

New data and checklist of dragonflies (Odonata) of Lastovo Island, Croatia

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Abstract

In this paper we report the first overview of dragonfly fauna of Lastovo Island, southern Croatia, based on published literature data and recent surveys conducted in 2014 and 2018. So far 16 species have been recorded on the island. The following five species were detected for the first time for the island within this survey: *Ischnura elegans*, *Aeshna isoceles*, *Anax parthenope*, *Sympetrum sanguineum*, and *Selysiothemis nigra*. Of the recorded species the most important is the record of *S. nigra*, an endangered species according to the Red book of Odonata of Croatia, known only from a handful of localities across the coastal parts of the country. On the island, small ponds represent the only source of freshwater habitats suitable for dragonfly development. Most of the visited ponds are in favourable condition and some were also recently cleared of the surrounding vegetation and partially restored.

Zusammenfassung

Checkliste der Libellen (Odonata) der Insel Lastovo, Kroatien – Wir geben einen den ersten Überblick über die Libellenfauna der Insel Lastovo, Südkroatien auf Grundlage veröffentlichter Literaturodaten und neuerer Erhebungen aus den Jahren 2014 und 2018. Bislang wurden 16 Arten auf der Insel erfasst. Folgende fünf Arten konnten im Rahmen dieser Untersuchung erstmals für die Insel nachgewiesen werden: *Ischnura elegans*, *Aeshna isoceles*, *Anax parthenope*, *Sympetrum sanguineum* und *Selysiothemis nigra*. Von besonderer Bedeutung ist der Nachweis von *S. nigra*, einer in Kroatien gefährdeten Art, von der nur eine geringe Anzahl an Fundorten in den Küstengebieten des Landes bekannt ist. Auf der Insel stellen kleine Teiche die einzigen Lebensräume dar, die für die Entwicklung von Libellen geeignet sind. Die meisten der besuchten Teiche befanden sich in einem günstigen Zustand, und einige wurden auch vor kurzem von der umgebenden Vegetation geräumt und teilweise wiederhergestellt.

Introduction

Studies of the dragonfly fauna of Croatia started in the second half of the 19th century (CARRARA 1846), but in spite of that large areas of the country still remain under surveyed, and sometimes without any data (see BELANČIĆ et al. 2008). The same is true for the land area and coastal sea area (including islands) of the country. According to KLEMENČIĆ (1992) the coastal sea area of Croatia is about 33,200 km² of which 3,259 km² belongs to 1,246 islands, islets, and rocks (DUPLANČIĆ LEDER et al. 2004). Due to islands' positions and climate they harbour immense biodiversity, but yet, systematic overviews of their fauna are missing for almost all invertebrates and most vertebrate groups. Due to the uniformity of freshwater habitats and usually low species richness, the dragonfly fauna (Insecta, Odonata) of the Adriatic islands has received little attention so far and is only fragmentarily known (VINKO & PLANKL 2008a, 2008b). The only available systematic overviews were done for the dragonfly fauna of Mljet (FRANKOVIĆ & BOGDANOVIĆ 2010) and Krk (BOGDANOVIĆ & GRGIĆ 2016), while the data for all other islands remain scattered and very limited. These areas are in current times under much anthropogenic pressures, especially from tourism on the one hand, and the changes in rural life and abandonment of villages and traditional agricultural practices on the other. Accordingly, the knowledge about their fauna may prove to be extremely important for future habitat restorations, revitalizations as well awareness-raising activities on the islands.

Our goal is to present a complete overview of the dragonfly fauna of Lastovo Island based on all available literature and recent surveys. Lastovo Island is a part of a National Park which additionally gives importance to the researched area, and given remarks about dragonfly habitat and threats, along with pond management guidelines will help in the Park management.

Materials and methods

Study area

Lastovo Island belongs to the southern Dalmatian group of islands, and with its area of 40.82 km² it is ranked 15th in size among all Croatian islands, islets, and rocks (DUPLANČIĆ LEDER et al. 2004). The island is part of the Lastovo archipelago, which was declared a Nature Park in 2006, and is also the largest island within the protected area.

The climate is Mediterranean with mild, humid, and rainy winters and hot and dry summers. The average annual rainfall is 612.5 mm (1991–2007) and the mean annual temperature for the same period is 15.4°C (HUSNJEK et al. 2014). The vegetation cover is the best reflection of climatic conditions, and on Lastovo Island more than 70% of the island's surface is covered in evergreen oak forests *Quercus ilex* and Aleppo pine forests *Pinus halepensis* (RIĐANOVIĆ 1971/72).

The terrain of the island consists of many elevations, ranging mainly between 150 and 420 m a.s.l. with the highest peak being Veli Hum located at 417 m a.s.l. (RIĐANOVIĆ 1971/72). Between the numerous hills numerous larger and smaller karstic fields and many sinkholes are developed. Karstic fields are mostly used for agricultural purposes for the cultivation of vines, olives or arable crops (RIĐANOVIĆ 1971/72), while the slopes of the hills are mostly overgrown with mixed forest vegetation or vegetation of rocky pastures and garrigues (TRINAJSTIĆ 1967/68, 1979).

Due to the limestone-dolomitic base, there are no permanent watercourses on the island (RIĐANOVIĆ 1971/72), but there are about a dozen ponds located in different karstic fields (e.g. Vinopojе, Žegovo, Hrastove, Lokavje, Veja lokva, Kal). Some of them are still active and serve agricultural purposes, while most are overgrown and in high stage of succession (Fig. 1). Regardless of their condition and purpose, all water bodies are an indispensable source of water and a refuge for many aquatic organisms, especially in the dry summer months.

Sampling took place at the following five localities (10 ponds), see also Figure 2:

1. Lastovo Island, Vinopojе field, olive groves, vineyards and overgrown surface around the three ponds; (42,75592° N, 16,84314° E); 1a 18-v-2018, TK; 20-vii-2018, AŠ, TK
2. Lastovo Island, Žegovo field, olive groves and grasslands around a small pond; (42,74702° N, 16,87271° E); 21-vii-2018, AŠ, TK
3. Lastovo Island, Hrastove field, two ponds surrounded by *Quercus ilex* forest, arable and overgrown fields; (42,75631° N, 16,87939° E); 17-v-2018, TK; 20-v-2018, TK; 20-vii-2018, AŠ, TK
4. Lastovo Island, Lokavje field, two ponds surrounded by grasslands, maquis and olive groves; (42,76022° N, 16,89530° E); 06-viii-2014, MF; 18-v-2018, TK; 20-vii-2018, AŠ, TK
5. Lastovo Island, Veja lokva field, overgrown fields and grasslands around two ponds; (42,74015° N, 16,90026° E); 16-v-2018, TK

Data collection

To get an insight into Odonata diversity of Lastovo Island we have collected and analyzed all the available literature data and supplemented it with newly collected records. We visited Lastovo Island three times, once in 2014 for a single day, twice in 2018 for a total of eight days period. According to Croatian Mountain Rescue Service's topographic map of Lastovo from 2015, Park's data (MATOKOVIĆ et al. 2018) and ANDLAR & CELIJA (2020) there are 14 ponds on the island. During our survey we visited 12 of them, since according to literature one pond is inaccessible and visible only by drone (Kal field), and for another one we didn't know it existed (Dovin do field). From 12 visited ponds, only ten ponds were inventoried, because one was completely dry during our visits (Kalac pond) and another one couldn't be found (Nižno field). As a pond in Nižno field was not mentioned in the latest pond analysis by ANDLAR (2020), we consider it to have completely disappeared from the island.



Figure 1. Ponds on the Lastovo Island: **a)** natural temporal pond in Skrivena Luka, 16-v-2018; **b)** seminatural pond in Žegovo polje, 17-v-2018; **c)** artificial pond in Lokavje, 20-vii-2018. – **Abbildung 1:** Teiche auf Lastovo: **a)** natürlicher temporäres Gewässer in Skrivena Luka, 16.05.2018; **b)** halbnatürliches Gewässer in Žegovo polje, 17.05.2018; **c)** künstliches Gewässer in Lokavje, 20.07.2018. Photos: TK and AS

During our survey in 2018, aside from Lastovo we visited one more island in the Lastovo archipelago, Prežba Island. It is also part of the National Park and is connected to Lastovo by a 40 m long bridge. According to topographic maps, only one pond existed in the past on the island but was completely dry during our visit.

Adult specimens of dragonflies were sampled using an entomological net, identified in the field, photographed, and released. Identifications were made using DIJKSTRA & LEWINGTON (2006). To gain a wider perspective about the dragonfly fauna of Lastovo, a comparison with the closest island in Dalmatia was done, based on the available literature.

Results

Literature about the dragonfly fauna of the Adriatic islands in general is very scarce. The earliest finding on the Lastovo dates from the very beginning of the 20th century when, traveling through Dalmatia, GALVAGNI (1902) recorded *Anax imperator*. During a student camp TRILAR & BEDJANIČ (1999) recorded seven species, six of which were new to the island. Nine years later, another student camp was taking place in Lastovo Island, where eight species have been recorded and

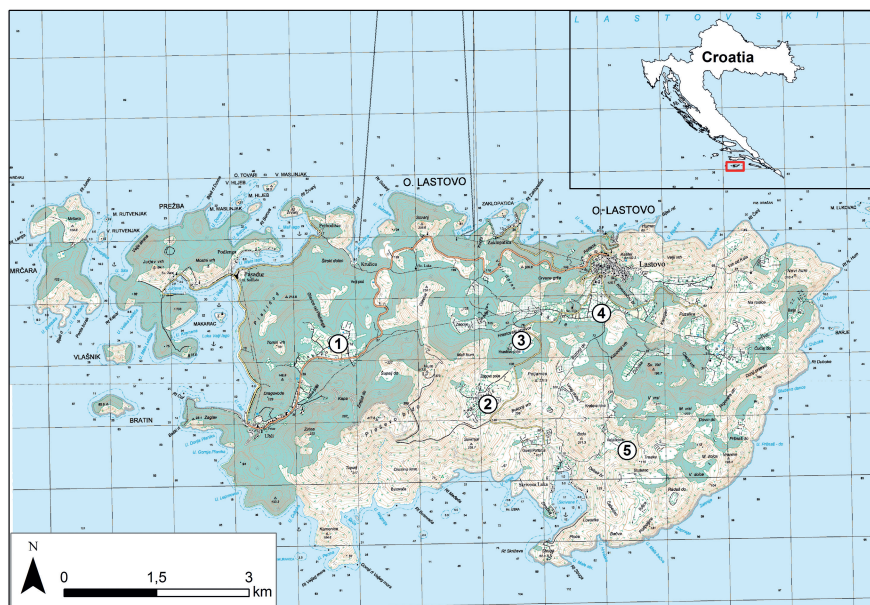


Figure 2. The map of Lastovo Island with newly surveyed localities on the island. 1 Vино-poje field, 2 Žegovo field, 3 Hrastove field, 4 Lokavje field, 5 Veja lokva field. – **Abbildung 2:** Karte der Insel Lastovo mit Lage der Fundpunkte 1–5.

four were new to the island (DUBRAVČIĆ et al. 2008). VILENICA & MIHOCI (2018) analyzed the Odonata collection from Croatian Natural History Museum in Zagreb and noted two species already known for the island due to previous research. In total eleven species were recorded on the island so far as found in the literature sources.

During the mentioned researches, a dragonfly inventory was done on the 4 localities which were also visited during our survey (GALVAGNI 1902 – does not mention any specific site; TRILAR & BEDJANIČ 1999 – locality number 1, 3, 4, cisterns in Ždrelo and Prgovo field; DUBRAVČIĆ et al. 2008 – locality number 1, 3, 4, 5; VILENICA & MIHOCI 2018 – probably locality number 1).

During this survey, 14 species were observed on Lastovo Island, five of which were recorded for the first time in the studied area (*Ischnura elegans*, *Aeshna isoceles*, *Anax parthenope*, *Sympetrum sanguineum*, *Selysiothemis nigra*), while two species known from the literature have not been confirmed (*A. mixta*, *Cordulia aenea*) (Table 1). Considering the literature findings, as well as the results of this research, 16 Odonata species are known so far for Lastovo Island. This number represents 22% of the 71 Odonata species in Croatia (FRANKOVIĆ & BOGDANOVIĆ 2009; FINKENZELLER 2010).

The most common species, recorded in more than four localities were: *Lestes barbarus*, *A. imperator* and *Crocothemis erythraea*. All the other species were recorded only on one or two localities on the island. Tandems were noticed in *L. barbarus*, *Coenagrion scitulum*, *Libellula depressa* and oviposition in *A. imperator*, *L. depressa*, *C. erythraea* (Table 1). Among recorded species five are listed in the Croatian Red Data Book: *L. barbarus*, *A. isoceles*, *A. parthenope* and *Sympetrum fonscolombii* as Near threatened and *S. nigra* as Endangered (BELANČIĆ et al. 2008).

In comparison with other Dalmatian islands, Mljet had the highest number of recorded species, followed by Brač. All other islands have five or less species recorded so far (Table 2).

Discussion

While research of the dragonflies of Croatia has a very long tradition (see BELANČIĆ et al. 2008), most of the regions in the country still have only a very limited amount of available data. The data are even lacking for many National or Nature parks which would need to have such data easily available for proper species and habitat management. Accordingly, the lack of comprehensive odonatological data for Nature park Lastovo is not very surprising.

During this survey five additional species have been recorded on the island, raising the number of known species on the island to 16. This is not a very high number especially if we compare it to mainland areas or other islands like Mljet on which 27 species have been recorded so far (FRANKOVIĆ & BOGDANOVIĆ 2010). As Mljet is the only southern Adriatic island with available complete overview of Odonata fauna, the comparison of this work with it is most meaningful.

Table 1. Systematic list of Odonata recorded on Lastovo Island so far. Species marked with * represent newly recorded species for the island. **1** Vinopoje field, **2** Žegovo field, **3** Hras-tove field, **4** Lokavje field, **5** Veja lokva field; **M** male, **F** female, **ovip** oviposition, **tand** tandem, **ind** individuals. – **Tabelle 1:** Liste der bisher auf der Insel Lastovo erfassten Libellen-arten. **1** Vinopoje, **2** Žegovo, **3** Hrastove, **4** Lokavje, **5** Veja lokva; **M** männlich, **F** weiblich, **ovip** Eiablage, **tand** Tandem, **ind** Individuen.

Systematic list of species	This survey	Literature records
1. <i>Lestes barbarus</i> (Fabricius, 1798)	1 (18-v-2018: 2 ind, 20-vii-2018: 1 tand, 1 ind); 2 (21-vii-2018: 3 ind); 3 (17-v-2018: 2 ind, 20-vii-2018: 3 ind); 4 (06-viii-2014: >20M, >20F, tand)	TRILAR & BEDJANIČ (1999), DUBRAVČIĆ et al. (2008)
2. <i>Coenagrion scitulum</i> (Rambur, 1842)	1 (20-vii-2018: 1F); 3 (20-v-2018: 3 ind); 4 (06-viii-2014: >20 M, >20F, tand)	TRILAR & BEDJANIČ (1999), DUBRAVČIĆ et al. (2008), VILENICA & MIHO-CI (2018)
3. <i>Ischnura elegans</i> (Vander Linden, 1820)*	4 (06-viii-2014: > 20M, > 20F)	/
4. <i>Aeshna mixta</i> Latreille, 1805	/	DUBRAVČIĆ et al. (2008)
5. <i>Aeshna affinis</i> Vander Linden, 1820	4 (06-viii-2014: 5M, 1F)	DUBRAVČIĆ et al. (2008)
6. <i>Aeshna isocles</i> (Müller, 1767)*	5 (16-v-2018: 1 ind)	/
7. <i>Anax imperator</i> Leach, 1815	1 (20-vii-2018: 3M, 1 ovip); 3 (20-v-2018: 1M, 20-vii-2018: 1M, 1 ovip); 4 (06-viii-2014: 5M, 1 ovip, 18-v-2018: 1M, 20-vii-2018: 1M, 1 ovip); 5 (16-v-2018: 1M)	GALVAGNI (1902), TRILAR & BEDJANIČ (1999), DUBRAVČIĆ et al. (2008)
8. <i>Anax parthenope</i> (Selys, 1839)*	4 (06-viii-2014: 2M, 20-vii-2018: 1M)	/
9. <i>Cordulia aenea</i> (Linnaeus, 1758)	/	TRILAR & BEDJANIČ (1999) (Prežba Island)
10. <i>Libellula depressa</i> Linnaeus, 1758	4 (06-viii-2014: 3M, 1 tand, 1 ovip)	TRILAR & BEDJANIČ (1999)
11. <i>Crocothemis erythraea</i> (Brullé, 1832)	1 (20-vii-2018: 4M); 2 (21-vii-2018: 1M); 3 (17-v-2018: 1M, 20-v-2018: 2M, 20-vii-2018: 11M, 2F); 4 (06-viii-2014: 10M, 1 ovip, 18-v-2018: 2M, 20-vii-2018: 1M, 1 ovip)	TRILAR & BEDJANIČ (1999), DUBRAVČIĆ et al. (2008), VILENICA & MIHO-CI (2018)

Systematic list of species	This survey	Literature records
12. <i>Orthetrum cancellatum</i> 4 (06-viii-2014: 6M) (Linnaeus, 1758)		DUBRAVČIĆ et al. (2008)
13. <i>Sympetrum striolatum</i> 4 (06-viii-2014: 3M, 3F; 18-v-2018: 2M) (Charpentier, 1840)		DUBRAVČIĆ et al. (2008)
14. <i>Sympetrum fonscolombii</i> 2 (21-vii-2018: 1M); 3 (20-vii-2018: 1 M); (Selys, 1840) 4 (06-viii-2014: >20M, >20F, 20-vii-2018: 1M)		TRILAR & BEDJANIČ (1999)
15. <i>Sympetrum sanguineum</i> 4 (06-viii-2014: >10M, >10 F) (Müller, 1764)*		/
16. <i>Selysiothemis nigra</i> 4 (06-viii-2014: 1M) (Vander Linden, 1825)*		/

Table 2. Comparison of the number of dragonfly species on the South Adriatic islands where dragonfly data have been collected so far. – **Tabelle 2:** Vergleich der Anzahl der Libellenarten auf den südadratischen Inseln, auf denen bisher Libellendaten gesammelt wurden.

Island	Surface/km ²	Number of species	Literature
1. Šolta	58,98	3	GEELEN & OOMEN 1965
2. Brač	394,57	15	WERNER 1919; OLIAS & SERBEDIA 1998; FERLETIČ, 2005; VINKO & PLANKL 2008b
3. Hvar	299,66	12	NOVAK 1890; ST. QUENTIN 1944
4. Vis	90,26	4	GALVAGNI 1902; ST. OLIAS & SERBEDIA 1998
5. Korčula	276,03	8	ADAMOVIĆ 1967; KOTARAC 1999; LABUS 2005; VINKO & PLANKL 2008b
6. Prežba	2,81	1	TRILAR & BEDJANIČ 1999
7. Mljet	100,41	27	RÖSSLER 1900; ADAMOVIĆ 1967; MIHOKOVIĆ et al. 2005; VINKO & PLANKL 2008a; FRANKOVIĆ & BOGDANOVIĆ 2010
8. Palagruža	0,40	2	GALVAGNI 1902; ST. QUENTIN 1944; OLIAS & SERBEDIA 1998
9. Lokrum	0,69	5	ST. QUENTIN 1944; OLIAS & SERBEDIA 1998

All the species recorded on Lastovo have also been found on Mljet, with ten additional species not recorded so far on Lastovo: *Chalcolestes parvidens*, *Erythromma lindenii*, *E. viridulum*, *Hemianax ephippiger*, *Libellula quadrimaculata*, *Lindenia tetraphylla*, *Orthetrum brunneum*, *O. coerulescens*, *Sympetrum flaveolum*, and *S. meridionale*.

Most of the mentioned species have different habitat requirements and they are usually connected to larger waters, that are not present on Lastovo, but lakes and swamps are present on Mljet, providing suitable habitats for such species. Such examples are *E. lindenii* which inhabits larger, well oxygenated waters (lakes, gravel pits), slow flowing rivers and wide canals, and *L. quadrimaculata* which can usually be found around larger, usually shallow still waters with well-developed vegetation. Some species observed on Mljet like *H. ephippiger* and *S. flaveolum* are known migrants, and it is possible that they will also reach Lastovo in the future.

For some species recorded on Mljet, like *C. parvidens*, that inhabits any type of standing or slow flowing waters with bordering trees and bushes Lastovo could provide suitable habitats so it is possible that the species will be recorded there in the future.

On all other south Dalmatian Islands less than ten species have been recorded so far (Table 2) indicating the need for further surveys. Due to the different intensity of surveys on mentioned islands the comparisons with the fauna of Lastovo Island is not meaningful at this point. This however indicates a need for a systematic overview of the dragonfly fauna of the Adriatic islands, in order to see the possible patterns in their distribution and their conservation status.

All recorded species are common along the Adriatic coast and are typical for ponds, which are the most abundant wetlands and predominant Odonata habitats on Croatian islands. Of the newly recorded species on Lastovo Island only the record of *Selysiothemis nigra* can be regarded as important. Only a single specimen was observed so far so it is impossible to know if it is a vagrant specimen or the species has a resident population on the island. On the Mljet Island, one of the rare southern Adriatic islands with recently published dragonfly fauna, the species was categorized as "common and not threatened" (FRANKOVIĆ & BOGDANOVIĆ 2010). In Croatia this species is confined to the coastal areas of the eastern Adriatic, from the Kvarner island of Krk in the north, middle Dalmatian island of Pag and across the coastal parts of Dalmatia in the south (BELANČIĆ et al. 2008; pers. obs. of the authors). Still, the number of published records is very low (BELANČIĆ et al. 2008; VILENICA et al. 2016) indicating that the species distribution requires further studies. According to the Red book of dragonflies of Croatia this species is characterized as endangered (EN) (BELANČIĆ et al. 2008). This may however change in future assessments, as the number of sites on which this species has been observed is constantly rising (e.g. VILENICA et al. 2016). The global distribution of *S. nigra* includes central Asia, the Middle East and the Mediterranean area (DIJKSTRA & LEWINGTON 2006; BOUDOT & KALKMAN 2015). It seems that the species have been spreading across the Mediterranean parts of Europe, and in recent years positive population trends and additional breeding sites have been

observed, probably due to the increase in number of suitable man-made habitats (e.g. SUBRERO 2014; UBONI et al. 2015). Such expansions were noted also in Slovenia where the species has spread only recently (ŠALAMUN 2012; VINKO 2019). Also, in the neighboring Bosnia & Herzegovina first country records were observed not a decade ago (KOREN et al. 2012; KULIJER et al. 2013), which may be due to the species spreading into new territories. It is possible that the specimen from Lastovo island may be just a migratory dragonfly looking for suitable habitats. This may be solved only with additional visits to the island and investigating all the potential breeding sites.

On the visited ponds across the island there is an obvious lack of small damselfly species. Accordingly, *Coenagrion scitulum* has been observed only on three and *I. elegans* on one pond (Table 1). During our surveys we have taken special attention in recording them, but alas, we could not confirm them in other localities. This is however in accordance with DUBRAVČIĆ et al. (2008) and TRILAR & BEDJANIČ (1999) when *C. scitulum* was observed on one and two localities, respectively.

During this survey two species known from the literature have not been confirmed, *Aeshna mixta* and *Cordulia aenea*. *Aeshna mixta* is common and widespread in large parts of Europe and the Mediterranean (KALKMAN et al. 2009). Aside from Lastovo where both sexes have been recorded in previous surveys, it is also known from four another Adriatic Islands (Krk, Pag, Hvar, Mljet). Accordingly, this species is expected to be confirmed on Lastovo during future studies.

Cordulia aenea is classified as Western-Siberian species, and is common in the temperate parts of Europe but becomes scarce towards the Mediterranean (KALKMAN et al. 2009). TRILAR & BEDJANIČ (1999) recorded one female individual of *C. aenea* on the seashore of the nearby Prežba Island, stating that no conclusions on the autochthony of the species on Lastovo are possible. So far the species was found on three other Adriatic islands (Krk, Cres, Mljet), while on the nearest island, Mljet, the species was found in larval stage (VINKO & PLANKL 2008b) and was categorized as »very rare with unknown status« (FRANKOVIĆ & BOGDANOVIĆ 2010). Species can be found in different types of standing waters, such as small worm pools (TRILAR & BEDJANIČ 1999), fishponds but it's more commonly found on larger standing water bodies (etc. large ponds, small lakes, bogs) (KOTARAC 1997; DIJKSTRA & LEWINGTON 2006), that are present on Mljet, but not on Lastovo Island. Among 14 surveyed ponds on Lastovo, only two are greater than 20 meters in diameter, all others are up to ten meters. So accordingly, it is possible that the specimen from Lastovo island may be just a migratory dragonfly from the nearby Mljet island, but further research is needed to prove this statement.

The dragonflies are during their life cycle closely connected to freshwater habitats and require the constant or at least temporary presence of such habitats in

order to survive (DIJKSTRA & LEWINGTON 2006). Freshwater habitats, especially ponds, are nowadays one of the most endangered habitats on the Adriatic islands as in the whole Mediterranean area. In the Mediterranean areas there has been a rapid decline in the area of natural wetlands, of 45–51% since 1970 (Mediterranean Wetlands Outlook 2 2018). Such habitats are nowadays extremely important as they present refugia for many endangered insect species.

On Lastovo Islands ponds are the only freshwater habitats available to Odonata for the completion of their life cycle. Most of the visited ponds are in good condition and retain water during the whole year. During our survey on Lastovo Island we observed several ponds which were partially restored by the employees of the Public Institution Nature Park Lastovo Islands. On those ponds the surrounding vegetation was partially removed (etc. small trees and bushes) and pond banks were restored and fortified. Such examples are rare on most Adriatic islands and represent good practices which can, in the long run, be very beneficial for freshwater plant and animal species on the island. Maintenance of waterbodies is recommended, but it must be well planned and performed. Each dragonfly species has different preferences regarding the water body structure, egg laying, fish abundance, succession, abundance of vegetation, or even shading by trees and bushes (JANSSEN et al. 2018). Therefore, restoration of ponds cannot be carried out according to one pattern and every pond must have separately developed measures. Additionally, in WILDERMUTH (1994) a rotation model for complexes of small waters (such as those found on Lastovo island) is suggested. The model is based on mosaic maintenance, so that different habitats (e.g. ponds in different succession stages) are available to all dragonfly species which they can exploit depending on their ecological preferences. General recommendations that can be useful in a Nature Park's pond maintenance can be found in WILDERMUTH (1994) and MAZZACANO et al. (2014).

While this contribution represents the first complete overview of the dragonflies of the Lastovo Island, it is still based on only a limited amount of field trips and visited localities. To gain a more detailed overview on the distribution and status of species on the island a systematic survey should be done in the future on all the available freshwater habitats on the island.

Literature

- | | |
|---|---|
| <p>ADAMOVIĆ Ž.R. (1967) Odonata collected in Dubrovnik district, Yugoslavia. <i>Deutsche Entomologische Zeitschrift</i> 14: 258–300</p> | <p>BELANČIĆ A., T. BOGDANOVIĆ, M. FRANKOVIĆ, M. LJUŠTINA, N. MIHOKOVIĆ & B. VITAS (2008) Crvena knjiga vretenaca Hrvatske. Državni zavod za zaštitu prirode, Zagreb</p> |
| <p>ANDLAR G. & K. CELIJA (2020) Analiza lovkvi otoka Lastova. Sveučilište u Zagrebu, Agronomski fakultet, Zagreb</p> | <p>BOGDANOVIĆ T. & M. GRGIĆ (2015) Vretenca (Odonata) otoka Krka – ugroženost i status. In: KLOBUČAR, G., N. KOPJAR, M.</p> |

- GLIGORA UDOVIČ, Ž. LUKŠA, J. DUŠAN (Eds) Book of abstracts of 12th Croatian Biological Congress with International Participation, Sveti Martin na Muri, Croatia: 104-105. Croatian Biological Society, Zagreb
- BOUDOT J.-P. & V.J. KALKMAN (Eds) (2015) Atlas of the European dragonflies and damselflies. KNNV publishing, Zeist
- BOUDOT J.-P., V.J. KALKMAN, M.A. AMORÍN, T. BOGDANOVIĆ, A. CORDERO RIVERA, G. DE-GABRIELE, J.-L. DOMMANGET, S. FERREIRA, B. GARRIGÓS, M. JOVIĆ, M. KOTARAC, W. LOPAU, M. MARINOV, N. MIHOKOVIĆ, E. RISERVATO, B. SAMRAOUI & W. SCHNEIDER (2009) Atlas of the Odonata of the Mediterranean and North Africa. *Libellula Supplement 9*: 1–256
- DIJKSTRA K.-D.B. & R. LEWINGTON (2006) Field Guide to the Dragonflies of Britain and Europe. British Wildlife Publishing
- DUBRAVČIĆ D., A. MELNJAK, V. ČAKTAŠ, M. VILENICA & M. FRANKOVIĆ (2008) Inventarizacija faune vretenaca Parka prirode Lastovsko otočje. In: PRVAN M. i V.V. ČAVRAK (Eds) Zbornik radova Interdisciplinarnog istraživačkog projekta Lastovsko otočje. Udruga studenata biologije: 172–175. "BIUS", Zagreb
- DUPLANČIĆ LEDER T., T. UJEVIĆ & M. ČALA (2004) Coastline lengths and areas of islands in the Croatian part of the Adriatic Sea determined from the topographic maps at the scale of 1:25 000. *Geoadria 9*: 5–32
- FERLETIĆ U. (2005) Odonatološka skupina. In: JAZBEC K. (Ed.) Brač 2003 in Korčula 2004: ekosistemi Dalmacije: 29–32. Društvo študentov biologije, Ljubljana
- FINKENZELLER M. (2010) First record of *Pantala flavescens* for Croatia (Odonata: Libellulidae). *Libellula 29*: 205–208
- FRANKOVIĆ M. & T. BOGDANOVIĆ (2009) Vretenca: priručnik za inventarizaciju i praćenje stanja. Državni zavod za zaštitu prirode, Zagreb
- FRANKOVIĆ M. & T. BOGDANOVIĆ (2010) Vretenca (Insecta: Odonata) i njihova staništa otoka Mljeta. *Proceedings of the symposium Branimir Gušić days – Mljet 2010*: 137–144
- GALVAGNI E. (1902) Beiträge zur Kenntniss der Fauna einiger dalmatinischer Inseln. *Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien 52*: 362–388
- GEELEN J.F.M. & H.C.J. OOMEN (1965) Verslag van de excursie naar N.W. Joegoslavie. Zoologisch Laboratorium, Katholieke Universiteit, Nijmegen: 1–30
- HUSNJAK S., V. KUŠAN, D. PERICA, D. KAUČIĆ & T. CAREVIĆ (2014) Proizvodni potencijal zemljišta na krškim poljima otoka Lastovo. *Hrvatske vode 22*: 213–226
- JANSSEN A., H. HUNGER, W. KONOLD, G. PUFAL & M. STAAB (2018) Simple pond restoration measures increase dragonfly (Insecta: Odonata) diversity. *Biodiversity and Conservation 27*: 2311–2328
- KLEMENČIĆ M. (1992) Geografski smještaj i položaj Hrvatske. *Geografski horizont 2*: 7–15
- KOREN T., D. TRKOV, K. VUKOTIĆ & M. ČRNE (2012) New records of the rare dragonfly, Black Pennant – *Selysiothemis nigra* (Vander Linden, 1825) (Insecta: Odonata) in Bosnia and Herzegovina. *Natura Sloveniae 14*: 65–69
- KOTARAC M. (1999) Additional note about androchrome females in *Crocothemis erythraea* (Brulle, 1832). *Exuviae 6*: 19–20
- KULIJER D., G. DE KNIJF & M. FRANKOVIĆ (2013) Review of the Odonata of Bosnia and Herzegovina. *Odonatologica 42*: 109–123
- LABUS N. (2005) Odonatološka skupina. In: JAZBEC K. (Ed.) Brač 2003 in Korčula 2004: ekosistemi Dalmacije: 59–61. Društvo študentov biologije, Ljubljana
- MATOKOVIĆ J., B. ĐUKOVIĆ & A. C. HORVAT (2018) Izvješće o ostvarivanju plana upra-

vljanja i godišnjeg programa zaštite, održavanja, očuvanja, promicanja i korištenja Parka prirode Lastovsko otočje, Lastovo

MAZZACANO C., D. PAULSON & J. ABBOTT (2014) Backyard Ponds: Guidelines for Creating and Managing Habitat for Dragonflies and Damselflies. Migratory Dragonfly Partnership, Portland

MIHOKOVIĆ N., N. HORVAT, M. LJUŠTINA & V. ZLATAR (2005) Doprinos poznavanju faune vretenaca (Insecta: Odonata) otoka Mljeta. In: Nikolić, V. i Sršen, P. (Eds) Zbornik istraživačkih radova Udruge studenata biologije – "BIUS" u Nacionalnom parku »Mljet«. Udruga studenata biologije: 69–72. "BIUS", Zagreb

MEDITERRANEAN WETLANDS OUTLOOK 2 (2018) Solutions for sustainable Mediterranean Wetlands. Tour du Valat, France

NOVAK G.B. (1890) Secondo cenno sulla Fauna dall' isola Lesina in Dalmazia. Orthoptera Parte II. *Glasnik Hrvatskoga Naravoslovnoga Društva* 5: 119–128

VINKO D. (2019) Drobtinice in ocvirki: Ponožno opazovanje temnega slaniščarja *Selysiothemis nigra* v Sloveniji. *Erjavcevia* 34: 70–77

VINKO D. & M. PLANKL (2008a) Prispevek k poznavanju kačjih pastirjev (Insecta, Odonata) otoka Mljeta (Dalmacija, južna Hrvatska) in primerjava Mljeta z izbranimi območji Hrvatske. Individualna naloga, Ljubljana

VINKO D. & M. PLANKL (2008b) Contribution to the knowledge of the Dragonfly fauna (Insecta, Odonata) of Mljet (Dalmatia, S Croatia) & Cres (Kvarner, N Croatia) Islands and comparison of Mljet with selected Croatian areas. Conference: ESPOU '08 (Experimental Science in Pablo de Olavide University conference), Sevilla, Spain

WILDERMUTH H. (1994) Dragonflies and nature conservation: an analysis of the current situation in central Europe. *Advances in Odonatology* 6: 199–221

OLIAS M. & M. SERBEDIA (1998) Zur Faunistik und Ökologie der Libellen der Kvarner-Insel Krk (Kroatien) (Diploma thesis). Fachhochschule Eberswalde, Eberswalde

RIĐANOVIĆ J. (1971/72) Prirodno-geografske značajke otoka Lastovo. *Geografski glasnik* 33–34: 159–175

RÖSSLER E. (1900) Odonata fabr. s osobitim naglaskom na Hrvatsku, Slavoniju i Dalmaciju. *Glasnik Hrvatskoga Naravoslovnoga Društva* 12: 1–97

STRAŽIČIĆ N. (1987) Prirodno-geografske značajke kao poticajni i ograničavajući faktori razvoja jadranskih otoka. *Pomorski zbornik* 25: 39–55

ST. QUENTIN D. (1944) Die Libellenfauna Dalmatiens. *Verhandlungen zoologisch-botanischen Gesellschaft in Wien* 90/91: 66–76

SUBRERO E. (2014) *Selysiothemis nigra* (Vander Linden, 1825) (Odonata: Libellulidae): riproduzione accertata in Piemonte. *Rivista piemontese di Storia naturale* 35: 99–108

ŠALAMUN A. (2012) Temni slaniščar *Selysiothemis nigra*, nova vrsta v Sloveniji... in druge zanimive fotografske najdbe v Škocjanskem zatoku in drugod po Sloveniji. *Erjavcevia* 27: 5–7

TRILAR T. & M. BEDJANIĆ (1999) Contribution to the knowledge of the dragonfly fauna of Lastovo island, Dalmatia, southern Croatia. *Exuviae* 6: 1–6

TRINAJSTIĆ I. (1967/68) Šumska vegetacija otoka Lastova. *Acta Botanica Croatica* 26–27: 43–51

TRINAJSTIĆ I. (1979) Pregled flore otoka Lastova. *Acta Botanica Croatica* (38): 167–186

UBONI C., G. NADALON & A. SCHRÖTER (2015) Evidence of breeding of *Selysiothemis nigra* in the regions of Friuli Venezia Giulia and Veneto, northeastern Italy (Odo-

nata: Libellulidae). *Notulae odonatologicae* 8: 117–155

VILENICA M. & I. MIHOCI (2018) Odonata collection of the Croatian Natural History Museum. *Natura Croatica* 27: 153–184

VILENICA M., A. Alegro, N. Koletić & Z. Mihaljević (2016) New evidence of *Lindenia tetraphylla* (Vander Linden, 1825) (Odonata, Gomphidae) reproduction at the north-western border of its distribution. *Natura Croatica* 25: 287–294

WERNER F. (1919) Beiträge zur Kenntnis der Fauna Dalmatiens, besonders der Insel Brazza. *Zoologische Jahrbücher. Abteilung für Systematik, Geographie und Biologie der Tiere* 42: 213–226

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