Has Aeshna viridis Eversmann, 1836 (Odonata: Aeshnidae) really disappeared from southern Poland (East-Central Europe)?

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Has *Aeshna viridis* EVERSMANN, 1836 (Odonata: Aeshnidae) really disappeared from southern Poland (East-Central Europe)?

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ABSTRACT. 50-100 years ago the southern boundary of the distribution area of *Aeshna viridis* ran through southern Poland. However, no records of this species from this area have been reported since then. The species is therefore considered as having retreated northwards. The present research disclosed three new sites of *A. viridis* on the edge of or just beyond its historical distribution area: one in south-western Poland (Trestno: 51º04'N, 17º08'E) and two in the south-east of the country (Krasiczyn: 49º46'N, 22º38'E, Bolestraszyce: 49º49'N, 22º51'E). All the sites were anthropogenic. This demonstrates the survival of a number of populations and the formation of new ones in water bodies formed *de novo* or to which *Stratiotes aloides* was introduced artificially. This suggests that the conservation of *A. viridis* is possible in this region.

KEY WORDS: Odonata, *Aeshna viridis*, Poland, distribution, decline, anthropogenic habitats, protection.

INTRODUCTION

Aeshna viridis EVERSMANN, 1836 is a Siberian zoogeographical element in the European fauna. Its current distribution is described as Palaearctic (BERNARD et al. 2009). It occurs from Siberia to the Netherlands (DIJKSTRA & LEWINGTON 2014). The boundary of its distribution area in East-Central Europe runs, inter alia, through Poland. Historically, it ran

through the southern part of the country, but nowadays *A. viridis* occurs mainly in northern Poland (BERNARD et al. 2009). The regress of this species is even more noticeable in Ukraine (GORB et al. 2000), whereas to the west of Poland *A. viridis* has already been designated "critically endangered" (OTT & PIPER 1997) or at best "vulnerable" (TERMAAT & KALKMAN 2012). For these reasons, all data on its occurrence along the southern border of its distribution area is invaluable. This is all the more significant because *A. viridis* is mentioned in two important European Legislation Acts. One is the Bern Convention on the Conservation of European Wildlife and Natural Habitats from 1979, the other is the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. In accordance with these acts, *A. viridis* is protected by law throughout the European Union, including Poland. In this context, therefore, all fresh faunistic data on this species is invaluable for its potential conservation and protection.

We searched for sites of *A. viridis* on the edge of its distribution area in southern Poland. The aim of the study was to test the assumption that some previously unknown or historical populations of *A. viridis*, occurring in areas not explored for many years, could have survived there.

MATERIAL AND METHODS

The fieldwork in south-western Poland was carried out between 2011 and 2014 in the Silesian Lowland, together with the Trzebnica Upland and the Milicz-Głogów Depression in the north and the Sudetic Foreland as far as the Central Sudetes in the south. The largest concentration of explored sites was in the Wrocław Plain mesoregion and the Wrocław Proglacial Valley (KONDRACKI 2000). The sites were selected for the presence of *Stratiotes aloides* LINNAEUS, 1753. Site research was based on Polish and German historical information, contemporary literature and Internet sources (ŚWIERKOSZ et al. 2012a, 2012b, GN 2014, SZTWIERTNIA 2014), data provided by botanists from the University of Wrocław and the Wrocław University of Environmental and Life Sciences, data obtained from the analysis of maps and satellite images from Google Maps and Geoportal (geoportal.gov.pl), as well as our own data from previous studies of other Odonata species. Many former sites of *S. aloides* have vanished as a result of overgrowth or drying out. Nevertheless, the species was found at three sites. Dragonfly imagines were observed and exuviae were looked for at all these sites. The data set was derived from 75 sites.

The fieldwork in southern and south-eastern Poland was carried out in 2006-2009, 2011 and 2014 in the following areas: (1) from Goczałkowice to Rzeszów, including the Western Beskid Foothills and the western and central parts of the Central Beskid Foothills together with some adjacent areas; (2) the vicinities of Łańcut and Przemyśl (the Sandomierz Basin);

(3) selected sites at Krasiczyn (eastern edge of the Central Beskid Foothills); (4) the vicinities of Lesko, Solina and Baligród (Forest Beskid Mountains) (KONDRACKI 2000). Records of imagines usually contained the number of individuals, and details regarding metamorphosis and reproductive behaviour. Exuviae were collected sporadically from shore vegetation, and larvae were caught with a hydrobiological sampler. The data was obtained from 170 sites.

On the basis of the material, the identified species were described as: 1) autochthonous (when larvae were caught, exuviae collected, metamorphosis or numerous reproductive activities observed); 2) probably autochthonous (when few reproductive activities were recorded or numerous populations were sighted in an environment appropriate to the species); 3) recorded species (in all other cases).

The surface areas of the water bodies were measured with tools available on the Geoportal website (geoportal.gov.pl), and altitudes were specified according to Google Earth.

RESULTS

Aeshna viridis was found at three sites: one in the Silesian Lowland, one in the Central Beskid Foothills and one in the Sandomierz Basin (Fig. 1). The results are discussed below. To indicate accompanying species, two asterisks (**) were used for autochthonous species and one (*) for probably autochthonous.

1. Trestno ad Wrocław (51º04'58"N, 17º08'25"E, UTM: XS46, 180 m amsl), former clay excavations

The Trestno site, a complex of overgrowing clay excavations, is situated in the Wrocław Proglacial Valley mesoregion, in the direct vicinity of the River Oder, within the Blizanowice-Trestno floodplain. Biogeographically the site belongs to NATURA 2000, PLH020017 – Grądy in the Valley of the River Oder – an area of extensively used meadows and forests (mainly alluvial alder-ash and oak-hornbeam forests), with numerous canals, streams, oxbow lakes overgrown with aquatic and marsh vegetation, drainage ditches, backwaters and polders. *Stratiotes aloides* occurred in two water bodies at this site.

Water body no. 1 (Fig. 2), the largest one, approx. 0.40 ha in area, situated 180 m south-west of the Nadodrzańska Street, partly covered with beds of *Typha angustifolia* LINNAEUS, 1753, contains the highest accumulation of *Stratiotes aloides*, which occupies an area of ca 0.16 ha. To the south-west, this water body is surrounded by *Alnus glutinosa* GAERTNER, 1791 and *Salix fragilis* LINNAEUS, 1753. The shore vegetation consists of *Carex pseudocyperus* LINNAEUS, 1753, *Phalaris arundinacea* LINNAEUS, 1753, *Tanacetum*

vulgare LINNAEUS, 1753, *Erigeron canadensis* LINNAEUS, 1753, *Cirsium vulgare* LINNAEUS, 1753, *Bidens frondosa* LINNAEUS, 1753, *Rosa canina* LINNAEUS, 1753 and *Salix fragilis* LINNAEUS, 1753.

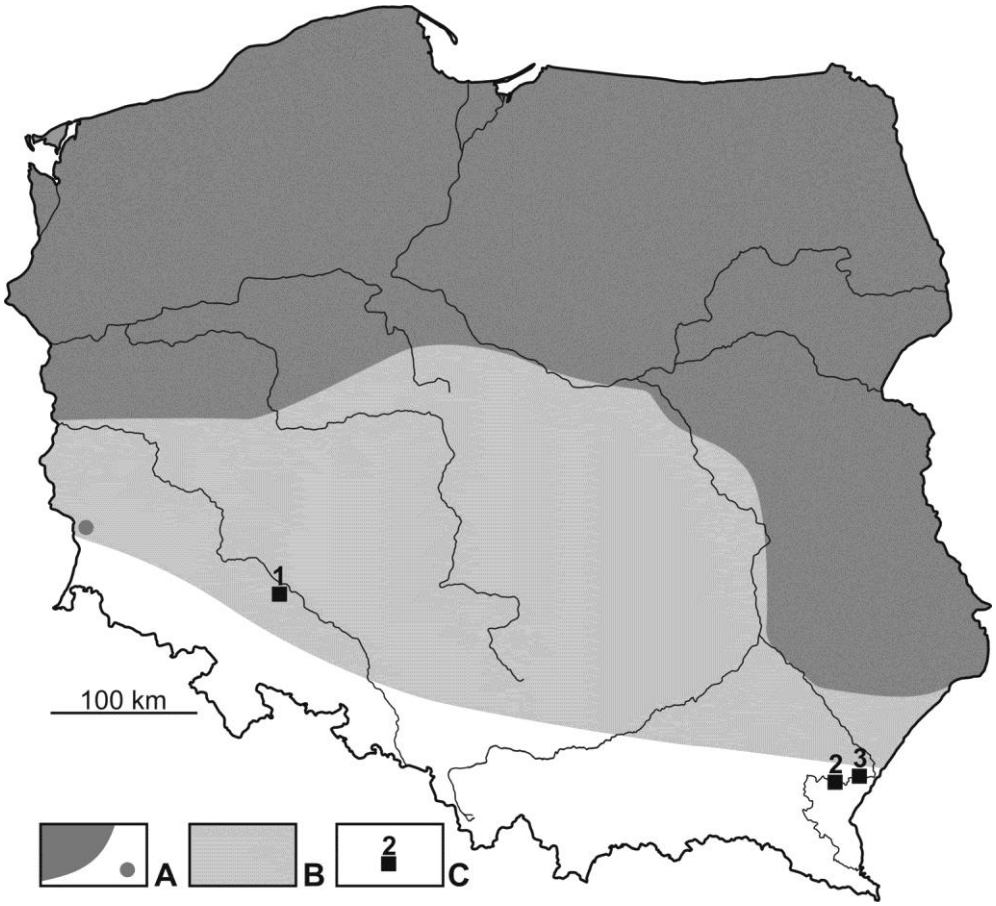

Fig. 1. Distribution area of *Aeshna viridis* in Poland (BERNARD et al. 2009) and new records of the species. A – current extent, B – probable historical extent, C – new records (numbering as in the text).

Water body no. 2 (ca 0.03 ha), situated 50 m from the floodbank, is surrounded by *Typha angustifolia* and entirely overgrown with *Stratiotes aloides*.

Fig. 2. Trestno, water body no. 1.

Water body no. 3 (0.065 ha), without *S. aloides*, situated in the neighbourhood of farmland and separated from it by just a narrow strip of shrubs, is an astatic water body, the water level of which depends on the amount of rainfall; fragments of alluvial plant communities are present. To the south this water body is surrounded by a hedge of *Salix cinerea* LINNAEUS, 1753 and *S. fragilis*. In this highly diverse, species-rich vegetation the dominants are *Eleocharis acicularis* (LINNAEUS, 1753) ROEMER et SCHULTES, 1817, *Carex pseudocyperus*, *Glyceria maxima* (HARTMAN, 1820) HOLMBERG, 1919, *Alopecurus aequalis* SOBOLEWSKI, 1799, *Sparganium erectum* LINNAEUS, 1753, *Ranunculus flammula* LINNAEUS, 1753, *Equisetum fluviatile* LINNAEUS, 1753, *Schoenoplectus lacustris* (LINNAEUS, 1753) PALLA, 1888 and the omnipresent *Typha angustifolia*.

Records of *A. viridis*:

– Water body no. 1: 17-08-2012, 30-07-2014 and 02-08-2014, each time 1♀ during oviposition on *Stratiotes aloides*. On 02-08-2014, 4 territorial ♂♂ were observed and one exuvium on *S. aloides* photographed (Fig. 3);

Fig. 3. Trestno, exuvium of *Aeshna viridis* on *Stratiotes aloides* – water body no. 1.

– Water body no. 3: 09-07-2013, 1♂ resting in the nearby wheat field; 23-07-2013, 1♂ in the wheat field; 30-07-2014, numerous ♂♂ and ♀♀ after sunset, hunting over the water body together with several ♂♂ *Aeshna affinis* VANDER LINDEN, 1820 and 1♀ *A. grandis* (LINNAEUS, 1758); 02-08-2014, numerous ♂♂ and ♀♀ hunting at dusk; 03-08-2014, 1♂ resting in the nearby shrubs (Fig. 4).

Except for a single examination, no follow-up observation was carried out in water body no. 2; accessibility was very difficult owing to the surrounding dense undergrowth and muddy bottom. Nevertheless, the presence of *A. viridis* seems to be obvious there.

Other Odonata species recorded during the research at this site (collectively): *Lestes sponsa* (HANSEMANN, 1823), *Sympecma fusca* (VANDER LINDEN, 1820), *Platycnemis pennipes* (PALLAS, 1771), *Coenagrion puella* (LINNAEUS, 1758), *C. pulchellum* (VANDER LINDEN, 1825), *Brachytron pratense* (O.F. MÜLLER, 1764), *Aeshna affinis*, *A. cyanea* (O.F. MÜLLER, 1764), *A. grandis*, *A. mixta* LATREILLE, 1805**, *Anax imperator* LEACH, 1815, *Gomphus flavipes* (CHARPENTIER, 1825), *G. vulgatissimus* (LINNAEUS, 1758), *Libellula quadrimaculata* LINNAEUS, 1758, *Orthetrum brunneum* (FONSCOLOMBE, 1837),

O. cancellatum (LINNAEUS, 1758), *Sympetrum danae* (SULZER, 1776)* and *S. sanguineum* (O.F. MÜLLER, 1764).

Fig. 4. Trestno, *Aeshna viridis* – ♂ resting close to water body no. 3.

2. Krasiczyn (49º46'27"N, 22º38'E56", FA11, 216 m amsl), pond in the park near the Krasicki Castle

The Krasicki Castle is situated on the right-bank of the San valley. In the nearby park there are two ponds: one is a pool surrounded by a concrete embankment 0.34 ha in area, only periodically filled with water but without any typical aquatic vegetation (the so-called lower pond); the other pond (the upper pond) (Fig. 5) is a permanent one 1.4 ha in area, eutrophic, with turbid green water. The shores are covered with a dense bed of tall reeds dominated by *Phragmites australis* (CAVANILLES, 1799) TRINIUS ex STEUDEL, 1840. Locally, there are also small patches of *Nymphaea alba* LINNAEUS, 1753.

Fig. 5. Krasiczyn, park complex near the castle, the upper pond.

Records of *A. viridis*: the upper pond: 24 VII 2011, 1 exuvium on an old willow (*Salix* sp.), by the shore.

Other Odonata species (collectively): *Platycnemis pennipes*, *Ischnura elegans* (VANDER LINDEN, 1820)**, *Enallagma cyathigerum***, *Coenagrion puella***, *Aeshna grandis**, *Libellula depressa*, *Orthetrum cancellatum***, *Sympetrum sanguineum***, *S. vulgatum*.

3. Bolestraszyce (49º49'01"N, 22º51'41"E, FA32, approx. 200 m amsl), water bodies in the Arboretum and the Physiography Department at Bolestraszyce

The arboretum is situated on the left side of the San valley. There are three water bodies, known as the upper (0.1 ha), middle (0.42 ha) and lower (0.35 ha) ponds. They are almost certainly artificial, situated as they are beyond the belt of oxbow lakes on the River San; in the first half of the 19th century there were no water bodies here (HÜBER 1824). Despite lying among trees and shrubs, all three ponds receive adequate insolation.

The upper pond represents the naturally restored ecosystem of a strongly silted up, swampy eutrophic water body with the water surface completely covered by a pleustonic community with dominant *Lemna minor* LINNAEUS, 1753. The middle and lower ponds are deeper, with an open water surface. Both contain abundant cultivated vegetation, mainly bulrushes and nymphaeids, with numerous wild and cultivar varieties of native and exotic species. In the lower pond *Hippuris vulgaris* LINNAEUS, 1753 and *Salvinia natans* (LINNAEUS, 1753) ALLIONI, 1785 are also abundant. All three ponds contain *Stratiotes aloides*: it forms isolated patches with a total area of 0.005-0.01 ha (Fig. 6).

Fig. 6. Bolestraszyce, Arboretum, the lower pond.

Records of *A. viridis*:

– middle pond: 23-08-2014, 1 territorial ♂; 29-08-2014, 1♂ hunting over the paths near the pond;
– lower pond: 23-08-2014, 1-2 territorial ♂♂ and 1♀ flying low along the shore (probably looking for an oviposition site); 2014-08-29, 1 territorial ♂.

Other Odonata species (collectively): *Calopteryx splendens* (HARRIS, 1782), *Lestes sponsa***, *Chalcolestes viridis* (VANDER LINDEN, 1825)*, *Sympecma fusca**, *Ischnura elegans***, *Enallagma cyathigerum* (CHARPENTIER, 1840)**, *Coenagrion puella***, *Erythromma najas* (HANSEMANN, 1823)*, *E. viridulum* (CHARPENTIER, 1840)**, *Aeshna cyanea***, *A. grandis***, *A. isoceles* (O.F. MÜLLER, 1867)*, *A. juncea* (LINNAEUS, 1758)*, *A. mixta***, *Anax imperator***, *Cordulia aenea* (LINNAEUS, 1758)**, *Orthetrum cancellatum***, *Crocothemis erythraea* (BRULLÉ, 1832)*, *Sympetrum depressiusculum* (SÉLYS, 1841)*, *S. meridionale* (SÉLYS, 1841)*, *S. sanguineum***, *S. vulgatum* (LINNAEUS, 1758)**.

DISCUSSION

Distribution of *Aeshna viridis* in Central and East-Central Europe

Aeshna viridis inhabits a wide spectrum of stagnant and slowly flowing waters, but its occurrence is limited by its obligatory relationship with *Stratiotes aloides* (PETERS 1987). The leaves of this plant are where the eggs are laid, and the larvae live among its leaves. The presence of *S. aloides* is crucial for their survival: it protects them from attack by fish and larvae of other dragonfly species (RANTALA et al. 2004, SUUTARI et al. 2004). Nevertheless, the distribution area of *A. viridis* in Europe (DIJKSTRA & LEWINGTON 2014) is not wholly sympatric with that of *S. aloides*, which extends farther to the south and west (HULTÉN & FRIES 1986). This suggests the importance of other environmental factors, possibly climate conditions. The contiguous part of the distribution area of *A. viridis* ends in Poland. Farther west it occurs only in central and northern Germany and in the Netherlands but its occurrence is insular and scattered (DIJKSTRA et al. 2002, BÖNSEL et al. 2010). In the Czech Republic and Slovakia, which share a border with Poland in the south, *A. viridis* does not occur at all (DOLNÝ et al. 2007, ŠACHA 2012). In contrast, there are single sites and small small islands of occurrence in Hungary, Croatia and Austria (ST. QUENTIN 1944, RAAB et al. 2007, VAN TOL et al. 2013).

Historically, the border of the distribution area of *A. viridis* ran through southern Poland. It was determined by the following sites: Lubaczów (50°09'N, 23°07'E) (DZIĘDZIELEWICZ 1902), Chorzów (50°17'N, 18°57'E) (SCHOLZ 1909) and Wrocław (51°06'N, 17°02'E) (WOLF 1939). Since those records, *A. viridis* has not been recorded in south-eastern Poland. In Upper Silesia it was last reported by SAWKIEWICZ & ŻAK (1966), while in north-western Poland there was only one isolated site in the Silesian-Lusatian Lowland (BORKOWSKI 1999). Therefore, it was concluded that the distribution area of *A. viridis* had retreated northwards by almost 1° in the west of the country and by approx. 0.5° in the east (BERNARD et al. 2009). In Ukraine the situation was similar: in the west *A. viridis* had not been recorded for almost 100 years (GORB et al. 2000). Within the last

few decades, it was observed only in the Kiev Oblast (northern Ukraine) (GORB et al. 2000, KONOVALOVA & BUĬ 2012).

In the light of this data, the sites we found are especially interesting. They lie well beyond the contemporary distribution area of *A. viridis*, on the border of the historical distribution area (Trestno) or just beyond it (Krasiczyn, Bolestraszyce) (Fig. 1). They demonstrate that *A. viridis*, at least locally, still inhabits areas that were thought to have been abandoned (BERNARD et al. 2009).

Changes in the distribution areas of many dragonflies are currently being discussed against the background of global warming; this is very often a reasonable approach. One can distinguish the species that are benefitting from this phenomenon and those that are losing out. The "winners" are thermophilous species, representing a broadly defined Mediterranean zoogeographical element, while the "losers" are cryophilous Siberian species (e.g. OTT 2001, FLENNER & SAHLÉN 2008, BERNARD et al. 2009, CONZE et al. 2010, DE KNIJF et al. 2011). The regress of Siberian *A. viridis* on the southern edge of its distribution area in east-central Europe, including Poland, would appear to fit this pattern. However, our data casts a different light on this. Not every change in distribution area, even of species potentially sensitive to climatic conditions, has to be directly attributed to warming. Changes in habitats, such as the temporary drying out of previously permanent water bodies or modifications in their management, are also important (BERNARD et al. 2002, CLAUSNITZER 2003, OTT 2007). This can be related to global warming as warmer water bodies dry out more quickly, but this relationship is not obligatory or may be only partial: drained areas, even ignoring climate change, are more susceptible to drying out. With the exception of the lake districts, Polish data indicates that *A. viridis* is frequently associated with the valleys of large rivers (DZIĘDZIELEWICZ 1902, BUCZYŃSKI 1994, 2007, 2012, JÖDICKE 1999, TOŃCZYK 2007, KOVÁCS et al. 2009, data in this paper). The transformation of river valleys and river regulation (KUCHARCZYK 1999) are probably responsible for the partial destruction of potential habitats. The effects of the latter could also be accelerated by climate warming, rendering many water bodies astatic. Without a doubt, it is quite unfavourable for *A. viridis*, whose life cycle in Poland lasts two years (MÜNCHBERG 1930) and it is not adapted to drying out. Water bodies colonised by *A. viridis* are especially vulnerable to such changes because *Stratiotes aloides* usually grows in shallow eutrophic waters in the late stages of succession (REFOLS 1991, SMOLDERS et al. 1996, CHOVANEC & WARINGER 2001). This was confirmed by our search for *S. aloides* habitats near Wrocław. The present rediscovery of *A. viridis* on the edge of its distribution area indicates that the main reason for its disappearance lies in the indirect impact of climate changes coupled with habitat changes possibly caused by human activities. However, if suitable habitats with *Stratiotes aloides* are preserved, *A. viridis* can still exist there. The populations at Bolestraszyce and above all at Krasiczyn are small, so it

is difficult to assess their prospects of survival at those sites, but the population at Trestno seems to be large and most likely stable.

Implication for management

An interesting aspect of the data presented in this paper is the artificial character of these *Aeshna viridis* sites. This shows that effective conservation of this dragonfly is feasible by the creation of new water bodies and the introduction of *Stratiotes aloides*. This is especially evident at Bolestraszyce, where the plant was artificially introduced in the second half of the last decade (ANTONIEWSKA & CZERNICKI pers. comm.). According to MAUERSBERGER et al. (2005), 5 m^2 is the minimum surface area of *Stratiotes aloides* enabling *A. viridis* to survive, but optimal patches are at least 50 m^2 in area. The size of *S. aloides* patches was also reported as significant by SUHONEN et al. (2013); our observations confirm this. The greatest numbers of *A. viridis* were found at Trestno, where there are large patches of *S. aloides*. In the Bolestraszyce ponds, where the patches are ca 50-100 m^2 in area, only a few individuals were observed. The population at Krasiczyn was the smallest, where, at best, only single *S. aloides* plants exist as an admixture to the beds of *Phragmites australis*.

It is strongly recommended to initiate a programme evaluating the known sites of *Stratiotes aloides* (preferably in cooperation with botanists), coupled with an extensive search for *Aeshna viridis* at such sites and followed by the implementation of appropriate conservation measures. Certainly, only a few of the existing *A. viridis* sites have been found so far. Such a study should focus primarily on river valleys, large natural bodies of stagnant waters (especially oxbow lakes) and anthropogenic water bodies (fish ponds, flooded gravel, clay and sand excavations). All these activities could contribute to the body of knowledge about the dragonflies in the whole of southern Poland, where vast areas have still been insufficiently explored. This is particularly true as far as Lower Silesia is concerned, where existing data are largely historical (BERNARD et al. 2009). With respect to *A. viridis* this should lead to a better explanation of its actual situation and, where necessary, be a prelude to a more rational conservation approach.

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