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Dragonflies (Insecta: Odonata) of two glacial lakes and new data for *Trithemis annulata* in the north-eastern part of Italy

Abstract: A survey of Odonata was carried out in the northeastern part of Italy, in the Friuli Venezia Giulia region. Sampling sites included two glacial lakes of ancient origin, Ragogna Lake and Cornino Lake. Aiming for a general overview of the species composition, sampling effort was conducted between May 2020 and April 2021. A total of 30 species of Odonata were collected, belonging to 17 genera and 8 families. The most representative family was Aeshnidae (31%), while *Calopterygidae* and *Libellulidae* each comprise 15%, and *Lestidae*, *Coenagrionidae*, *Platynemididae*, *Cordulegastridae*, and *Corduliidae* each comprise 8% of the total number of species. The most important result was the finding of 16 individuals of *Trithemis annulata*, a newly recorded species for Friuli Venezia Giulia and for the whole Northeast Italy, representing one of the most northeastern data for the species worldwide.

Riassunto: *Libellule (Insecta: Odonata) di due laghi glaciali e nuovi dati su Trithemis annulata nella parte nord-orientale dell'Italia.*

Da maggio 2020 ad aprile 2021 è stato effettuato uno studio volto a delineare l'odonatofauna di due laghi glaciali, il Lago Ragogna e il Lago Cornino, situati nell'Italia nord-orientale, nella regione Friuli Venezia Giulia. Sono state raccolte 30 specie di Odonati appartenenti a 17 generi e 8 famiglie. La famiglia più rappresentativa è quella degli Aeshnidae (31%), mentre *Calopterygidae* e *Libellulidae* costituiscono ciascuna il 15%, mentre *Lestidae*, *Coenagrionidae*, *Platynemididae*, *Cordulegastridae*, *Corduliidae* costituiscono ciascuna l'8% del numero totale di specie. Il risultato più importante è stato il ritrovamento di 16 individui di *Trithemis annulata*, una specie di nuova segnalazione per il Friuli Venezia Giulia e per l'intero Nord-Est d'Italia, che rappresenta uno dei dati più nord-orientali per la specie a livello mondiale.

Key words: climate change, ecology, global warming, species richness, violet dropwing.

INTRODUCTION

Friuli Venezia Giulia, characterized by a sub-oceanic climate, is situated in the northeastern part of the Italian peninsula, reflecting a high biological, ecological, and landscape richness. In fact, this region can be considered as a biogeographical crossroads that influenced the wide postglacial migratory currents: this condition reflects in a great species richness that must be also correlated with a strong spatial heterogeneity of many ecological factors, such as the presence of endemism's and tertiary relicts and with the use of the territory that led to the creation and maintenance of numerous secondary habitats. Moreover, the presence of the coastal zone represents the maximum northern expansion of the Adriatic Sea, allowing many Mediterranean species to reach the highest latitude of their distribution range. On the other hand, the proximity of the Alps, located just 80 km from the sea, permits the penetration of Middle-European and typically Alpine components in the region. In addition, in this area,

central-western European, eastern European, and Balkan elements occur (Dolce & Lapini, 1987; AA.VV., 2009). In conclusion, in Friuli Venezia Giulia, Illyrian, Central European, Continental, Arctic, Alpine, Endemic and Mediterranean contingents converge. In this context, the number of habitats protected under the 'Habitat' Directive is currently 70, and the number of community interest species (Annexes II and IV 'Habitat' Directive) is equal to 92 for the animal kingdom and 22 for the vegetal one. The number of bird species reported in the region referred to Annex I of Directive 79/409/EEC is 120 (De Colle *et al.*, 2012).

In Friuli Venezia Giulia, habitats' heterogeneity also reflects a very interesting odonatofauna, with 64 species detected, representing 67% of the Italian dragonflies (Riservato *et al.*, 2014; Zandigiacomo *et al.*, 2020). Among the species, many of them are noteworthy: *Cordulegaster heros* Theischinger, 1979, *Lindenia tetraphylla* (Vander Linden, 1825), *Leucorrhinia pectoralis* (Charpentier, 1825), *Coenagrion ornatum*

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(Selys, 1850), *Selysiotthemis nigra* (Vander Linden, 1825), *Nehalennia speciosa* (Charpentier, 1840), *Hemianax ephippiger* (Burmeister, 1839). The first four species are listed in the Annexes of the ‘Habitat’ Directive. *Lindenia tetraphylla*, that in Italy has only a few fragmented populations in Tuscany, Campania, and Sardinia and in the Balkans, has disjunctive populations, was found in the coastal part of the region (Uboni *et al.*, 2020); *Cordulegaster heros* is an endemic species to south-east Europe (Uboni *et al.*, 2007; Chiandetti *et al.*, 2015) that is rapidly expanding its range across the region; *Leucorrhinia pectoralis* is an euro-siberian species very rare in Italy, with populations only in Alto Adige and in Friuli Venezia Giulia (Festi, 2012; Zandigiacomo *et al.*, 2020); *Coenagrion ornatum* is a mainly south-easter Europe species (Dijkstra & Lewington, 2006) present in the whole Italy with only few populations (Mastropasqua & Liuzzi, 2016), it was found in the southern part of the region (Zandigiacomo *et al.*, 2020); *Hemianax ephippiger* is an obligate afro-tropical migrant species that breeds in the coastal part of the Region (Uboni *et al.*, 2018); *Selysiotthemis nigra* is an eremic species and its presence in Friuli Venezia Giulia represents the northernmost evidence of breeding in Europe and even worldwide (Uboni *et al.*, 2015); *Nehalennia speciosa* is a Palearctic species whose population in the region is one of the only two present in whole Italy (Chiandetti *et al.*, 2014; Aguzzi *et al.*, 2017).

Study area

This study was conducted in the upper plain of Friuli Venezia Giulia (North-east Italy) in two lakes,

Ragogna Lake (46°10'3" N, 13°0'8" E, altitude 188 m a.s.l.) and Cornino Lake (46°13'45" N, 13°1'27" E, altitude 161 m a.s.l.) (Fig. 1). The two lakes were formed by the retreat of the Glacier of the Tagliamento River nearly 16.000 years ago.

Ragogna Lake (Fig. 2) is a Special Area of Conservation belonging to the Natura 2000 European Network, and it represents the last intramorainic lake in Friuli Venezia Giulia; it originated when the Glacier of

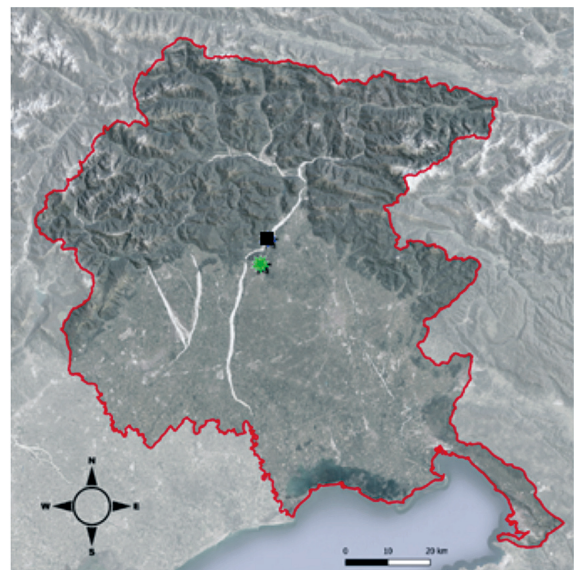


Fig. 1. Friuli Venezia Giulia region. Ragogna Lake (star) and Cornino Lake (square).



Fig. 2. Ragogna Lake (left) and Cornino Lake (right).

the Tagliamento River was retreating, resulting in several belts of morainic hills, currently visible (Monegato, 2006). Ragogna Lake is characterized by temperate thermic stratification (Reisenhofer *et al.*, 1985), and its waters can be considered eutrophic, probably due to chemicals and fertilizers used in the nearby cultivated areas (Oriolo *et al.*, 2013). This site is surrounded by cultivated fields, grasslands, poplar woods, and wooden areas, together with the presence of *Salix alba* L., 1753, *Populus nigra* L., 1753, *Alnus glutinosa* (L.) Gaertn., 1790, and *Fraxinus excelsior* L. as the dominant species. Lake's edges are covered by *Phragmites australis* Cav. reeds and *Salix cinerea* L., 1753 formations, *Potamogeton* sp. L., 1753, *Nymphaea alba* L., 1753, *Nuphar luteum* (L.) Sm., 1809, *Najas marina* L., 1753 and *Trapa natans* L., 1753 (the only site for the species in the whole Friuli Venezia Giulia) (Oriolo *et al.* 2013). Considering the fauna, many species have been reported for the site: *e.g.*, *Esox lucius* L., 1758, *Tinca tinca* L., 1758, *Cyprinus carpio* L., 1758, *Phalacrocorax carbo* L., 1758, *Fulica atra* L., 1758, *Alcedo atthis* L., 1758, *Ardea cinerea* L., 1758, *Rana latastei* (Boulenger, 1879), *Hyla intermedia* (Boulenger, 1882), *Natrix natrix* L., 1758, *Micromys minutus* (Pallas, 1771), *Mustela putorius* L., 1758, *Muscardinus avellinarius* L., 1758, (Oriolo *et al.*, 2013), *Austropotamobius pallipes* (Lereboullet, 1858), *Astacus astacus* L., 1758, bivalve molluscs of genus *Unio* (AA.VV., 2020).

The Cornino Lake (Fig. 2) is situated in the Regional Natural Reserve of Cornino Lake (AA.VV., 2008); it is located at Monte Prât calcareous karstic Upland's feet, whose sides collapsed after the retreat of the Glacier of the Tagliamento River. One of these landslides fell over the glacier's front and, after ice melting, gave rise to a small endorheic depression closed on the sides by a detrital ridge, where today lies the Cornino Lake (Genero *et al.*, 2000). It is a homeothermic and oligotrophic lake (8-12°C all year round), characterized by the lack of phytoplankton and zooplankton. It is primarily supplied by underground waters coming from the karst circulation of Monte Prât Upland and from the aquifer of the nearby Plain of Osoppo (AA.VV., 2008). The rocky bed of the site, where macrophytes cannot develop, is covered by algae (*Chlorophyceae*, *Conjugatae*, colonies of *Cyanophyceae*, and several species of *Diatomeae*) while its surroundings present various habitats such as thermophilic scrub (*Fraxinus ornus* L., *Ostrya carpinifolia* Scop., *Quercus pubescens* Willd., 1805 and herbaceous plants and shrubs (*Crategus* sp.

L., 1753, *Cornus* sp. L., 1753, *Corylus avellana* L., 1753). On detrital coverings are found *Ficus carica* L., 1753, *Cotynus coggygria* Scop., 1771, *Pistacia terebinthus* L., 1753, and pioneer species (*Sedum* sp. L., 1753, *Asplenium* sp. L.), while on cliffs grows Mediterranean species like *Quercus ilex* L., 1753, which reaches here one of the northernmost points of its distribution (Genero *et al.*, 2000). Due to its unusual characteristics, only a few faunal species are closely connected to the site, for example, *Salmo trutta trutta* L., 1753, *Phoxinus phoxinus* L., 1758, *Austropotamobius pallipes* (Lereboullet, 1858), *Natrix tessellata* (Laurenti, 1768), *Salamandra salamandra* L., 1758; and *Tachybaptus ruficollis* (Pallas, 1764), the only bird that nests in the site (Genero *et al.*, 2000).

METHODS

From May 22, 2020, to November 6, 2020, and from March 25, 2021, to April 20, 2021, every two weeks, adult dragonflies were sampled, and exuviae were collected. The sampling method was a hand-held dragonfly net with a mesh size lower than 1 mm, which was used on sunny days during the peak time of Odonata activity (between 10:00 am to 6:00 pm), with temperatures higher than 20°C and low wind speed (Buchwald, 1994; Uboni *et al.*, 2020). Adults were searched for approximately 30 minutes along the lake banks on a pre-determined transect of 10×5×5 in size (length, width, and height, relative to the surface of the lakes), until no new species were encountered. Along the same transects, exuviae were also collected. Each transect was selected as a function of the pond size, in order to maintain a similar sampling intensity throughout the study area. All the adults were identified with a field guide (Dijkstra & Lewington, 2006; Dijkstra *et al.*, 2020), photographed, and then released; exuviae were determined (Uboni C.) using Gerken & Sternberg (1999). Statistical analyses were performed using MS Excel 2010.

RESULTS

In the study area, a total of 4126 individuals belonging to 30 species were collected, with 12 of them confirmed by exuviae (Tab. 1). These species belong to 8 families: Calopterygidae, Lestidae, Coenagrionidae, Platycnemididae, Aeshnidae, Cordulegastridae, Corduliidae, and Libellulidae.

Tab. 1. Total observation of Odonata in the Ragogna Lake and in the Cornino Lake.

TAXON	Ragogna		Cornino	
	Individual/species	Exuviae	Individual/species	Exuviae
ZYGOPTERA				
CALOPTERIGIDAE				
<i>Calopteryx splendens</i> (Harris, 1780)	13		3	
<i>Calopteryx virgo</i> (Linnaeus, 1758)	2		18	
LESTIDAE				
<i>Chalcolestes</i> sp.	1092	X	11	
<i>Sympecma fusca</i> (Vander Linden, 1820)	4	X	0	
COENAGRIONIDAE				
<i>Coenagrion puella</i> (Linnaeus, 1758)	133	X	4	
<i>Erythromma lindenii</i> (Selys, 1840)	13		0	
<i>Erythromma viridulum</i> (Charpenter, 1840)	547		0	
<i>Ischnura elegans</i> (Vander Linden, 1820)	542	X	0	
PLATYCYNEMIDIDAE				
<i>Platycnemis pennipes</i> (Pallas, 1771)	17		12	
ANISOPTERA				
AESHNIDAE				
<i>Aeshna cyanea</i> (Müller, 1764)	8		32	
<i>Aeshna isoceles</i> (Müller, 1767)	1		0	
<i>Aeshna mixta</i> Latreille, 1805	137		2	
<i>Anax imperator</i> Leach, 1805	67		6	
<i>Anax Parthenope</i> (Selys, 1839)	71	X	2	
CORDULEGASTRIDAE				
<i>Cordulegaster boltonii</i> (Donovan, 1807)	0		24	
CORDULIIDAE				
<i>Cordulia aenea</i> (Linnaeus, 1758)	12		1	
<i>Somatochlora meridionalis</i> Nielsen, 1935	2		0	
LIBELLULIDAE				
<i>Crocothemis erythraea</i> (Brullé, 1832)	326	X	0	
<i>Libellula depressa</i> Linnaeus, 1758	1		0	
<i>Libellula fulva</i> Müller, 1764	8		0	
<i>Libellula quadrimaculata</i> Linnaeus, 1758	2		0	
<i>Othetrum albistylum</i> (Selys, 1848)	247	X	0	
<i>Othetrum brunneum</i> (Fonscolombe, 1837)	6		0	
<i>Othetrum cancellatum</i> (Linnaeus, 1758)	177	X	0	
<i>Othetrum coerulescens</i> (Fabricius, 1798)	48	X	0	
<i>Sympetrum fonscolombii</i> (Selys, 1840)	74	X	0	
<i>Sympetrum pedemontanum</i> (Allioni, 1766)	1		1	
<i>Sympetrum sanguineum</i> (Müller, 1764)	213	X	0	
<i>Sympetrum striolatum</i> (Charpenter, 1840)	164	X	60	
<i>Trithemis annulata</i> (Palisot de Beauvois, 1807)	16		0	
Total	3944		176	

In detail, the number of individuals and species differed between the two sites, with 3945 individuals (29 species) in the Ragogna Lake and 176 individuals (13 species) in the Cornino Lake; 13 species were in common between them. In the Ragogna Lake, the predom-

inant family (46%) was Libellulidae, and the predominant genera were *Sympetrum* and *Orthetrum*, whereas in the Cornino Lake, the predominant family (31%) was Aeshnidae, and the predominant genera were *Calopteryx*, *Aeshna*, and *Anax* (Tabs. 2 and 3).

Tab. 2. Number of Odonata species observed per family in the two study sites.

Suborder / Family	Ragogna		Cornino	
	N	%	N	%
Zygoptera				
<i>Calopterygidae</i>	2	6.90	2	15.38
<i>Lestidae</i>	2	6.90	1	7.69
<i>Coenagrionidae</i>	4	13.79	1	7.69
<i>Platycnemididae</i>	1	3.45	1	7.69
Anisoptera				
<i>Aeshnidae</i>	5	17.24	4	30.77
<i>Cordulegastridae</i>	0	0.00	1	7.69
<i>Corduliidae</i>	2	6.90	1	7.69
<i>Libellulidae</i>	13	44.84	2	15.38
Total	29	100	13	100

Tab. 3. Number of Odonata species observed per genus in the two study sites.

Suborder/Genus	Ragogna		Cornino	
	N	%	N	%
Zygoptera				
<i>Calopteryx</i>	2	7	2	15.38
<i>Chalcolestes</i>	1	3	1	7.69
<i>Sympecma</i>	1	3	0	0
<i>Coenagrion</i>	1	3	1	7.69
<i>Erythromma</i>	2	7	0	0,00
<i>Ischnura</i>	1	3	0	0,00
<i>Platycnemis</i>	1	3	1	7.69
Anisoptera				
<i>Aeshna</i>	3	10	2	15.38
<i>Anax</i>	2	7	2	15.38
<i>Cordulegaster</i>	0	0	1	7.69
<i>Cordulia</i>	1	3	1	7.69
<i>Somatochlora</i>	1	3	0	0
<i>Crocothemis</i>	1	3	0	0
<i>Libellula</i>	3	10	0	0
<i>Orthetrum</i>	4	14	0	0
<i>Sympetrum</i>	4	14	2	15.38
<i>Trithemis</i>	1	3	0	0
Total	28	100	13	100

In the Ragogna Lake, *Chalcolestes sp.* was the species collected with more individuals, and *A. isoceles*, *L. depressa*, and *S. pedemontanum* were the species collected with only 1 individual (Fig. 3). In the Cornino

Lake, the most common species was *S. striolatum*, and the rarest (1 individual) were *S. pedemontanum* and *C. aenea* (Fig. 4).

It must be underlined that the finding of 16 spec-

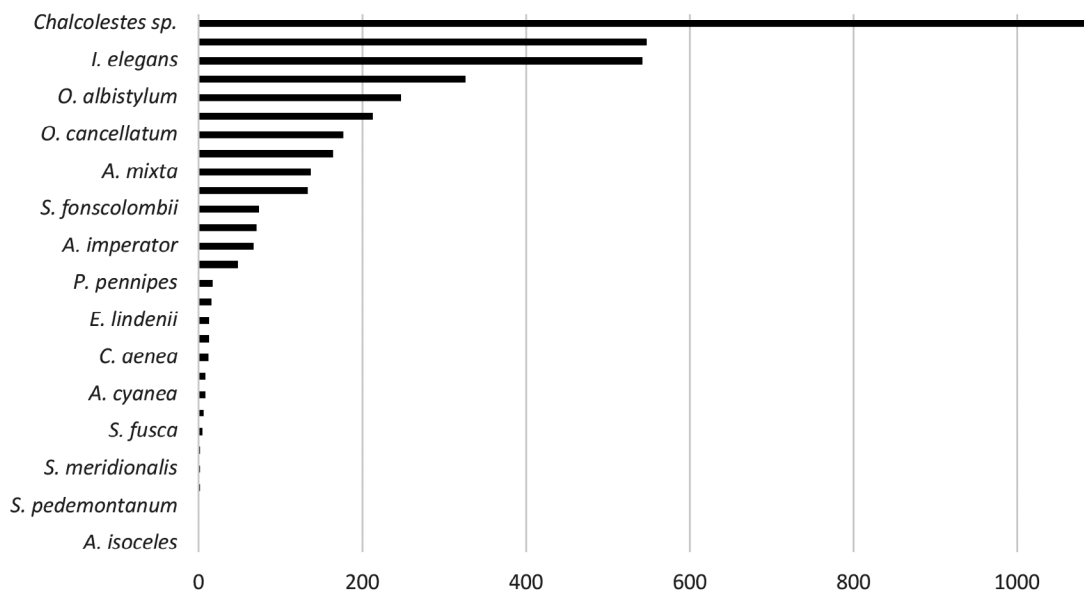


Fig. 3. Frequency of records of odonates in the Ragogna Lake.

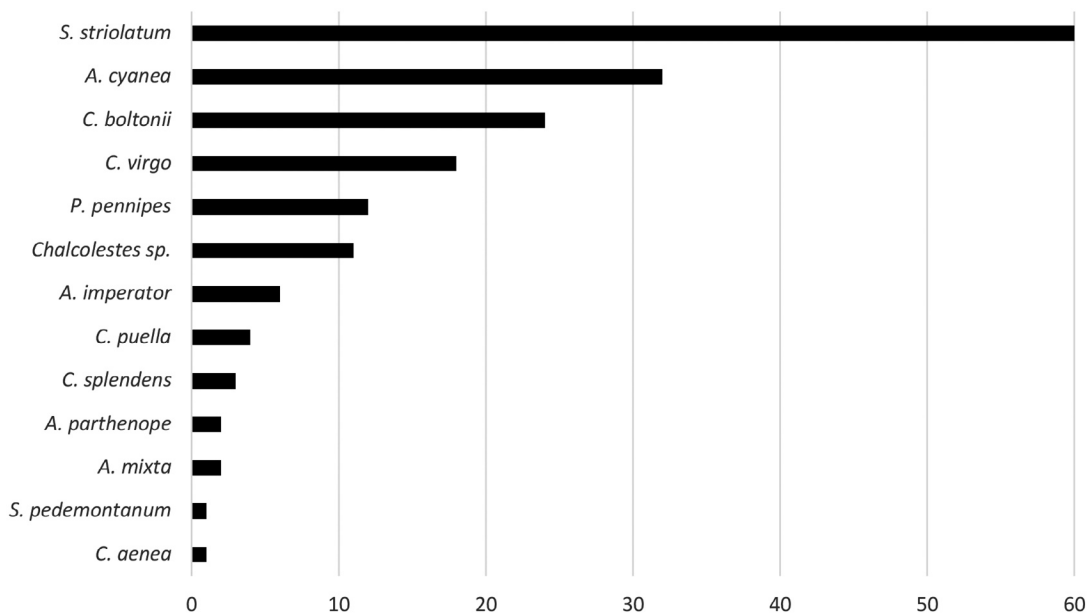


Fig. 4. Frequency of records of odonates in the Cornino Lake.

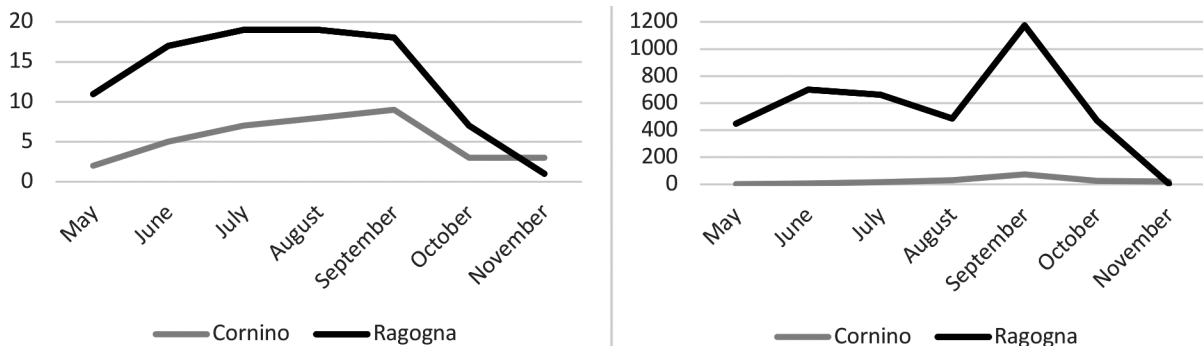


Fig. 5. Number of species (left) and individuals (right) detected in both sampling sites from May to November.

imens of *Trithemis annulata* (15 males and 1 female), observed from September 2 to October 13, 2020.

From the biogeographical point of view (Otonello & Oneto, 2013), the odonates collected in the Ragnona Lake were mainly represented by Palearctic elements (83%), Holarctic elements (3%), Afro-euro-pean elements (10%), and Afro-tropical elements (3%), as follows:

Palearctic elements: (eurosiberian) – *C. splendens*, *C. virgo*, *P. pennipes*, *C. puella*, *A. mixta*, *S. sanguineum*, *S. pedemontanum*, *C. aenea*, *Chalcolestes* sp.; (western palearctic) – *S. fusca*, *I. elegans*, *A. cyanea*, *L. depressa*, *L. fulva*, *O. cancellatum*, *O. albistylum*, *O. coerulescens*, *S. striolatum*; (submediterranean) – *E. viridulum*, *Aeshna isoceles*, *O. brunneum*; (mediterranean) – *E. lindenii*, *A. parthenope*, *S. meridionalis*. Holarctic elements: *L. quadrimaculata*. Afro-european elements: *A. imperator*, *C. erythraea*, *S. fonscolombii*. Afro-tropical elements: *T. annulata*.

A similar trend was detected in the Cornino Lake, with Palearctic elements (85%) more widespread than Holarctic elements (8%) and Afro-european elements (8%), as follows:

Palearctic: (eurosiberian) – *C. splendens*, *C. virgo*, *P. pennipes*, *C. puella*, *A. mixta*, *C. aenea*, *Chalcolestes* sp.; (western palearctic) – *A. cyanea*, *C. boltonii*, *S. striolatum*; (mediterranean) – *A. parthenope*; Holarctic: *S. pedemontanum*; Afro-european elements: *A. imperator*.

In both lakes, species and individuals were more abundant during the summer period, especially from July to August, with an evident decline at the end of September (Fig. 5).

DISCUSSION AND CONCLUSIONS

In 2020, a monitoring of Odonata was conducted in two ancient glacial lakes, situated in the high plain of the central part of Friuli Venezia Giulia, the Ragnona Lake and the Cornino Lake, providing interesting results. In the Ragnona Lake, odonotofauna was already investigated in 1989, with the result of 30 species, equal to 47% of the odonotofauna of the Region (Pecile, 1989). For the Cornino Lake, there are no published data. The results of this research permit the definition of the list of dragonflies present in the Ragnona Lake, with 29 species (9 Zygoptera, 20 Anisoptera), and the creation of the first checklist of 13 species (5 Zygoptera, 8 Anisoptera) for the Cornino Lake. Among the two sites, 12 species were in common, and one species (*Cordulegaster boltonii*) was present only in the Cornino Lake.

The dragonflies sampled in the Ragnona Lake represents 45.3% of the Friuli Venezia Giulia odonotofauna and 30.2% of the Italian one, while in the Cornino Lake, they represent respectively 20.3% and 13.5%. This difference in species among the two sites was probably due to the particular characteristics of the Cornino Lake, a homeothermic and oligotrophic lake (8-12°C). This result can be observed not only for the species number, but also for the number of individuals, with 3945 individuals in Ragnona and 176 in Cornino.

Considering the chorology (www.faunaitalia.it) of the sampled species, 60% of them are widespread in the whole of Italy and none of them is considered as threatened.

In the Cornino Lake, ovideposition was observed for two species, *A. cyanea* and *S. striolatum*, even if no exuviae were collected. Otherwise, in the Ragogna Lake ovideposition was observed for 15 species (*Chalcolestes* sp., *E. viridulum*, *P. pennipes*, *A. isoceles*, *A. mixta*, *A. imperator*, *A. parthenope*, *C. erythraea*, *O. albistylum*, *O. cancellatum*, *O. coerulescens*, *S. fonscolombii*, *S. sanguineum*, *S. striolatum*) of which reproduction was proved by collected exuviae for 12 species (*Chalcolestes* sp., *C. puella*, *S. fusca*, *I. elegans*, *A. parthenope*, *C. erythraea*, *O. albistylum*, *O. cancellatum*, *O. coerulescens*, *S. fonscolombii*, *S. sanguineum*, *S. striolatum*).

In the Ragogna Lake, comparing the data of the present study and those reported by previous research (Pecile, 1989), it was possible to confirm the presence of 23 of 30 species. The species not reconfirmed were *A. affinis*, *S. flavomaculata*, *S. metallica*, *B. pratense*, *O. forcipatum*, *S. depressiusculum*, *S. vulgatum*. The modifications of the habitats surrounding the lake, due to intensive agricultural practices, the consequent water pollution, and the hydraulic works (e.g., abstraction for irrigation purposes) that can cause the drying up of more or less extensive parts of the rivers where the larvae live, may represent a threat to that species. On the other side, thanks to this study, the list was implemented with 6 species: 3 are Palearctic elements (*Chalcolestes* sp., *C. aenea*, *S. pedemontanum*), 1 is a Mediterranean element (*E. lindenii*), 1 is an Afro-european element (*S. fonscolombii*), and 1 is an Afro-tropical element (*T. annulata*). This last species is of particular interest, since *T. annulata* represents a new species not only for the Friuli Venezia Giulia region, incrementing the regional odonatofauna species to 65, but also for northeastern Italy. Moreover, this species is one of the most abundant dragonflies of tropical Africa (Dijkstra & Lewington, 2006) that is expanding its range into Europe along the Mediterranean (Askew, 2003) and that reached the southern Alps in 2023 (Puff *et al.*, 2024). First records in Spain dated back to the late 1970s and in Corsica in the late 1980s (Ferreras Romero, 1981; Roche, 1989; Grand, 1990; Bonet Betoret, 2000; Boudot *et al.*, 2009; Groppali, 2009). In Italy, the species is reported for the first time in 1939 in Lake Avernus (Campania) (Harting, 1939), and after that in 1952 in southern Italy (Consiglio, 1952). In the following

decades, the species expanded its areal distribution reaching northern Italy in 2018, in the provinces of Milan and Brescia (Gheza *et al.*, 2019; Chiari *et al.*, 2020). The flying season ranges from mid-April to late December in Malta (Gauci, 2018), from May to October in southern France (Boudot *et al.*, 2017), and in the Po Plain (Gheza *et al.*, 2019). In Liguria, in slow-flowing waters present in the alluvial Plain of the Magra River, the flight season was from June to August (Ottonello & Oneto, 2013).

T. annulata is an undemanding species, typical of still waters or at least less running waters, characterized by low oxygen concentration and neutral pH, typical conditions in the arid Mediterranean regions (Bonet Betoret, 2000). Consequently, the slow rise in average temperatures combined with the decrease in the rainfall of the last decades has favored the spread of the species in the regions with greater similarity to the conditions present in the area of its original distribution.

In this study, *T. annulata* was found in a fish-pond lake, and thanks to this data, it is possible to confirm that the species can survive in all types of freshwaters, both standing and running, because it is an opportunistic and ubiquitous species. It can reproduce successfully even in temporary water bodies because it has a short larval period (Boudot *et al.*, 2016). In the Ragogna Lake, the flying period of *T. annulata* was from the beginning of September to the middle of October, probably because the species arrived in the lake from somewhere else in the surroundings; it must be underlined that no exuviae have been found and no reproductive behaviors have been observed, maybe because of the low-density number of individuals. However, we confirmed that the species can fly until Autumn, as already described (Boudot *et al.*, 2017; Gauci, 2018). Males were observed in territorial behavior, patrolling the lake shores fighting against *C. erythraea*'s males, as already reported (Gheza *et al.*, 2019). Since the species is characterized by good dispersion ability, new studies should be carried on in order to confirm the presence of the species in this site and deepen its phenology. Its detection is interesting since it is a species of African origin that is rapidly expanding its areal as a result of global warming (Ott, 2010; Gheza *et al.*, 2019; Vinko & Šalamun, 2021), confirming the role of Odonata as good bioindicators of climate change (Hassall, 2015; Termaat *et al.*, 2019). More-

over, the increase in temperatures may favor range expansion to the north or shifts of thermophilous odonatan, allowing larval development at greater latitudes and altitudes (Groppali, 2009; Gheza *et al.*, 2019).

In conclusion, the finding of *T. annulata* in the Ragogna Lake, a habitat on the limit between the hilly area and the Pre-Alps, confirms the expansion of this species towards central Europe, arriving just behind the Alps. It should also be underlined that this finding represents one of the most North-eastern spots for the species in its European distribution.

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CONTRIBUTIONS

CU, conceptualization, methodology, validation, writing – original draft; CU, LB, data curation, formal analysis, software; SB, funding acquisition. CU, LU, SB, investigation; CU, SB, supervision, writing – review and editing.

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