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Anisops sardeus (Heteroptera): A new expansive species in Central Europe

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Abstract: Although insects form a large part of the aquatic fauna worldwide, expansive species of aquatic insects are quite rare. Recently, we can observe a tendency to the range expansions in several aquatic insect species. Here, we present the first record of water bug species *Anisops sardeus sardeus* (Heteroptera: Notonectidae) from Slovakia. This is the northernmost record of this small-bodied backswimmer which is native to Sahelo-Sindian area, extending to Mediterranean. However, the species shows recent range expansion northward in Europe. We document the current distribution of *A. s. sardeus* in Slovakia and Europe, and discuss the drivers of expansion and possible impact of the alien species on resident fauna.

Key words: *Anisops sardeus;* aquatic Heteroptera; alien species; aquatic insect invasions; Slovakia

Introduction

Biological invasions of fresh waters are numerous and the threat posed by invasive species on biodiversity is widely recognized (Strayer 2012). Although insects form a large part of the aquatic fauna worldwide, invasive species of aquatic insects are quite rare. Karatayev et al. (2009) recognized that only 0.01% of North American and 0.06% of European freshwater insects were listed among invaders, and only 2.6% of freshwater invaders in North America and 5.3% in Europe were insects.

The successful integration of alien species into native communities depends on (1) the ability of potential invader to create a population under local conditions and (2) the invasibility of native community (Moyle & Light 1996). The spread of invaders could be facilitated by the interactions between alien species and other stressors of freshwater ecosystems such as pollution and climate warming, to name the most important. Recently, we can observe a tendency to the range expansions in several species of aquatic insects in Europe. Global warming is supposed to be the important driving force behind the distributional shifts in dragonflies *Sympetrum meridionale* (Selys, 1841) and *Crocothemis erythraea* (Brullé, 1832), tiger mosquito *Aedes albopictus* (Skuse, 1894), stonefly *Leuctra geniculata* Stephens, 1836 and caddisfly *Hydropsyche exocellata* Dufour, 1841 (Lukáš 2004; Kenis 2006; Benedict et al. 2007; Pařil 2011). In Europe, only *Trichocorixa verticalis* (Fieber, 1851) is considered truly invasive water bug species (Rodriquéz-Pérez et al. 2009). On the other hand, there are several species that can be regarded as expansive, e.g., *Cymatia rogenhoferi* (Fieber, 1848) in Western Europe, mainly in Britain (Cianferoni 2013), *Lethocerus patruelis* (Stål, 1855) in Italy (Cianferoni & Nardi 2013), *Sigara iactans* Jansson, 1983 and *Microvelia pygmaea* (Dufour, 1883) in the Czech Republic and Slovakia (Kment & Smékal 2002; Kment et al. 2013).

This paper deals with the first record of *Anisops sardeus sardeus* Herrich-Schaeffer, 1849 in Slovakia. This small-bodied backswimmer belongs to the infraorder Nepomorpha, family Notonectidae, subfamily Anisopinae (Polhemus 1996). Among the Central European backswimmers, the species can be distinguished by (1) shorter, slender, and laterally slightly depressed body (7.2–8.4 mm), (2) whity translucent hemielytrae, (3) sensoric pit at anterior end of hemielytral comisure, and (4) large conical protuberance of male frons (Fig. 1). Diagnostic characters of *Anisops sardeus* were published, figured and keyed by Soós et al. (2010) and Berchi (2011). *Anisops* species live in temporal and permanent fresh, brackish and salt water ponds, lakes and springs with aquatic vegetation (Brooks 1951; Barry 1997). Interestingly, this Sahelo-Sindian species with distribution extending to Mediterraenan shows recent range expansion northward in Europe. Here, we document the current distribution of *A. s. sardeus* in Slovakia and Europe, and discuss the drivers of expansion and possible impact of the alien species on native fauna.

Material and methods

At the global scale, we conducted a review of published information on distribution of *Anisops sardeus sardeus* with special focus on the recent data from Europe.

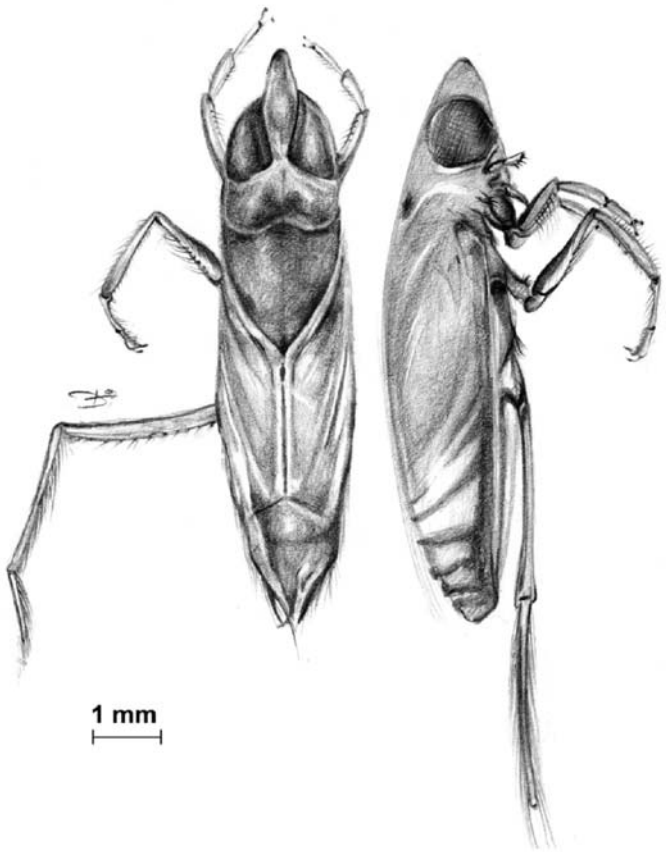

Fig. 1. Dorsal and lateral view of male *Anisops sardeus sardeus* from Radošovský rybník pond (orig. Denisa Svitková).

At the regional scale, we examined data from Slovakia that come from three sources: 1) our own material, 2) undetermined material provided by our colleagues and 3) published data. During 2010 and 2011, we made an extensive field survey of 103 sites scattered across the whole territory of Slovakia. We combined kicking method with sweeping of littoral and submersed vegetation and individual collection to obtain a species inventory as complete as possible. Material of water bugs was preserved in 70% ethanol in field and transferred to the laboratory for determination. Material was determined to the lowest possible taxonomic level using morphological keys (Tempelman & von Haaren 2009). Basic water parameters were measured at each site using WTW Multi 340i.

Our own data were supplied by undetermined material from 52 additional sites kindly provided for determination by our colleagues (for details see Acknowledgement).

Data on occurrence of *Anisops sardeus* in Slovakia have never been published (e.g., Hoberlandt 1977; Polhemus 1996; Aukema et al. 2013).

Results and discussion

Among 191 sites investigated for water bugs in Slovakia during the past 12 years (2000–2012), *Anisops sardeus sardeus* has been recorded at only one site, Radošovský rybník pond near Radošovce village (western Slovakia, 48°45′58.1″ N, 17°17′49.5″ E, 229 m a.s.l.) (Fig. 2). We collected the first specimen (1 male, leg. and det. B. Reduciendo Klementová) on August 27, 2011. Het-

Fig. 2. Position of sites investigated for aquatic Heteroptera in Slovakia during the last 12 years (2010–2012). Presence of *Anisops sardeus sardeus* is denoted by star.

eropteran assemblage at the site involved *Notonecta glauca glauca* (L., 1758), *Micronecta scholtzi* (Fieber, 1860), *Sigara striata* (L., 1758) and *Gerris lacustris* (L., 1758).

The pond area is about 1 ha and it was built on the Chropov stream for irrigation and flood control purposes. Nowadays, the pond is shallow (max. depth 1.5 m) and almost entirely filled with sediments. Due to the beaver activity and their damming practices, the open water area is fragmented into the system of small pools and channels. The bottom substrate is dominated by thick layer of mud and organic matter. Riparian vegetation consisted primarily of *Salix alba* covering ∼50% of pond surface. Basic water characteristics in the time of sampling were as follows: pH 7.58; conductivity 963 μS cm^{-1} and O_2 concentration 7.16 mg L^{-1} (O_2 saturation 91.6%).

Anisops s. sardeus has a wide distribution including Africa (tropical region, Algeria, Egypt, Libya, Morocco, Tunisia), Asia (Armenia, Azerbajan, Georgia, India, Iran, Iraq, Israel, Jordan, Lebanon, Myanmar, Saudi Arabia, Syria, Turkey, Turkmenistan, the United Arab Emirates, Yemen) and Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, France (Corsica), Greek, Italy (incl. Sicily and Sardinia), Malta, Portugal, Spain) (Brooks 1951; Polhemus 1996; Protić 1998; Katbeh 2000; Linnavuori & Hosseini 2000; Linnavuori 2009; Cianferoni 2011; Fent et al. 2011; Kment & Beran 2011; Linnavuori et al. 2011; Aukema 2013).

Recently, the species showed a tendency to spread its range northward (Fig. 3). New records have been reported from southern Russia, Hungary and Romania (Khatukhov et al. 2008, 2011; Soós et al. 2010; Berchi 2011), northern regions of Italy (Cianferoni & Pinna 2012; Cianferoni & Terzani 2013), and was rediscovered in Middle Dalmatian Islands (Croatia) after seven decades (Kment & Beran 2011). Based on the frequent findings of this species outside of its original distribution, we can conclude that this is regular trend rather than random occurrence. Western Slovakia is the northern boundary of the actual distribution of *A. s. sardeus*. Although the species has not been recorded from the Czech Republic yet, we can reasonably expect its presence also there since the distance from Radošovský rybník pond to the Czech state border is only about 7 km.

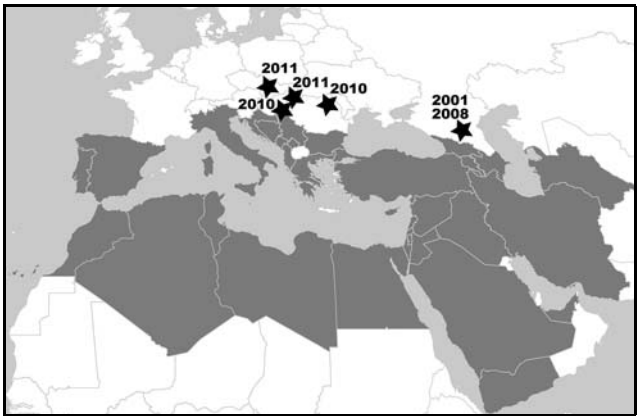

Fig. 3. Current distribution of *Anisops sardeus sardeus* in the Western Palearctic and nearby regions by countries (dark gray). Stars denote records of *A. s. sardeus* outside its native range. Dates of those findings are displayed.

The tendency to range expansion was observed for several true bug species. During the last decades, an increasing number of Heteroptera species have shifted their range margins northwards (Hickling 2006; Rabitsch 2008a, 2010). In Central Europe, Rabitsch (2008a) refers to the process as Mediterranization since most of the new species arrive from the native regions in Mediterranean.

However, aquatic insects are seldom recognized as expansive species (Kenis et al. 2007; Pyšek et al. 2010). Of the entirely aquatic orders of insects only the Odonata are noted as regular invaders (de Moor 1992). Karatayev et al. (2009) proposed four hypotheses which could explain the paucity of invaders among aquatic insects: (1) saturated niches due to the high diversity of insects in native communities, (2) the need to match both the aquatic and terrestrial environments for completion of their life history, (3) reproductive limitations due to an aerial adult stage, (4) vector limitations. In other words, resistance of native aquatic community and life history constraints of new colonizers are the main limitations of potential invaders among aquatic insects. Considering resistance to invasions, new colonizers of waterbodies have to face competitors and predators in native communities where most niches may already be saturated. However, biological invasions and climate change are integrated processes and changing climate affects populations of native as well as invasive species. The changed climatic conditions may alter population dynamics of native species and, thus, also their distributional ranges, the structure and composition of communities and functioning of ecosystems. Furthermore, an indirect effect of climate change might occur as some ecosystems become less resistant to invasive species or more resilient to their impacts under future climates. On the other hand, climate directly influences the likelihood of alien species being introduced into a territory and also affects their chances of naturalization (Walther 2009). Regarding life history constraints, aquatic bugs have many species which show excellent colonizer qualities in contrast to major aquatic insect groups such as Ephemeroptera, Plecoptera or Trichoptera (de Moor 1992). Specifically, backswimmers (Notonectidae), such as *A. sardeus,* are excellent fliers and belong to early colonizers of newly created waterbodies (Schaefer 2003). In combination with climate-induced changes in native communities, aquatic Heteroptera may become successful invaders.

A recent review (Musolin 2007) suggests that terrestrial and aquatic Heteroptera species respond to climate change by shifting their distributional ranges, changing abundance, phenology, voltinism, physiology, behaviour, and community structure. Depending on climate scenario, global average surface temperature is predicted to increase in likely ranges from 1.1 to 6.4 ℃ during the 21st century (IPCC 2007). The ongoing warming is expected to further widen the distributional ranges and increase the abundances of heteropteran species invading new regions (Rabitsch 2008a). We suppose that climate warming has enabled *A. sardeus sardeus* to expand into regions in which the species previously could not survive and reproduce.

In Slovakia, we have recorded a single specimen of *A. sardeus sardeus* at only one site. Thus, we are unable to confirm its reproduction, and further work is required to decide whether the species is invasive or not. However, *A. sardeus sardeus* becomes relatively frequent in Hungary (Petri et al. 2012) and establishment of this species in the local heteropterofauna is suggested (Boda et al. 2012). Yet, *Trichocorixa verticalis verticalis* (Fieber, 1851) is the only aquatic bug species recognized as alien in Europe (Rabitsch 2008b). This species exhibits invasive character in some saline wetlands of south-western Iberian Peninsula where *T. verticalis verticalis* established dominant reproductive populations and overwhelmed native corixid species (Rodriquéz-Pérez et al. 2009).

The potential impact of *A. sardeus* on native communities is unknown. Backswimmers, generally, are aggressive predators, attacking pelagic and benthic invertebrates and also small invertebrates such as fish larvae and amphibian tadpoles, and therefore are recognized as important organizers of freshwater foodwebs (Balustein 1998; Papáček 2001). Specifically, *A. sardeus* can restructure the aquatic community by direct consumption of prey. Also, the prey behaviour may change as a response to presence of this new predator (Eitam et al. 2002). Inter-specific competition with other water bugs is also very likely to occur. However, prediction of the effect of an alien species on freshwater communities is difficult. Either the invader or the resident community may change with global warming and the resulting "no-analogue" ecosystems might be largely unpredictable (Strayer 2010). Therefore continual monitoring of alien species is an essential tool to predict the success and effects of invading species under multiple stressors.

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