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FIRST DATA ON DRAGONFLY (INSECTA, ODONATA) FAUNA IN THE VUGROVEC AREA, ZAGREB AND THE FIRST CHECKLIST OF THE DRAGONFLIES OF ZAGREB

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The fauna of Zagreb has been well investigated during the last two centuries, which is evident from a series of publications. Even so, only limited data on dragonfly fauna of Zagreb have been published, and there is no current checklist. During the three years period (2009-2011) we conducted a survey of the dragonfly and damselfly fauna (Insecta, Odonata) in Vugrovec village, located on the eastern slopes of Mt Medvednica. The aim of this study is to present the first data on dragonflies from the Vugrovec area and to compile the first checklist of dragonflies of Zagreb. The suborder Zygoptera is represented in Vugrovec by 4 families and 5 species, while the suborder Anisoptera is represented by 4 families and 9 species in the area. After a review of all the available literature, in conjunction with the newly collected data, a checklist of dragonflies of Zagreb was created, including 44 species, 14 of which are listed in the Red Book of Dragonflies of Croatia. This indicates a high richness in comparison to the 70 known species from Croatia.

Dragonfly, Odonata, fauna, diversity, checklist, Zagreb, *Orthetrum coerulescens*

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Fauna Zagreba istraživana je tijekom posljednja dva stoljeća, što je vidljivo iz brojnih objavljenih radova. Ipak, objavljeno je vrlo malo podataka o fauni vretenaca, bez popisa vrsta. U razdoblju od 2009-2011. godine istraživali smo faunu vretenaca (Odonata) na području sela Vugrovec, koje se nalazi na istočnim obroncima Medvednice. Cilj ovoga istraživanja jest predstaviti prve podatke za faunu vretenaca Vugrovca te sastaviti prvi popis vretenaca Zagreba. U Vugrovcu smo zabilježili 4 porodice i 5 vrsta podreda Zygoptera te 4 porodice i 9 vrsta unutar podreda Anisoptera. Pregledom sve dostupne literature, zajedno s novo prikupljnim podatcima, napravljen je prvi popis

vretenaca grada Zagreba koji uključuje 44 vrste. Četrnaest pronađenih vrsta nalazi se u Crvenoj knjizi vretenaca Hrvatske. Tako veliki broj vrsta upućuje na bogatstvo faune vretenaca na tome području, pogotovo ako uzmemo u obzir da je na području cijele Hrvatske zabilježeno 70 vrsta vretenaca.

Vretenca, Odonata, fauna, raznolikost, popis vrsta, Zagreb, *Orthetrum coerulescens*

Introduction

The first data on Croatian dragonflies can be found in scientific works that originate from the mid-19th century (Charpentier, 1841, Charpentier, 1843, Heer, 1847). Thenceforth, a large number of researchers showed great interest in working with that group of insects in this country (Frauenfeld, 1860; Novak, 1890; Kohaut, 1896; Mocsary, 1900; Rössler, 1900; Koča, 1925; St. Quentin, 1944; Adamović, 1948, 1967; Geelen & Oomen, 1965; Miškić, 1992; Franković, 1995; Franković, 1997; Bogdanović & Mikuska, 2003; Perović & Perović, 2003). Recent contributions to the knowledge of Croatian dragonflies are published in the Croatian Red Book of Dragonflies (Belančić et al., 2008), the review of dragonfly fauna of the Turopolje area (Vilenica et al., 2010) and the survey of Odonata fauna of the Kornati Islands (Bobinec & Matejčić, 2010). The European dragonfly fauna consists of 138 species (Kalkman et al., 2010), while the number of species in Croatia differs from author to author. According to Franković & Bogdanović (2009) 70 species have been recorded in our country, while in the European Red List of Dragonflies (Kalkman et al., 2010) 66 species are listed. Research into Croatian dragonfly fauna started many years ago, ample data having been collected since that time. However, we can state with certainty that the dragonfly fauna of Croatia remains poorly understood, since most research is carried out sporadically and rarely systematically.

There are just four scientific papers in which we can find information about the Zagreb dragonfly fauna (Rössler, 1900; Koča, 1925; Miškić et al., 1992; Vukić, 1992) and all the data were collected between the years 1863 and 1991.

No data about the dragonfly fauna of Vugrovec have ever been published, but since the investigating sites in the works of Rössler (1900) and Koča (1925) are not precise, there is a possibility that Vugrovec is included under the broader name of Zagreb. The aim of this study is to present new data about the dragonflies from the Vugrovec area and to compile the first checklist of the dragonflies of Zagreb.

Materials and Methods

During the years 2009, 2010 and 2011, in the period from May to October, we collected dragonflies in the area around Vugrovec village (Fig. 1). A total of 24 field trips weremade during the three year period (8 field trips in 2009, 14 in 2010 and 2 in 2011). Odonata were mostly collected using entomological nets, while some individuals were caught by hand. Only adults were collected and determined by the determination key for dragonflies of Europe (Dijkstra & Lewington, 2006). After determination, the dragonflies were photographed and released at the locations where they were caught. We made a systematic list of species according to the Fauna Europaea website (http://www.faunaeur.org/).

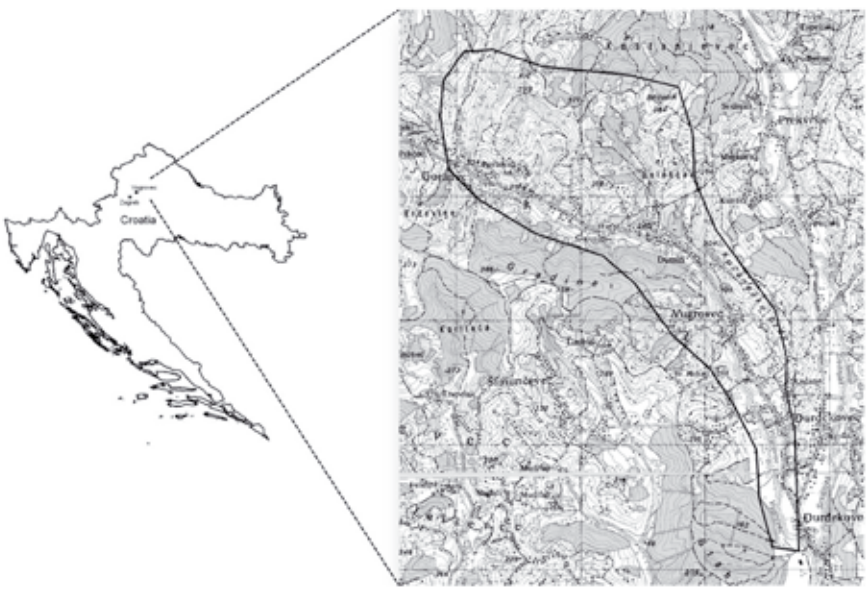

Figure 1. Map of Croatia with the location of Vugrovec village and the research area.

Study Area

Vugrovec is located about 15 km from the center of Zagreb and is situated on the peripheral part of the city, on the eastern slopes of Mt. Medvednica. It was formerly a part of Medvednica Nature Park, but in 2009 the range of the Park was reduced so Vugrovec is no longer within its boundaries. Two shallow streams,

Vugrovec and Goranec, and their tributaries, flow through the village. Both streams are slow running and partially dry up in the warmer part of the year, if there is not enough precipitation.

Roughly half of the Vugrovec stream is channeled and does not represent a suitable habitat for dragonflie's larval development. Fortunately, some parts are still intact and suitable for dragonflies.

In the village there is also a little concrete pool which is filled with water most of the year, and is cleared of silt and overgrown vegetation at least once a year. In the past, on the slopes of the small hills that surround Vugrovec, there were a lot of small ponds, but now they have all been filled in or have dried up.

Results and Discussion

Figure 2. Male specimen of *Orthetrum coerulescens.*

During the three years of fieldwork, approximately 100 adult dragonfly specimens were caught in Vugrovec village. The largest number of specimens was found at or near sources of fresh water, while some specimens roam over a wider surrounding area. These specimens have been found far from their breeding sites, for example, on meadows or in orchards. After identification, 14 species belonging to both Odonata suborders were noted. One of these species, *Orthetrum coerulescens* (Fabricius, 1789) (Fig. 2), has been recorded for the first time for the Zagreb area (Rössler, 1900; Koča, 1925; Miškić, 1992; Vukić, 1992). The

suborder Zygoptera is represented by 4 families and 5 species, and the suborder Anisoptera by 4 families and 9 species. The family Libellulidae was the most numerous, with 3 genera and 6 species, which represents 43 % of all recorded species. The number of species identified in the Vugrovec area represents 31.81 % of the total number of dragonfly species so far recorded in Zagreb and its surroundings (Rössler, 1900; Koča, 1925; Miškić, 1992; Vukić, 1992).

The list of the recorded Odonata species in Vugrovec area with dates of the ir collections:

Suborder Zygoptera

Family Calopterygidae

1. *Calopteryx splendens* (Harris, 1782)
   Records: 26/05.2009, 06/06.2009, 13/06.2010, 17/07.2010.
2. *Calopteryx virgo* (Linnaeus, 1758)
   Records: 24/05.2009, 26/05.2009, 05/07.2009, 13/06.2010, 15/08.2010.

Family Lestidae

1. *Sympecma fusca* (Vander Linden, 1820)
   Records: 16/08.2009, 15/07.2010, 24/10.2010, 16/08.2011.

Family Coenagrionidae

1. *Ischnura pumilio* (Charpentier, 1825)
   Records: 18/07.2010.

Family Platycnemididae

1. *Platycnemis pennipes* (Pallas, 1771)
   Records: 24/05.2009, 26/05.2009, 31/05.2009, 05/06.2009, 06/06.2009, 05/07.2009, 16/08.2009, 13/06.2010, 18/07.2010, 25/07.2010.

Suborder Anisoptera

Family Aeshnidae

1. *Aeshna cyanea* (Müller, 1764)
   Records: 31/10.2010.

Family Gomphidae

1. *Onychogomphus forcipatus* (Linnaeus, 1758)
   Records: 26/05.2009, 27/07.2009, 18/07.2010, 15/08.2010, 25/06.2011.

Family Cordulegastridae

1. *Cordulegaster bidentata* Selys, 1843
   Records: 25/06.2011.

Family Libellulidae

1. *Libellula depressa* Linnaeus, 1758
   Records: 06/06.2009, 05/07.2009, 20/06.2010.
2. *Orthetrum brunneum* (Fonscolombe, 1837)
   Records: 26/05.2009, 05/06.2009, 06/06.2009, 05/07.2009, 04/07.2010, 11/07.2010, 18/07.2010, 15/08.2010.
3. *Orthetrum coerulescens* (Fabricius, 1798)
   Records: 24/05.2009, 26/05.2009, 31/05.2009, 05/06.2009, 06/06.2009, 05/07.2009, 16/08.2009, 17/07.2010, 15/08.2010.
4. *Sympetrum fonscolombii* (Selys, 1840)
   Records: 15/08.2010, 21/08.2010.
5. *Sympetrum sanguineum* (Müller, 1764)
   Records: 27/07.2009, 22/07.2010, 11/08.2010, 15/08.2010.
6. *Sympetrum striolatum* (Charpentier, 1840)
   Records: 15/08.2010, 25/06.2011.

With about 5,680 species, dragonflies constitute a relatively small insect order (Kalkman et al., 2008). In Europe, 138 dragonfly species are present, 48 of which are damselflies and 90 are true dragonflies (Kalkman et al., 2010). As we mentioned before, different authors give different numbers of species for the Croatian dragonfly fauna. According to the European Red List of Dragonflies (Kalkman et al., 2010) Croatia has 66 species. However, in the Croatian Red Book of Dragonflies (Belančić et al., 2008) 75 species are listed, five of which are considered doubtful and the authors suggest their removal from the list. The reason for the different numbers of species in different references is that there is still scientific controversy about the taxonomic status of some species and subspecies. Thus, in the Croatian Red Book of Dragonflies (Belančić et al., 2008) the subspecies *Orthetrum coerulescens anceps* (Schneider, 1845) is raised to the level of species *Orthetrum ramburii* (Selys, 1848) (Synonym*: O. anceps*), and subspecies *Calopteryx splendens balcanica* (Fudakowski, 1930) is recognized as a separate species *Calopteryx balcanica*. It should be noted that in this work we consider *O. ramburii* as a subspecies of *O. coerulescens*.

Almost twenty years ago, Franković (1995) unified all of the previously published and unpublished data and created a distribution map of Croatian dragonflies within the 10×10 km UTM grid. According to the map, in the UTM quadrant WL where Zagreb is also located, *Erythromma lindenii* (Selys, 1840) is marked as present. *E. lindenii* is found in southwest and southern Europe, can be abundant in the Mediterranean region and is slowly expanding its range northwards (Clausnitzer, 2007). This species is not mentioned in any other published paper for the Zagreb area, and since there is no specific locality mentioned on the UTM map, we cannot know the exact locality at which it was found. This is why we decided not to include it in the list of dragonflies for the Zagreb area. A similar case can be found in the Red Book of Dragonflies of Croatia (Belančić et al., 2008). In it, an additional five species are marked around the Zagreb area (*Sympetrum depressiusculum, Lestes dryas, Coenagrion pulchellum, Anax parthenope, Orthetrum ramburii*), which, also because of the lack of precise locality, we did not include in the checklist.

If only data gathered from published papers is considered (Rössler, 1900; Koča, 1925; Miškić 1992; Vukić, 1992), it is evident that there are 44 dragonfly species listed for the Zagreb area and its surroundings. With *Orthetrum coerulescens*, a species that is found in Vugrovec and is recorded for the first time for Zagreb, the fauna of Zagreb counts 45 species and represents 64.28% of the Croatian dragonfly fauna (Tab. 1). But if we take into consideration that the species *Sympetrum danae* (Sulzer, 1776) has not been found in Croatia for almost 112 years, and is listed in the Red Data Book (Belančić et al., 2008) as regionally extinct, we can easily say that nowadays 44 species inhabit Zagreb and its surroundings. This emphasizes the importance of recent surveys, especially for records of rare, protected or endangered species.

Among collected species in Vugrovec, two are listed in the Croatian Red Data Book: *Orthetrum coerulescens* (DD) and *Sympetrum fonscolombii* (Sélys, 1840) (NT).

Orthetrum coerulescens, a new species for Zagreb, is common around the Mediterranean, more locally distributed in central and northern Europe, whilst marginally entering into Russia (Dijkstra & Lewington, 2006). This species is present in almost the whole of Croatia (Belančić et al., 2008). It lives near running water, such as streams and ditches (Clausnitzer, 2007), but can also be found close to lakes and pools (Belančić et al., 2008). In the north of its range it

Table 1: The list of dragonfly species found in Zagreb and its surroundings in the last 100 years

Families and species	Zagreb area*				Vugrovec	Belančić et al. (2008)**
	Rössler (1900)	Koča (1925)	Mišković et al. (1992)	Vukić (1992)		
Family Calopterygidae						
Calopteryx splendens (Harris, 1782)	+	+	+	+	+	/
Calopteryx virgo (Linnaeus, 1758)	+	+	+	+	+	/
Family Lestidae						
Sympecma fusca (Vander Linden, 1820)	+	+	+	+	+	/
Lestes viridis (Vander Linden 1825)		+	+			/
Lestes barbarus (Fabricius, 1798)		+	+			NT
Lestes sponsa (Hansemann, 1823)			+			NT
Lestes virens (Charpentier, 1825)	+	+				VU
Family Coenagrionidae						
Erythromma najas (Hansemann, 1823)			+			NT
Erythromma viridulum (Charpentier, 1840)			+			/
Coenagrion puella (Linnaeus, 1758)	+	+	+			/
Enallagma cyathigerum (Charpentier, 1840)			+			/
Ischnura elegans (Vander Linden, 1820)	+	+	+	+		/
Ischnura pumilio (Charpentier, 1825)	+	+	+		+	/
Family Platycnemididae						
Platycnemis pennipes (Pallas, 1771)		+	+	+	+	/

Table 1. - continued

Family Aeshnidae								
Brachytron pratense (Müller, 1764)	+	+	+					/
Aeshna affinis Vander Linden, 1820			+					/
Aeshna mixta Latreille, 1805		+	+					/
Aeshna cyanea (Müller, 1764)		+	+			+		/
Aeshna grandis (Linné, 1758)			+	+				EN
Aeshna isoceles (Müller, 1767)			+					NT
Anax imperator Leach, 1815	+	+	+	+				/
Family Gomphidae								
Gomphus vulgatissimus (Linnaeus, 1758)	+	+	+					/
Gomphus flavipes (Charpentier, 1825)			+					/
Ophiogomphus cecilia (Fourcroy, 1785)		+						VU
Onychogomphus forcipatus (Linnaeus, 1758)		+	+			+		/
Family Cordulegastridae								
Cordulegaster bidentata Selys, 1843	+	+	+			+		/
Cordulegaster heros Theischinger, 1979			+					/
Family Corduliidae								
Cordulia aenea (Linné, 1758)	+	+	+	+				/
Somatochlora meridionalis Nielsen, 1935			+	+				/
Somatochlora flavomaculata (Vander Linden, 1825)		+						NT
Epitheca bimaculata (Charpentier, 1825)			+					EN
Family Libellulidae								

Table 1. - continued

Libellula depressa Linnaeus, 1758	+	+	+	+	+	+	/
Libellula fulva Müller, 1764			+				/
Libellula quadrimaculata Linné, 1758			+				/
Ortethrum albistylum (Selys, 1848)		+	+				/
Ortethrum brunneum (Fonscolombe, 1837)			+	+	+	+	/
Orthetrum cancellatum (Linné,1758)			+	+			/
Ortethrum coerulescens (Fabricius, 1798)						+	DD
Crocothemis erythraea (Brulle, 1832)		+	+	+			/
Sympetrum danae (Sulzer, 1776)		+					RE
Sympetrum fonscolombii (Selys, 1840)			+			+	NT
Sympetrum meridionale (Selys, 1841)			+				NT
Sympetrum sanguineum (Müller, 1764)		+	+	+	+	+	/
Sympetrum striolatum (Charpentier, 1840)			+	+	+	+	/
Sympetrum vulgatum		+	+				NT

* Rössler (1900)- dragonflies found in Zagreb and Božjakovina; Koča (1925)- lists dragonflies from collections of the Zoological department in the Croatian Natural History Museum and lists data from literature (Rössler, 1900); Miškić et al. (1992)- data from Bregana, Samobor, Zaprešić, Vrapče, Jarun, Bundek, Maksimir, Savica, Medvednica and Velika Gorica; Vukić (1992)- only data from the localities Bregana, Bobovica and Laduč were taken into consideration.
**Statuses in the Red Data Book of the Dragonflies of Croatia: RE-regionally extinct, EN-endangered, VU-vulnerable, NT-near threatened, DD-data deficient

mainly inhabits boggy areas (Clausnitzer, 2007). Adults can be seen from April to November, but are most abundant from June to August (Dijkstra & Lewington, 2006). Females lay eggs in shallows without vegetation, but larvae live in the mud, among aquatic plants and the roots of riparian vegetation (Belančić et al., 2008). Adults are usually prone to wandering and so can be recorded far away from water (Nelson et al., 2000). Most of the specimens we found were flying around the stream or on the surrounding meadows, a maximum of about 500 meters away from running water.

Dragonflies are a group of insects that are connected to both terrestrial and aquatic ecosystems throughout their life cycle. But in order for them to survive, the aqueous medium is indispensable, since the larvae develop, feed and grow in it. Nowadays, aquatic ecosystems are among the most endangered habitats on Earth, and all factors (e.g. land reclamation, pollution by heavy metals, use of pesticides) that negatively affect them also represent a major threat to the survival of dragonflies (Kalkman et al., 2010).

As Vugrovec is situated far away from the city's crowds and noise, it represents a very attractive place to live in, so each year new cottages are built, roads are extended and all of this leaves a mark on the fauna and flora of that area. Unfortunately, in the last two years we have also witnessed the negative aspects of human activity on the environment. We noticed frequent garbage disposal near the stream, which may have a negative impact on water quality and development of dragonflies. In 2009, some parts of the tributaries were culverted. In 2010, a large area was devastated and covered with gravel while a nearby road was being repaired and widened, and accordingly was no longer a suitable habitat for dragonflies. One other important problem is that most households still do not have sewage infrastructure and discharge sewage directly into the streams, thus influencing water quality.

Further studies should be aimed at the faunistics and ecology of Odonata in different locations around Zagreb, in order to see if all historical records can be confirmed. This data can be used for future conservation purposes.

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