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THE FIRST RECORDS OF *TRITHEMIS ANNULATA* (PALISOT DE BEAUVOIS, 1807) (ODONATA: LIBELLULIDAE) IN CROATIA

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In August 2022 the first individuals of the dragonfly species Violet dropwing, *Trithemis annulata* (Palisot de Beauvois, 1807), were observed in Croatia, at three localities in southern Dalmatia. Two males were observed at the Peračko Blato lake, while both males and females were recorded at two localities at the Baćinska Lakes. At the Baćinska Lakes, more than 10 individuals were observed indicating a possible established population. The nearest known reproducing population is located about 160 km to the south, in Montenegro. Due to the species expansion in Europe, and recent records as north as Slovenia, additional records and established populations are to be expected in Croatia. As the species is now known from Croatia, we propose a vernacular name for this species, "ljubičasta skitnica" meaning purple tramp, referring to its coloration, wandering behavior and dispersal potential.

Key words: climate change, range expansion, distribution, dragonflies, Libellulidae, Dalmatia

Koren, T., Koller Šarić, K. & Kelava, L.: Prvi nalazi *Trithemis annulata* (Palisot de Beauvois, 1807) (Odonata: Libellulidae) u Hrvatskoj. Nat. Croat., Vol. 31, No. 2, 293-302, Zagreb, 2022.

U kolovozu 2022. u Hrvatskoj su uočeni prvi primjerci vretenca *Trithemis annulata* (Palisot de Beauvois, 1807). Ova je vrsta zabilježena na tri lokaliteta u južnoj Dalmaciji, dva mužjaka na Peračkom blatu, te mužjaci i ženke na dva lokaliteta na Baćinskim jezerima. U Baćinskim jezerima uočeno je više od 10 jedinki što ukazuje na moguću uspostavljenu populaciju. Najbliža poznata populacija nalazi se oko 160 km južno u Crnoj Gori. Zbog širenja vrste u Europi i nedavnih nalaza na sjeveru čak do Slovenije, očekuju se nova opažanja i ustanovljene populacije ove vrste u Hrvatskoj. Budući da je vrsta sada poznata iz Hrvatske, predlažemo naziv za ovu vrstu - "ljubičasta skitnica", pozivajući se na njezinu boju, lutajuće ponašanje te potencijal širenja.

Ključne riječi: klimatske promjene, povećanje areala, rasprostranjenost, vretenca, Libellulidae, Dalmacija

INTRODUCTION

Dragonflies (Odonata) are the most agile and the strongest fliers among insects, capable of traversing extremely long distances. Most species migrating or dispersing to Europe arrive either from northern Africa or the Middle East. Recently, several such species have been spreading across Europe increasing their distribution range across the Mediterranean parts of Europe (Corso *et al.*, 2012). Many reasons exist for such expansions, global warming being one of the most important ones, causing northward expansions (Termaat *et al.*, 2019).

In Croatia, one such species was recorded so far, *Pantala flavescens* Fabricius, 1798. In 2010, several individuals were observed flying along the coastal area of Krk island (Finkenzeller, 2010). The presence of another nomadic species, *Trithemis annulata* (Palisot de Beauvois, 1807) has been expected for some time, as the populations in neighboring Montenegro have been established since 2008 and it successfully reproduces at the Skadar Lake (De Knijf *et al.*, 2013).

Trithemis annulate, an ubiquitous and pioneer species is distributed across Africa and the Middle East, with a tendency of rapid colonization of south and south-western parts of Europe (Kalkman *et al.*, 2015). It inhabits a variety of stagnant and slow-flowing waters, such as freshwater lagoons, streams, and rivers, as well as artificial water bodies like ditches, reservoirs, gravel pits, quarry lakes, and barrage lakes (Kalkman *et al.*, 2015; Wildermuth & Martens, 2019; Dijkstra *et al.*, 2020). In Europe, this species can have two generations per year (Boudot *et al.*, 2017) and is in flight from February to November (Kalkman *et al.*, 2015; Chiari *et al.*, 2020). The larvae develop in 7–8 weeks (Boudot *et al.*, 2017). Adults can be easily identified by abdomen color and patterning, frons color, thorax patterning and wing coloration (Dijkstra *et al.*, 2020), and their nymphs and exuviae by the dorsal spine on segment six pointing upward (Brochard *et al.*, 2013).

Here we report the first observations of *Trithemis annulata* in Croatia.

MATERIALS AND METHODS

Study area

The fieldwork was done in the period between 5.08.-7.08.2022 in southern Dalmatia as a part of the *Lindenia tetraphylla* (Van der Linden, 1825) habitat survey (which is the part of the project "Razvoj sustava praćenja stanja vrsta i stanišnih tipova. Grupa predmeta nabave 17: Izrada i razvoj programa praćenja za vretenca s jačanjem kapaciteta dionika sustava praćenja i izvješćivanja"). The visited localities encompassed relatively large water bodies in the area from Vrgorac to the Neretva River Delta.

The Dinaric karst region is poor in surface waters (Crkvenčić *et al.*, 1974) and not many natural lakes exist in the karst area, yet there are quite many artificial ones, constructed primarily as a part of the flood protection system. Those man-made lakes are also used for irrigation, sports, recreation, or fishing, similarly to natural lakes (Tadić *et al.*, 2020). In southern Dalmatia, several larger lakes can be found, including the artificial Zeleno Lake, and natural Modro and Crveno lakes, and natural lakes like the Prološko blato lake, Baćinska Lakes, and several other lakes in the Neretva River Delta.

The Zeleno and Prološko blato lakes are situated in the north-western part of Imotsko polje, while the Baćinska Lakes belong to Neretva valley and are less than one kilometer away from the Adriatic Sea, so there is an impact from seawater (Bonacci & Roje-Bonacci, 2020). The man-made Zeleno Lake was created in 1985 by the construction of a dam, primarily for the purposes of irrigation. Prološko blato is a seasonally flooded karst lake (Ivkić *et al.*, 2019). Baćinska Lakes are a system consisting of five connected lakes (the Plitko, Podgora, Očuša, Sladinac, Crniševo lakes) and an unconnected one (the Vrbnik Lake) (Bonacci & Roje-Bonacci, 2020). The natural state of the system existed until the end of 1912 when a connection of the lakes with the Adriatic Sea in the southwest and with the Vrgorac field in the northeast was made via tunnels and canals with the purpose of preventing flooding (Smirčić *et al.*, 1995).

The climate in the study area is typically Mediterranean (Cs) with hot and dry summers and mild and wet winters (Šegota & Filipčić, 2003). The average annual air temperature varies between 15 °C and 17 °C, while air temperatures below 0 °C occur very rarely. The highest air temperatures occur in July and August when the average exceeds 28 °C. The average rainfall is 1300 mm (varies between 700–1800 mm). Precipitation is low between June and August, with a clear minimum in July, while the maximum rainfall occurs in the period from October until December, with a clear maximum in November (Bonacci & Roje-Bonacci, 2020).

Odonata survey

This study was conducted at eight sites in the period 5.–7.8.2022 (Fig. 1) in southern Dalmatia:

1. Imotski, S of Ričice village, the Zeleno Lake, northwestern part of the lake, rocky and muddy shoreline, mostly completely bare, 43°30'29.4" N 17°07'16.5" E, 470 m a.s.l.
2. Imotski, W of Postranje village, the Prološko Blato lake (Fig. 1a), the SE part of the lake, shoreline with only small traces of old reed sticking out from the ground, mostly completely bare, 43°28'29.6" N 17°07'15.9" E, 270 m a.s.l.
3. Imotski, near Krušovljane village, the Prološko Blato lake, the E part of the lake, shoreline with rocky boulders, most completely bare, 43°28'03.4" N 17°07'25.0" E, 272 m a.s.l.
4. Imotski, Lokvičići village, the Prološko Blato lake, SW part of the lake, shoreline with only small traces of old reed sticking from the ground, mostly completely bare, 43°27'51.9" N 17°06'10.4" E, 390 m a.s.l.
5. Baćine, the Baćinska lakes, the Crniševo Lake, NW part of the lake, shoreline partially covered in the reed, 43°04'46.6" N 17°24'18.2" E, 16 m a.s.l.
6. Baćine, north of Kovačeva lazina, the Baćinska Lakes, the Vrbnik Lake, southern part of the lake, shoreline partially covered in reed, 43°04'13.4"N 17°25'13.7"E, 16 m a.s.l.
7. Baćine, the Baćinska Lakes, Peračka plaža, the Podgora Lake (Fig. 1b), 43°04'52.8"N 17°25'57.0"E, 16 m a.s.l.
8. Baćine, the Baćinska Lakes, the Očuša Lake, northern part of the lake, shoreline partially covered in reed, 43°04'54.3" N 17°25'34.0" E, 16 m a.s.l.

At each site, Odonata fauna was surveyed for 90 minutes, until no additional species were detected. Only adults and exuviae were searched for. Species flying or perching were documented and counted. Odonata were observed visually and identified by eye or using close-focusing binoculars. Some species were captured with an entomological net (e.g., *Sympetrum* sp.), identified in the field, photographed, and released. Voucher specimens of *Trithemis annulata* (1 ♂ from site 2, 1 ♂ & 1 ♀ from site 7) were collected and stored in the private Koren Collection in Zagreb.

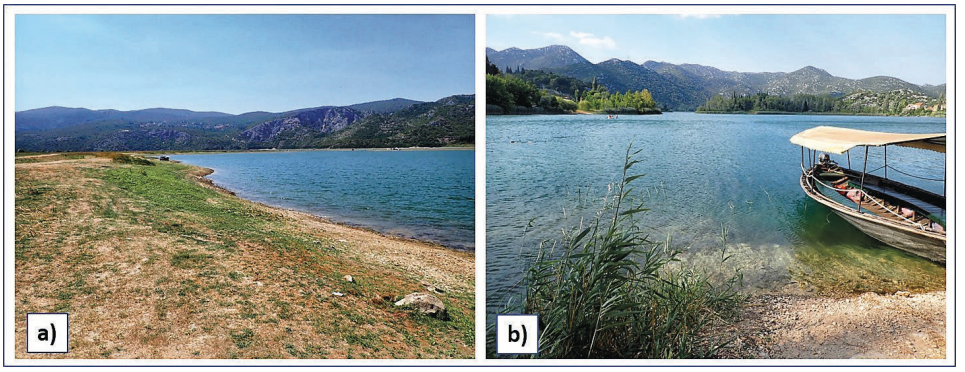

Fig. 1. Known sites of *Trithemis annulata* in Croatia. a) the Prološko Blato lake, b) the Baćinska Lakes north of Kovačeva lazina (Photos by T. Koren).

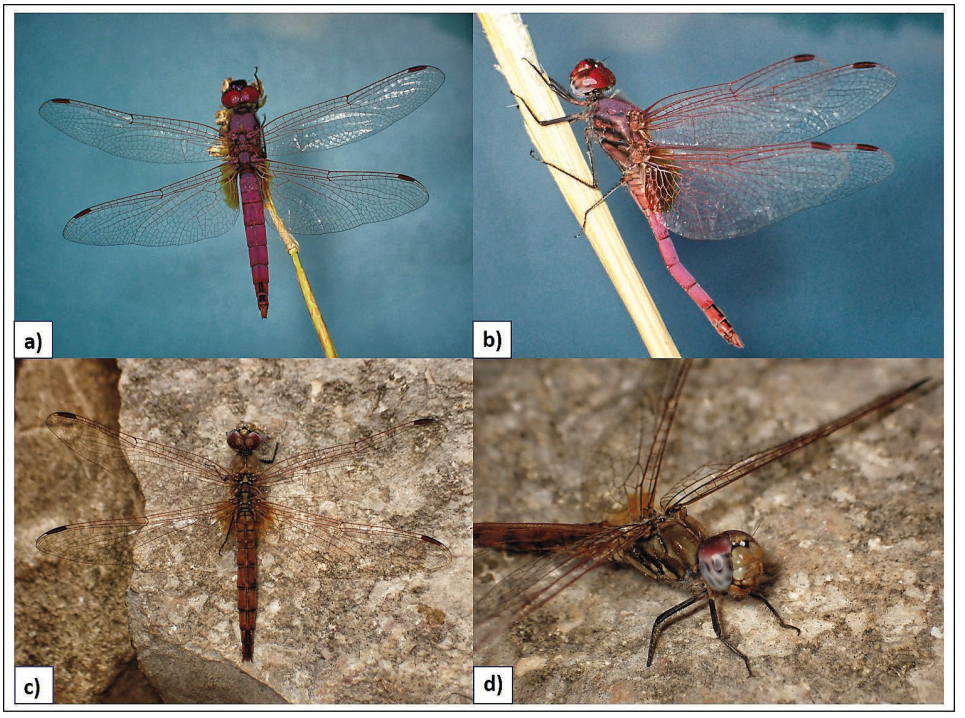

Fig. 2. *Trithemis annulata* male from the Prološko Blato lake, a) dorsal view, b) lateral view; *Trithemis annulata* female from the Baćinska Lakes, c) dorsal view, d) front-lateral view (Photos by T. Koren).

RESULTS

During the four field trips in August 2022, 14 Odonata species were recorded at the studied lakes in southern Dalmatia (Tab. 1). *Trithemis annulata* was recorded at three sites (Fig. 3); at site 2, Imotski, W of the Postranje village, the Prološko Blato lake, 2 juvenile males (Fig. 2a, b), obs. TK, KKŠ, LK, 5.8.2022; site 6, Baćine, N of Kovačeva

lazina, the Baćinska Lakes, the Vrbnik Lake, the southern part of the lake, 5 males, obs. TK, 6.8.2022 and site 7, Baćine, Baćinska Lakes, Peračka plaža, 3 males, 2 females (Fig. 2c, d), obs. TK, KKŠ, LK, 6.8.2022. At all three sites, exuviae of *T. annulata* were searched for on the shoreline but none were found.

This is a new genus and species for the fauna of Croatia.

Fig. 3. Observations of *Trithemis annulata* in the region (yellow dots) with three new records from Croatia (red dots). The map is modified from Vinko & Šalamun (2021).

Two males were observed flying on the shoreline of the Peračko Blato lake at around 13 a.m., occasionally perching on dry reed remains and fallen tree branches along the lake's shoreline. They were immediately recognized as something "unusual" due to their rather violet coloration, which is very different from the similar *Crocothemis erythraea* (Brullé, 1832) that is abundant in the area. This was further confirmed when they were observed perching and had a posture different from that of other dragonflies in the area. However, it was not easy to catch one in the net and confirm that it was indeed *Trithemis annulata*, and not some similar species. This was done after about an hour-long chase when a male individual was finally captured and its identity was confirmed. Afterwards, other accessible parts of the lake were visited but no additional individuals were observed.

At the second site, in the southern part of the Baćinska Lakes, several males were observed immediately after the first author entered the water intending to swim at about 11 a.m. At the small beach, no less than 30 swimmers were in the water, but the *Trithemis annulata* males were not in the least bothered, they perched on nearby dry reed steams, and were flying among the swimmers, hunting their prey.

Tab. 1. List of species recorded in southern Dalmatia during this survey. Site numbers correspond to the ones given in the Materials and methods section. The conservation statuses follow the Red Book of Odonata of Croatia (Belančić *et al.*, 2008) and European Red List of Dragonflies (Kalkman *et al.*, 2010). Taxonomy follows the Atlas of the European dragonflies and damselflies (Boudot & Kalkman, 2015).

Species		Site number	Red List Croatia	Red list Europe
Aeshnidae				
1.	*Anax imperator* Leach, 1815	3,4,5		
2.	*Anax parthenope* (Selys, 1839)	2,4	DD	
Calopterygidae				
3.	*Calopteryx splendens* (Harris, 1782)	1		
Coenagrionidae				
4.	*Erythromma lindenii* (Selys, 1840)	2,6,8		
5.	*Erythromma viridulum* (Charpentier, 1840)	2,3,4		
6.	*Ischnura elegans* (Vander Linden, 1820)	2,8		
Gomphidae				
7.	*Lindenia tetraphylla* (Vander Linden, 1825)	5,6	EN	VU
Libellulidae				
8.	*Crocothemis erythraea* (Brullé, 1832)	2,3,4,5,7,8		
9.	*Orthetrum albistylum* (Selys, 1848)	2,3,4,6		
10.	*Orthetrum cancellatum* (Linnaeus, 1758)	1,2,5		
11.	*Orthetrum coerulescens* (Fabricius, 1798)	2,5,8		
12.	*Selysiothemis nigra* (Vander Linden, 1825)	6,7	EN	
13.	*Sympetrum fonscolombii* (Selys, 1840)	2,8	NT	
14.	*Trithemis annulata* (Palisot de Beauvois, 1807)	2,6,7		

The third site was visited late in the day, at around 5 p.m., due to the strong wind earlier that day. Several dragonfly species; *Crocothemis erythraea* (Brullé, 1832), *Selysiothemis nigra* (Vander Linden, 1825) and *Sympetrum fonscolombii* (Selys, 1840) were observed in the grassland, resting on branches or reeds, several meters from water (probably due to the shelter that the area provided in comparison with the windy water). Among them, three males and two females of *Trithemis annulata* were observed. At the same site the species was again recorded on 20th of September (https://observation.org/observation/255595306/) using the web site Observation (Observation, 2022). At that time five males and five females were observed.

DISCUSSION

Due to the ongoing climate change and habitat fragmentation, dispersal is one of the key processes that promote the survival of species (Gros *et al.*, 2008). The rapid expansion of Mediterranean species to northern parts of Europe is already known, but recently species occurring in Africa and the Middle East started to reach the Pyrenees and southern France (Ott, 2010), as well as the eastern Mediterranean (De Knijf *et al.*, 2013), what is attributed to global warming (Gauci, 2021).

The expansion of *Trithemis annulata* across southern Europe has been actual for some time, in both in the western and the eastern Mediterranean. In the Balkan Peninsula, its spreading is also well known, and with the populations in Montenegro being established, it was only a question of time when the first specimens and/or populations

would be recorded in Croatia. With the observed progression rate of around 20 to 30 km per year in the western Mediterranean (Renoult, 2013) its colonization of Croatia was expected to occur rather soon after that of Montenegro. The distance from the populations in Montenegro to the southern border of Croatia is less than 50 km, and the distance from the Baćinska Lakes is about 160 km. Having in mind that in Montenegro the species has been established since 2008 (De Knijf *et al.*, 2013) the colonization was expected to occur even sooner. The species might have been established in Croatia for some years now, but this was not confirmed sooner due to the lack of targeted odonatological studies in most of the country, with some rare recent examples (Vilenica *et al.*, 2011; Vinko & Vilenica, 2013; Vilenica & Dijkstra, 2014; Vilenica, 2017; Štih *et al.*, 2020; Štih & Koren, 2022).

That the species would soon be recorded in Croatia was recently additionally emphasized with records of the species as far north as Slovenia (Vinko & Šalamun, 2021) and even in Hungary at one of the Danube oxbows (Farkas, 2017). Those records can most likely be attributed to the expanding Italian population (Vinko & Šalamun, 2021) rather than the population originating from the eastern Mediterranean, as is probably the case in southern Croatia.

Still, without additional evidence of successful reproduction, the records from Croatia cannot be considered to represent resident populations. At the Prološko Blato lake, the most likely scenario is that the observed individuals were in search for suitable water bodies or food, as only two male individuals were observed. On the other hand, at the Baćinska Lakes, both males and females were observed in some numbers. And while no exuviae or mating behavior were observed during our short field trip, it is highly likely that the species is permanently present in the area and probably reproduces there. This was additionally corroborated by the observations on September 20th when 10 specimens, males and females were observed by Hans Ehmann (https://observation.org/observation/255595306/). However, the status of the permanent populations of this species in Croatia should be additionally confirmed with future field trips and the recordings of nymphs and/or exuviae.

The area of Baćinska Lakes, as well as the Neretva River Delta, has been regularly visited by the first author each year in the last decade as well as by other odonatologists (Vinko, 2014; Bogdanović *et al.*, 2008), but this is the first time that *T. annulata* has been recorded. This may indicate a recent spread or an increase in the number of specimens and consequently their detectability in the area. The species has still not been recorded in neighbouring Bosnia and Herzegovina (Kulijer *et al.*, 2013; Kulijer, 2014) but records are expected as the area of the Neretva river as well as Hutovo blato may represent suitable habitats.

In any case, if it has not already, *Trithemis annulata* can be expected to become a permanent member of the dragonfly fauna of Croatia shortly. The preferred reproductive habitats of this species across Europe, such as quarry lakes, and large reservoirs (Brochard & Ploeg, 2013), are present in some numbers in the Mediterranean part of the country and are probably not a limiting factor for the species' survival. The same is true for temperatures, as in the same latitudes it occurs also in Italy and France (Renoult, 2013).

As the species is now known from Croatia, we propose a vernacular name for this species, "ljubičasta skitnica" meaning purple tramp, referring to its coloration, wandering behavior and potential for dispersal.

The species from the *Trithemis* genus are strongly territorial, often abundant, and show a competitive life strategy. Such species which colonize and multiply in a habitat in a short time could outcompete others, especially if the resources they are using are limited (Osborn, 1995). This is true for *Trithemis annulata* which is extremely aggressive to other dragonfly species (Corso *et al*., 2012). In the Mediterranean, no replacement of indigenous species with African species was reported until now (Ott, 2010). However, targeted ecological research is needed to determine the degree of competition and overlapping of microhabitats with other species present in Croatia. One should have in mind that this species could be expected, at least occasionally, also in the other aquatic biotopes in the Mediterranean region of Croatia.

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