Thus, we think that the current situation, even in the Balkan Peninsula, needs a re-evaluation.

Speight et al. (2013) also pointed out that *P. abdominalis* is decreasing in France; this means that although not yet recognizably threatened, there has been a noticeable decrease in numbers and/or range within the geographical area concerned during the twentieth century. More recently in France, *Psarus* was listed as Critically Endangered for the Alsace region (Treiber 2014), i.e. there is an extremely high risk of extinction in the wild.

In Germany, *P. abdominalis* is considered to be "threatened with extinction" and extremely rare. Before 1930 in Germany, *P. abdominalis* was known from seven different map squares (*c.* 10 × 10 km²) distributed over five Federal States (Bavaria, Baden-Württemberg, Brandenburg, Hesse and Saxonia). Since 1980 there have only been records from two squares, in Bavaria and in Baden-Württemberg close to the French population in Alsace. Ssymank et al. (2011) mentioned the apparent sharp decline of this species over the long term, and a similar sharp decline was indicated by Popov (2009) for Ukraine.

Limiting factors or causes for this decline are not established. This species is evidently a victim of forest clearance and forest management throughout Western Europe (Speight 1988), while the dwindling amount of broad-leaved habitats with forest grazing is considered the most important declining factor in southern Sweden (Bartsch 2009). Popov (2009) also referred to deforestation and forest management as causes of its decline in Western Europe, although he proposed another possible factor: a critical relationship with certain endangered plant associations and/or plant species.

Regular flooding of its habitat (Grißheimer Trockaue) would destroy grasslands and might diminish or wipe out *Psarus* populations (Stuke 2000). Interestingly, the localities in the Grißheimer Trockaue in Germany where Stuke (2000) reported the species are secondary habitats only established after the Rhine correction. Carried out by the engineer Johann Gottfried von Tulla and complete by 1862, this shortened the Rhein River by 81 km and lowered the ground water table substantially, which allowed the development of dry oak forest with a mosaic of dry shrub vegetation with *Hippophae rhamnoides* L., *Crataegus monogyna* Jacq., etc. Thus *Psarus abdominalis* can in principle recolonize new habitats under certain conditions. Whether the species was present in primary dry oak forests in the German Rhine valley before these were cleared, is not known.

As the distribution of *Geranium sanguineum* is much wider than the actual distribution of *Psarus abdominalis*, and many thermophilous forest fringes with Geranion sanguinei vegetation still exist, we assume that a distinct mosaic of microhabitats in warm dry climate is necessary to support *Psarus* populations. This kind of mosaic is possibly related to the specific forest use called "coppice with standards" [in German "Mittelwaldwirtschaft"; in French "taillis sous futaie"]. This historic form of forest use was widespread in oak and oak-hornbeam forests in the Middle Ages, and lasting until the last century when it almost vanished in Germany, with the exception of a few

localities. *Geranium sanguineum* may simply be the only flower observed to be visited by *Psarus abdominalis* because it delivers a lot of nectar and yet is an open flower, easily accessible to species with a relatively short proboscis. Some wild bee species are known to use *Geranium sanguineum* flowers for nectar, while they use different pollen sources to provide supply for their offspring (Westrich & Schmidt 1986).

Psarus seems to be a rare and little-known species across its entire distributional range, and hence may become extinct in the wild. The fact that it is the only species in its genus and is endemic to Europe makes its status of greater significance. If ever there were a syrphid which required special protection measures to ensure its survival in Europe, then *P. abdominalis* is it (Speight 1988). Bartsch (2009) suggested preserving grazing in open deciduous forests and pastures in southern Sweden, but appropriate conservation measures to protect *Psarus* and its habitat are not yet definable.

Recent records from Bulgaria, Russia and Greece may perhaps indicate that the species is rare, low in number and circumscribed to specific habitats. Accordingly, *Psarus* might be threatened locally due to an observed/inferred population reduction, a decline in the area of occupancy and number of locations, and habitat fragmentation (mature oak forests). Nevertheless, French populations of *Psarus* in Alsace have some genetic variability, based on the DNA barcodes obtained during this survey. A population-genetic study would give us better information.

The importance of the studied area, the so-called "Colmarer Trockeninsel", is highlighted by the number of endangered species collected, i.e. two species Critically Endangered [*P. abdominalis* and *Doros profuges* (Harris 1780)], one Endangered [*Chrysotoxum elegans* Loew 1841], and four Near Threatened [*Microdon devius* (L. 1761), *Platycheirus occultus* Goeldlin, Maibach & Speight 1990, *Volucella inflata* (Fabricius 1794), *Xanthandrus comtus* (Harris 1780)]. If these syrphid communities are related to forest use and forest management, it is also in our hands to preserve this habitat and their insect diversity.

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