



**CONTRIBUTION TO THE KNOWLEDGE OF DRAGONFLY FAUNA OF THE
BREGALNITSA RIVER, MACEDONIA (INSECTA: ODONATA)**

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Synopsis

Six Odonata species have been established as possibly breeding in Bregalnitsa River during a hydrobiological research conducted from the source region to the lower part of the watercourse. Dragonfly larvae are found in seven out of thirteen sampling points. Other six species have been discovered during faunistic research performed in the adjacent area and added to the overall dragonfly check-list for the region. All together are discussed according to their autochthony, habitat specialisation and zoogeographical affiliation.

***DOPRINOS POZNAVANJU FAUNE ODONATA SA REKE
BREGALNICE, MAKEDONIJA (INSECTA: ODONATA)***

Synopsis

Tokom hidrobiološkog istraživanja Reke Bregalnice obavljenih od izvorisnog regiona sve do donjeg teka, ustanovljene su šest vrste Odonata. Pretpostavlja se da je reka moguće staniste za njihovo razmnozavanje. Na sedam od ukupno trinaest lokaliteta registrovano je prisustvo larvi. Ostale šest vrste otkrivene su u toku istraživanja susednjih oblasti i ove vrste su uključene na listi Odonata za područje. Svi zajedno su procenjeni saglasno njihove autohtonosti, specijalizacije prema habitatu i zoogeografske pripadnosti.

INTRODUCTION

Odonata constitute a well-known, widely distributed order of insects. About 6,000 described species are known to date (Corbet & Brooks 2008). Dragonflies are most abundant and diverse in lentic (standing) waters, but many species also occur in lotic (flowing) waters (Bouchard, 2004).

Most of the published data about Odonata fauna in R. Macedonia mainly focused on stagnant ecosystems (Herbert, 1918, 1919, 1921; Petkov, 1921; Filevska, 1954; Buchholz, 1963; Karaman, 1969, 1972, 1978, 1979, 1981, 1987, 1992; Smiljkov et al, 2008).

Analyses of dragonflies along the rivers have great faunistical and ecological importance. Unfortunately there have been only few studies in Macedonia that concerned to dragonflies from running waters (Adamovic, 1990; Angelovski et al., 1992; Karaman, 1992). The scarce published data illustrate the need for detailed study on Odonata fauna from the running waters in R Macedonia.

The objective of this study was to provide more detailed information about autochthony, habitat specialisation and zoogeographical affiliation of dragonfly fauna of Bregalnitsa River and its surroundings. As a result of the urbanization in the Bregalnitsa basin, the river has been heavily influenced by a number of pollution sources from mining (Zletovo and Sasa mines) and industrial facilities (food industry, poultry, textile, cellulose, pharmaceutical industry, sand separation systems), as well as from communal waste water. Additionally, intensive agriculture activities cause water quality degradation in the basin.

Namely, it is well known that amphibious larvae of dragonflies are sensitive with regard to water quality and aquatic morphology of streams; the effects of chemical pollution on macroinvertebrates (including Odonata) in aquatic systems (e.g. for tropical Africa) have been reported by Matagi (1996). The adults are responsive to habitat structure and are excellent indicators of river disturbance (e.g. Samways & Steytler 1996; Stewart & Samways 1998). So, the knowledge about dragonfly from Bregalnitsa river could be contributed in future monitoring research.

It should be mentioned that this study was made as a part of complex hydrobiological investigation on macrozoobenthos of River Bregalnica (yet unpublished data).

SUBJECT AND METHOD OF RESEARCH

The Bregalnitsa River is the biggest left tributary of the Vardar River, situated in the eastern part of Republic Macedonia. The river source consists of a few streams flowing down the Maleshevski Mts. The river's total length from the source (1690 m altitude) to the mouth of the River Vardar near the village of Ubogo (137 m altitude) is 225km. The catchment is 4,306.8 km² and the average slope of the terrain is $J = 0.86\%$

The Bregalnitsa River has well-developed hydrographic network and some of its numerous tributaries are as follows: the Pehchevska, Ratevska, Zelevica, Kamenichka, Osojnica, Orizarska, Kochanska, Zrnovska, Zletovica, Kriva Lakavica and the Sveti Nikolska River (Gaševski, 1979). They collect water either from the Maleshevski, Osogovo or from Plachkovica mountains (Gaševski, 1979). Behind the confluence of the River Kamenica and Bregalnitsa, dam Kalimanci was constructed in 1968. Thus, the river course was converted into a lake ecosystem. This habitat facilitates development of lentic dragonfly forms, which are not included in the current research.

Hydrobiological research on macrozoobenthos of the Bregalnitsa river was conducted from September 2007 until June 2008 from the source region to the lower part of the watercourse. A total of 13 sampling points (locality 1, locality 1', locality 2... locality 12) were established and visited on a monthly basis. They were selected before and after the large towns as well as before and after the mouths of the tributaries polluted by communal and industrial waste water. Such a selection of a sampling station helped understand the real condition in the Bregalnitsa river, as well as the influence by the towns of Berovo, Delcevo, Kochani i Stip over the water quality.

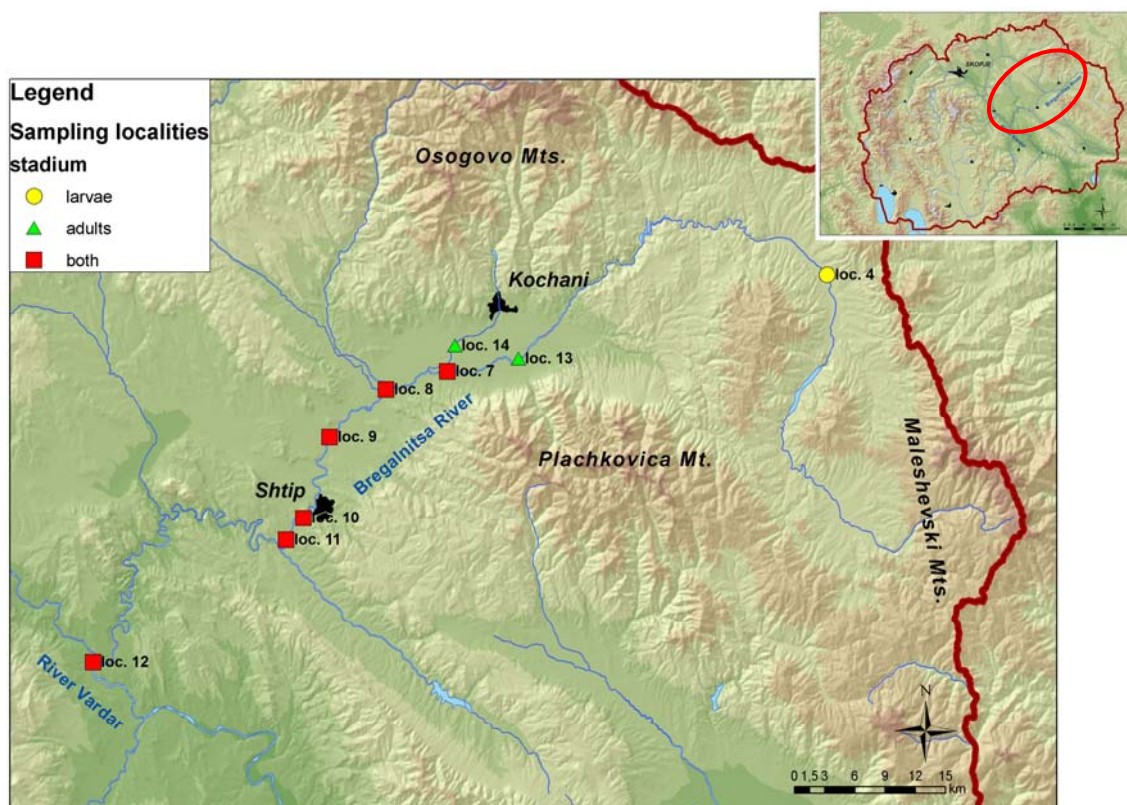


Fig. 1 Map of research area.

Dragonfly larvae have been found in seven out of thirteen sampling localities as follows:

Locality 4 – The Bregalnitsa river, upstream of the town of Delchevo, UTM/WGS84 34T 649494/4645190. Open sunny area among surrounding vegetation. The river is 7 to 14 m wide and 0.2 to 0.4 m deep. The substrate is predominantly composed of pebbles and cobbles.

Locality 7 – The Bregalnitsa river, downstream of both Osojnichka and Kochanska rivers, village of Teranci (near the town of Kochani), UTM/WGS84 34T 611791/4635453. The river flows near rice field. It is 9 to 10 m wide and the depth varies between 0.3 and 0.7 m. The banks are overgrown with riparian vegetation. Two different kinds of substrate existed. The first one is a mixture of pebbles and cobbles, while the second one is fine sand covered with macrophytes.

Locality 8 - Mouth of the Zletovica in the Bregalnitsa river, UTM/WGS84 34T 605944/4633640. The right bank is stony, while the left is overgrown with riparian vegetation of willow and other bushes. Near the sampling sites there are rise fields. The width of the channel here ranges between 6 and 11 m. The river's depth varies between 20 and 43 cm. The substrate is mainly composed of pebbles and coarse sand. During the vegetation period, macrophytes increased and covered up part of the area of the sampling site.

Locality 9 – The Bregalnitsa river, village of Dolni Balvan, UTM/WGS84 34T 600123/4628733. Open sunny area. There are small temporal waters. The right bank is stony, while the left one is overgrown with bushes and trees. The river's channel here has a width ranging between 11 and 14 m and depth that varies between 0.3 and 0.6 m. The bottom is mainly covered with pebbles, cobbles and coarse sand.

Locality 10 - The Bregalnitsa river, Kezovica Spa in Stip, UTM/WGS84 34T 598139/4620795. Open sunny area among riparian vegetation, as willow. The channel is 11 to 16 m wide here and depth varies from 0.3 to 0.7 m. There are two different kinds of substrates. First is mixture of pebbles, cobbles and coarse sand, while the second one is coarse sand. During summer/autumn macrophytes covered up part of area of sampling site.

Locality 11 - The Bregalnitsa river, village of Sofilari, UTM/WGS84 34T 595704/4618599. Open sunny area among riparian vegetation. The channel is from 7.5 to 15 m wide here and the depth varies between 0.3 and 0.9 m. There are two different kinds of substrates. The bottom is mainly covered with pebbles, cobbles and coarse sand. Near the banks fine substrate (silt) is accumulated.

Locality 12 - Mouth of the Bregalnitsa river, village Ubogo, UTM/WGS84 34T 576813/4606428. The river's channel here has a width ranging between 15 and 18 m

and depth that vary between 0.41 and 1.3 m. It is overgrown with riparian vegetation of trees and bushes, and sporadically with reed. The middle part of the channel is covered with coarse sand while near the banks there is accumulated silt.

Faunistical samples on adult Odonata have been collected during hydrobiological research. Additionally, adults have been obtained from the following two localities:

Locality 13 - Mouth of the Zrnovska river in Bregalnitsa river, UTM/WGS84 34T 619226/4636776. The river bed has been widened artificially, thus, the water flows slowly. The right bank is stony, wide and overgrown with reed, while the left one is overgrown with riparian vegetation of willow, poplar and other bushes. The bottom is covered with cobbles and silt. Near the locality, there are canals with slow-flowing water overgrown with reed as well as temporal waters overgrown with low vegetation.

Locality 14 - The Kochanska river near the village of Dolni Podlog, UTM/WGS84 34T 612342/4637940. There are rice field and canals between the Kochanska and the Bregalnitsa rivers. The canals are overgrown with reed and the water is slow-flowing.

Benthic fauna samples from different substrates were collected with Surber net with mesh of the size 500 μm , and in some cases (coarse sand and silt) with an Ekman grab. To complete the species list, qualitative samples were taken with a hand net. For preservation of macrozoobenthos, 4% formaldehyde was used. Further processing of the collected and conserved material was conducted in the Laboratory of Invertebrates and Animal Ecology, the Biology Institute, Faculty of Natural Science and Mathematics, Skopje. In the laboratory, the animals were flushed with tap water through a standard sieve (280 μm pore size). Odonata larvae were separated from the other animals and then analyzed with the Olympus SZX9 binocular microscope and scanned Mini VID USB camera. The calculated densities are finally referred to as a number of individuals per square metre of sediment surface ($\text{ind}\cdot\text{m}^2$). In order to determine the dominance and frequency of larvae, Balogh's (1958) and Southwood's (1984) formulas were applied. The classification of mineral substrates by particle size was according to Wentworth (1922).

Adults were collected during the period from June to July 2008 with entomological net and stored in paper envelopes that were marked appropriately. Identification of dragonflies was performed using Beschovski (1994) and Marinov (2000).

For assessing species autochthony a classification scheme was used (Schmidt, 1985). Zoogeographical distribution was given according Beschovski (1994).

RESULTS AND DISCUSSION

During the hydrobiological research on the Bregalnitsa river and the adjacent area, presence of 12 Odonata species was established (Table 1 and 2 respectively). Among them, *Calopteryx splendens*, *C. virgo*, *Platycnemis pennipes*, *Gomphus flavipes*, *G. vulgatissimus* and *Onychogomphus forcipatus* in both larval and imago stages only in middle and lower part of the river were found. Presence of ultimate exuviae wasn't noticed, so it is not certain that the mentioned species ends its development in the territory. According classification scheme by Schmidt (1985) and Chovanec & Waringer (2001), this species are established as possibly breeding species (Table 2).

It is worth highlighting that none of the above-mentioned species were found in the upper part of the river which is opposite of the research of Karaman (1969). According to her investigation *Calopteryx splendens*, *C. virgo* and *Onychogomphus forcipatus* were registered near village Vladimirovo, which is located on the upper part of the river Bregalnitsa. The absence of this species in the upper part of the river, maybe due to the fact that they prefer clean oxygenated water (Beschovski & Marinov, 2007), (even *Onychogomphus forcipatus* could be much more tolerant), while in this sector river is heavy polluted (unpublished data).

Tab. 1 List of Odonata larvae from the sampling sites along the Bregalnitsa river. Abbreviations: + = taxa observed in qualitative samples only.

Sampling sites	loc-4	loc-7		loc-8	loc-9	loc-10		loc-11		loc-12		
Species /substrate	pebbles and cobbles	pebbles and coarse sand	fine sand covered with macrophytes	pebbles and coarse sand	pebbles, cobbles, coarse sand	pebbles, cobbles, coarse sand	coarse sand	pebbles, cobbles, coarse sand	silt	coarse sand	Silt	Frequency in sampling sites (%)
<i>Calopteryx splendens</i> (Harris, 1782)												14,2
<i>Calopteryx virgo</i> (Linnaeus, 1758)												28,6
<i>Platycnemis pennipes</i> (Pallas, 1771)												42,9
<i>Onychogomphus forcipatus</i> (Linnaeus, 1758)								+				71,4
<i>Gomphus flavipes</i> (Charpentier, 1825)												28,6
<i>Gomphus vulgatissimus</i> (Linnaeus, 1758)												42,9

Based on the results presented in table 1, a qualitatively more varied community of larvae was noted at the 7th and 10th sampling stations (4 taxa). This is probably a result of the diversity of the microenvironment. Despite the heterogeneous distribution of bottom sediment on sampling site 11, the lowest number of species (only *Gomphus vulgatissimus*) was recorded. In June presence of dead larvae of *Onychogomphus forcipatus* was noticed near the banks. It is possible that the measured high concentration of ammonia and the low value of oxygen (unpublished data) reduced the diversity of dragonflies and had a lethal impact of larval stage.

The analyses of the ecological complexes: rheophilous (inhabiting running water) and limnophilous (inhabiting stagnant water) (Beschovski, 1967, 1968), show that all six founded species are rheophilous. According their affinities (Beschovski, 1967), larvae of rheophilous epiphytic species *Calopteryx splendens*, *C. virgo* and *Platycnemis pennipes* were found mainly among vegetation developed on localities 7, 8 and 10.

Onychogomphus forcipatus was recorded in lithoreophilous communities, usually underside of stones or under stones in sand. As was mentioned in description of sampling sites, river bed is consisted of different type of stones. So, it is obviously why it is the most frequent (71.4 % of sampling site) species. *Gomphus vulgatissimus* was discovered in psammorheophilous communities from the sampling station 10 and 12, as well in silt from the mouth of investigated river, and thus with the highest average abundance of 54.44 ind·m² (Fig. 2). Same species was discovered in the pelorheophilous community from the mouth of River Bregalnitsa where it shared common habitat with *G. flavipes* (Fig. 2).

Tab. 2 List of Odonata adults from the Bregalnitsa river and the adjacent area. . Abbreviations: B – breeding species; PBS – possible breeding species; AC – accidental species.

Localities	loc-7		loc-8		loc-9	loc-10	loc-11	loc-12	loc-13		loc-14
Species / habitats	Riparian vegetation	Rise field	stony bank, riparian veg. slow flowing water	Rise field, canal with reed	Temporal water	Riparian vegetation	Open sany areas, low vegetation	Riparian vegetation	stony bank, riparian veg. slow flowing water	Rece field, canals with reed	Rece field, canals with reed
<i>Calopteryx splendens</i> (Harris, 1782)	PBS		PBS		PBS	PBS	PBS	PBS	PBS		
<i>Calopteryx virgo</i> (Linnaeus, 1758)									AS		
<i>Sympecma fusca</i> (Vander Linden, 1820)				AS					AS		

<i>Platycnemis pennipes</i> (Pallas, 1771)			PBS	PBS		PBS			PBS	PBS	PBS
<i>Coenagrion ornatum</i> (Sélys, 1850)			AS						AS		
<i>Ischnura elegans</i> (Vander Linden, 1820)			AS	AS			AS		AS	AS	AS
<i>Onychogomphus forcipatus</i> (Linnaeus, 1758)			PBS			PBS			PBS	PBS	PBS
<i>Gomphus flavipes</i> (Charpentier, 1825)									PBS		
<i>Gomphus vulgatissimus</i> (Linnaeus, 1758)			PBS						PBS		
<i>Libellula depressa</i> (Linnaeus, 1758)									AS		
<i>Sympetrum fonscolombii</i> (Sélys, 1840)		AS	AS							AS	AS
<i>S. sanguineum</i> (Müller, 1764)			AS							AS	AS

The results of this study show that adults rheophilous *C. splendens*, *P. pennipes* and *O. forcipatus* were the most frequent species in the riparian habitats. Later is given as widely distributed in Macedonian running water (Karaman, 1992).

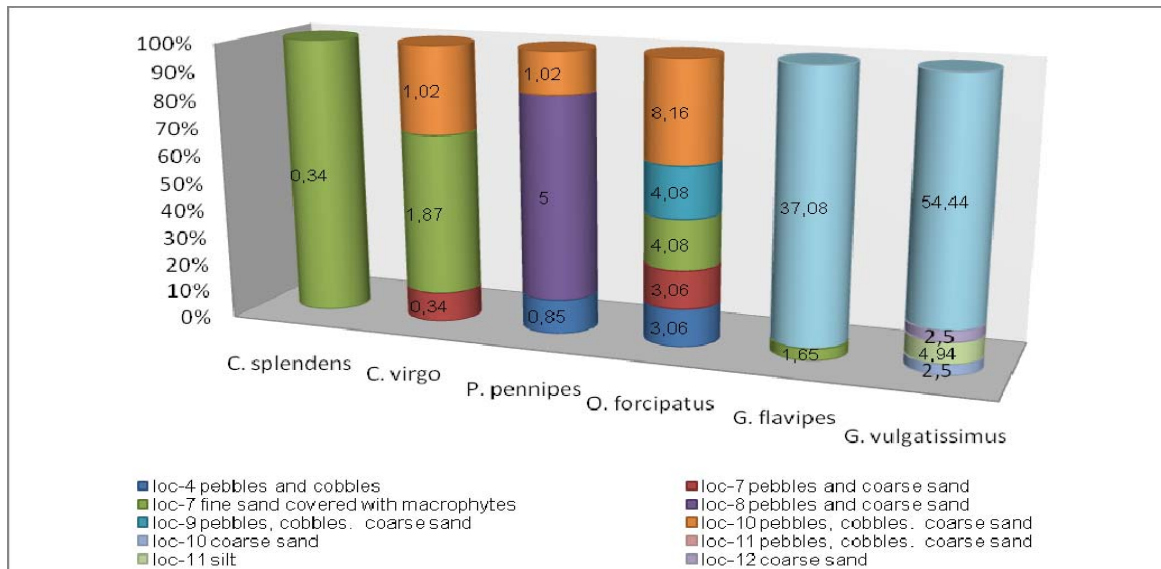


Fig. 2 Average abundance of Odonata larvae related to type of substrate.

This faunistic list lacks larvae of any representative of other rheophilous Odonata family, namely Cordulegastridae. They were neither presented in the samples on larvae nor on the adults. *Cordulegaster bidentata* (Selys, 1854) is

currently established for the neighbouring region of Osogovo Mts (D. Kitanova pers. observ.). It is known as restricted to sources and brooks (Leipelt 2005) and was anticipated as one of the species that should be present within the study area. Leipelt (2005) claims *C. bidentata* has a low ability to withstand strong hydraulic stress. That could be one of the reasons for its absence in the samples.

Adults of six remaining species (*Coenagrion ornatum*, *Ischnura elegans*, *Sympecma fusca*, *Libellula depressa*, *Sympetrum sanguineum* and *Sympetrum fonscolombeii*) were discovered during faunistic investigations performed in adjacent area (as small bogs, rice field...) and added to the total dragonfly check-list for the region (Tab. 2). The latter are limnophilous species (Beschovski & Marinov, 2007), so they completely were lacking in investigated river.

Tab. 3. Zoological and geographical affiliation of the registered species.

Species	Eurosiberian type (75%)					Mediterranean type (25 %)					
	Holarctic group	Holopalaearctic group (16,7%)	Eurosiberian group (8,3 %)	European group (16,7%)	European-Mediterranean group (33,3 %)	Holomediterranean group (16,7%)	East Mediterranean group	West mediterranean group	Balkan-Mediterranean group	Mediterranean-Afrotropical group	Mediterranean-Paleotropical group (8,3%)
<i>Calopteryx virgo</i>											
<i>Calopteryx splendens</i>											
<i>Simpepma fusca</i>											
<i>Platycnemis pennipes</i>											
<i>Coenagrion ornatum</i>											
<i>Ischnura elegans</i>											
<i>Gomphus flavipes</i>											
<i>Gomphus vulgatissimus</i>											
<i>Onychogomphus forcipatus</i>											
<i>Libellula depressa</i>											
<i>Sympetrum fonscolombeii</i>											
<i>Sympetrum sanguineum</i>											

Of the species contained in the list, *Coenagrion ornatum* and *Gomphus flavipes* are particularly important. Both are incorporated in international conservation lists: *C. ornatum* is included in Annex II of Habitat Directive 92/43, while *G. flavipes* in Bern Convention, ANNEX II and Habitat Directive 92/43 – ANNEX IV.

The list with adults is far complete. Future investigations surely will enlarge it with more species belonging to other ecological groups. It is expected to be enriched with inhabitants of temporary water bodies, which are weakly, represented here. Only two *Sympetrum* species are reported and no any *Lestes* was observed.

All dragonfly species founded during the research belong only to Boreal complex (Tab. 3). According to their origin and recent distribution they present elements of European-Siberian and Mediterranean zoogeographical types and belong to six different groups, defined by Beschovski (1994). Results show that the fauna is dominated by European-Mediterranean elements (33,3%) of European-Siberian type (75%).

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Summary

CONTRIBUTION TO THE KNOWLEDGE OF DRAGONFLY FAUNA OF THE BREGALNITSA RIVER, MACEDONIA (INSECTA: ODONATA)

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In this paper are reported part of results obtained during complex hydrobiological investigation on macrozoobenthos of River Bregalnica, the biggest left tributary of river Vardar, with special emphasis to Odonata fauna.

Research was conducted from September 2007 until June 2008, from the source region to the lower part of the watercourse. The presence of 12 Odonata species was established. Of these, *Coenagrion ornatum* and *Gomphus flavipes* are particularly important. Both are incorporated in international conservation lists. Results show that the fauna is dominated by European-Mediterranean elements (33,3%) of European-Siberian type (75%).

Calopteryx splendens, *C. virgo*, *Platycnemis pennipes*, *Gomphus flavipes*, *G. vulgatissimus* and *Onychogomphus forcipatus* in both larval and imago stages only in middle and lower part of the river. The analyses of the ecological complexes: show that all six founded species are rheophilous.

Adults of six remaining species (*Coenagrion ornatum*, *Ischnura elegans*, *Sympecma fusca*, *Libellula depressa*, *Sympetrum sanguineum* and *Sympetrum fonscolombei*) were discovered during faunistic investigations performed in adjacent area (as small bogs, rice field) and added to the total dragonfly check-list for the region.

The list with imagines is far complete. Future investigations surely will enlarge it with more species belonging to other ecological groups. It is expected to be enriched with inhabitants of temporary water bodies, which are weakly, represented here. Only two *Sympetrum* species are reported and no any *Lestes* was observed.