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**DRAGONFLIES (ODONATA)  
OF THE LEFT-BANK BUG RIVER VALLEY BETWEEN  
WŁODAWA AND KODEŃ (MIDDLE-EASTERN POLAND)**

**Abstract**

The presented paper analyses the occurrence of dragonflies in the left-bank (Polish) part of the Bug River valley between Włodawa and Kodeń (65 km of the river course, 51°32'–51°55' N, 23°31'–23°38' E). In total, 40 species were recorded. The key sites for dragonflies were oxbow lakes, the Bug River and its tributaries. Species diversity was found to be relatively low due to a lack of peatlands and dystrophic waters, as well as strong astatism of small water bodies. The effects of strong water pollution in the Bug River were evident. The species composition of dragonflies was typical, but densities of Gomphidae (particularly *Ophiogomphus cecilia*) suggested an adverse state of the environment. This is caused by surface runoffs of agricultural wastewater in Poland, but also by strongly polluted rivers in the territory of Ukraine.

The study includes a review of earlier research conducted in the upper course Bug River valley. Considering both the old and new data, 54 dragonfly species were recorded in the Middle Bug River valley between Gołbie and Kodeń (246 km of the river course at the border of Poland with Ukraine and Bela-

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rus). It is an area of high importance for the protection of dragonflies in terms of species diversity and species assemblages.

**Keywords:** Dragonflies, Odonata, middle-eastern Poland, the Bug River, river valley, floodplain, faunistics, assemblages, conservation

## **Introduction**

The Bug River is the longest right-bank tributary of the Vistula River (755 km), and the largest unregulated river of Central Europe. Its middle and lower course with a total length of 587 km is located in Poland. Buczyński (2006, 2007) studied in the years 1993–2005 the dragonfly fauna of the left-bank Middle Bug River valley along a transect of 204 km of the river course: from Gołębie, where the Bug River begins to constitute the border between Poland and Ukraine, to Pawluki (12 km north of Włodawa). He found a fauna rich in qualitative terms, with numerous stenotopes, protected and indicator species, typical of natural or semi-natural river floodplains. This article presents the results of the continuation of the study in the Bug River valley along the Włodawa–Kodeń section. A part of the area (Kodeń–Pawluki, 23 km of the Bug River course) was already studied before, but only partially, and with only several single species determined. No data has been provided so far from the further 42 km (Pawluki–Kodeń) (Fig. 1). The primary objective of the study was to analyse the species composition and diversity of dragonflies; to determine whether wastewater from Włodawa, the largest city at this part of the river, negatively affects the odonatofauna of the Bug River; and to estimate to what extent dragonfly communities similar to lacustrine ones develop in oxbow lakes frequently larger and potentially more lacustrine than those located in upper section of the river valley.

## **Study Area**

The study was conducted in the left-bank (Polish) part of the Bug River valley between Włodawa and Kodeń, along a transect of 65 km of the river course. It is located in the West Polesie macroregion, and in the Brzeskie Polesie mesoregion

(Kondracki 2002). The study covered an area from 51°32' to 51°55' N and from 23°31' to 23°38' E.

The Bug River is the longest right-bank tributary of the Vistula River (755 km), and one of the largest unregulated rivers of Central Europe. Its middle and lower course with a total length of 587 km is located in Poland. The width of the Bug River valley within the study area varied between 4–8 km, and the width of the river channel varied from 30 to 100 m (40–50 m on average) (Michalczyk & Wilgat 1998). The valley bed is sandy, with only few peats (Szwajgier et al. 2002). In the study area, the river is of natural character, with numerous meanders (the meander belt has a width of 1.5 km) and oxbow lakes. The channel is deeply indented (max. 6–10 m), locally with islands and furcations, and its slopes reach several meters in height. Banks are weakly erosive and accumulative, low, gently inclined or vertical. The near-bank area is shallow to moderately deep (0.15–1.00 m), with a discharge rate from 0.29 to 1.00 m·s<sup>-1</sup>. A major part of the valley is extensively used as hay meadows. It is locally occupied by intensively cultivated fields. Forests are scarce, mainly occupying the valley's drier fragments south of Kodeń. The banks of the Bug River are overgrown by willow shrubs and degraded remains of floodplain (riparian) forests.

The surface waters, in spite of their large surface area and high number, are little differentiated.

The flowing waters are mostly constituted by the Bug River itself, there are only some small tributaries. They are distinguished by a sandy and/or sandy-silty bottom, low discharge, and abundant development of aquatic vegetation (particularly at the banks). The drainage basin of the Bug River is among the most polluted fluvial systems in Poland, mainly by surface runoffs from agricultural areas. During the study, the water of the Bug River was categorised to quality class IV, and in Włodawa and Stawki periodically to class V. The factor with the highest values was chlorophyll "a" concentration, related to the agricultural character of the river's drainage basin. High values were also reached by: ChZT<sub>5</sub>, colour, phosphates, nitrogen compounds, total organic carbon, and sanitary indices. The values of water oxygenation and electrolytic conductivity were included to class I–II. The Kałamanka and Włodawka Rivers were classified as water quality class IV, and the Hanna River as class V. This was also determined by eutrophication and sanitary indices (Iwaniuk & Piebiak 2008; Miazga et al. 2006; Miazga & Parcheta 2007).

The meandering Bug River forms numerous, usually large and deep oxbow lakes. Along the extensively used valley sections, they have the character of moderately eutrophic lakes with well developed assemblages dominated by *Nuphar lutea* (L.) Sm. and *Nymphaea* spp. In places dominated by arable fields, lakes are strongly eutrophicated, and covered with a thick layer of *Lemna* spp. with dominance of *Lemna trisulca* L. in the growing season. A number of lakes are distinguished by high floristic values (Urban & Wójciak 2002).

Backwaters on the Bug River result in abundance of small water bodies, but not many of them are permanent with typically aquatic vegetation. They are mostly temporary water bodies, often very ephemeral, drying out in June at the latest, and sometimes already in May.

The study area is located in the climatic Podlasie province (Stopa-Boryczka & Boryczka 2005). It is cold, particularly in winter. Mean temperature in January amounts to  $-4^{\circ}\text{C}$ , in July  $-17.8^{\circ}\text{C}$ , mean annual temperature  $-7.4^{\circ}\text{C}$ . Winter lasts for 90–100 days. The snow cover lasts for more than 70 days. The vegetation period is 200–210 days, and the annual precipitation is 520–600 mm.

## Methods and Material

Systematic field surveys were conducted in the years 2005–2007, three times in each year: one examination of each study site was made in spring (May or June), summer (July or August), and autumn (September). Additional samples and observations from the years 1999, 2000, and 2010 were also used.

The basic study method was capturing dragonfly larvae by means of a hydrobiological sampler (semi-qualitative samples). The material was placed in bags, and selected in the laboratory. The larvae obtained were then preserved in 70% ethanol. Observations of imagines were also conducted. The following was recorded: numbers of individual species, teneral and juvenile specimens, and reproductive behaviour. Also, exuviae were collected from the bank vegetation and from the ground. In 2007, the collection of exuviae from some of the sites in the Bug River was of quantitative character – it was carried out two times in June as part of the *Ophiogomphus cecilia* monitoring programme in Poland (Bernard 2010). In total, the following were collected: 1288 larvae, 804 exuviae, and 270 observations of imagines (day/site/species).

The autochthony of all species was evaluated for each site under the following three categories: ‘development recorded’ – when larvae and exuviae were collected, metamorphosis was recorded, and/or mass reproductive behaviour was observed; ‘probable development’ – when sporadic reproductive behaviour was observed, or abundant occurrence in a habitat favourable for the species; and ‘recorded’ – in other cases.

The following dominance structure was adopted in the quantitative analysis of the study material: eudominants ( $\geq 10\%$ ), dominants (5.1–10.0%), subdominants (2.1–5.0%), recedents (1.1–2.0%) and euredents ( $\leq 1.0\%$ ) (Plewka 2007).

The following parameters were measured at the study sites: water temperature, pH, conductivity, and dissolved oxygen saturation. The measurements were conducted by means of a Slandi TM204 thermometer, a Slandi PH204 pH meter, a Slandi CM204 conductometer, and a Hanna Instruments HI 9145 oxygen meter. The water flow velocity in the near-bank area of the Bug River in 2007 was measured by applying the floating object method.

The faunistic similarities between the types of the studied water bodies were calculated according to the Jaccard’s (Szujewski 1983) and Biesiadka’s (1978) formulae. The results were processed by means of the simplified dendrite method. Ecological groups of dragonflies were adopted from Bernard et al. (2009).

Sozological analyses were based on: protected species (Rozporządzenie... 2011), Red List of Europe and the European Union (Kalkman et al. 2009), Red List of dragonflies of Poland (Bernard et al. 2009), Red List of dragonflies of the Lublin Province (Buczyński 2009a), and umbrella species (Bernard et al. 2002) (in consideration of only those species, which were found in habitats of which they are indicative). Based on these sources, the following categories of species were distinguished in the material collected: a) endangered in Europe or the European Union, of high importance (categories  $\geq$  VU), scoring 7 points; b) endangered in Europe or the European Union, of low importance ( $\leq$  NT) – 6 points; c) endangered on national scale, of high importance – 5 points; d) endangered on national scale, of low importance ( $\leq$  NT) – 4 points; e) endangered on regional scale only, of high importance – 3 points; f) endangered on regional scale only, of low importance – 2 points; g) protected by law and/or umbrella species – 1 point. Each species was classified only once, considering only the highest scores in relevant groups.

Data from before 2009 was analysed for use in the “Atlas of distribution of dragonflies (Odonata) in Poland” (Bernard et al. 2009).

## Study Sites

The study was conducted at 31 sites located in 15 localities (Fig. 2). Those were: 1) Suszno (UTM FC71) (the Bug River); 2) Szuminka (FC71) (a) the Bug River, b) the Kanał Partyzantów Stream, c) a temporary meadow water body on the first flood terrace, d) a permanent meadow water body on the first flood terrace); 3) Różanka (FC82) (the Bug River); 4) Stawki (FC72) (a. the Bug River, b. a water-hole at the bottom of a periodically flowing canal); 5) Pawluki (FC72) (a) the Bug River, b) the Bug River oxbow lake on the second flood terrace, c) a temporary meadow water body on the first flood terrace); 6) Dołhobrody (FC72) (a) the Bug River, b) the Bug River oxbow lake on the first flood terrace, c) a small permanent water body – dug out and used for watering cows, d) a temporary meadow water body on the first flood terrace); 7) Hanna (FC73) (a) the Hanna River, b) a regulated meadow stream); 8) Kolonia Kużawka (FC73) (the Bug River); 9) Sławatycze (FC73) (a) the Bug River, b) a Bug River oxbow lake on the second flood terrace); 10) Mościce Dolne (FC74) (a Bug River oxbow lake on the second flood terrace); 11) Nowosiółki (FC74) (the Bug River); 12) Jabłeczna (FC84) (a) the Bug River, b) a Bug River oxbow lake on the first flood terrace); 13) Kolonia Szostaki (FC74) (the Sajówka Stream); 14) Szostaki (FC74) (the Bug River); 15) Kodeń (FC75) (a) the Kałamanka River, b) a Bug River oxbow lake on the second flood terrace, on the Łęgi Range, c) the Bug River, d) a canal at the shrine to the Virgin Mary, e) a small water body in the shrine).

The selected, typical habitats of dragonflies in the Bug River valley in the study area are presented in the photographs (Phot. 1–9).

The warmest habitat during summer was definitely the Bug River. Its waters in the near-bank area reached up to 29.6°C in summer. All the stagnant waters were also warm (maximum temperatures from 24.1 to 27.8°C). Small flowing waters were moderately warm (20–21°C).

The waters studied were distinguished by reaction from slightly alkaline to alkaline. Similar outcomes were recorded at all of the sites studied: in the Bug River it amounted to 7.46–8.59 (8.14 on average), in smaller rivers to 7.40–8.50 (7.90 on average), and in stagnant waters to 7.27–8.54 (7.83 on average).

The conductivity in the Bug River varied from 627 to 876  $\mu\text{S} \cdot \text{cm}^{-2}$  (723 on average). The value of 376  $\mu\text{S} \cdot \text{cm}^{-2}$  was recorded only once (Stawki, spring 2007). In other flowing waters, the values varied between 274 and 840  $\mu\text{S} \cdot \text{cm}^{-2}$  (531 on average). In stagnant waters, they oscillated between

356 and 875  $\mu\text{S} \cdot \text{cm}^{-2}$  (579 on average), whereas the lowest electrolytic conductivity was observed in the oxbow lakes in Pawluki and Kodeń III ( $< 500 \mu\text{S} \cdot \text{cm}^{-2}$ ).

The best oxygen conditions occurred in the waters of the Bug River: 4.9–15.9  $\text{mg O}_2 \cdot \text{dm}^{-3}$  (10.2 on average). An instance of dissolved oxygen concentration below 5  $\text{mg} \cdot \text{dm}^{-3}$  was recorded only once (Dołhobrody, autumn 2006). Much lower values were determined in other flowing waters: 1.2–14.1  $\text{mg O}_2 \cdot \text{dm}^{-3}$  (5.4 on average), whereas 60% of measurements were below 5  $\text{mg O}_2 \cdot \text{dm}^{-3}$ . The lowest values were recorded in stagnant waters: 0.9–15.2  $\text{mg O}_2 \cdot \text{dm}^{-3}$  (4.1 on average), with 73% of measurements below 5  $\text{mg O}_2 \cdot \text{dm}^{-3}$ .

## Results

A total of 40 dragonfly species were recorded. Development was recorded for 33 species, and probable development for 6 species. In the case of *Lestes virens*, only the occurrence of the species was recorded (Table 1).

Eudominants among larvae and exuviae were: *Calopteryx splendens*, *Platycnemis pennipes*, *Gomphus vulgatissimus*, *G. flavipes*, and *Ophiogomphus cecilia*. The remaining 21 species represented lower classes of domination. Imagines were the most frequently observed forms in the case of *Calopteryx splendens* and *Platycnemis pennipes*. Also *Sympetrum sanguineum*, *Lestes sponsa*, *Gomphus vulgatissimus*, *Sympetrum flaveolum*, and *S. sanguineum* were present at large (Table 1).

The most extensive occurrence in the study area concerned *Calopteryx splendens* and *Platycnemis pennipes* (22 sites each), and *Gomphus vulgatissimus* (15). In at least 10 sites, *Coenagrion puella*, *Gomphus flavipes*, *Ophiogomphus cecilia*, *Sympetrum flaveolum*, and *S. sanguineum* were also recorded (Table 1).

The widest habitat spectrum was reached by *Platycnemis pennipes*, *Sympetrum flaveolum*, and *S. sanguineum* – with recorded or probable development in all of the habitats studied. In four types of water bodies, a similar record was made on *Ischnura elegans*, *Coenagrion puella*, *Erythromma najas*, and *Aeshna cyanea*, in three: *Lestes barbarus*, *L. sponsa*, *Aeshna affinis*, *A. grandis*, *Gomphus vulgatissimus*, and *Sympetrum vulgatum* (Table 1).

In each type of water body the number of recorded species differed between 6 and 32, including 5–30 with recorded or probable development. The fauna of

oxbow lakes was the richest. The fauna of the Bug River and its tributaries was moderately rich, and that of small water bodies was the poorest (Table 1).

The fauna of the Bug River (21 species, of which 16 were autochthonous or probably autochthonous) was dominated by rheobionts and rheophiles: *Calopteryx splendens*, *Platycnemis pennipes*, *Gomphus vulgatissimus*, *G. flavipes*, and *Ophiogomphus cecilia*. They were the only eudominants. Larvae of rheophilic *Somatochlora metallica* and of four eurytopic species were very sparse, and the remaining species were only recorded as imagines (Table 1).

In the tributaries of the Bug River, 17 species were found (including 17 autochthonous or probably autochthonous ones). They were strongly dominated by: *Calopteryx splendens* (52.3% of larvae and exuviae collected) and *Aeshna cyanea* (30.3%). Apart from those, also 7 species were recorded as larvae (none of which were numerous). Those were two rheophiles and five eurytopes. The remaining 8 species were only recorded as imagines (Table 1).

In the oxbow lakes, 32 dragonfly species were found, including 30 autochthonous or probably autochthonous ones. Four eudominants (*Coenagrion puella*, *C. pulchellum*, *Erythromma najas*, and *Cordulia aenea*) constituted a total of 74.1% of larvae and exuviae collected. One dominant was also distinguished, namely *Aeshna grandis* (Table 1).

In the small water bodies, very few species were collected as larvae. In temporary waters, these were *Lestes barbarus* and *Platycnemis pennipes*, and in permanent ones *Coenagrion puella* (Table 1). *P. pennipes* larvae in stagnant waters were only collected in the first half of May. This suggests that they were transported from the Bug River during a flood, and later died in most of the water bodies – out of all of the stagnant waters studied, metamorphosis and intensive reproductive behaviour were only observed in two oxbow lakes (at sites 5b and 9b).

In the analysis of qualitative faunistic similarities, at a level of 46–48%, two groups of habitats were distinguished. One of them includes flowing waters, and the other small permanent and temporary water bodies. Oxbow lakes, in faunistic terms, are mostly similar to small temporary water bodies. In the analysis of quantitative similarities, at a level of 5.5–6.0%, a group including flowing waters and small permanent water bodies was evident. The similarity of the remaining habitats is at a level of 1.4–1.5% (Fig. 3).

The presence of the following was recorded: two species from the Red List of dragonflies of the European Union (*Aeshna viridis* and *Leucorrhinia caudalis*



– both in the “near threatened” (NT) category); one species from the Red List of dragonflies of Poland (*Orthetrum coerulescens* – NT); one species from the Red List of dragonflies of the Lublin Region (*Orthetrum coerulescens* – NT); 6 protected species (*Sympecma paedisca*, *Aeshna viridis*, *Gomphus flavipes*, *Ophiogomphus cecilia*, *Leucorrhinia caudalis*, and *L. pectoralis*); and four umbrella species (*Gomphus flavipes* and *Ophiogomphus cecilia* – for medium and large rivers, *Orthetrum coerulescens* – for small streams of open areas, and *Leucorrhinia caudalis* – for lakes) (Table 2).

Below are the details concerning records of the species mentioned in the previous paragraph. Abbreviations: L (LL) – larva (larvae), ex. (exx.) – exuvium (exuviae), img. – imago (imagines), ten. – teneral individuals, ter. – territorial individuals. The numbers at imagines denote the number of individuals recorded in a transect with a length of 100 m of the shoreline.

- *Sympecma paedisca* – site 5b (26 VII 2005, 1 L); 9b (26 VII 2005, 1 img., ten.); 12a (10 V 2006, 1♂, ter.).
- *Aeshna viridis* – 5b (26 VII 2005, 1 L, 13 VII 2006, 1♂, ter.); 12b (28 VIII 2005, < 10 img., ter., 13 VII 2006, < 10 img., ter.).
- *Gomphus flavipes* – 1 (8 VI 2007, 2 exx., 28 VI 2007, 5 LL, 60 exx.); 2a (27 VIII 1999, 3 LL, 26 VII 2005, 1 L, 5 exx., 13 VII 2006, < 10 img., ter.); 3 (28 VI 2007, 35 exx.); 4a (8 VI 2007, 1 ex., 28 VI 2007, 11 exx.); 5a (26 VII 2005, 1 ex., 13 VII 2006, 1 ex., 10 V 2006, 1 L; 15 V 2007, 1 L, 28 VI 2007, 15 exx.); 6a (27 VIII 1999, 3 LL, 13 VII 2006, 1 L, 8 VI 2007, 1 img., ten., 17 VII 2007, 1 L, 8 VIII 2007, 3 exx.); 8 (21 IX 2000, 1 L, 8 VI 2007, 2 exx., 28 VI 2007, 23 exx.); 9a (26 VII 2005, 1 L, 13 VII 2006, 1 L, 1 img., ten., 8 VI 2007, 2 exx., 29 VI 2007, 20 exx.); 11 (27 VIII 1999, 1 img.); 12a (25 VIII 2005, 4 LL, 8 VIII 2010, 1 img.); 14 (25 VIII 2005, 16 LL); 15c (25 VIII 2005, 15 LL, 13 VII 2006, 1 L). Densities of exuviae determined within the monitoring programme of *Ophiogomphus cecilia* in 2007 (ind. · 10 m<sup>-1</sup> of the shoreline): Suszno (site No. 1) – 11.7, Różanka (3) – 0.0, Stawki (4a) – 4.1, Pawluki (5a) – 0.0, Dołhobrody (6a) – 0.0, Kolonia Kużawka (8) – 8.9, Sławatycze (9a) – 4.1.
- *Ophiogomphus cecilia* – 1 (8 VI 2007, 1 img., 6 exx., 28 VI 2007, 1 L, 11 exx.); 2a (26 VII 2005, < 10 img., ter.); 3 (8 VI 2007, 2 exx., 28 VI 2007, 3 exx.); 4a (8 VI 2007, 5 exx., 1 img., 28 VI 2007, 8 exx.); 5a (13 VII 2006, 5 exx., < 10 img., ten., 8 VI 2007, 12 exx., 30 VI 2007, 30 exx.); 6a (27 VIII 1999, 1 img., 26 VII 2005, 1 L, 8 VI 2007, 4 exx., 29 VII 2007, 87 exx.); 8 (8 VI 2007, 12 exx., 28 VI 2007, 1 L, 18 exx., 1 img.); 9a (8 VI 2007, 16 exx., 29 VII 2007,

11 exx.); 10 (29 VI 2007, 1 img.); 14 (25 VII 2005, 6 LL); 15c (25 VII 2005, 42 LL). Densities of exuviae determined within the monitoring programme of those species in 2007 (ind. · 10 m<sup>-1</sup> of the shoreline): Suszno (site No. 1) – 3.4, Różanka (3) – 1.7, Stawki (4a) – 4.4, Pawluki (5a) – 14.0, Dołhobrody (6a) – 2.2, Kolonia Kużawka (8) – 10.3, Sławatycze (9a) – 5.4 (5.2 ind. · 10 m<sup>-1</sup> on average). Thus, full cover was observed (*O. cecilia* exuviae were collected in 100% of the transects and sub-transects studied).

- *Orthetrum coerulescens* – 2b (13 VII 2006, 1 img., ter.).
- *Leucorrhinia caudalis* – 9b (26 VII 2005, 1 L, 17 VII 2007, 1 L).
- *Leucorrhinia pectoralis* – 12b (25 VIII 2005, 1 L).

Special care and/or indicator species occurred at 17 sites (55%), scoring 1-7 points. Those were mainly sites in the Bug River, scoring 1-2 points due to the presence of *Gomphus flavipes* and *Ophiogomphus cecilia*. This concerns as many as 13 out of 14 transects of the Bug River studied. Three chosen sites represented oxbow lakes. Two of them scored the highest number of 7 points, which mainly resulted from the presence of *Aeshna viridis*, near threatened in the European Union. One site represented the tributaries of the Bug River. It was a stream with a population of *Orthetrum coerulescens*, near threatened in Poland (Fig. 4).

Special care and/or indicator species were recorded in three out of five types of waters studied. They were not observed in small water bodies. In terms of mean number of points per site, the highest score was reached by oxbow lakes, followed by the Bug River and the tributaries of the Bug River (Fig. 5).

## Discussion

The odonate fauna of the study area was moderately rich in qualitative terms: in a number of lowland sites in Poland with a similar or even much smaller area, significantly richer fauna was found (Buczyński 2003, 2004; Buczyński & Łabędzki in press; Brockhaus & Rychła 2009; Łabędzki 1987, 2006; Śniegula 2009; Śniegula & Gołąb 2009; Tończyk & Stankiewicz 2009). A similar number of species was recorded in areas with increasing agricultural pressure (Bernard et al. 2009; Buczyński 2001; Mielewczyk 1966; Tończyk & Stankiewicz 2008).

The relatively low species richness of the dragonfly fauna is of high significance, because dragonflies are good indicators of total species richness of fauna and the state of the environment (e.g. Briers & Biggs 2003; Hornung & Rice

2003; Osborn 2005; Sahlén & Ekestubbe 2001; Rehfeldt 1986; Schmidt 1983). In the area studied, such a state does not result from the degradation of the environment – it should be mainly related to low differentiation of surface waters. This becomes evident when analysing data on the fauna richness and species composition of each habitat. Only the fauna of small water bodies is poorer, which can be related to their strong astatism. Dragonfly communities in the Bug River, oxbow lakes, and in smaller flowing waters resemble those in the Bug River valley above Włodawa. Although somewhat lower numbers of species were identified in these areas (Buczyński 2006, 2007)<sup>1</sup>, the numbers were still significantly higher than in similar habitats of the Vistula Valley (Buczyński, unpubl. data) and at the same time as equally rich as those found in the Narew Valley, Narew National Park (Buczyński et al. 2007). This is true in particular for the Bug fauna, which is only slightly poorer in fauna than the Allier River – in terms of natural preservation considered to be the shining gem among Europe's rivers (Lohr 2010). This fact is of great significance as Poland has a much poorer population of Gomphidae than Western Europe. The high number of autochthonous species in the Bug River is supported by the presence of some types of stagnophiles, including even thermophile species such as *Orthetrum albistylum*. These species are drawn by attractive conditions for development within the river's pleagic zone, which in some places tends to warm up noticeably.

The list of dragonflies occurring in the Bug River valley above Włodawa (Buczyński 2006, 2007) and absent along the transect Włodawa–Kodeń, is dominated by species related to habitats absent or rarely encountered in the area. Those are mainly tyrphophiles and tyrphobionts (Bernard et al. 2009; Buczyński et al. 2009; Mielewczyk 1969): *Coenagrion hastulatum* (Charpentier, 1825), *C. lunulatum* (Charpentier, 1840), *Aeshna juncea* (Linnaeus, 1758), *Somatochlora flavomaculata* (Vander Linden, 1825), *Sympetrum danae* (Sulzer, 1776), *Leucorrhinia dubia* (Vander Linden, 1825), and *L. rubicunda* (Linnaeus, 1758). It is worth noticing that also *Lestes virens*, a tyrphophile as well, was clearly rarer and less numerous (Bernard et al. 2009). The occurrence of pioneer species was also less abundant. No presence of *Ischnura pumilio* (Charpentier, 1825) or *Orthetrum brunneum* (Fonscolombe, 1837) was recorded. So, the scarce representation of those ecological groups, and the generally lower species richness in the Bug River valley above Włodawa, results from different natural condi-

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<sup>1</sup> It is worth noting that the data collected was obtained from a several times shorter valley section and thus from a fewer number of sites.

tions and somewhat different land management: lack of peatlands and dystrophic waters, less extensive sand excavation, and less frequent renovations of ditches and canals (or simply their lower number). Very poor representation of pioneer fauna, including the only sporadically recorded *Libellula depressa*, further suggests that the determined dragonfly communities are stable in spite of their low species richness.

Data suggesting the deterioration of the state of the environment was only collected from the Bug River. This fact is visible not as much in the fauna species composition, typical of well-preserved rivers (Bernard et al. 2002), but in the numbers of indicator representatives of the Gomphidae family: *Gomphus flavipes* and *Ophiogomphus cecilia*<sup>2</sup>. Particularly the data from the monitoring of *O. cecilia*, in spite of full cover and even distribution of the river's inhabitancy, suggests an unfavourable state of preservation of the species. Along the transect Włodawa–Sławatycze, the result of the general evaluation of the Bug River was dissatisfactory (U1), and the species densities in individual control transects corresponded to the following states: bad (U2 – < 20 exuviae in a 100-m stretch of the river bank) (site No. 3), dissatisfactory (U1 – 20–99) (sites No. 1, 4, 6a, 9a) and accurate (FV – ≥ 100) (5a, 8). The evaluation of the state of the habitat and perspectives for preservation of the species was similar. Such a state was attributed to the poor quality of water in the Bug River (Iwaniuk & Piebiak 2008; Miazga et al. 2006; Miazga & Parcheta 2007), and the composition of bottom sediments unfavourable for some species. The sediments are too fine-grained, with a too high contribution of mud (Bernard 2008; Buczyński 2008). This remains in accordance with published data on the microhabitat preferences of species in the Oder River (Müller 2002). It is assumed that an improvement in water quality may cause a change in the numbers of *Ophiogomphus cecilia* to the preferred good state (FV) (Bernard 2008, 2010; Buczyński 2008).

No deterioration of the state of the dragonfly fauna of the Bug River below Włodawa was observed. It had the same species composition as the areas above the city (Buczyński 2006, 2007). Indicator *Gomphus flavipes* and *Ophiogomphus cecilia* occurred even more extensively and in higher numbers. In *G. flavipes*, sporadic high densities of larvae were also recorded (Buczyński 2006). It should be remembered that *G. flavipes* prefers large rivers. A significant part

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<sup>2</sup> The study area lies far outside the distribution area of *Onychogomphus forcipatus* (Linnaeus, 1758) (cf. Bernard et al. 2009) – therefore the lack of this species bears no bioindicators significance.

of the course of the Bug River above Włodawa is not suitable for this species in terms of habitat. Therefore, data on *O. cecilia* are the most representative. This suggests that the main factor degrading the fauna of the Bug River is regional pollution, i.e. surface runoffs from agricultural areas, flowing into the river more or less evenly along its course, and not local pollution, i.e. inflows of household and industrial wastewater. Attention should be paid to the fact that the quality of water in the Bug River is already bad at the outflow of the river from the territory of Ukraine (Bondarchuk 2009). Along the border section, it is not subject to any drastic deterioration (Iwaniuk & Piebiak 2008; Miazga et al. 2006; Miazga & Parcheta 2007). Threats to the river in Ukraine are numerous, and some of them are becoming more extensive (Bondarchuk 2009). New data also confirms the information that rheophilic dragonflies are much less sensitive to water pollution than was assumed in the past (Bernard et al. 2002). It should largely depend on the type of pollution. The history of recognising Gomphidae and other dragonflies as organisms preferring clean environment began with bioindication systems mainly evaluating organic matter load (Liebmann 1951; Zelinka & Marvan 1961). They currently seldom constitute a serious problem in European rivers. The Bug River in the study area is a  $\beta$ -mesosaprobic river ( $S = 1.98$ ) (Błachuta & Błachuta 2003), and the saprobic numbers of the majority of dragonflies in medium-sized and large rivers amounts to 1.9–2.1 (Morpugo 1996).

Responses of invertebrates to pollution are varied. In the case of the Bug River along the transect Włodawa–Kodeń, it is possible to compare the results of simultaneous studies on several taxonomic groups. Conclusions very similar to those regarding dragonflies were presented in relation to caddisflies, including indicator species from the genus *Hydropsyche* Pictet, 1834 (Buczyńska 2006). The pollution of the Bug River had a very strong negative effect on watermites (Stryjecki 2009) – similar to the Middle Wieprz River, very alike in habitat terms, flowing in the Lublin region (Stryjecki 2010). Aquatic beetles turned out to be the most resistant (Buczyński et al. 2011). These two taxonomic groups, extremely sensitive and resistant, correspond well with the results of the complex studies by Gerecke (1991), conducted in the waters of Sicily, extremely unfavourable in terms of habitat.

The autochthonous occurrence of limnophilic *Leucorrhinia caudalis* at site 9b is interesting. It evidences a more lacustrine character of the oxbow lakes of the study area in comparison with those in the Bug River valley above Włodawa, where the species was not recorded. Among typical limnophiles, only *Epitheca*

*bimaculata* was found in the mentioned area (Buczyński 2006, 2007). It is also one of the relatively few sites of *L. caudalis* known in central-eastern Poland (Bernard et al. 2009). Further, another typically lacustrine dragonfly *Anax parthenope* (Sélys, 1839) was not recorded. It was not found in the entire Middle Bug River valley (Buczyński 2006 2007; data included herein). Until the 1980's, the species was known in eastern Poland only in the Suwałki Region and at one historical site in Puławy (Bernard et al. 2009; Buczyński 2012; Kolosov 1916). Within the last twenty years, however, the species largely expanded, and it currently inhabits numerous lakes, ponds, and dam reservoirs in Polesie (Bernard et al. 2009; Buczyński 2009b, 2009c, unpublished data). Polish literature provides no data on the occurrence of *A. parthenope* and *L. caudalis* in oxbow lakes. Several sites of *A. parthenope* were only lately found in the Oświęcim Basin (Kotlina Oświęcimska) and on the South Podlasie Lowland (Nizina Południowo-podlaska) (Buczyński unpubl. data). Data on *L. caudalis* from Sławatycze constitutes the first record of the species. Such records from the neighbouring countries are also scarce, and always concern valleys of large rivers, such as the Danube (Kúdela et al. 2004) and Moselle River (Trockur & Didion 1999). In Poland, very few valleys of such large rivers have been studied so far. Perhaps future studies in the Lower Oder or Lower Vistula River valleys will expand the knowledge on the odonatocoenoses of very large oxbow lakes – larger than those in the Middle Bug River valley.

In the Bug River valley between Włodawa and Kodeń, only one species from the Red List of dragonflies of Poland was recorded (Bernard et al. 2009), marked by the low category NT (“near threatened”). None was recorded upstream of Włodawa (Buczyński 2006, 2007). Three species from the “waiting list” were also recorded, including dragonflies which are not included in the Red List, but sensitive to habitat changes, and likely to be in regress in the future (Bernard et al. 2009). Those were: *Coenagrion lunulatum*, *Aeshna viridis*, and *Leucorrhinia caudalis*. This generally suggests low value of the study area in terms of dragonfly protection. It should be remembered, however, that the situation of dragonflies in Poland is still very good in comparison with many other European countries. Therefore, not many species are qualified to be included in the Red List. It includes only 9.6% of the national fauna (Bernard et al. 2009), i.e. 5.6–7.0 times less than in the neighbouring countries (David 2001; Dolný et al. 2007; Ott & Piper 1998). Such a comparison is not fully representative due to the still existing differences in the methods of preparing such lists in spite of generally acces-

sible guidelines (IUCN 2011). Moreover, threatened or near threatened species in Poland include few dragonflies related to environments occurring in valleys of large rivers. Such areas are of high importance as refuges of threatened species in countries bordering with Poland. This is evidenced by the determination of the following species in the Middle Bug River valley (Buczyński 2006, 2007; data included herein): 35 species from the Red List of dragonflies of Germany (79% included in the list), 24 species from the Red List of dragonflies of the Czech Republic (63%), and 29 species from the Red List of dragonflies of Slovakia (62%) (David 2001; Dolný et al. 2007; Ott & Piper 1998). Other countries bordering with Poland do not have Red Lists, but as many as 10 species from their Red Books were recorded in the Middle Bug River valley: *Calopteryx splendens* (Ukraine – category R), *C. virgo* (Ukraine – R), *Sympecma paedisca* (Belarus – category VU), *Ischnura pumilio* (Latvia – I), *Gomphus flavipes* (Latvia – V), *Ophiogomphus cecilia* (Belarus – NT, Latvia – I), *Brachytron pratense* (Belarus – VU), *Aeshna viridis* (Belarus – VU, Latvia – R), *Anax imperator* (Belarus – VU, Russia, Kaliningrad Oblast – R, Ukraine – R), *Leucorrhinia caudalis* (Latvia – R), and *L. pectoralis* (Latvia – I) (Aidukaitė 2007a, 2007b, 2007c; Budrys 2007; Budrys, Dapkus 2007; Ermolenko 1994; Gurin 2004; Tumulovich 2010).

The Middle Bug River valley is also one of the hot spots for dragonfly species richness in Poland. Along the section Gołębie–Kodeń, a total of 54 dragonfly species were found (Buczyński 2006, 2007; data included herein). Therefore, it is an area with a high level of species diversity for this group of insects on national scale (Buczyński & Łabędzki in press). It is a place of occurrence of 74% of all national species. Importantly, no significant threats to the current state seem to be visible (Buczyński 2007). The number of 54 species also constitutes 73% of the fauna of Ukraine (Gorb et al. 2000; Matushkina 2007) and 86% of the fauna of Belarus (Buczyński et al. 2006; Buczyński & Moroz 2008). Therefore, similar significance can be ascribed to the Bug River valley for the neighbouring countries.

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Table 1. Dragonflies recorded in the study area. Numbering of sites like in the text. %O – percentage share in the observations of imagines, %LE – percentage share in the number of larvae and exuviae collected, A-E – habitats (A – the Bug River, B – its tributaries, C – oxbow lakes, D – small temporary water bodies, E – small permanent water bodies). Habitat distribution: ○ – species recorded, ● – probable development of species, 1-5 – species development recorded (1 – euredent in larvae and exuviae collected, or development recorded based on observations of imagines, 2 – recedent, 3 – subdominant, 4 – dominant, 5 – eudominant)

Species	Material		Sites	Habitat distribution				
	%O	%LE		A	B	C	D	E
<i>Calopteryx splendens</i> (Harris, 1782)	17.0	20.9	1, 2a-b, 2d, 3, 4a-b, 5a, 6a, 6d, 7a, 8, 9a, 10, 11, 12a, 13, 14, 15a, 15c-e	5	5	○	○	○
<i>C. virgo</i> (Linnaeus, 1758)	2.2	–	2a, 6a, 7a, 11, 13, 15c	○	1			
<i>Sympecma paedisca</i> (Brauer, 1877)	0.7	>0.1	5b, 9b, 12a	●		1		
<i>Lestes barbarus</i> (Fabricius, 1798)	1.9	>0.1	2c-d, 6d, 9b			1	5	1
<i>Lestes dryas</i> Kirby, 1890	0.7	–	2c, 6d		●		●	
<i>L. sponsa</i> (Hansemann, 1823)	4.8	–	2d, 5b, 6b, 6d, 9b, 10, 12b, 15a-b			1	●	●
<i>L. virens</i> (Charpentier, 1825)	0.7	–	6d, 12b			○	○	
<i>Platynemis pennipes</i> (Pallas, 1771)	15.6	20.9	1, 2a-c, 3, 4a, 5a-c, 6a, 6d, 7a, 8, 9a-b, 11, 12a-b, 14, 15a-d	5	3	2	5	●
<i>Ischnura elegans</i> (Vander Linden, 1820)	2.6	0.1	1, 2a, 4a, 5b, 6a, 9b, 12a, 15a	1	●	4		●
<i>Enallagma cyathigerum</i> (Charpentier, 1840)	2.2	>0.1	9b, 15b, 15c		1	1		
<i>Coenagrion puella</i> (Linnaeus, 1758)	3.3	2.8	1, 2a, 2c-d, 5b, 6b-c, 9b, 10, 15a-b	●	2	5	○	5
<i>C. pulchellum</i> (Vander Linden, 1825)	1.5	1.4	5b, 9b, 10, 12b, 15a			5		
<i>Erythromma najas</i> (Hansemann 1823)	1.9	1.2	1, 5b, 9b, 15a-b, 15e	●	3	5		●
<i>E. viridulum</i> (Charpentier, 1840)	0.7	–	9b, 12b			●		
<i>Pyrrhosoma nymphula</i> (Sulzer, 1776)	0.7	>0.1	2b, 8	○	1			
<i>Brachytron pratense</i> (O.F. Müller, 1764)	0.4	>0.1	5b			1		
<i>Aeshna affinis</i> Vander Linden, 1820	2.6	–	2c, 2d, 5b, 6b			1	●	●
<i>A. cyanea</i> (O.F. Müller, 1764)	1.9	1.9	4b, 6a, 14, 15a, 15d-e	●	5	●		●
<i>A. grandis</i> (Linnaeus, 1758)	2.6	0.6	2b, 5b, 6b, 9b, 12a, 12b, 15a-b	○	●	4		
<i>A. mixta</i> Latreille, 1805	1.9	–	1, 6a, 11, 12b, 15e	○		1		●
<i>A. viridis</i> Eversmann, 1836	1.1	>0.1	5b, 12b			1		
<i>Anax imperator</i> Leach, 1815	–	>0.1	9b			1		
<i>Gomphus flavipes</i> (Charpentier, 1825)	2.2	14.2	1, 2a, 3, 4a, 5a, 6a, 8, 9a, 11, 12a, 14, 15c	5				
<i>G. vulgatissimus</i> (Linnaeus, 1758)	4.4	20.0	1, 2a, 3, 4a, 5a, 6a, 7a, 8, 9a, 11, 12a, 12b, 13, 14, 15c	5	3	1		
<i>Ophiogomphus cecilia</i> (Fourcroy, 1785)	2.6	13.4	1, 2a, 3, 4a, 5a, 6a, 8, 9a, 10, 14, 15c	5		○		

<i>Cordulia aenea</i> (Linnaeus, 1758)	1.9	0.8	6b, 9b, 10, 12b, 15b			5			
<i>Somatochlora metallica</i> (Vander Linden, 1825)	0.7	>0.1	4a, 6a, 15a	1	•				
<i>Epithea bimaculata</i> (Charpentier, 1825)	–	0.2	9b, 15b			3			
<i>Libellula depressa</i> Linnaeus, 1758	0.7	–	3, 9b	○		•			
<i>L. fulva</i> O.F. Müller, 1764	1.5	–	2a, 6a, 9a	•					
<i>L. quadrimaculata</i> Linnaeus, 1758	0.7	–	9b			•			
<i>Orthetrum albistylum</i> (Sélys, 1848)	1.9	–	2a, 3, 4a, 9a	1					
<i>O. cancellatum</i> (Linnaeus, 1758)	0.7	0.1	6b, 9b			2			
<i>O. coerulescens</i> (Fabricius, 1798)	0.4	–	2b		•				
<i>Sympetrum flaveolum</i> (Linnaeus, 1758)	4.4	–	2a-d, 5b, 6b, 6d, 9b, 12a-b	•	1	1	1	1	1
<i>S. fonscolombii</i> (Sélys, 1840)	0.4	–	5b			1			
<i>S. sanguineum</i> (O.F. Müller, 1764)	9.3	0.3	2a, 5b, 6a-b, 6d, 7a-b, 9b, 11, 12a, 15a-c, 15e	1	3	3	•	•	
<i>S. vulgatum</i> (Linnaeus, 1758)	1.1	0.4	2a, 9b, 12b	1	1	1			
<i>Sympetrum</i> sp. larvae juv.	–	0.2	5b, 9b			3			
<i>Leucorrhinia caudalis</i> (Charpentier, 1840)	–	0.1	9b			1			
<i>L. pectoralis</i> (Charpentier, 1825)	–	>0.1	12b			1			
				species number:	21	17	32	10	12
				with recorded or probable development:	16	17	30	7	11

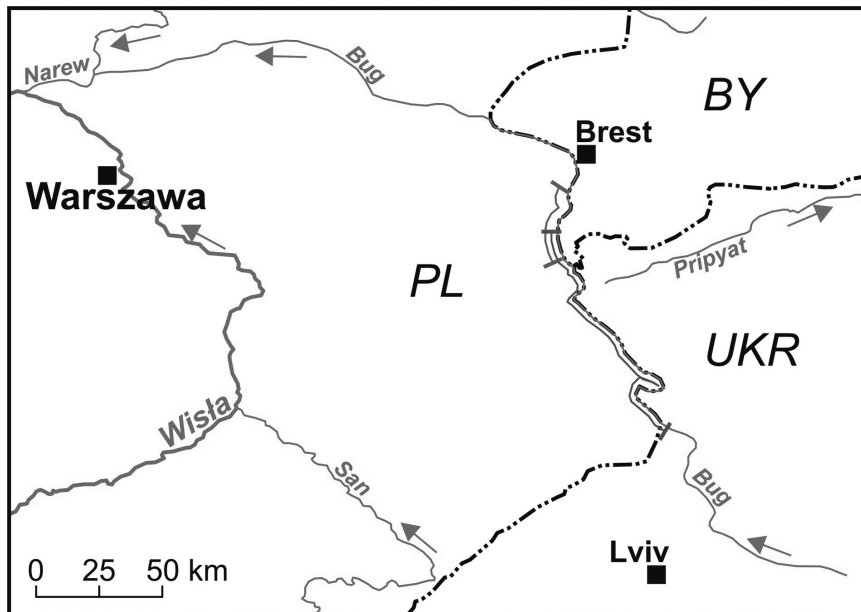


Fig. 1. Sections of the Bug River valley studied by Buczyński (2006, 2007) (red line) and analysed in this paper (green line). PL – Poland, BY – Belarus, UKR – the Ukraine

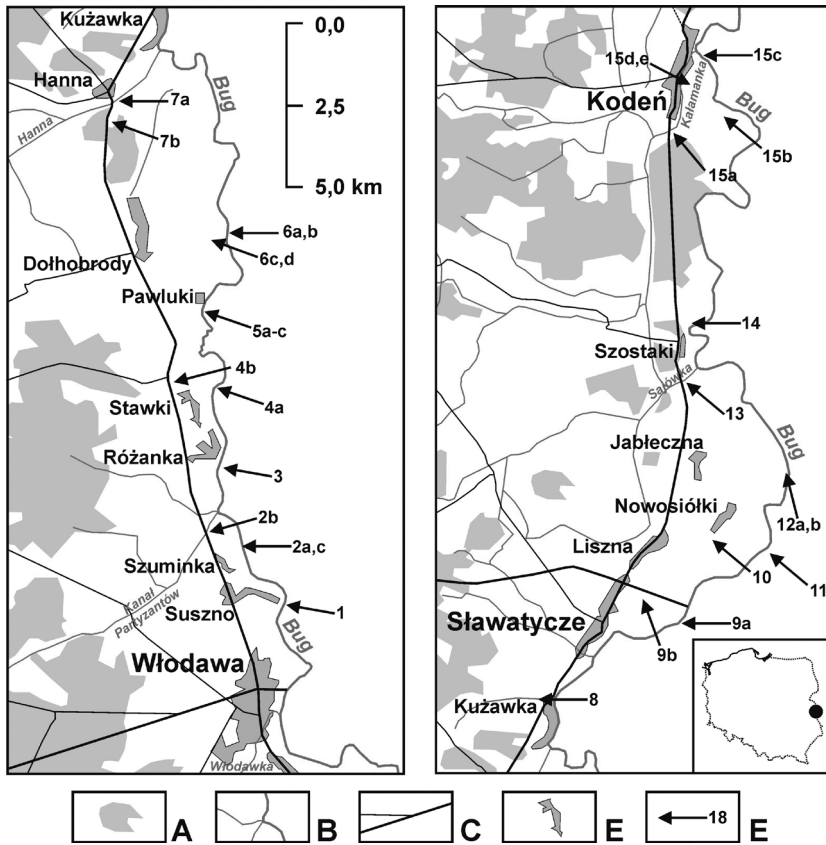


Fig. 2. Study area. A – forests and larger tree stands, B – flowing waters, C – roads, D – towns, E – study sites

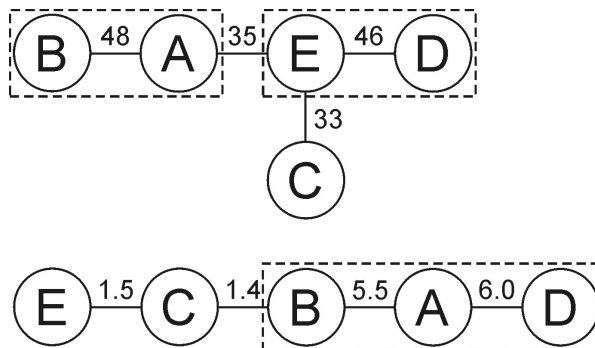


Fig. 3. Simplified Wrocław dendrite of faunistic similarities [%] between the environments studied. Upper diagram – qualitative similarities, lower diagram – quantitative similarities (designations as in Table 1)

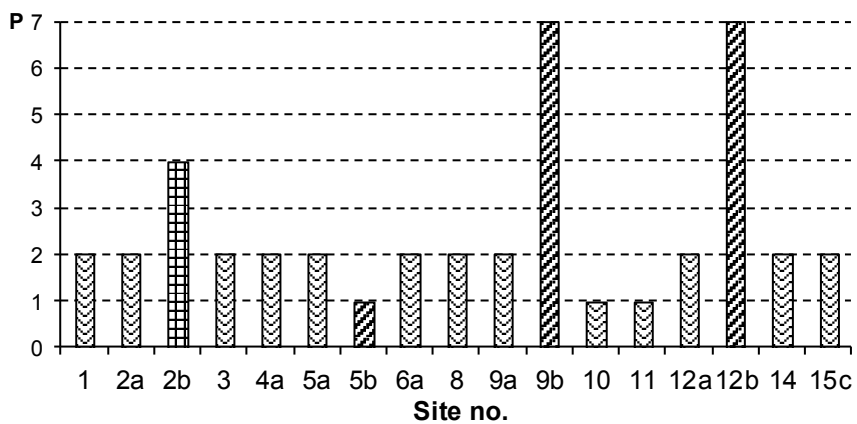


Fig. 4. Zoological significance of individual sites (bars filled with curved line: the Bug River, checked: Bug River tributaries, diagonal lines: oxbow lakes). P – points.

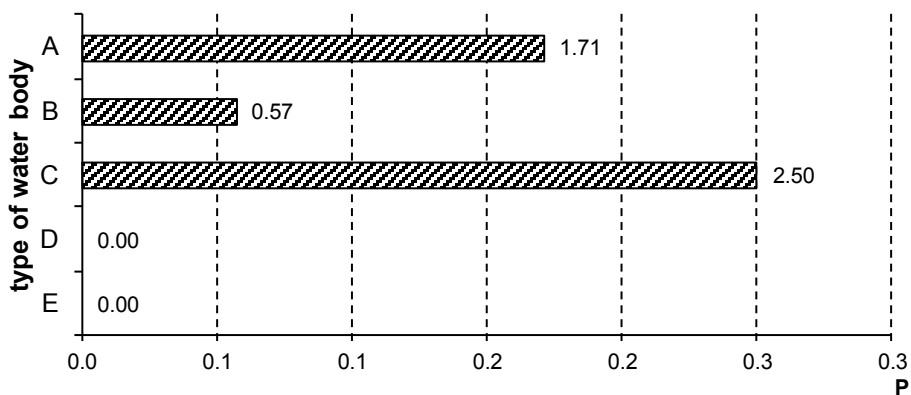


Fig. 5. Zoological significance of individual habitats: mean number of points per site. P – points.



Phot. 1. The Kanał Partyzantów Stream in Szuminka (site No. 2b). (Phot. Edyta Buczyńska)



Phot. 2. Permanent Meadow water body in Szuminka (site No. 2d). (Phot. Edyta Buczyńska)



Phot.3. The Bug River in Stawki (site No. 4). (Phot. Paweł Buczyński)



Phot. 4. Bug River oxbow Lake in Pawluki (site No. 5b). (Phot. Edyta Buczyńska)



Phot. 5. Astatic water body in Pawluki (site No. 5c). (Phot. Edyta Buczyńska)



Phot. 6. Bug River tributary – the Hanna River in Hanna (No. 7a). (Phot. Edyta Buczyńska)



Phot. 7. Bug River oxbow Lake in Sławatycze (site No. 9b). (Phot. Paweł Buczyński)



Phot. 8. Bug River oxbow Lake in Jabłeczna (site No. 12b). (Phot. Edyta Buczyńska)



Phot. 9. Bug River tributary – the Kalamanka River in Kodeń (site No. 15a). (Phot. Edyta Buczyńska)



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## WAŻKI (ODONATA) LEWOBRZEŻNEJ DOLINY BUGU MIĘDZY WŁODAWĄ I KODNIEM (POLSKA ŚRODKOWO-WSCHODNIA)

### Streszczenie

Analizowano występowanie ważek w lewobrzeżnej (polskiej) części doliny Bugu pomiędzy Włodawą i Kodniem (65 km biegu rzeki, 51°32'–51°55' N, 23°31'–23°38' E). Wykazano 40 gatunków. Kluczowe dla występowania ważek były: starorzecza, rzeka Bug i jej dopływy. Stosunkowo małe bogactwo jakościowe odonofauny wynikało z małego

zróznicowania siedlisk, zwłaszcza z braku torfowisk i wód dystroficznych oraz z silnego astatyzmu drobnych zbiorników. Widać było skutki silnego zanieczyszczenia wody w Bugu: skład gatunkowy ważek był prawidłowy, ale zagęszczenia Gomphidae (zwłaszcza *Ophiogomphus cecilia*) wskazywały na niekorzystny stan środowiska. Jest to spowodowane przez spływy powierzchniowe ścieków rolniczych w Polsce, ale też silne zanieczyszczenie rzeki jeszcze na obszarze Ukrainy.

Omawiane prace były kontynuacją wcześniejszych badań, prowadzonych w dolinie Bugu w wyższym biegu rzeki. Podsumowując nowe i stare dane, w dolinie środkowego Bugu między Gołębiami i Kodniem (246 km biegu rzeki na granicy Polski z Ukrainą i Białorusią), stwierdzono 54 gatunki ważek, co stanowi 74% fauny Polski jak też 73% fauny Ukrainy i 86% fauny Białorusi. Jest to obszar o dużym znaczeniu dla ochrony ważek pod względem bogactwa gatunkowego i zgrupowań gatunków. Występuje tu niewiele ważek zagrożonych w Polsce, ale jest to istotny rezerwuar taksonów zagrożonych w Europie Środkowej: stwierdzono 62–79% gatunków z Czerwonych list krajów sąsiadujących z Polską.

**Słowa kluczowe:** ważki, Odonata, Polska środkowo-wschodnia, rzeka Bug, dolina rzeczna, terasa zalewowa, faunistyka, zgrupowania, ochrona