



Dragonflies (Odonata) of some small anthropogenic water bodies in Cracow City

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Abstract: Dragonflies of small anthropogenic water bodies were studied in Cracow City (south Poland) in the years 2001–2004. 38 species were recorded, of which 24 were autochthonous and 6 probably autochthonous. Many southern and southeastern species occurred, of which the most interesting are: *Aeshna affinis* (Vander L.), *Orthetrum albistylum* (Sél.), *Sympetrum fonscolombii* (Sél.) and *Crocothemis erythrea* (Brullé). Also important are the tyrphobiontic and tyrphophilous species: *Coenagrion hastulatum* (Charp.), *Lestes sponsa* (Hansem.), *Sympetrum danae* (Sulz.), *Leucorrhinia dubia* (Vander L.) and *L. rubicunda* (L.). The importance of these secondary biotopes for the protection of dragonflies is discussed.

Key words: Odonata, Poland, secondary biotopes, sandy ponds, urban area

INTRODUCTION

Cracow is a city rich in surface waters. Within its area several tens of greater and smaller waterbodies, rivers and streams are located. However, the knowledge of their fauna, including dragonflies, is very poor. Studies on Odonata were conducted in Cracow mainly in the period between the World Wars (Prüffer 1920, Zaćwilichowski 1922, 1929, Fudakowski 1924, Rymar 1935). For over 70 years no further studies on this group have been conducted. Considering the great changes that have taken place since that time, information presented in these papers are of historical value but do not help us assess the present status of odonate fauna. This also applies to other large cities in Poland and information is limited (Bernard 2002, Tończyk 2004, Tończyk & Pakulnicka 2004, Buczyński 1995, 2002, Buczyński & Lewandowski in press). Much more interest of odonatologists in Poland is attracted rather by protected or not degraded areas (e.g. Fudakowski 1930, Mielewczyk 1966, 1978, Łabędzki 1987, 1995, 2000, Buczyński 1997, Buczyński & Tończyk 2004). However, recently, a little more attention has been paid to the odonate fauna of small anthropogenic water ponds (Mielewczyk 1972, Buczyński 1999, Buczyński & Pakulnicka 2000, Tończyk 2004).

The present paper considers the preliminary results of studying the species composition of dragonflies at one type of water reservoir. Studies on dragonflies of ponds formed in limestone quarries, numerous waterbodies near the Vistula river, large lakes or running waters will be a subject of separate studies.

STUDY AREA

The study was carried out in four small ponds located in the southern part of Cracow.

1. Surface area 0.84 ha, rectangular, maximum depth ca 1.5 m, sandy bottom, with a mixture of silt and detritus, water transparency low. Around the edge are scattered rushes: *Typha angustifolia* L., *Phragmites communis* Trin., *Juncus compressus* Jacq. and *Carex* spp. Hydrophytes are represented by: *Potamogeton natans* L., *P. crispus* L., *Myriophyllum*

spicatum L.. Along about one third of the bank branches of *Alnus glutinosa* and *Salix* sp. hang over water.

2. Surface ca 400 m², shape close to rectangular, maximum depth ca 0.7 m, sludgy bottom, water of low transparency. Subaquatic and aquatic vegetation are much richer than in the remaining ponds. Among the helophytes are *Rumex hydrolapathum* Huds. – numerous clumps, *Sparganium ramosum* Huds., *Juncus effusus* L., *Equisetum limosum* L., *Iris pseudoacorus* L., *Alisma plantago – aquatica* L. and various species of sedge *Carex* spp.. More numerous elodeids are represented: *Myriophyllum spicatum* L., *Elodea canadensis* Rich. and *Ceratophyllum demersum* L. were present. Their abundant shoots cover the whole surface of the pond from June. On the bottom of the pond rubbish is abundant, such as tyres, kitchen furniture, rubble and plastic containers. This pond has a connection with a wetland densely covered with different species of sedge. Between the pond and sedge wetland there is a wedge of willow thickets, the branches of which hang over part of the water surface. In autumn 2003 this pond was filled with soil and sand.

3. Surface ca 700 m², shape almost oval, maximum depth ca 1.2 m. Sludgy bottom, water of low transparency. Most of the bank is covered with high rush vegetation with dominating *Typha angustifolia* L. Among the most numerous helophytes *Juncus effusus* L., *Sparganium ramosum* Huds., as well as few species of *Carex* spp.. Nymphaeids and elodeids are represented by: *Potamogeton natans* L., *Myriophyllum spitatum* L. and *Ceratophyllum demersum* L. from June these three species almost fill the pond.

4. Surface area ca 110 m², kidney-shaped, maximum depth ca 0.6 m, with a sandy bottom and transparent water. The community of helophytes is poor and formed by *Typha angustifolia* L., *Phragmites communis* Trin. and *Equisetum limosum* L.. Similarly, the hydrophytes are represented by only a few species: *Potamogeton natans* L., *Lemna* spp., *Elodea canadensis* Rich., *Ceratophyllum demersum* L. Shoots of the last two species fill the whole pond by the end of the summer. The pond is strongly littered with tyres, plastic containers and bags with concrete. The pond is surrounded by willow thickets, the branches of which hang over the water surface and partly shadow it. Around the pond are wet meadows on a sand substratum, reedbeds and rushes with small permanent and ephemeral water ponds and drainage ditches.

During the summer months all of the ponds are strongly insulated, for most of the day. The water level in the ponds underwent smaller or greater changes in subsequent seasons. The largest changes were observed in the smallest pond (4) and, in 2003 it dried up almost completely. In the same year pond 2 decreased in size to several tens of square meters, while in the remaining two ponds the water level fell to a maximum of ca 20–35 cm.

A common feature of all four ponds was their origin. Their basins were formed by the commercial removal of sand, although pond 2 may also have had some of the deeper clay layer extracted.

MATERIAL AND METHODS

Studies were conducted in 2001–2004, from spring to autumn. To determine the timing of appearance and disappearance of imagines of species, observations were performed at least every two weeks; sometimes more frequently. Exuviae were collected; also a small number of adults to confirm the species.

Recorded species were divided into three categories:

- confirmed breeding – when exuviae or juvenile imagines were collected
- probable breeding – observation of reproductive behaviour, egg laying
- adults present – mature imagines, lack of reproductive behaviour.

In total 1130 imagines and 35 exuviae were collected. Most of the preserved material is stored in the collection of the first author in the Institute of Biology CPU in Cracow and the remaining part in collections of the co-authors.

RESULTS

Thirty eight species of dragonflies were recorded. In 24 species development was recorded (autochthonous species) and in a further 6 probable development (probably autochthonous species). The dragonfly fauna was similar in all sites. The richest fauna was found in ponds 1 and 2 with 32 and 35 species, respectively. Ponds 3 (17 species) and 4 (23 species) were poorer (Table 1).

Table 1. Dragonflies recorded on the particular sites in Cracow (● – breeding confirmed, ■ – breeding probable, ○ – adults present).

No.	Species	Pond			
		1	2	3	4
1	<i>Calopteryx splendens</i> (Harr.)	○	○	○	
2	<i>C. virgo</i> (L.)	○	○	○	○
3	<i>Sympecma fusca</i> (Vander L.)	●	●	○	■
4	<i>Lestes barbarus</i> (Fabr.)	○	○		
5	<i>L. dryas</i> Kirby		○	■	
6	<i>L. sponsa</i> (Hansem.)	○	●		●
7	<i>L. virens</i> (Charp.)	○	●		
8	<i>L. viridis</i> (Vander L.)	●	●		■
9	<i>Platycnemis pennipes</i> (Pall.)	○	○		
10	<i>Ischnura elegans</i> (Vander L.)	○	○		
11	<i>Enallagma cyathigerum</i> (Charp.)	●	●	●	●
12	<i>Pyrrhosoma nymphula</i> (Sulz.)	○	○		○
13	<i>Coenagrion hastulatum</i> (Charp.)		○		
14	<i>C. puella</i> (L.)	●	●	●	●
15	<i>C. pulchellum</i> (Vander L.)	●	●		○
16	<i>Erythromma najas</i> (Hansem.)	●	●	●	●
17	<i>E. viridulum</i> (Charp.)	●	●		○
18	<i>Aeshna affinis</i> Vander L.	●	■	○	■
19	<i>A. cyanea</i> (O. F. Müll.)	■	●	○	○
20	<i>A. grandis</i> (L.)	■	●	■	
21	<i>A. mixta</i> Latr.	■	●	■	○
22	<i>Anax imperator</i> Leach	■	●	■	○
23	<i>Cordulia aenea</i> (L.)	●	●	■	
24	<i>Somatochlora metallica</i> (Vander L.)	■	●		
25	<i>Libellula depressa</i> L.	■	■		
26	<i>L. quadrimaculata</i> (Vander L.)	●	●	●	●
27	<i>Orthetrum albistylum</i> (Sél.)	●	■		
28	<i>O. cancellatum</i> (L.)	●	■	■	
29	<i>Crothocemis erythrea</i> (Brullé)	○	○		
30	<i>Sympetrum danae</i> (Sulz.)	■	●		■
31	<i>S. flaveolum</i> (L.)	■	■	■	■
32	<i>S. sanguineum</i> (O. F. Müll.)	●	●		●
33	<i>S. striolatum</i> (Charp.)	■	■		○
34	<i>S. fonscolombii</i> (Sél.)		○		
35	<i>S. vulgatum</i> (L.)	●	●	■	●
36	<i>Leucorrhinia dubia</i> (Vander L.)		○		○
37	<i>L. pectoralis</i> (Charp.)				○
38	<i>L. rubicunda</i> (L.)				○

Among southern species the presence of *Aeshna affinis*, *Orthetrum albistylum*, *Sympetrum fonscolombii*, *Crothocemis erythrea* is especially worth attention.

There is also a relatively high number of tyrphobiontic and tyrphophilous species, represented by: *Coenagrion hastulatum*, *Lestes sponsa*, *Sympetrum danae*, *Leucorrhinia dubia* and *Leucorrhinia rubicunda*.

Among 73 species of dragonflies occurring in Poland (Dolný 2005, Mielewczyk 1990, 1997), 38 were recorded during the present study, which is over half (52.1%) of the Polish dragonfly fauna. In spite of covering only four sites, the number of species is high and this type of pond clearly provides favourable habitat for a wide range of species. Similar results were obtained, for example, in south-eastern Poland, where in 10 ponds of the same origin 41 species were found. (Buczyński 1999) and in waterbodies of the same type in the Białowieża National Park, 39 species were noted (Theuerkauf & Rouys 2001). Similar results have also been obtained in Western Europe (Ott 1995) – 40 species, (Wildermuth & Krebs 1983) – 39 species. It should be noted that in most of these studies were conducted in much higher number of sites and in some cases – of a different stage of succession more ponds were surveyed. However, generally in ponds of anthropogenic origin lower numbers of species are more often observed, e.g. Trockur (1997) – 30 species, (Buczyński & Pakulnicka 2000) – 30 species Chovanec (1998) – 26 species, Tończyk (2004) – 25 species.

For a single pond the number of species in ponds 1 (32 species) and 2 (35 species) was higher than in other ponds of this type in Poland. For example, Buczyński (1999) recorded a maximum of 23 species and Buczyński & Pakulnicka (2000) a maximum of 25 species.

The rich fauna of dragonflies in these ponds is due to the mosaic of different vegetation structure, spatial diversity, variety of places for laying eggs and heterogenic surroundings. These factors, as confirmed by observations of a number of authors, have great influence on the species richness of dragonfly communities (e.g. Stark 1977, Bernard 1996, Lenz 1991, Chovanec 1998).

Five sampling occasions in a year is enough for the assessment of RSO (Representative Spectrum of Odonata Species) (Schmidt 1985) but a higher number of sampling occasions provides more information, increasing the likelihood of encountering rare species or those which only occur for a short period of time (e.g. Schmidt 1985, Chovanec 1998).

The high abundance and density of different types of stagnant water and streams in Cracow is also of great importance as it allows for free movements among the sites and eliminates isolation.

The species recorded in this study are mostly ones with a wide ecological tolerance are widely distributed and common in Poland (eurytopic species and stagnophiles) and are representative of this type of water body.

The presence of species from the genus *Lestes* and the high numbers of *Coenagrion puella*, *Enallagma cyathigerum*, *Aeshna mixta*, *Libellula quadrimaculata*, *Sympetrum sanguineum* and *Sympetrum vulgatum* indicate the type of the community that prefers waterbodies with well developed rush vegetation and phytolittoral (Chovanec 1998). This association of species is also related to the coenosis *Lestes-Sympetrum-(Aeshna mixta)* described by Jacob (1969). Open water and the occurrence of nympheids (*Potamogeton* sp.) is favourable for the development of a dragonfly community comprising *Erythromma najas* and *Anax imperator* (Chwala & Waringer 1996). On the other hand, the abundance of *Orthetrum albistylum* is characteristic of pioneer communities (Buczyński 1999). Coexistence of these groups, sometimes in the same ponds, is possible due to the favourable architectural diversity of vegetation and bank profile (cf. Bernard 1996, Chwala & Waringer 1996). It is worth emphasizing that strong insolation seems to be crucial for the development of these communities (Chwala & Waringer 1996).

Representation of tyrphobiontic and tyrphophilous species was relatively rich for this type of water body. These species included a *Leucorrhinia dubia* (tyrphobiontic), *Leucorrhinia rubicunda*, *Sympetrum danae* and *Lestes sponsa* (1st level tyrphophilous) and – *Coenagrion hastulatum* (2nd level tyrphophilous) (c.f. Mielewczyk 1969).

The presence of several migratory and/or southern species is of particular importance: *Crocothemis erythrea*, *Orthetrum albistylum*, *Aeshna affinis*, *Sympetrum fonscolombii*.

Thus *Crocothemis erythraea* is a southern species, recorded in Poland for the first time in Cracow (Prüffer 1920). Re-occurrence of this species in Cracow at several sites (Piksa unpubl.) corresponds with a distinct increase in the presence of this species in Poland (Zaćwilichowski 1922, Bielewicz 1968, Czekaj 1993, Bernard 2000, Bernard & Samoląg 2000) and in Central Europe generally. Its occurrence fluctuates. It was recorded in the study area only in 2004. In years 2001–2003 it was not observed, in spite of conducting intensive studies. Its development has been observed only in the Białowieża Primeval Forest and in Silesia (Theuerkauf & Rouys 2001, Dolný & Misztal 2004).

The presence of a stable population of *Orthetrum albistylum* during the whole period of the study indicates a permanent 'settlement' of this species, corresponding with its intensive expansion and remarkable range extension recorded in Poland in recent years (Buczyński 1999, Buczyński et al. 2002).

It is similar in the case of *Aeshna affinis*, which also seems to be a stable element of the dragonfly fauna of Cracow, indicated by a permanent population during the whole period of the study. A similar situation has been observed in other regions of Poland, with stable populations recorded in parts of the Lublin region (Buczyński 1996, 1999) and near Poznań (Bernard & Samoląg 1997, Bernard et al. 2002b).

Sympetrum fonscolombii is a Mediterranean species, rarely recorded in Poland. It has an invasive character and its breeding activity is rare and temporary (Mielewczyk 1966, Bernard 1997, Buczyński & Czachorowski 1999, Buczyński 1999). Its accidental presence – only one specimen was caught - suggests that it was a vagrant individual, despite a lack of any signs of exhaustion.

Obtaining data from these small ponds is only a first step to gaining knowledge about the current dragonfly fauna of Cracow. Earlier records indicate 54 species (Dziędziewic 1891, 1902, 1917, Prüffer 1920, Zaćwilichowski 1922, 1929, Fudakowski 1924, Rymar 1935, authors) (Table 2). This current list is clearly incomplete, encountering several further species as well as confirmation of presence of other species stated in the period between wars is still possible. It is the more probable, as only a small part of waterbodies has been penetrated.

Until the present, studies on Odonata in the larger cities of Poland have been rare, hence the limited amount of comparative data. Only the dragonfly fauna of Poznań, Olsztyn and Łódź are relatively well described, with 55 (Bernard 2002), 47 (Buczyński & Lewandowski in press) and 41 (Tończyk 2004, Tończyk & Pakulnicka 2004) species of Odonata respectively. Fragmentary data are reported from Lublin (Buczyński 1995, 2002). In Cracow the dragonfly fauna is very rich and stenotopic species are still relatively abundant; a similar situation occurs in Olsztyn (Buczyński 1995, 2002).

From among indicator species the presence of two umbrella species, *Anax imperator* and *Orthetrum albistylum*, is characteristic for this kind of waterbody as also are *Leucorrhinia dubia* and *Leucorrhinia pectoralis* (cf. Czachorowski et al. 2000, Bernard et al. 2002b).

The importance of the described ponds for the conservation of threatened and protected species is not high. From 16 species listed in the Polish Red List (Bernard et al. 2002a) only one, *Aeshna affinis*, was observed and it is proposed that this species is proposed to be removed from the list (Bernard 2004). Out of 15 protected species only one, *Leucorrhinia pectoralis*, was encountered. A similar situation is faced in most ponds of a similar origin all over Poland (Buczyński 1999). Out of 41 species recorded by this author only three are included in the Polish Red List, namely *Aeshna affinis*, *Orthetrum brunneum* and *Orthetrum coerulescens*, and it has been proposed that *Aeshna affinis* and *Orthetrum brunneum* be removed from this list due to their relatively numerous occurrence Bernard (2004). Only two protected species were recorded in the study area, i.e. *Sympecma paedisca* and *Leucorrhinia pectoralis* (Buczyński 1999).

Tab. 2. Dragonfly species recorded in Cracow

No.	Species	Dziędzielewiez 1891, 1917	Prüffer 1920	Dziędzielewiez 1902	Zacwilichowski 1922	Zacwilichowski 1929	Fudakowski 1924	Rymar 1935	Authors
1	<i>Calopteryx splendens</i> (Harr.)		+		+		+		+
2	<i>C. virgo</i> (L.)		+		+		+		+
3	<i>Sympecma fusca</i> (Vander L.)		+		+				+
4	<i>Lestes barbarus</i> (Fabr.)				+				+
5	<i>L. dryas</i> Kirby							+	+
6	<i>L. sponsa</i> (Hansem.)		+		+				+
7	<i>L. virens</i> (Charp.)				+				+
8	<i>L. viridis</i> (Vander L.)					+			+
9	<i>Platycnemis pennipes</i> (Pall.)		+		+				+
10	<i>Ischnura elegans</i> (Vander L.)		+		+		+		+
11	<i>I. pumilio</i> (Charp.)		+		+				+
12	<i>Enallagma cyathigerum</i> (Charp.)		+		+		+		+
13	<i>Pyrrhosoma nymphula</i> (Sulz.)	+	+	+	+		+		+
14	<i>Coenagrion armatum</i> (Charp.)					+	+		+
15	<i>C. hastulatum</i> (Charp.)		+		+				+
16	<i>C. lunulatum</i> (Charp.)		+						+
17	<i>C. puella</i> (L.)		+		+		+		+
18	<i>C. pulchellum</i> (Vander L.)		+		+				+
19	<i>Erythromma najas</i> (Hansem.)				+				+
20	<i>E. viridulum</i> (Charp.)							+	+
21	<i>Gomphus vulgatissimus</i> (L.)		+		+		+		+
22	<i>Ophiogomphus cecilia</i> (Fourcr.)				+				+
23	<i>Onychogomphus forcipatus</i> L.						+		+
24	<i>Brachytron pratense</i> (O. F. Müll.)		+		+				+
25	<i>Aeshna affinis</i> Vander L.				+				+
26	<i>A. cyanea</i> (O. F. Müll.)		+		+				+
27	<i>A. grandis</i> (L.)		+		+				+
28	<i>A. isoceles</i> (O. F. Müll.)		+		+				+
29	<i>A. juncea</i> (L.)		+		+				+
30	<i>A. mixta</i> Latr.				+				+
31	<i>Anax imperator</i> Leach		+		+				+
32	<i>A. parthenope</i> Sél.					+			+
33	<i>Cordulegaster bidentata</i> Sél.		+						+
34	<i>Cordulia aenea</i> (L.)		+		+				+
35	<i>Somatochlora flavomaculata</i> (Vander L.)				+				+
36	<i>S. metallica</i> (Vander L.)						+	+	+
37	<i>Libellula depressa</i> L.		+		+		+		+
38	<i>L. quadrimaculata</i> (Vander L.)		+		+				+
39	<i>Orthetrum albistylum</i> (Sél.)		+		+				+
40	<i>O. cancellatum</i> (L.)		+		+				+
41	<i>O. coerulescens</i> (Fabr.)							+	+
42	<i>O. brunneum</i> (Fonsc.)						+	+	+
43	<i>Crothocemis erythrea</i> (Brullé)		+		+				+
44	<i>Sympetrum danae</i> (Sulz.)		+		+				+
45	<i>S. flaveolum</i> (L.)		+						+
46	<i>S. sanguineum</i> (O. F. Müll.)		+		+		+		+
47	<i>S. striolatum</i> (Charp.)				+				+
48	<i>S. fonscolombii</i> (Sél.)					+			+
49	<i>S. meridionale</i> (Sél.)							+	+
50	<i>S. vulgatum</i> (L.)		+		+				+
51	<i>Leucorrhinia caudalis</i> (Charp)				+				+
52	<i>L. dubia</i> (Vander L.)	+		+					+
53	<i>L. pectoralis</i> (Charp.)		+		+				+
54	<i>L. rubicunda</i> (L.)		+		+				+

In other regions of Central and Western Europe this type of water body is more important for conservation of threatened and protected species and the number of recorded species of dragonflies is high. This does not result from their greater species richness, but from the fact that a number of species which are common in small ponds in Poland, are included in the Red Lists in other countries, e.g. in Austria (Raab & Chwala 1997), Germany (Ott & Piper 1998) and Switzerland (Gonseth & Monnerat 2002). If we use the same criteria as, e.g., in Switzerland, as many as 34 of the species recorded in the present study would be included in such a list; among them many species common in Poland, e.g. *Coenagrion puella*, *Enallagma cyathigerum*, *Ischnura elegans* and *Libellula quadrimaculata*. The status of threat to the Polish fauna of dragonflies is distinctly lower, thanks to much better preservation of aquatic habitats (Czachorowski & Buczyński 2000).

In our opinion, such small anthropogenic ponds could be important in diversifying the monotonous landscape of urban areas in Poland and become important for the preservation of species diversity of the dragonflies in these areas (Bernard et al. 2002b), as is the case in other countries where the role of such ponds are appreciated (Chovanec 1994). Unfortunately, the future of this type of pond is poor. Rapid development of the Cracow conurbation, with the assignment of more and more land for building, means that such water bodies are easily lost by being filled in, as has already happened to the most 'odonatologically' attractive pond (number 2).

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STRESZCZENIE

[Ważki (Odonata) małych zbiorników wodnych Krakowa]

Praca ma charakter studium faunistyczno-fenologicznego ważek drobnych zbiorników wodnych pochodzenia antropogenicznego położonych na terenie Krakowa. Celem jej było poznanie składu gatunkowego odonatofauny oraz prześledzenie fenologii pojawu imagines. W trakcie badań prowadzonych w latach 2001–2004 nad czterema zbiornikami wodnymi stwierdzono występowanie 38 gatunków ważek, w przypadku 24 gatunków zaobserwowano rozwój, w przypadku 6 jest on prawdopodobny. Wśród gatunków ciepłolubnych na uwagę zasługiwała obecność: *Aeshna affinis* (Vand. Lind), *Orthetrum albistylum* (Sél.), *Sympetrum fonscolombii* (Sél.), *Crocothemis erythrea* (Brullé). Stosunkowo licznie reprezentowane były również gatunki tyrfofilne i tyrfobiontyczne: *Coenagrion hastulatum* (Charp.), *Lestes sponsa* (Hansem.), *Sympetrum danae* (Sulz.), *Leucorrhinia dubia* (Vander L.), *Leucorrhinia rubicunda* (L.). Wyniki tych badań przedstawiono na tle dotychczasowego stanu wiedzy o ważkach Krakowa i innych miast Polski. Również znaczenie tego typu zbiorników w ochronie ważek było dyskutowane.

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