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Dragonflies (Odonata) of the city of Lublin (Eastern Poland)

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Abstract: The authors discuss the dragonfly fauna of Lublin based on fragmentary historical data and the results of their own research from the period 1992-2019. A total of 54 dragonfly species were recorded: 17 in the historical period and 53 contemporarily. Although the Lublin area is a hot spot of odonate species richness in both the Lublin Upland and central and eastern Poland, it is of little importance for habitat specialists and also endangered and protected species. The species composition of the fauna was analysed in three zones of the city: the outskirts, the urbanized area and the City Centre. The diversity and numbers of dragonflies decreased significantly along this urbanization gradient and some groups of stenotopic species disappeared. The importance of anthropogenic water bodies in maintaining the diversity of dragonflies in urban areas, in particular stormwater ponds and garden ponds, is emphasized.

Key Words: biodiversity, conservation potential, urban landscape, garden pond, stormwater pond

Introduction

For many reasons, the study of urban fauna has become very popular. Even though cities are steadily increasing in area, which is the case throughout Europe (Antrop 2004), and a great amount of relevant data is available, our understanding of the influence of urbanization on the environment remains unsatisfactory. Urban areas have highly specific habitat conditions and microclimates (Erell *et al.* 2011, Pathirana *et al.* 2014), so the natural environment in them is interesting for purely cognitive reasons. Moreover, although many natural habitats in cities have been destroyed, other habitats are merely undergoing transformation, and yet others are being created from scratch. Whatever the aims of such measures may be, they are all sites where animals occur and reproduce. Knowledge about how they function may help to reconcile utilitarian aims with nature conservation. What is more, the creation of specific types of habitat, like water bodies, may be a means of improving the microclimatic conditions in cities (Manteghi *et al.* 2015).

Dragonflies are a useful research model for analysing urban biodiversity. They are easy to study; their biology and ecology are well-known; particular species have specific habitat requirements and are sensitive to changes in temperature and the quality of the environment; being organisms that inhabit aquatic and terrestrial habitats, they react to changes in both; they are good surrogates of the general biodiversity of aquatic habitats (Villalobos-Jiménez *et al.* 2016, Kietzka 2019). Data on their occurrence in European cities have been used to carry out interesting

syntheses and meta-analyses (Willigalla & Fartmann 2010, 2012, Goertzen & Suhling 2015, 2019). Most of these papers are limited to urban areas in just a few central European countries, mainly Germany and Austria, sometimes also to single cities in Switzerland and the Czech Republic. Nevertheless, similar data are also available from elsewhere in Europe, e.g. from Poland, where the Odonata of the cities of Łódź (Tończyk & Pakulnicka 2004), Olsztyn (Buczyński & Lewandowski 2011) and Kielce (Gwardjan *et al.* 2015) have been described. Hence, the results of all these analyses, though undoubtedly valuable, are not universal, so it is worth supplementing them with data from other areas. The demand for further research in this respect remains considerable (Villalobos-Jiménez *et al.* 2016).

The authors of the present paper analyse the occurrence of dragonflies in the urban area of Lublin, a city situated on the borderlands between western and eastern Europe (Kondracki 2002). Although the dragonflies of the entire area of the city have never been researched during one period, a vast amount of information has been gathered with varying intensity since 1992, over three-quarters of which has never been published. In addition, there are some historical records. In the meantime, the environment around Lublin has been changing dynamically as a result of the transformation of the various parts of the existing city, the gradual disappearance of the hitherto rural character of the outskirts with encroaching urbanization, and climatic changes. Therefore, there is an urgent need to assess the status of contemporary research in this subject, which will become the point of reference for the results of future studies.

The main aims of this paper are as follows: a) to collate all the historical and contemporary data concerning the odonate fauna of Lublin; b) to analyse its diversity along the urbanization gradient; c) to evaluate whether newly-created water bodies in the city are important as habitats for dragonflies as regards the conservation of species richness, assemblages typical of natural habitats and so-called “special care species”.

Material and methods

Research area

Lublin (51°08’23”-51°17’47”N, 22°29’09”-22°40’25”E) is the biggest city in Poland east of the River Vistula and the capital city of Lublin Province with a population of 339 700 and an area of 147.5 km^2. Situated on the Lublin Upland (Wyżyna Lubelska) (163-238 m a.s.l.), it straddles the border of four mesoregions: the Nałęczów Plateau (Płaskowyż Nałęczowski) to the west, the Świdnik Plateau (Płaskowyż Świdnicki) to the east, a small part of the Bełżyce Plain (Równina Bełżycka) in the south-west, while the narrow wedge of the Giełczew Elevation (Wyniosłość Giełczewska) extends from the south almost into the city centre. Lublin is situated in a region overlain by a 20 m thick layer of loess. Topographically, the city is divided into two characteristic parts by the valley of the River Bystrzyca: the left bank has a diverse relief with a deep valley and old loess ravines, while the right bank is flatter and less diverse. This diversity relates to the soil cover: brown soils are dominant in the west, fluvisols and brown soils in the east (Kłosowski 2012, Solon *et al.* 2018, GUS 2019).

The Lublin of today has a far larger population and, above all, covers a much wider area than, say, in the 19th century. In 1827, the city was a mere 13.5 km^2 in area, but by 1938 it had grown to ca 31 km^2. By 1960, it had expanded to 93.2 km^2 and by 1980 to 118.5 km^2. The present-day area of Lublin was not reached until around 1989 (Jakubowski *et al.* 2018). It follows that areas of a rural character, which make up quite a large part of the city’s area, have become urbanized to only a minimal extent, so that local elements of natural habitats have survived, especially in the southern part of

Lublin. Even some of the areas situated fairly close to the city centre were transformed not so long ago, e.g. the valley of the River Czechówka: back in the 1970s, this river near the Saxon Garden (Ogród Saski) was only partially regulated and fishponds were still in existence there.

What is typical of the Lublin Upland in general (Kondracki 2002) is the fact that Lublin is poor in surface waters and that these are concentrated in the river valleys. The biggest river is the Bystrzyca, a 70.3 km-long left-hand tributary of the River Wieprz, here in its middle course (Wilgat 1998). Smaller rivers – the Nędznica, Czerniejówka and Czechówka – flow into the Bystrzyca within the city area; in addition, the small Konopniczanka Stream is a tributary of the Czechówka. There are fishponds and other small water bodies in the river valleys, on the outskirts of the city. Remnants of alder forests and fens have persisted in the Bystrzyca valley, even though they have unfortunately been almost completely drained. In 1974, the Zemborzyce storage reservoir (area: 278 ha, av. depth: 2.3 m), constructed on this river, came into use (Wilgat 1998). On the other hand, a number of stormwater ponds have been built in the valley of the Konopniczanka Stream, which contain water permanently or temporarily. The stream itself is now drying out below Laskowa St., and farther on its bed is dry, unless there has been recent heavy rain.

In the urbanized part of Lublin, the rivers are regulated and the banks have been stabilized in most places. In addition, the Czechówka flows through a 3.5 km tunnel under the Old City (Stare Miasto), which was built in the 1970s during the construction of the East-West Transit Route across the city. Apart from rivers, there are various types of artificial water bodies. These may be ornamental, like the ponds on the Czechówka in the Lublin Open Air Village Museum and those in the Botanical Garden of the Maria Curie-Skłodowska University (henceforth: UMCS Botanical Garden). In this garden, there is also a small pond on an artificial channel that passes through the rock garden, which carries water only in the tourist season, and another, similar in size, in the so-called biblical garden. There are also park ponds, like the one for water birds in the Saski Garden (Ogród Saski), and firewater ponds, like the one on Kąpielowa St. Moreover, in the Folk Park (Park Ludowy), established in the 1950s on the peaty meadows in the Bystrzyca valley, water is frequently present in the deepest of the ditches draining the park.

The quality of water in Lublin's rivers has been analysed in the Bystrzyca. This is classified as poor (class V), although the biological indicators are somewhat better – class III or IV, depending on the year of testing (e.g. Żelazny 2017, 2018). The poor quality of the water in the Bystrzyca, due among other things to the high concentrations of nutrients derived from surface runoff in its drainage area above Lublin, affects the Zemborzyce Reservoir. This is strongly eutrophic or hypertrophic, a state that is reflected in the excessive growth of phytoplankton, especially the frequent Cyanobacteria blooms. This state of affairs is exacerbated by the shallowness of the reservoir, the long period of water retention, inappropriate fish stocking management and exploitation by anglers (Dobrowolski *et al.* 2016). Furthermore, the poor state of the reservoir itself further worsens the quality of water in the Bystrzyca below it.

Lublin has a humid continental climate. The average air temperature is 7.3°C, the average monthly air temperature is the lowest in February (-4.0°C) and the highest in July (18.2°C). Sub-zero temperatures are recorded from December to March, while hot days with temperatures >25°C occur from April to September. The annual average precipitation is 560 mm. The growing season lasts from 210 to 220 days (Kłosowski 2012).

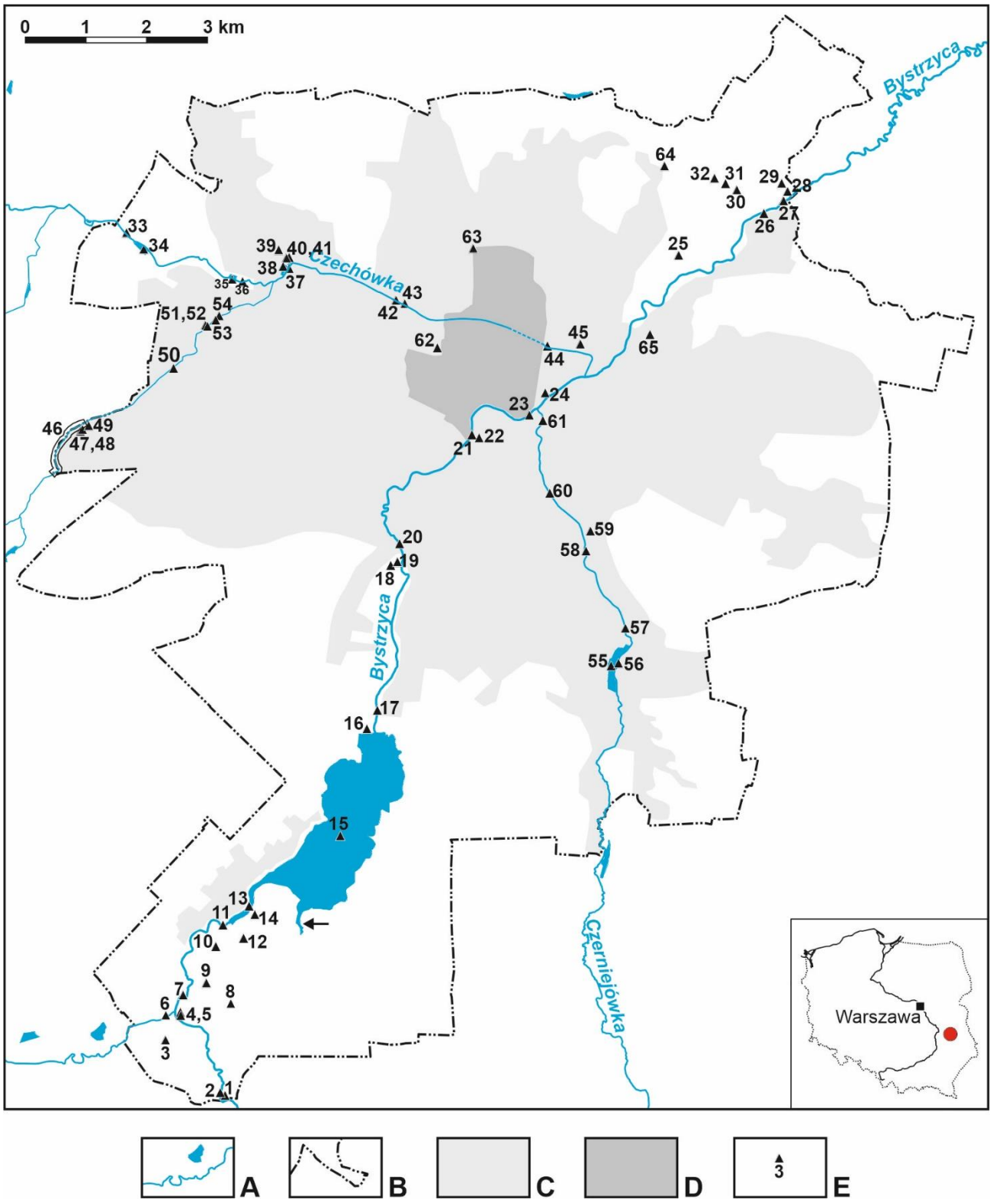

Fig. 1. Research area: A) streams, rivers and larger standing water bodies; B) border of the city; C) urbanized areas (after Trzaskowska & Adamiec 2016); D) city centre; E) research sites (numbering as in the text). The black arrow indicates the Rękaw Bay.

Research sites

The research material was gathered at 64 sites (Fig. 1). These are listed below together with their 10x10 km UTM squares and GPS coordinates (basically, for the centre of the site or for the borders where longer sections of rivers, streams and the Zemborzyce Reservoir are concerned). The sites have been ordered according to their locations in the river valleys or in their vicinity: the Bystrzyca, the Czechówka, the Konopniczanka Stream and the Czerniejówka. Finally, other sites located at some distance from the valleys are given.

1. Ponds in the angling permit area near Prawiednicka St. (FB06; 51°08’25”N 22°30’06”E).
2. The River Bystrzyca below Prawiednicka St. (FB06; 51°08’27”N 22°30’02”E).
3. Small water bodies in the former sand quarry in the Rudki forest (Las Rudki) (FB06; 51°08’56”N 22°29’16”E).
4. A small permanent water body at the edge of the alder forest in the Bystrzyca valley (FB06; 51°09’08”N 22°29’32”E).
5. Fen in the Bystrzyca valley (FB06; 51°09’06”N 22°29’36”E).
6. The River Nędznica above its confluence with the Bystrzyca (FB06; 51°09’10”N 22°29’21 E).
7. The River Bystrzyca near the bridge on Roślinna St. (FB06; 51°09’20”N 22°29’29”E).
8. Small permanent water bodies on meadows in the Bystrzyca valley (FB06; 51°09’17”N 22°30’06”E).
9. Drainage canal on a meadow in the Bystrzyca valley (FB06; 51°09’17”N 22°29’52”E).
10. Flooded meadows in the Bystrzyca valley above Cienista St. (FB06; 51°09’47”N 22°29’59”E).
11. The River Bystrzyca above the bridge on Cienista St. (FB06; 51°09’56”N 22°30’04”E).
12. Small water bodies in the former sand workings in the Bystrzyca valley, in the fork between Cienista and Roślinna Sts. (FB06; 51°09’49”N 22°30’21”E).
13. The River Bystrzyca – inflow section to the Zemborzyce Reservoir (FB06 and FB07; 51°10’07”N 22°30’28”E).
14. Drainage ditches in the Bystrzyca valley below Cienista St. (FB06 and FB07; 51°10’05”N 22°30’39”E).
15. The Zemborzyce Reservoir (FB06 and FB07; 51°09’51”-51°11’36”N, 22°30’38”-22°32’35”E)
16. Ditch surrounding the Zemborzyce Reservoir below the dam (FB07; 51°11’37”N 22°32’04”E).
17. The River Bystrzyca below Żeglarska St. (FB07; 51°11’42”N 22°32’11”E).
18. Small water bodies near Koło St. – the remains of an oxbow of the Bystrzyca (FB07; 51°13’03”N 22°32’25”E).
19. The canal joining the small water bodies at site 18 with the Bystrzyca (FB07; 51°13’04”N 22°32’29”E).
20. The River Bystrzyca – the section between the mouth of the canal (site 20) and the footbridge below the bridge from Jana Pawła II St. (FB07; 51°13’04”N 22°32’21”E – 51°13’36”N 22°32’31”E).
21. The River Bystrzyca adjoining the footbridge near the south-western part of the Folk Park (Park Ludowy) (FB07; 51°14’09”N 22°33’29”E).
22. Drainage canal in the Folk Park (FB07; 51°14’06”N 22°32’30”E).
23. The River Bystrzyca near the Culture Bridge (Most Kultury) (FB07; 51°14’20”N 22°34’16”E).
24. Reinforced firewater pond on Kąpielowa St. (FB07; 51°14’31”N 22°34’29”E).
25. A ditch on the meadow near the railway embankment in the Bystrzyca valley (FB17; 51°15’43”N 22°36’29”E).
26. The Hajdów sewage treatment plant – the concrete-lined canal draining treated waste to the River Bystrzyca (FB18; 51°16’02”N 22°37’34”E).
27. The River Bystrzyca below the outfall of treated waste from the Hajdów sewage

treatment plant (FB18; 51°16’10”N 22°37’45”E).
28. A small seasonal water body in the Bystrzyca valley below the Hajdów sewage treatment plant (FB18; 51°16’14”N 22°37’51”E).
29. The oxbow of the River Bystrzyca near Pliszczyńska St. (FB18; 51°16’20”N 22°37’45”E).
30. Lipnik loess ravine (Uroczysko Lipnik), a small temporary water body in the ravine on the slope of the Bystrzyca valley (FB18; 51°16’19”N 22°37’05”E).
31. Lipnik loess ravine, a small permanent water body in the ravine on the slope of the Bystrzyca valley (FB18; 51°16’20”N 22°36’58”E).
32. Lipnik loess ravine, a small seasonal water body in the ravine on the slope of the Bystrzyca valley (FB18; 51°16’24”N 22°36’53”E).
33. The River Czechówka near Zakątek St. (FB08; 51°15’56”N 22°28’41”E).
34. The pond on the Czechówka on Główna St. (FB08; 51°15’47”N 22°28’57”E).
35. The pond on the Czechówka in the Lublin Open Air Village Museum (FB07; 51°15’32”N 22°30’12”E).
36. The River Czechówka in the Lublin Open Air Village Museum (FB07; 51°15’31”N 22°30’24”E).
37. The River Czechówka near the UMCS Botanical Garden (FB07; 51°15’34”N 22°30’34”E).
38. Ponds in the UMCS Botanical Garden (FB07; 51°15’37”N 22°30’55”E).
39. A small ornamental pond in the so-called biblical garden in the UMCS Botanical Garden (FB07; 51°15’47”N 22°30’36”E).
40. A small ornamental pond in the rock garden in the UMCS Botanical Garden (FB07; 51°15’42”N 22°30’58”E).
41. Sulphate springs in the former health resort of Sławinek (they ran dry in the 1960s when the “Sławinek” deep water intake was built) (FB07; ~51°15’37”N ~22°30’46”E).
42. The fishponds on the River Czechówka on the site of today’s Solidarności Avenue (in the 1970s they were filled in) (FB07; ~51°15’19”N ~22°32’29”E).
43. The River Czechówka near the Poniatowskiego Viaduct (FB07; 51°15’11”N 22°33’01”E).
44. The River Czechówka below Unii Lubelskiej Avenue (FB17; 51°14’54”N 22°34’48”E).
45. Wetland near the “Młynarz” allotment gardens (FB17; 51°14’57”N 22°34’58”E).
46. The Konopniczanka Stream in the Zimne Doły ravine – the section parallel to Laskowa St. (FB07; 51°13’50”N 22°27’45”E – 51°14’17”N 22°28’11”E).
47. Stormwater ponds in the valley of the Konopniczanka Stream on Laskowa St. (FB07; 51°14’13”N 22°28’02”E).
48. The canal draining water from the stormwater ponds at site 47 to the Konopniczanka Stream (FB07; 51°14’14”N 22°28’05”E)
49. Wetland at a spring on the meadow below sites 47 and 48 (FB07; 51°14’15”N 22°28’08”E).
50. Stormwater pond in the valley of the Konopniczanka Stream on Lipniak St. (FB07; 51°14’45”N 22°29’23”E).
51. Stormwater pond in the valley of the Konopniczanka Stream on Łużyczan St. (FB07; 51°15’07”N 22°29’49”E).
52. The course of the Konopniczanka Stream by the pond on Łużyczan St. (site 51); this section of the stream is permanently filled with water which percolates out of the pond (FB07; 51°15’07”N 22°29’51”E).
53. The course of the Konopniczanka Stream above Nałęczowska St., seasonally containing rainwater (FB07; 51°15’10”N 22°29’56”E).
54. Stormwater pond in the valley of the Konopniczanka Stream on Nałęczowska St. (FB07; 51°15’11”N 22°30’00”E).
55. Fishponds on the River Czerniejówka above Głuska St. (FB17; 51°12’06”N 22°35’24”E).
56. The Czerniejówka River by the fishponds above Głuska St. (FB17; 51°12’06”N

22°35’27”E).
57. The River Czerniejówka below the fishponds (site 55) (FB17; 51°12’28”N 22°35’36”E).
58. The River Czerniejówka by Mickiewicza St. (FB17; 51°13’08”N 22°35’04”E).
59. Oxbow of the River Czerniejówka in the Dziesiąta district (FB17; 51°13’20”N 22°35’09”E).
60. The River Czerniejówka by Pawia St. (FB17; 51°13’39”N 22°34’34”E).
61. The River Czerniejówka by Fabryczna St. (FB17; 51°14’16”N 22°34’27”E).
62. Artificial water body for birds in the Saxon Garden (FB07; 51°14’54”N 22°33’01”E).
63. A small permanent water body at the construction site in Szeligowskiego St. (FB08; 51°14’46”N 22°33’29”E).
64. A small permanent water body on the field near Palmowa St. (FB18; 51°16’25”N 22°36’15”E).

Moreover, a small part of the data refers to imagines observed and collected while they were feeding or flying over streets and other places far from water. In the present paper, such records have been assigned to a given city district (see Fig. 2). Such data were gathered in 16 of the 27 districts: Abramowice, Za Cukrownią, Czechów South (Czechów Południe), Czechów North (Czechów Północ), City Centre (Śródmieście), Dziesiąta, Felin, Kalinowszczyzna, Old Town (Stare Miasto), Ponikwoda, Rury, Sławin, Sławinek, Tatary, Wieniawa, Zemborzyce.

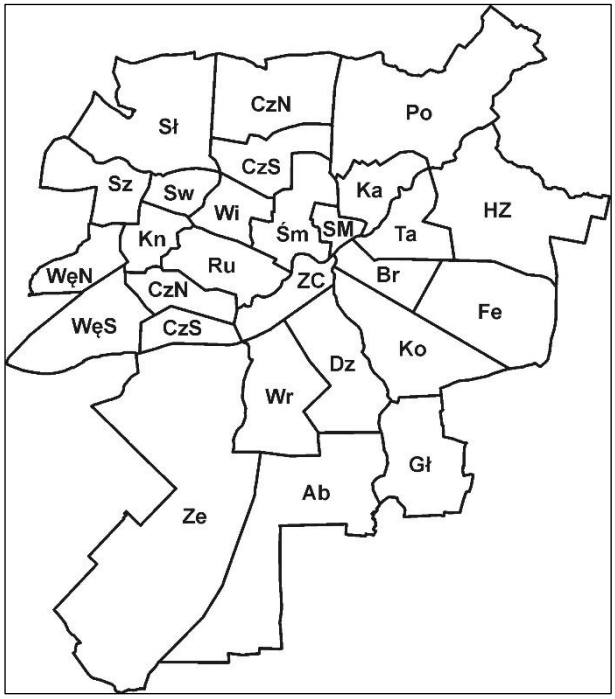

Fig. 2. Administrative division of the city of Lublin. Ab – Abramowice, Br – Bronowice, CuN – Czuby North, CuS – Czuby South, CzN – Czechów North, CzS – Czechów South, Dz – Dziesiąta, Fe – Felin, Gł – Głusk, HZ – Hajdów-Zadębie, Ka – Kalinowszczyzna, Kn – Konstantynów, Ko – Kośminek, Po – Ponikwoda, Ru – Rury, Sł – Sławin, Sw – Sławinek, SM – Old Town, Sz – Szerokie, Śr – City Centre, Ta – Tatary, WęS – Węglin South, WęN – Węglin North, Wi – Wieniawa, Wr – Wrotków, ZC – Za Cukrownią, Ze – Zemborzyce.

Data sampling

In the present paper, all the data available from natural habitats in the contemporary area of Lublin have been taken into consideration.

Historical data (before 1990) are based on the materials of the first author of this paper from the following collections: the former Department of Zoology and Hydrobiology of the University of Life Sciences in Lublin (two imagines from 1964) and the former Department of Zoology of the Maria Curie-Skłodowska University (a total of 146♀♀, 370♂♂ and two larvae from 1948, 1950, 1964 and 1986). Most of these records have already been discussed in detail (Buczyński 2002, 2005). Single literature records from the 19th and early 20th centuries are also included (Dzięddzielewicz 1867, Pongrácz 1919).

The contemporary data were gathered from 1992 to 2019, some of which have been published before: Buczyński (1994, 1995, 2006) (selected faunistic data), Buczyński (2015) (ecological analysis of the fauna of some anthropogenic waters), Balana *et al*. (2006) (the fauna of the Lipnik ravine), Rychła *et al.* (2019) (one record of *Calopteryx splendens* (Harris, 178) in a study of the early metamorphosis of adult dragonflies). In addition, 14 specimens of *Ischnura elegans* (Vander Linden, 1820), collected by the first

author of this paper at site 15, were used for genetic analyses by Wellenreuther *et al.* (2007) and Sánchez-Guillén *et al.* (2011). In order to obtain a comprehensive picture of the odonate fauna of Lublin, all these data have been treated as the source database.

The main method used was the systematic visual observation of adult dragonflies. Some were caught with an entomological net and subsequently released following species identification. Only a small number of individuals (232♀♀ and 64♂♂) were preserved in 70% ethanol. Data recorded: species composition of an assemblage, number of individuals of a species per 100 m of shore, presence of tenerals, reproductive behaviour. A total of 1583 records were obtained (species / site / day). Supplementary methods used at some sites involved catching larvae (1024 specimens) and occasionally collecting exuviae (48). The larvae were determinated in the laboratory and preserved in 70% ethanol, whereas the exuviae were stored dry.

The material evidence for the present paper is housed in the first author's collection at the Department of Zoology and Nature Protection, Institute of Biological Sciences, Maria Curie-Skłodowska University. The photographic documentation of the sites and dragonfly records are in the collections of the various authors.

Data analysis

On the basis of the data obtained, the species have been classified as: autochthonous – when larvae were caught, exuviae collected, or teneral imagines / intensive reproductive behaviour observed; probably autochthonous – when reproductive behaviour was occasional or numerous individuals were observed in a suitable habitat; recorded – all other cases.

The following scales were used to describe the contemporary occurrence of species:

- frequency of occurrence (a simplified version of the scale used in Bernard *et al.* (2009)): species found at >35 sites – common; 20–34 – fairly common; 15–19 – widespread; 7–14 – thinly scattered; 4–6 – rare; 1–3 – very rare;
- frequency of records: species recorded very frequently – >10% of all records; frequently – 5.1–10%; quite frequently – 2.1–5%; seldom – 1.1–2%; very seldom – ≤1%.

The qualitative similarities of the fauna between habitats were calculated on the basis of autochthonous and probably autochthonous species using only Jaccard's index (Szujecki 1980) and ordered using the Wrocław dendrite method (Grabiński 1992).

The statistical analyses were conducted using Statistica 13 software. The distribution of many independent samples was evaluated using the Kruskal-Wallis test, and the post-hoc analysis was performed with the Tukey test.

Results

Review of species

Fifty-four species were recorded. Both historical and contemporary data are now presented and discussed in detail. The scientific names follow the "World Odonata List" (Paulson & Schorr 2020).

- *Calopteryx splendens* (Harris, 1780)

Historical data: 14, 37, 55–57; far from water – Sławinek.

The species was found at a few sites in the valleys of the Rivers Bystrzyca, Czechówka and Czerniejówka; 10♀♀ and 16♂♂ were caught. The specimens collected on 15.06.1950 at site 55 were tenerals.

Contemporary data: 2, 6, 7, 9, 11–24, 26, 27, 2931, 33-38, 44, 46–49, 54, 56, 58, 59, 61; far from water: Czechów North, Felin, Ponikwoda, Rury, Sławin, City Centre, Tatary, Wieniawa, Za Cukrownią, Zemborzyce.

A very common species, the second in order of distribution (66% of sites), very frequently recorded. Mainly associated with rivers and streams: recorded at 90% of the sites of this type; in most cases probably autochthonous. Very frequent on the

Bystrzyca and Czerniejówka on both the outskirts and the urbanized areas including the City Centre, but rather scarce along the whole course of the Czechówka within the city limits. Often recorded in other habitats, though not in the fens. However, autochthonous populations, usually small, were seldom recorded and then only in the canals and standing waters in the river valleys, either open or inundated by the rivers. Single imagines were also frequently observed flying far from water, even a very long way from the nearest water bodies.

- *Calopteryx virgo* (Linnaeus, 1758)

  Historical data: 37.

  Collected on 22.06.1950: 1♀ by the River Czechówka near the UMCS Botanical Garden, together with *C. splendens*.

  Contemporary data: 2, 6, 7, 9, 11, 14, 15, 20, 23, 27, 33, 35, 36, 38, 40, 43, 46, 47, 56, 58, 61; far from water – Abramowice, City Centre, Wieniawa.

  A common species, recorded quite frequently. Its distribution was similar to that of *C. splendens*, but differed in abundance. Large numbers of *C. virgo* were recorded at only a few sites on the River Bystrzyca and the Konopniczanka Stream on the southern outskirts of the city. On the same watercourses in the City Centre and below it, as well as along the Rivers Czechówka and Czerniejówka, this damselfly was very scarce. Imagines flying far from water were sighted only sporadically.

- *Lestes barbarus* (Fabricius, 1798)

  Historical data: none.

  Contemporary data: 29, 38.

  A very rare species, very seldom recorded. A few imagines (<10 ind. per 100 m) and their reproductive behaviour were observed, once in the oxbow of the River Bystrzyca in the north-eastern part of the city (1.09.2005) and once on the ponds in the UMCS Botanical Garden (08.09.2019). Both water bodies had shallow littoral zones, drying out in some places.

- *Lestes dryas* Kirby, 1890

  Historical data: none.

  Contemporary data: 31, 32, 38, 50, 51, 54, 64.

  A thinly scattered species, very seldom recorded. It preferred small water bodies in open areas with considerable fluctuations in the water level and, at least in a few places, with shallow littoral zones and low emergent vegetation. These were both artificial and natural waters: e.g. *L. dryas* regularly occurred in the concrete stormwater ponds in the valley of the Konopniczanka Stream. Distinctly larger populations were noted in natural water bodies, however. One imago was recorded on the ponds on the Czechówka in the UMCS Botanical Garden.

- *Lestes sponsa* (Hansemann, 1823)

  Historical data: 55–57.

  Numerous imagines (31♀♀ and 137♂♂) caught on 15–22.06.1950 in the pond complex above Głuska St. in the valley of the River Czerniejówka and on the Czerniejówka nearby. Some of the specimens collected on 16.06.1950 at site 55 were tenerals.

  Contemporary data: 5, 8, 11–15, 18, 19, 29, 31, 32, 38, 43, 47, 50, 51, 54, 58, 64; far from water – Wieniawa.

  A common species, yet seldom recorded. Though noted at all the sites, it reproduced mainly in small natural water bodies and on the Zemborzyce Reservoir, and somewhat less frequently in small artificial water bodies. This species clearly preferred small water bodies or isolated shallow sections of larger ones with rich emergent vegetation. Very rarely observed far from water (only one record).

- *Lestes virens* (Charpentier, 1825)

  Historical data: none.

  Contemporary data: 8, 15, 31.

  A very rare species, very seldom recorded. Occurred only in the Bystrzyca valley on the outskirts of the city. It was found on small, natural, permanent water bodies in open areas where the shallow littoral zones

supporting emergent vegetation are tending to dry out. In addition, one imago was caught in Rękaw Bay (Zatoka Rękaw) on the Zemborzyce Reservoir.

- *Chalcolestes viridis* (Vander Linden, 1825)

Historical data: none.

Contemporary data: 15, 31, 35, 36, 38, 40, 44, 47, 57.

A thinly scattered species, recorded very seldom and in small numbers (up to ca 20 ind. per 100 m). Associated with a wide spectrum of habitats: lentic zones of rivers, the Zemborzyce Reservoir, fishponds, small water bodies of various kinds. All these habitats have a shallow littoral zone, even if only on a short section of the bank/shore, with trees nearby.

- *Sympecma fusca* (Vander Linden, 1820)

Historical data: none.

Contemporary data: 15, 18, 38, 55.

A rare species, recorded very seldom and only in small numbers. It was found in Rękaw Bay on the Zemborzyce Reservoir, where the abundance was the greatest – up to 20 ind. per 100 m), on small water bodies – the remains of the oxbow of the River Bystrzyca near Koło St., on the ponds on the Czechówka in the UMCS Botanical Garden and the fishponds on the Czerniejówka above Głuska St. At each of these sites, reproductive behaviour took place only in the shallow littoral zone with dense emergent vegetation.

- *Sympecma paedisca* (Brauer, 1877)

Historical data: 60.

1♂ collected on 14.05.1950 on the River Czerniejówka.

Contemporary data: 38.

A very rare species, recorded only once on 2.05.2018, when ca 10 ind. per 100 m, including territorial ♂♂ and tandems during oviposition, were observed on the ponds on the River Czechówka in the UMCS Botanical Garden.

- *Platycnemis pennipes* (Pallas, 1771)

Historical data: 14, 18, 37; far from water – Sławinek.

A total of 11♀♀ and 49♂♂ collected from 21.05. to 16.07.1950 at several sites in the valleys of the Rivers Bystrzyca and Czerniejówka.

Contemporary data: 1, 2, 5, 7–9, 13, 15, 17–21, 23, 24, 26–29, 31, 33–36, 38, 40, 43, 44, 46–50, 53, 56, 58, 61; far from water – Czechów North, Wieniawa.

A very common species, frequently recorded, with a wide spectrum of habitats. Autochthonous or probably so at most of the river bank sites, on the Zemborzyce Reservoir, all the fishponds, some of the ditches and canals, and on small natural and artificial water bodies. Sporadic reproductive behaviour was even recorded on one of the fens in the Bystrzyca valley. Like *Calopteryx splendens*, it formed large populations on the rivers in the highly urbanized part of the city. Imagines were only very rarely observed far from water.

- *Ischnura elegans* (Vander Linden, 1820)

Historical data: 42; far from water – Sławinek; “Lublin”.

On 03.05.1964, 1♀ collected at the former ponds in the Czechówka valley, and on 19.06.1950, 4♂♂ far from water in the Sławinek district. Moreover, Dzięddzielewicz (1867) noted this species in the Lublin area of his day.

Contemporary data: 1, 2, 7–9, 11, 13–15, 17–19, 23, 27–29, 31, 32, 34–36, 38, 40, 43, 46–52, 54, 58.

A very common species, frequently recorded. It colonized much the same kinds of habitats as the previous species, though with some differences: (1) it was not recorded on the fens; (2) it was much more numerous in lentic than lotic waters; (3) populations in highly urbanized areas were distinctly less numerous than on the outskirts of the city. Very rarely sighted far from surface waters (one record).

- *Ischnura pumilio* (Charpentier, 1825)

Historical data: 18.

On 21.05.1950, 1♂ collected on small water bodies – the remnants of the oxbow of the River Bystrzyca near Koło St.

Contemporary data: 8, 18, 27, 31, 32, 34, 43, 47, 49, 51, 52, 54, 63, 64.

A thinly scattered species, seldom recorded. It inhabited mainly small natural and artificial water bodies. It was most numerous on sites being colonized by pioneer plant species or on others disturbed by drying out, dredging, and/or vegetation removal (up to ca 50 ind. per 100 m). Small populations were also recorded on some sections of rivers and on fishponds.

- *Enallagma cyathigerum* (Charpentier, 1840)

Historical data: 18, 55–57.

On 21.05.1950, 1♀ collected on small water bodies – the remnants of the oxbow of the River Bystrzyca near Koło St. On 22.06.1950, 1♂ was caught at the ponds on the River Czerniejówka above Głuska St. and 1♂ on the River Czerniejówka; in addition, 1♂ was taken on the Czerniejówka below Głuska St. on 29.05.1950.

Contemporary data: 14, 15, 18, 29, 35, 38, 47, 50, 51, 54.

A thinly scattered species, seldom recorded. It inhabited standing and slow-flowing waters with well-developed vegetation with floating leaves and/or plants submerged just below the water surface. Large populations were recorded in artificial water bodies, also in the urbanized area of the city, but not in the City Centre.

- *Coenagrion hastulatum* (Charpentier, 1825)

Historical data: 14, 59, 60.

This species was caught in the following localities: the drainage ditch in the Bystrzyca valley at Zemborzyce (21.05.1950, 1♂); the oxbow of the River Czerniejówka near Sokolniki St. (14.05.1950, 1♂); the River Czerniejówka near Pawia St. (14.05.1950, 1♂, and 18.05.1950, 2♀ and 2♂).

Contemporary data: 4, 18, 31, 38, 55, 64.

A thinly scattered species, very seldom recorded. Associated with the small water bodies situated in meadows and fields on the outskirts of the city. A few imagines (up to 20 ind. per 100 m), including some displaying reproductive behaviour, were also recorded (once at each locality) in the UMCS Botanical Garden and at the ponds on the River Czerniejówka above Głuska St.

- *Coenagrion lunulatum* (Charpentier, 1840)

Historical data: 60.

Species collected only once in the oxbow of the River Czerniejówka (14.05.1950, 1♂).

Contemporary data: none.

- *Coenagrion puella* (Linnaeus, 1758)

Historical data: 14, 42, 55–57, 60; far from water – Dziesiąta, Sławinek.

21♀♀ and 82♂♂ were collected in 1950 at several sites in the valleys of the Bystrzyca, Czechówka and Czerniejówka. 2♂♂ caught at site 55 on 15.06.1950 were tenerals. Moreover, on 13.05.1964, 1♀ was taken at the former ponds in the Czechówka valley.

Contemporary data: 3–5,7–9, 11–15, 17–21, 23–25, 27–29, 31, 32, 34–36, 38, 40, 45–56, 58, 62–64.

A very common species, present at the greatest number of sites (75%), very frequently recorded (second in order of records – 11.3%). Autochthonous, often in great numbers at all the sites, from watercourses and water bodies resembling natural ones to artificial and heavily modified water bodies. Rarely observed far from water.

- *Coenagrion pulchellum* (Vander Linden, 1825)

Historical data: 14, 55–57; far from water – Sławinek.

All this material is from 1950: 9♀♀ and 62♂♂ collected in the valleys of the Bystrzyca and Czerniejówka and far from water in the Sławinek district. Some of these damselflies collected at site 55 on 15.06.1950 were tenerals.

Contemporary data: 8, 9, 12–15, 18–20, 29, 31, 34, 37, 38, 55, 64.

Widespread, recorded quite frequently. At least autochthonous in all the habitats except the fens, but conditions for this species were optimal on the city's outskirts, in small natural water bodies and in the southern part of the Zemborzyce Reservoir, where the bank is not concreted and is richer in vegetation. Very rarely observed far from water.

- *Erythromma najas* (Hansemann, 1823)

Historical data: 41, 42, 55, 57.

Records from near the sulphate spring in the Sławinek district (01.09.1948, 1♂); at the former fishponds in the Czechówka valley (19.06.1950, 1♀ and 1♂, 13.05.1964, 49♀♀); at the fishponds on the Czerniejówka above Głuska St. (15.06.1950, 1♀ teneral); on the Czerniejówka below the ponds (29.06.1950, 1♂).

Contemporary data: 13, 15, 18, 34, 35, 38, 40, 47, 54, 55.

A thinly scattered species, but recorded quite frequently. It preferred fertile water bodies, with well-developed floating vegetation or plants submerged just below the water surface. It reproduced mainly on the Zemborzyce Reservoir (southern part), fishponds and small artificial water bodies; consequently, it was often recorded in the urbanized part of the city, though not in the City Centre. Seldom recorded if at all in other habitats.

- *Erythromma viridulum* (Charpentier, 1840)

Historical data: none.

Contemporary data: 13, 15, 18, 29, 35, 38, 40, 47, 51.

A thinly scattered species, seldom recorded. Distribution and habitat preferences similar to those of *E. najas*, with which it coexists.

- *Pyrrhosoma nymphula* (Sulzer, 1776)

Historical data: "Lublin".

Recorded in the Lublin of that time by Pongrácz (1919).

Contemporary data: 3, 7, 15, 17, 31, 35, 36, 38, 46, 48.

A thinly scattered species, seldom recorded. Associated mainly with rivers, streams and open water bodies (fishponds and decorative water bodies) with cool water and dense shore vegetation. Also autochthonous in small isolated, shaded and acidified water bodies in an old woodland sand quarry (site 3), where the only input of water is from precipitation.

- *Brachytron pratense* (O.F. Müller, 1764)

Historical data: none.

Contemporary data: 8, 13, 15, 18, 27, 29.

A rare species, recorded very infrequently. Mainly associated with small natural water bodies and the southern part of the Zemborzyce Reservoir. A few territorial ♂♂ were also recorded along slow-flowing or surging sections of the River Bystrzyca. These sites share certain features: the presence of a belt of vegetation or at least clumps of tall emergent vegetation (reeds, bulrushes) in the littoral zones of the water bodies.

- *Aeshna affinis* Vander Linden, 1820

Historical data: none.

Contemporary data: 5, 8, 18, 29, 31, 32; far from water – Rury, Wieniawa.

A rare species, seldom recorded. Associated almost exclusively with small, natural, usually very shallow water bodies in the peripheral zone of the city, situated in at least partly open terrain, or with shallow areas of larger water bodies with strong water level fluctuations. Imagines were sighted a few times migrating far from water.

- *Aeshna cyanea* (O.F. Müller, 1764)

Historical data: none.

Contemporary data: 3, 12, 14, 15, 29, 35, 36, 38, 39, 40, 46, 47, 52, 54, 58, 62; far from water – Czechów South, Czechów North, City Centre, Ponikwoda, Rury, Sławin, Wieniawa.

A widespread dragonfly, recorded quite frequently. An eurytopic species, it was found to be autochthonous or probably so in all the habitats apart from the fens. Perfectly at home in all parts of the city, it is one of the

few species that reproduces on water bodies in the City Centre. Imagines were observed while hunting and migrating, many times well away from water.

- *Aeshna grandis* (Linnaeus, 1758)

Historical data: none.

Contemporary data: 5, 14, 15, 64; far from water – Ponikwoda.

A rare species, very seldom recorded, and then only in small numbers. It occurred mainly in the Bystrzyca valley on the outskirts of the city: on the Zemborzyce Reservoir (Rękaw Bay) and to the south of it. In addition, 5 larvae were caught in a small field pond in Ponikwoda, and in the same district, one imago was sighted far from water.

- *Aeshna isoceles* (O.F. Müller, 1767)

Historical data: none.

Contemporary data: 13, 15, 38, 47.

A rare species, very seldom recorded. Almost all the records were from the southern part of the Zemborzyce Reservoir (mainly Rękaw Bay) and the inflow section of the Bystrzyca above the reservoir, in places with quite dense emergent vegetation. Moreover, a relatively high number of individuals (ca 20 per 100 m) were found just once in Rękaw Bay. A few territorial ♂♂ were recorded on one occasion on the ponds in the UMCS Botanical Garden and over the concrete stormwater pond on Laskowa St.

- *Aeshna mixta* Latreille, 1805

Historical data: none.

Contemporary data: 8, 11, 13–15, 18, 27, 29, 31, 35, 38, 40, 62; far from water – Czechów South, City Centre, Old Town, Ponikwoda, Rury, Wieniawa.

A thinly scattered species, though recorded quite frequently. Associated above all with the Zemborzyce Reservoir (southern part) and small, natural rather than artificial water bodies. Recorded less often near the rivers, canals and fishponds. It preferred small water bodies or isolated parts of larger habitats with dense emergent vegetation. This species was recorded far more rarely in the urbanized parts of the city than on the outskirts. But imagines flying or hunting far from water were observed in the former quite often.

- *Anax ephippiger* (Burmeister, 1839)

Historical data: none.

Contemporary data: 15, 47, 54.

A very rare species, recorded three times. On 16.06.2013 at the head of Rękaw Bay on the Zemborzyce Reservoir, one territorial ♂ and one pair laying eggs were sighted. On 1.06.2019 *A. ephippiger* was observed at two stormwater ponds in the valley of the Konopniczanka Stream: a few territorial ♂♂, two pairs copulating and two pairs laying eggs at site 47, and 1 territorial ♂, one pair laying eggs and two individuals feeding near the water body at site 54.

- *Anax imperator* Leach, 1815

Historical data: none.

Contemporary data: 8, 13, 15, 18, 34, 38, 47, 48, 49, 50, 51, 54, 64.

A thinly scattered species, but recorded quite frequently. Associated mainly with the Zemborzyce Reservoir and small water bodies, less often observed in slow-flowing sections of rivers, larger canals and fishponds. It preferred permanent water bodies situated in at least partly open terrain with dense vegetation including nymphaeids and elodeids. It was frequent and numerous on both natural and artificial waters on the outskirts and in the urbanized zone, although it was not recorded in the City Centre.

- *Anax parthenope* (Selys, 1839)

Historical data: none.

Contemporary data: 15, 29.

Very rare, and very seldom recorded. Most records come from the Zemborzyce Reservoir and the surrounding area, mainly Rękaw Bay, where territorial ♂♂ were regularly recorded. On one occasion, a pair *in copula* was observed and, unusually for this species, a relatively high density of individuals (>10 per 100 m). Moreover, 1 territorial ♂ was observed once, on 1.10.2005, on the oxbow

of the River Bystrzyca in the north-eastern part of Lublin.

- *Gomphus vulgatissimus* (Linnaeus, 1758)

Historical data: none.

Contemporary data: 6, 7, 11, 15, 20, 21, 27, 57; far from water – Felin.

A thinly scattered species, seldom recorded. Associated almost exclusively with rivers (the Bystrzyca, Nędznica and Czerniejówka). Its probably autochthonous occurrence in standing waters was recorded only on the Zemborzyce Reservoir on the inflow section of the Bystrzyca into this water body. Most colonized sites were unregulated, with the bottom dominated by inorganic sediments. They were situated on the outskirts of the city or where these merged with the urbanized area. Closer to the City Centre, only single imagines were observed, in potentially suitable habitats or flying far from water.

- *Stylurus flavipes* (Charpentier, 1825)

Historical data: none.

Contemporary data: 27.

A very rare species. Recorded just once on 18.08.2006, when 1♀ (immature but not teneral) was caught by the River Bystrzyca in the north-eastern part of Lublin.

- *Ophiogomphus cecilia* (Geoffroy in Fourcroy, 1785)

Historical data: none.

Contemporary data: 2, 7, 14, 43.

A rare species, recorded very infrequently. Autochthonous populations were recorded only on the outskirts of the city – on the River Bystrzyca above the Zemborzyce Reservoir. It was probably from those populations that individuals were observed feeding in the sunny glades near the reservoir (near Rękaw Bay). Beyond this area, just one imago was sighted flying above the River Czechówka near the Poniatowski Viaduct.

- *Cordulia aenea* (Linnaeus, 1758)

Historical data: none.

Contemporary data: 15, 18, 62.

A very rare species, hardly ever recorded. Moderately numerous territorial ♂♂ (up to ca 20 ind. per 100 m) were recorded on the Zemborzyce Reservoir (Rękaw Bay), and single ♀♀ during oviposition on the oxbow of the Bystrzyca in north-eastern Lublin. Both sites are situated on the outskirts of the city. On 01.05.2018 two exuviae were photographed near the bird pond in the Saxon Garden (Ogród Saski) on a patch of planted narrow-leaved bulrush *Typha angustifolia* L.

- *Somatochlora flavomaculata* (Vander Linden, 1825)

Historical data: none.

Contemporary data: 3, 15.

A very rare species, recorded very infrequently. Reproduction was confirmed only in the former sand workings in Rudki Forest, where one larva was collected on 09.10.2018. In addition, one hunting ♂ was recorded in a forest clearing near the Zemborzyce Reservoir (Rękaw Bay) on 10.06.2018.

- *Somatochlora metallica* (Vander Linden, 1825)

Historical data: none.

Contemporary data: 15, 36, 38.

A very rare species, hardly ever recorded. Imagines were regularly observed in the southern part of the Zemborzyce Reservoir, especially Rękaw Bay, and by the ponds in the UMCS Botanical Garden. It was also recorded once by the River Czechówka in the Lublin Open Air Village Museum. Territorial ♂♂ were recorded at all those sites.

- *Libellula depressa* Linnaeus, 1758

Historical data: none.

Contemporary data: 9, 11–15, 17, 24, 31, 32, 34–36, 38, 43, 46–51, 53, 54, 58, 63; far from water – Kalinowszczyzna, Wieniawa.

A common dragonfly, recorded quite frequently. An eurytopic species, it was noted in all the habitats except the fens. It was the

most numerous and autochthonous in fishponds and small artificial water bodies: for this reason it was as frequent on the outskirts of the city as in the urbanized zone. A large autochthonous population was also recorded in the southern part of the Zemborzyce Reservoir, especially Rękaw Bay.

- *Libellula fulva* O.F. Müller, 1764

  Historical data: none.
  Contemporary data: 9, 15, 32, 47.

A rare species, not recorded very often. It occurred on the drainage ditches in the Bystrzyca valley, on the Zemborzyce Reservoir (Rękaw Bay) and on two stormwater ponds in the valley of the Konopniczanka Stream. Only a few imagines were recorded (up to 10 ind. per 100 m); except for site 32, these were almost always territorial ♂♂.

- *Libellula quadrimaculata* Linnaeus, 1758

  Historical data: none.
  Contemporary data: 3–5, 8, 10, 12–15, 18, 29, 31, 32, 34–36, 38, 47, 50, 51, 54, 55, 64.

Common, recorded quite frequently. This eurytopic species inhabited all the different types of standing water bodies and fens, and was also occasionally recorded on slow-flowing sections of rivers and canals. It preferred hydrologically stable habitats, undisturbed by human activities, with dense emergent vegetation and silty sediments. That is why the large majority of localities of *L. quadrimaculata*, especially where it was autochthonous, were situated on the outskirts of the city.

- *Orthetrum albistylum* (Selys, 1848)

  Historical data: none.
  Contemporary data: 11, 13, 15, 17, 18, 34, 46–49, 51, 52, 54.

Though thinly scattered, this species was recorded quite frequently. It preferred shallow standing waters in at least partly open, sunlit and warm shores with or without sparse stands of emergent vegetation. These sites included suitable sections of the Zemborzyce Reservoir, fishponds, small natural and artificial water bodies. The species also occurred in some sections of flowing waters, so long as the above-mentioned conditions were met.

- *Orthetrum brunneum* (Fonscolombe, 1837)

  Historical data: none.
  Contemporary data: 49.

A very rare species, recorded very infrequently. In July 2018, it was observed twice on waterlogged patches of a meadow in the valley of the Konopniczanka Stream supplied with spring water. The density of the species was quite large (>20 ind. per 100 m), and intense reproductive behaviour was recorded (territorial ♂♂, tandems, pairs *in copula*, oviposition).

- *Orthetrum cancellatum* (Linnaeus, 1758)

  Historical data: 15.
  Two larvae were caught on the Zemborzyce Reservoir on 14.07.1986.
  Contemporary data: 13, 15, 17, 18, 20, 27, 31, 32, 35, 38, 46–49, 51, 54, 55.

A widespread species, recorded quite frequently. Its habitat preferences were similar to those of *O. albistylum*, though cooler waters were also colonized. *O. cancellatum* was usually numerous, and autochthonous or probably so, mostly on the Zemborzyce Reservoir, fishponds, and small natural and artificial water bodies. It also inhabited some sections of slow-flowing rivers and canals with a well-developed lentic zone.

- *Crocothemis erythraea* (Brullé, 1832)

  Historical data: none.
  Contemporary data: 13, 15, 38, 47, 54.

A rare species, with very few records. It inhabited standing waters and dammings of flowing waters that were well-insolated, warm, with dense vegetation and a silty bottom. The density of imagines was not very high (up to 10 ind. per 100 m), but reproductive behaviour was recorded: usually there were at least territorial ♂♂ and often tandems; tenerals were also observed in the southern part of the Zemborzyce Reservoir.

- *Sympetrum danae* (Sulzer, 1776)

Historical data: none.

Contemporary data: 18, 19, 31, 38, 45; far from water – Dziesiąta.

A rare species, hardly ever recorded. Associated mainly with small natural water bodies and the wetlands – shallow with lush, often fen-like vegetation – in the Bystrzyca and Czechówka valleys. It was recorded once at the ponds in the UMCS Botanical Garden (08.09.2019, ≤10 ind. per 100 m, including territorial ♂♂ and tandems) and also once, far from water, near the Czerniejówka valley in the Dziesiąta district, where it was present in small numbers (≤10 ind. per 100 m).

- *Sympetrum depressiusculum* (Selys, 1841)

Historical data: none.

Contemporary data: 35.

An extremely rare species, recorded just once on 02.08.2015: 1 hunting ♂ at the pond on the River Czechówka in the Lublin Open Air Village Museum.

- *Sympetrum flaveolum* (Linnaeus, 1758)

Historical data: far from water – Za Cukrownią.

1♀ caught on 30.07.1964 near the "Start" athletic club's stadium.

Contemporary data: 5, 8, 9, 12, 14, 15, 18–20, 23, 28, 29, 31, 32, 38, 43, 46, 49–51, 53, 54; far from water – Czechów South, Rury.

A common species, recorded quite frequently. Associated mainly with small, shallow or astatic water bodies situated in open or semi-open terrain. The water levels in them can fluctuate widely. Also recorded at many other kinds of sites, with shallow and periodically drying out littoral zones. This species frequently reproduces in artificial water bodies, a crucial factor in the second half of the last decade, when many natural water bodies dried out because of the lack of precipitation and the higher air temperatures. During that time, the largest populations were recorded in anthropogenic water bodies, such as the stormwater ponds in the valley of the Konopniczanka Stream.

- *Sympetrum fonscolombii* (Selys, 1840)

Historical data: none.

Contemporary data: 54.

A very rare species, recorded just once: 1 teneral ♀ on a stormwater pond in the valley of the Konopniczanka Stream on 01.09.2018.

- *Sympetrum meridionale* (Selys, 1841)

Historical data: none.

Contemporary data: 47, 49.

A very rare species, very seldom recorded. Known from two adjacent sites in the valley of the Konopniczanka Stream: a permanent stormwater pond, and waterlogged patches of a meadow supplied with spring water. In August and September 2019, a fairly high density (up to >20 ind. per 100 m) of intensively reproducing imagines was recorded.

- *Sympetrum pedemontanum* (Müller in Allioni, 1776)

Historical data: none.

Contemporary data: 14, 15, 46, 49.

A rare species, recorded very infrequently. It was noted in two small areas. One was the Bystrzyca valley in the southern part of the city where it was found by the main drainage canal on the fen meadows above the Zemborzyce Reservoir, to which it also came to feed (Rękaw Bay). The other was the valley of the Konopniczanka Stream, where a few territorial ♂♂ (≤10 ind. per 100 m) were recorded over the stream and numerous imagines (>50 ind. per 100 m) were reproducing intensively on waterlogged patches of a meadow supplied with spring water.

- *Sympetrum sanguineum* (O.F. Müller, 1764)

Historical data: far from water – Za Cukrownią.

1♂ collected on 30.07.1964 near the "Start" athletic club's stadium.

Contemporary data: 4, 5, 7–15, 17–20, 23,

24, 27–29, 31–38, 40, 43–47, 49, 53, 54, 57, 62, 64; far from water – Czechów South, Kalinowszczyzna, Rury, Wieniawa.

Very common (with the same number of sites as *Calopteryx splendens*), frequently recorded. A eurytopic species inhabiting all the types of habitats including flowing waters, often occurring in large numbers. Recorded similarly frequently in all areas of the city. This dragonfly is often sighted far from water.

- *Sympetrum striolatum* (Charpentier, 1840)

  Historical data: none.

  Contemporary data: 9, 18, 31, 47, 49, 51.

A rare species, very seldom recorded. Associated mainly with small natural water bodies, less frequently with man-made ones (mainly stormwater ponds), and with meadow wetlands.

- *Sympetrum vulgatum* (Linnaeus, 1758)

  Historical data: 55–57.

Recorded at the ponds on the River Czerniejówka above Głuska St. (22.06.1950, 5♀♀ and 3♂♂); on the Czerniejówka by these ponds (22.06.1950, 2 teneral ♂♂); on the Czerniejówka below these ponds (29.06.1950, 1♀ and 2♂).

Contemporary data: 5, 7–9, 12, 14, 15, 18, 19, 27–29, 31, 32, 35, 38, 40, 45–47, 49, 51, 54, 58, 62; far from water – Czechów South, City Centre, Rury, Wieniawa.

A common species, quite frequently recorded. Its habitat preferences were like those of *S. sanguineum* – very often these two species occurred together. *S. vulgatum*, too, was recorded in all areas of the city. Imagines were very frequently observed a long way from water bodies.

- *Leucorrhinia dubia* (Vander Linden, 1825)

  Historical data: none.

  Contemporary data: 5.

A very rare species, recorded just once: on 30.04.2001 a larva was caught on the fen in the Bystrzyca valley in water among a dense carpet of sedges and the moss *Drepanocladus aduncus* (Hedw.) Warnst.

- *Leucorrhinia pectoralis* (Charpentier, 1825)

  Historical data: none.

  Contemporary data: 5, 8, 18.

A very rare species, hardly ever recorded. Four larvae were caught on the fen in the Bystrzyca valley along with larvae of *L. dubia* and *L. rubicunda*. Imagines were observed once by the small meadow water bodies in the same section of the Bystrzyca valley (29.05.2003, ≤20 ind. per 100 m, including territorial ♂♂, tandems and oviposition), and twice by small water bodies – the remnants of the Bystrzyca oxbow near Koło St. (29.06.1995, ≤10 ind. per 100 m, including territorial ♂♂; 22.05.2006, 1 territorial ♂).

- *Leucorrhinia rubicunda* (Linnaeus, 1758)

  Historical data: none.

  Contemporary data: 5, 8, 17.

A very rare species, very seldom recorded. One larva was caught on the fen in the Bystrzyca valley together with larvae of *L. dubia* and *L. pectoralis*. Imagines were also observed once over the small meadow water bodies in the same section of the Bystrzyca valley (≤10 ind. per 100 m, including territorial ♂♂) and once on the Bystrzyca below the Zemborzyce Reservoir (30.05.2012, 1 flying ♂).

General comments

Of the 54 species recorded, the historical data refer to 17 (obtained from 12 sites) and the contemporary data (from 60 sites) to 53 (Table 1). Only *Coenagrion lunulatum* among the species recorded in the past was not recorded recently.

As the historical data are fragmentary, it is impossible to analyse the odonates of Lublin in the past. The following analysis thus deals solely with the contemporary fauna.

Among the recently recorded species, 45 are autochthonous, 6 are probably autochthonous (*Lestes barbarus*, *Sympecma paedisca*, *Anax ephippiger*, *Somatochlora metallica*, *Libellula fulva* and *Sympetrum meridionale*), while the other two have

recorded status (*Stylurus flavipes* and *Sympetrum depressiusculum*) (Table 1).

Four of the 53 contemporary species were very common, seven were common, three were widespread, 11 were thinly scattered, 12 were rare and 16 were very rare. Eurytopic species were dominant at most sites, whereas stenotopic species were represented by just a few rheophiles and astatic water specialists. Among the rare and very rare species there were proportionally fewer eurytopes, even though all the synecological groups were represented; all the dragonflies associated with fens and lakes were classified as rare or very rare (Fig. 3). This distribution concurs with the number and availability of the various types of habitats in the present-day area of Lublin, with rivers crossing the highly urbanized part of the city and many sites in a poor state of preservation and mainly on the city's outskirts.

Each of the habitats explored made an important contribution to the dragonfly species richness (Table 1). The most important ones as regards the number of species were small artificial water bodies (39 spp., of which 38 were autochthonous or probably so), small natural water bodies (39 and 35 spp.), storage reservoirs (36 and 33 spp.) and rivers (31 and 29 spp.). The odonate species richness was average on the canals and ditches (23 and 21 spp. respectively) and fishponds (21 and 18 spp.). Fens were the poorest in species numbers (14 and 12 spp.). Nevertheless, even the habitats with the lowest diversity were important for certain species or their groups, e.g. the fens for the tyrphobionts and tyrphophiles (especially *Leucorrhinia* spp.) or the ditches and canals for *Sympetrum pedemontanum*.

The odonate faunas of the various habitats intermingled. To a large extent, this can be explained by the close proximity of many localities to the surface-water richest sections of the river valleys. The dendrite of faunistic similarities (Fig. 4) shows that one big unit

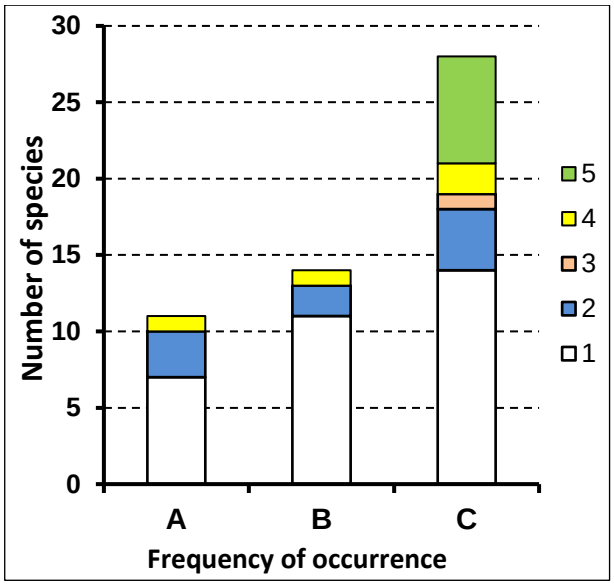

Fig. 3. Synecological groups of species with various frequencies of occurrence. A – common and fairly common species, B – widespread and thinly scattered species, C – rare and very rare species, 1 – eurytopes, 2 – rheobionts and rheophiles, 3 – limnophiles, 4 – species of astatic waters, 5 – tyrphophiles and tyrphobionts.

consists of all the habitats apart from the fens and that they exhibit a high level of faunal similarity (55.8–59.5%). The distinctiveness of the fens is due to the species composition of their fauna and the small number of species recorded there.

There was a significant decrease in species richness along the urbanization gradient from the outskirts to the City Centre (Table 1, Fig. 5). In the urbanized zone (excluding the City Centre), there were 14% fewer species overall and 33% fewer autochthonous ones than on the outskirts. In addition, the populations of many species were smaller there. However, the City Centre fauna was very poor, even in this context, with just four autochthonous species being recorded there (only ca 10% of those recorded on the outskirts).

These differences between the city zones, were thoroughly analysed at the levels of sites and samples (monitoring of imagine occurrence): in every case, the relevant indices decreased in value along the urbanization gradient (Table 2). The differences in the overall species richness of

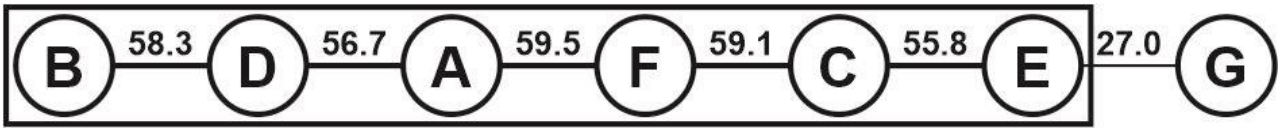

Fig. 4. Faunistic similarities [%] between the habitats. A – rivers and streams, B – canals and ditches, C – storage reservoirs, D – fishponds, E – natural small water bodies, F – artificial small water bodies, G – fens.

the sites were distinct but statistically insignificant. But in the case of the number of species and the number of odonates in a sample, these differences were statistically highly significant, and post-hoc analyses showed the differences between all zones to be significant for both parameters. The decrease in odonate abundance along the urbanization gradient was fairly even, but while the differences in species richness between the peripheral and urbanized zones turned out to be minimal, there was a very large drop in these values in the City Centre (Table 2).

The differences between the city's zones could have been due to faunal changes within some habitats, e.g. along the rivers in the City Centre and to a great extent in the other urbanized areas. The occurrence of phytorheophilic species was less variable, although species associated with bottom sediments, especially gomphids, declined or were seldom recorded and then only in small numbers. However, other habitats such as fens were almost non-existent in the urbanized zone: only the marshy ground near the "Młynarz" allotment gardens represented this kind of habitat. Different again were the odonate assemblages typical of small temporary and permanent water bodies: on the outskirts of the city, dragonflies were present on the natural water bodies, whereas in the urbanized zone (but not in the City Centre), these habitats were effectively replaced by man-made water bodies. The best example of this was the very interesting and, in some ways, valuable fauna of the stormwater ponds in the valley of the Konopniczanka Stream.

A few areas and particular sites appeared to be particularly important for odonates as regards the preservation of their species richness or of particular species and assemblages. These were concentrated mainly in the Bystrzyca valley. The section of this valley from the city limits to the Zemborzyce Reservoir was valuable, with the rich habitat diversity of its surface waters and the best-preserved fens in the whole of Lublin. On the other hand, 66% of the species occurring in the Lublin area were recorded by the Zemborzyce Reservoir, albeit only its southern part, especially Rękaw Bay, can boast a really rich fauna. On the remainder of the reservoir, with its reinforced concrete banks, no shallow littoral zone and weakly differentiated vegetation, the odonate fauna is poor in species and numbers. Nevertheless, the reservoir is the principal habitat of *Anax parthenope* in Lublin, the only dragonfly recorded in the city with a preference for lakes. Another interesting locality in the Bystrzyca valley is what remains of the oxbow of this river near Koło St. along with its immediate vicinity. This is the last biodiversity hot spot of dragonflies in the Bystrzyca valley before the river reaches the City Centre. Both in the past and nowadays, legally protected species were and still are recorded in this place.

The odonate fauna of the valley of the Konopniczanka Stream also turned out to be quite valuable. The stream itself in the section close to the city border supports the best-preserved assemblage of dragonfly species in Lublin typical of upland streams. However, the stormwater ponds located in a few places along the ravine, astatic to various degrees, support assemblages of dragonfly species typical of small, temporary and permanent water bodies. By the end of this study, when there was far less precipitation than in earlier years, it was the only locality in the Lublin area where *S. flaveolum* was quite numerous.

Table 1. Dragonflies (Odonata) recorded in the city of Lublin. Periods: A – before 1990, B – after 1990; N_S – number of sites, $\%_R$ – proportion of records [%]. Zones: D – City Centre, U – remainder of the urbanized area, P – peripheries. Habitats: A – rivers and streams, B – canals and ditches, C – storage reservoirs, D – fishponds, E – natural small water bodies, F – artificial small water bodies, G – fens, H – far from water. Status of species: ● – autochthonous, ⊙ – probably autochthonous, ○ – recorded.

Species	Period													
	A	B												
		Material		Zone			Habitat							
		N_S	$\%_R$	D	U	P	A	B	C	D	E	F	G	H
Calopteryx splendens	+	40	11.4	●	●	●	●	●	⊙	●	●	⊙		○
Calopteryx virgo	+	21	2.7	⊙	●	●	●	●	⊙	○		○		○
Lestes barbarus		2	0.1		⊙	○					○	⊙		
Lestes dryas		7	0.5		⊙	●					●	⊙		
Lestes sponsa	+	20	2.0		●	●	⊙	⊙	●		●	●	○	○
Lestes virens		3	0.2			●			⊙		●			
Chalcolestes viridis		9	0.8		⊙	●	●		●	⊙		⊙		
Sympecma fusca		4	0.3		●	●			●		○	●		
Sympecma paedisca	+	1	<0.1		⊙							⊙		
Platycnemis pennipes	+	37	6.2	●	●	●	●	●	●	●	●	●	⊙	○
Ischnura elegans	+	33	8.3	⊙	●	●	●	●	●	●	●	●		
Ischnura pumilio	+	14	1.4		●	●	●				●	●		
Enallagma cyathigerum	+	10	1.9		●	●		●	●	●	⊙	●		
Coenagrion hastulatum	+	6	0.5		⊙	●					●	⊙		
Coenagrion lunulatum	+													
Coenagrion puella	+	45	11.3	●	●	●	●	●	●	●	●	●	●	
Coenagrion pulchellum	+	16	3.3		●	●	●	●	●	●	●	●		
Erythromma najas	+	10	2.2		●	●	⊙		●	●	⊙	●		
Erythromma viridulum		9	1.6		●	●	⊙		●	●	⊙	●		
Pyrrhosoma nymphula	+	10	1.0		●	●	⊙	⊙		●	○	●		
Brachytron pratense		6	0.6			●	⊙		●		⊙			
Aeshna affinis		6	1.0		○	●					●			○
Aeshna cyanea		15	3.6	⊙	●	●	●	⊙	●	●	●	●	○	○
Aeshna grandis		4	0.3		○	●		○	⊙		●		⊙	○
Aeshna isoceles		4	0.7		⊙	●	⊙		●			⊙		
Aeshna mixta		13	2.5	○	⊙	●	⊙	⊙	●	○	●	⊙		○
Anax ephippiger		3	0.2		⊙	⊙			⊙			⊙		
Anax imperator		13	2.5		●	●	⊙	⊙	●	●	●	●		
Anax parthenope		2	0.3			●			●		⊙			
Gomphus vulgatissimus		8	1.0	○	●	●	●		⊙					○
Stylurus flavipes		1	<0.1			○	○							
Ophiogomphus cecilia		4	0.3		○	●	●		○					
Cordulia aenea		3	0.3	●		●			●		⊙	●		
Somatochlora flavomaculata		2	0.1			●			○			●	●	
Somatochlora metallica		3	0.6		⊙	⊙	⊙					⊙		
Libellula depressa		25	4.2		●	●	⊙	●	●	●	●	●		○
Libellula fulva		4	0.3		⊙	⊙		⊙	⊙		○	⊙		
Libellula quadrimaculata		23	3.0		●	●	●		●	●	●	●	●	
Orthetrum albistylum		13	2.2		●	●	●	⊙	●	●	●	●		
Orthetrum brunneum		1	0.1		●						●			
Orthetrum cancellatum		17	4.1		●	●	●	⊙	●	⊙	●	●		
Crocothemis erythraea		5	0.5		●	●	⊙		●			●		
Sympetrum danae		5	0.3		⊙	●		●			●	⊙	⊙	○

Sympetrum depressiusculum		1	<0.1			○				○				
Sympetrum flaveolum	+	22	2.1	○	●	●	●	●	●		●	●	●	○
Sympetrum fonscolombii		1	<0.1		●							●		
Sympetrum meridionale		2	0.2		⊙						⊙			
Sympetrum pedemontanum		4	0.4		●	○	⊙	○	○		●	⊙		
Sympetrum sanguineum	+	40	8.4	⊙	●	●	●	●	●	●	●	●	●	○
Sympetrum striolatum		6	0.5		●	●		○			●	⊙		
Sympetrum vulgatum	+	25	3.6	○	●	●	⊙	●	●	●	●	●	●	○
Leucorrhinia dubia		1	<0.1			●							●	
Leucorrhinia pectoralis		3	0.2			●					●		●	
Leucorrhinia rubicunda		3	0.2			●	○				⊙		●	

Discussion

Odonate species richness and composition

The fifty-four species of dragonflies recorded in the Lublin area make up 73.0% of all the species known from Poland, 77.9% of those from Lublin Province and 88.5% of those from the Lublin Upland (Buczyński 1999, Bernard *et al.* 2009, Buczyński *et al.* 2019, Buczyński unpubl. data). Apart from *Coenagrion lunulatum*, all the species were recorded again. The reason for the absence of *C. lunulatum* after 1990, in any case a very rare species on the Lublin Upland, should be sought in its disappearance from almost the whole belt of lowlands and uplands in southern Poland. For climatic reasons, other Siberian species are experiencing a similar regression (Bernard *et al.* 2009).

A 55th dragonfly species was once recorded In Lublin. This was *Crocothemis servilia* (Drury, 1773), an exotic dragonfly caught in 2012 in a pet shop aquarium, where it had been accidentally introduced with aquarium plants (Buczyński & Bielak-Bielecki 2012). In these circumstances, it cannot be treated as belonging to the city's fauna. In addition, one exuvia of *Erythromma viridulum* was found in the same shop in the same year, which shows that species living in natural habitats are capable of colonizing such small, isolated and specific habitats (Buczyński & Bielak-Bielecki 2019).

The considerable species richness of the Lublin odonates as an urban fauna is plain to see in comparison with other Polish cities. Poznań is 77% larger than Lublin and, more pertinently, is situated in the Greater Poland Lake District (Pojezierze Wielkopolskie), so it is richer in surface waters. Fifty-five species of dragonflies have been recorded in Poznań, although two of them are no longer extant there (Bernard 2002). The present-day odonate faunas of both cities are thus equally rich. Olsztyn, also lying in a lake district, has 49 species (Buczyński & Lewandowski 2011). Łódź and Kielce, which like Lublin, are situated in a range of uplands, have 46 and 41 species, respectively (Tończyk & Pakulnicka 2004, Gwardjan *et al.* 2015). The "Dragonflies of large cities" ("Ważki dużych miast") project, carried out by members of the Odonatological Section of the Polish Entomological Society, yielded from 24 to 41 odonate species in the various urban areas they investigated. Only the 58 species from the 14 cities making up the Silesian conurbation, exceeded the number for Lublin (Miłaczewska 2019).

The data available from other central European countries are similar. The total numbers of species recorded in the cities of those countries were high. For example, Goertzen & Suhling (2015) analysed the odonate fauna of 30 central European cities and found that 75 out of the 81 (92.6%) species recorded in the respective regional species pools were found in those urban

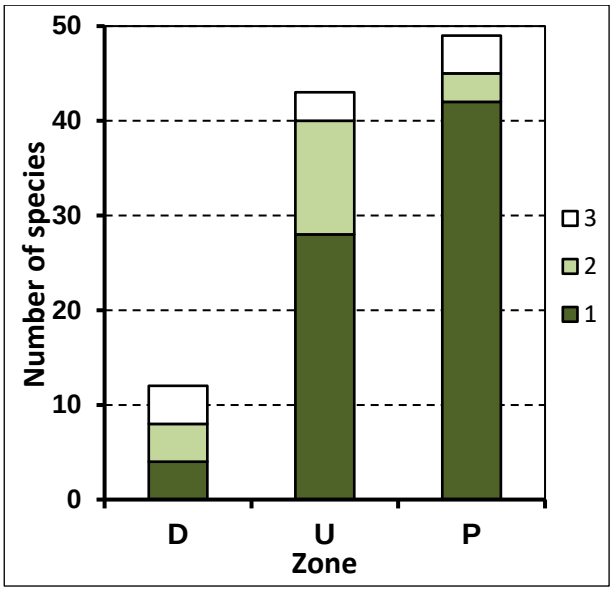

Fig. 5. General species richness in different zones of the city of Lublin. NS – number of species, D – City Centre, U – remainder of the urbanized area, P – peripheries. Status of species: 1 – autochthonous, 2 – probably autochthonous, 3 – recorded.

areas. This is proportionally close to the data given by Miłaczewska (2019) from Poland (86.9%). However, the species richness in individual cities is significantly lower. For instance, 41 species of dragonflies were recorded in Prague (Šťastný *et al.* 2015), 36 in Rotterdam (Moerland et *al.* 2015), 19 in Bucharest (Manu *et al.* 2015), and 22 – 44 in 22 German cities analysed by Willigalla & Fartmann (2012).

What is equally interesting is that the number of species recorded in Lublin is similar to or only slightly lower than that recorded in protected areas considered to be important wildlife refuges and hot spots of odonate diversity in central and eastern Poland. For example, 59 species were recorded in the Polesie National Park (Poleski Park Narodowy) (Buczyński & Tarkowski 2019), 58 in the Janów Forests Landscape Park (Park Krajobrazowy „Lasy Janowskie") (Buczyński & Łabędzki 2012), and 54 in the middle stretch of the River Bug (Buczyński 2012). In contrast to those areas, however, ubiquitous species are predominant in Lublin and there are not many habitat specialists with specific requirements regarding environmental quality or "special care species". All the species found in Lublin are classified in the category LC (Least Concern) in the Red List of Dragonflies of Poland (Bernard *et al.* 2009) and the Lublin Region (Buczyński 2009). Only four of the 15 protected species in Poland (Rozporządzenie Ministra Środowiska 2016) were recorded: *Sympecma paedisca*, *Stylurus flavipes*, *Ophiogomphus cecilia* and *Leucorrhinia pectoralis*. They were rarely sighted and then only in small numbers. Not many umbrella species were present in appropriate habitats either, i.e. those designated as indicator species (Bernard *et al.* 2002). *Sympetrum depressiusculum*, classified as vulnerable (VU) in Europe (Kalkman *et al.* 2010), would be of international importance if it were more numerous and autochthonous.

In the light of the conclusions drawn by Willigalla & Fartmann (2012), Lublin has at least three features favouring the occurrence of a large number of odonate species. The city covers a large area; it lies on the floodplain of a river that used to boast a wide variety of habitats; in the upper part of this floodplain (above the Zemborzyce Reservoir), those aquatic habitats have retained their continuity. Chobotow & Czarniawski (2007, 2010) drew similar inferences from their research into the amphibians of Lublin. The human factor is also important: the artificial Zemborzyce Reservoir, the southern part of which has no shore reinforcements and is surrounded by woodlands, is shaped in such a way that it can support a qualitatively rich fauna with the elements of lacustrine dragonfly assemblages (Buczyński 2015).

A feature typical of urban odonate faunas, also present in Lublin, is the falling number of species along the urbanization gradient and the increasing dominance of generalists (Willigalla & Fartmann 2010, 2012). Moreover, just as Goertzen & Suhling (2015) found, the dragonflies recorded in the City Centre of Lublin were almost always opportunists, though not necessarily thermophilous species,

Table 2. Species richness and abundance of dragonflies in various zones of the city of Lublin (average values and range of values). GNSS – overall number of species recorded at a site, NSC – number of species in a count of imagines, NIC – number of imagines per count [ind.·100 m]. D – City Centre, U – urbanized areas, P – peripheries.

Parameter	Zone		
	D	**U**	**P**
GNNS*	5.5 ± 1.3 (4–7)	9.0 ± 7.4 (1–30)	10.5 ± 7.7 (1–36)
NSC**	1.33 ± 3.76 (1–3)	4.70 ± 3.76 (1–16)	4.83 ± 4.67 (1–18)
NIC ***	31 ± 66 (1–200)	76 ± 103 (1–466)	104 ± 136 (1–739)
*p=0.4314, **p<0.00001, ***p=0.00001			

an aspect that those same authors postulated as a rule in their later paper (Goertzen & Suhling 2018). However, as regards specialized species, especially rheophiles, we recorded only those that offer the greatest resistance to unfavourable environment conditions (Bernard *et al.* 2002).

Analysis of the contemporary aquatic habitats in Lublin shows very clearly why the City Centre fauna is impoverished: above all, it is because of the dramatic decline in habitat quality and numbers along the urbanization gradient. An additional factor specific to Lublin is the degradation of water quality in the River Bystrzyca due to the benthic outflow from the hypertrophic Zemborzyce Reservoir (Dobrowolski *et al.* 2016). The small number of water bodies is at least as important as their quality, but whether the cause is natural or anthropogenic is debatable. The City Centre of Lublin lies mainly on two hills, which on the Lublin Upland means that it must always have been poor in surface waters (Wilgat 1998, Kondracki 2002). Nonetheless, these hills are separated by the valley of the River Czechówka. Though a small river, it should be capable, together with the nearby riparian water bodies, of supporting at least 20-30 odonate species, as suggested by the data from the UMCS Botanical Garden, which lies higher up the river. On the other hand, in the south, the City Centre adjoins the Bystrzyca valley. In this context, a perusal of older maps of Lublin, available on the NN Theatre website (http://teatrnn.pl/ikonografia/galeria_ikon/galeria/9), is highly informative. Even after World War II, there were fishponds in the Czechówka valley near today's Poniatowski Viaduct, and further along the river there were an outdoor swimming pool and sundry small water bodies. Moreover, this river regularly inundated the surrounding area at least until the 1930s (Szulc *et al.* 2017). These odonate-favourable habitats in and around the City Centre survived until the 1970s; today, only a short, highly regulated section of the Czechówka remains above ground while the rest of its course runs through a tunnel. Thus, if it had not been for these drastic changes, the City Centre fauna could still be at least a few times richer in species than it is today. The Bystrzyca valley in the urbanized areas has also been strongly modified: this is manifested, for example, by the absence of riparian water bodies.

Possibilities of dragonfly conservation

Goertzen & Suhling (2015) indicate that cities may be valuable areas for dragonfly conservation, including "special care" species, i.e. endangered, protected or indicator species for habitats worth protecting, as well as for maintaining the species richness of these insects. This is confirmed by the data on the dragonflies of Lublin which, compared to the rest of the Lublin Upland, seems to be a veritable hot spot of odonate species richness (cf. Bernard et al. 2009). However, in areas which are undergoing rapid and not always well-controlled urbanization, maintaining this state of affairs may be difficult in the absence of a relevant conservation policy.

The subject literature (Bernard *et al.* 2002, Willigalla & Fartmann 2010, 2012, Buczyński 2015, Goertzen & Suhling 2015) and the data

presented in the present paper provide an opportunity for improving the state of Lublin's odonate fauna. These conservation measures, some of which may need to be active, should be twofold: the promotion of certain species and assemblages, and of species richness.

Willigalla & Fartmann (2012) emphasize the importance to dragonflies of environmental heterogeneity: this can be restored by, for instance, renaturalizing the river valleys or by re-creating them from scratch. The first of these possibilities is limited in Lublin, as the river valleys are almost totally built over. However, it would be worth undertaking such measures in the Bystrzyca valley above the Zemborzyce Reservoir, especially above Cienista St.: if they contained more surface water, the slightly or not decomposed peat meadows in this area could maintain a locally and regionally valuable dragonfly assemblage typical of fens. It is important to note that some of the species forming such an assemblage have managed to survive. This would improve the conditions for specialist species, including some protected ones.

Given the contemporary layout of the urbanized part of Lublin, there are few possibilities of restoring the populations of stenotopic and "special care" species, apart from the Bystrzyca. If the water quality of this river could be improved, it might be recolonized by *Ophiogomphus cecilia*. To a large extent, however, this depends on the surface runoff entering the river above the city (Dobrowolski *et al.* 2016). That is why the focus should be on enhancing the species richness of dragonflies by increasing the number and diversity of their habitats, especially by the creation of ponds in gardens and parks, and also stormwater ponds (Willigalla *et al.* 2003, Le Viol *et al.* 2009, Willigalla & Fartmann 2009, Hall & Wood 2014, Hassall & Anderson 2015). The ornamental ponds in the UMCS Botanical Garden demonstrate the relevance of such water bodies for dragonflies. However, the real value of stormwater ponds is best shown by the fauna in the valley of the Konopniczanka Stream (ca 30 species), the great majority of which were associated with such water bodies. Of course, as is the case with every anthropogenic habitat, these water bodies have to be created and subsequently managed in an appropriate way (Bernard *et al.* 2002, Buczyński 2015, Goertzen & Suhling 2015, 2018). Two aspects of importance in this respect are the shape of the water body, and the abundance and spatial structure of the vegetation in and around the water. It is also important that the hydrological regime be adjusted to the life cycles of the dragonflies that are likely to use such a site. Otherwise, it will become an ecological trap for these insects. Finally, the connectivity of such habitats is very important (Willigalla & Fartmann 2012, Buczyński 2015, Villalobos-Jiménez *et al.* 2016). A larger number of such suitably modelled water bodies should enhance dragonfly species richness, even in strongly built-up areas (Villalobos-Jiménez *et al.* 2016).

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