

Research articleSubmitted: November 16th, 2018 - Accepted: March 25th, 2019 - Published: May 31st, 2019**A critical review of the odonate fauna of Trentino: annotated check-list and new relevant data for Italy (Insecta: Odonata)**

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giacomo.assandri@gmail.com**Abstract**

By the first half of the Twentieth Century, the Odonate fauna of Trentino (Oriental Alps, Italy) was quite well known; subsequently, few surveys on dragonflies were carried out, resulting in a limited update of the knowledge on this taxon. The aim of this study is to provide a critical and annotated check-list of the Odonata of this province for the period from 1851 to 2018. This synthesis is based on a total of 3814 records obtained from the literature (955 records), revision of collections (1048 records), and unpublished recent data (1811 records). An updated and comprehensive Odonatological bibliography of the region is also provided. Overall, sixty-one species were confirmed to occur (or have occurred) in Trentino. These represent the 64% of the species recorded in Italy and the 43% of the species recorded in Europe. Presence of five additional species (*Ceriagrion tenellum*, *Coenagrion lunulatum*, *C. ornatum*, *Ophiogomphus cecilia*, and *Epietheca bimaculata*) should be considered doubtful for Trentino. Further two species (*Platycnemis latipes* and *Onychogomphus uncatus*) have to be excluded from the fauna of the study area. Fifty-four species were recorded also after 2000, whereas seven species were not confirmed after this year (*Lestes dryas*, *L. virens*, *L. barbarus*, *Sympecma paedisca*, *Coenagrion scitulum*, *Brachytron pratense*, and *Sympetrum flaveolum*). Several new records resulting from this study (referred to: *Erythromma najas*, *Aeshna subarctica*, *Aeshna caerulea*, *Aeshna grandis*, *Leucorrhinia pectoralis*) have a conservation or biogeographical relevance which transcends the borders of the study area, being noteworthy from an Italian or Alpine perspective and are thus commented in detail. Taxonomic notes on subspecies are also given when relevant.

Key words: *Aeshna caerulea*, *Aeshna grandis*, *Aeshna subarctica*, Alps, dragonflies, damselflies, *Erythromma najas*, *Leucorrhinia pectoralis*.

Introduction

Odonates, among insects, are one of the most studied and popular groups. In Europe, their appeal to the public and amateur naturalists increased from the late 1990s onwards, and this determined a notable increase of knowledge on their distribution (Kalkman et al. 2018). This led to the publication of the first European atlas in 2015 (Boudot & Kalkman 2015) and of a red list in 2010, which highlighted that 15% of European dragonflies are threatened, 11% near threatened and an overall 24% has declining populations (Kalkman et al. 2010).

Compared with other Mediterranean countries, Italy has a good odonatological tradition, and this is reflected in a reasonably good knowledge of its odonatofauna (Conci & Nielsen 1956; Utzeri & D'Antonio 2005). Similarly to the rest of Europe, knowledge steadily increased in approximately the last ten years, leading to the publication of a preliminary atlas in 2014 (Riservato et al. 2014c). However, not all the Italian regions are adequately known from an odonatological perspective; and, considering the rapid modifications affecting Odonate assemblages in response

to environmental and human-induced changes, constant monitoring and up-to-date faunistic knowledge are needed to rapidly detect negative impacts on species and to plan adequate conservation actions (Clausnitzer et al. 2009; Corbet & Brooks 2008).

Trentino is located in the core of the Oriental Alps (*sensu* Marazzi 2005) and represent a natural bridge between the Mediterranean and the Alpine biogeographical regions. The first odonatological data for this area are quite old, and date back to the second half of the 19th century, when Ambrosi (1851) reported the occurrence of seven species for the region. However, the first important contribution to the knowledge of the regional fauna was written by Ausserer (1869b), and reported 56 species with detailed notes on their distribution, flight period and identification. This study was considered by Nielsen (1932) as “very remarkable” and represented a key reference for many years, although it turned out not to be free of records that today seems, at least, unlikely.

After the First World War and up to 1957, the odonatological studies in Trentino were intensified, as witnessed by a number of specimens preserved in the collection of

the Museo Tridentino di Scienze Naturali (the first one collected in 1924; Assandri et al. 2019) and by the active field researches of some of the most prolific Italian odonatologists of their years: Cesare Nielsen, and, in particular, Cesare Conci (Conci 1948, 1956, 1957, 1948; Conci and Galvagni 1944, 1946; Nielsen 1932). In those years the odonatofauna of Trentino was considered “the most well-known of Italy” (Conci 1956), and Conci & Nielsen (1956) ascertained the presence of 59 species. Subsequently, odonatological studies in the region stopped for about ten years, then entered in a “modern” era, which however saw very few studies, often very local and encompassing short periods, with a few exceptions (i.e. Mascagni & Terzani 1983; Tagliapietra & Zanocco 1998; Terzani & Mascagni 2005). Recently, Maiolini & Carolli (2009) published an uncritical list of the 64 dragonflies and damselflies known for Trentino, based on historical and few recent data.

The odonatological research in Trentino, after a “golden era” which ended in the middle of the 20th century, almost ceased to exist for decades, and today, very little up to date knowledge on this taxonomic group is available. This lack of knowledge is very problematic when planning adequate conservation strategies for Odonata, or for particularly endangered species.

Thus, the main aim of this work is to organize and review the knowledge on the Odonata of Trentino after almost 10 years from the last review, a period in which Italian odonatology has grown considerably, only partially mirrored by an increase of knowledge on Trentino fauna.

The main result of the study is a commented check-list, which is based on literature review, revision of collections, and unpublished (recent) data. This list was reviewed critically in the sense that all the data were scrutinized to find inconsistencies or mistakes. The updated and comprehensive odonatological bibliography for Trentino is also provided.

Study Area

This review refers to the administrative boundaries of Trento Province (Trentino), which is located in the south-eastern Alps (NE Italy; approximately: 45.67–46.51° N; 10.51–11.96° E; Fig. 1), covering a surface of 6207 km². Trentino territory covers a wide altitudinal belt, between the 67 m asl of Lago di Garda to the 3764 m asl of Monte Cevedale; the territory is however mainly mountainous, with only 8.5% of the surface below 500 m asl and 19.9% higher than 2000 m asl.

Lowland areas are mostly occupied by intensive agriculture and infrastructures, that destroyed most of the natural and semi-natural habitats which used to occur there. Mountainsides are covered by woodlands, interspersed with orchards and vineyards (up to 1000 m asl). Anthropogenic grasslands are patchy and occur from 300 m asl.

These open habitats become more widespread between 800–2000 m asl where they co-exist with woodlands. The highest areas (above 2000 m asl) are mainly covered by alpine grasslands, rocks and glaciers.

Although the complex orography of the province determines the presence of a variety of local micro-climates, three main climate types can be distinguished in the study area: sub-Mediterranean in the South-West, temperate-oceanic in the Adige valley and the lateral valleys at altitudes up to 1000 m, and alpine-continental in the areas above 1000 m (Rossi 2005).

Due to this variable climate, complex geomorphology and mixed lithology (calcareous to siliceous), Trentino hosts a great variety of aquatic ecosystems, generally of reduced size, quite well preserved in the mountains and strongly anthropized and modified in the valley bottoms. Overall, about 350 lakes (many of which are Alpine lakes located at high altitudes), hundreds of wetlands (e.g. marshes, mires, wet meadows, reedbeds, etc) (Tomasi 2007) and thousands of kilometres of streams, rivers, channels and ditches belonging to nine main watersheds occur in the study area.

Materials And Methods

This synthesis is based on overall 3814 records obtained from various sources: literature, collections, author and collaborators’ unpublished data in a time span comprised between 1851 and 2018 (Fig. 2).

An extensive literature review allowed to obtain 955 records from 34 documents in which at least one new record was present. Data referred to specimens conserved in collections are 1048, the majority of which (803) in the collection “Miscellanea Invertebrati” (inventory: cINV017) of the MUSE of Trento (formerly Museo Tridentino di Scienze Naturali), recently studied by the author (Assandri et al. 2019). The remaining 1811 records are unpublished and come from recent field surveys by the author (1127 records between 2014 and 2018) and collaborators (684 records).

Three faunistic lists are provided. The first one is the check-list of Odonata species confirmed for Trentino, the second one contains the specie not confirmed or doubtful, and the third one contains species that must be excluded from the Odonatofauna of Trentino. Species recorded only historically were included in the first list only if voucher specimens were available.

For several species a brief comment is provided on relevant or incorrect data. Emphasis is given to records which are important from an Italian perspective or from a conservation point of view. When relevant, taxonomic notes at the subspecific level are given.

The lists follow the nomenclature and systematic order of the Atlas of European dragonflies and damselflies (Boudot & Kalkman 2015).

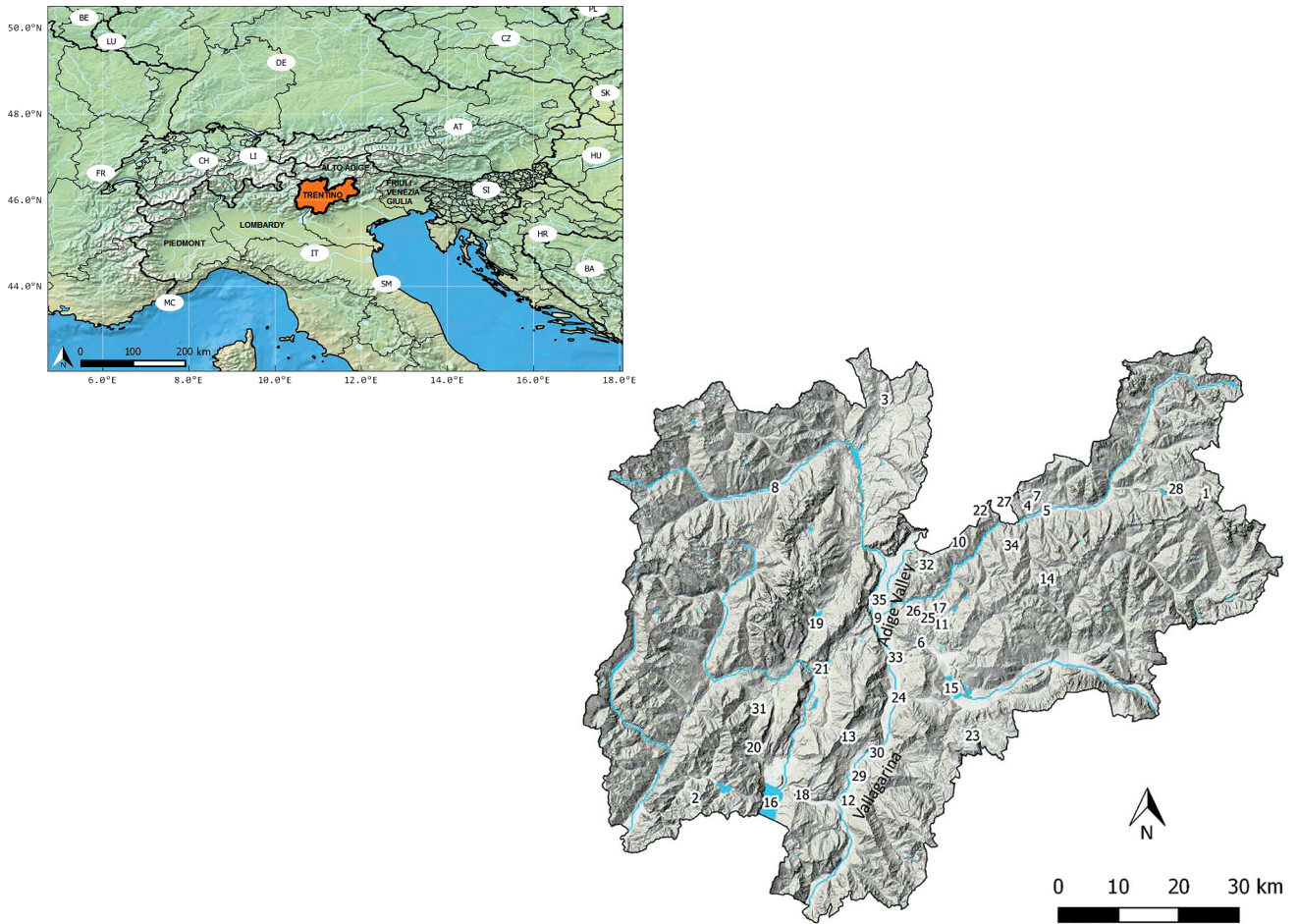


Fig. 1 – Top - Localization of Trento Province in the Alpine Region (in orange). The Italian regions cited in the text are shown in the map for the reader guidance. Bottom - Localities of Trentino cited in the text. Legend: 1. Baita Segantini; 2. Bocca di Caset; 3. Castel-fondo; 4. Castello di Fiemme; 5. Cavalese; 6. Civezzano; 7. Daiano; 8. Dimaro; 9. Foci dell’Avisio; 10. Lac del Vedes; 11. Laghestel di Pinè; 12. Laghetti di Marco; 13. Laghi di Cei; 14. Lago delle Buse; 15. Lago di Caldonazzo; 16. Lago di Garda; 17. Lago di Lases; 18. Lago di Loppio - Rio Camerata; 19. Lago di Molveno; 20. Lago di Tenno; 21. Lago di Toblino; 22. Lago Nero di Monte Corno; 23. Lavarone; 24. Mattarello; 25. Lago e Torbiera di S.Colomba e Palù di Fornace; 26. Palù Gross; 27. Palù Longa; 28. Paneveggio; 29. Rovereto; 30. Paludi dell’Adige e Taio di Nomi; 31. Torbiera di Fiavè; 32. Torbiera di Lagabrun; 33. Trento; 34. Valfloriana; 35. Zambana.

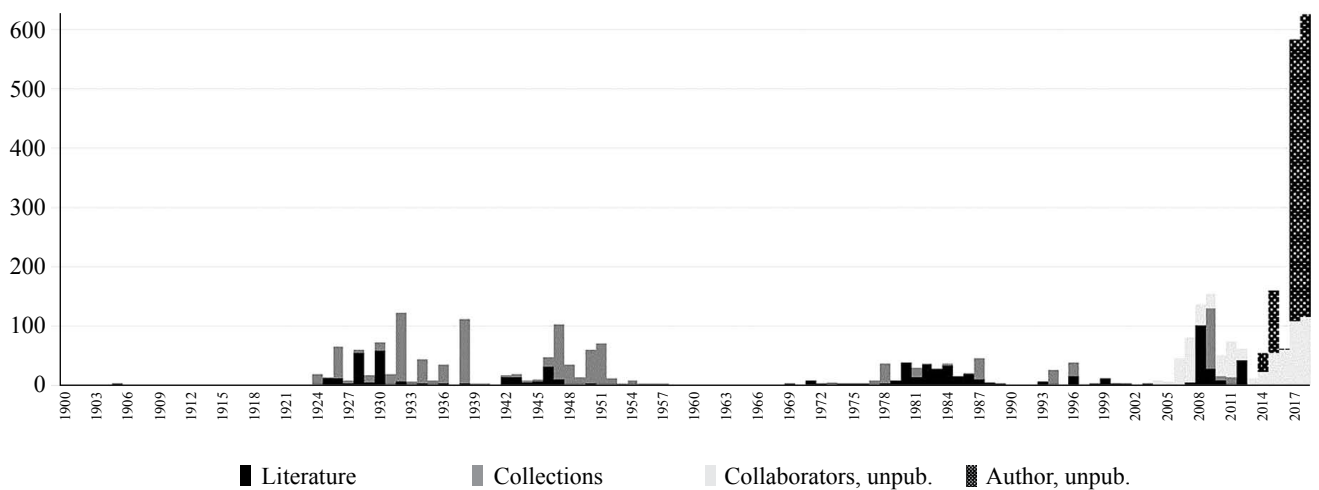


Fig. 2 – Annual distribution of the Odonate records available for Trentino from 1900 to 2018. Different record sources are highlighted with different grey tones or texture (see legends). N = 3544.

Results

Check-list of the Odonata of Trentino

A conservation status overview is given for each species based on:

1. **hd**: Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora); specifying to which Annexes (II or IV) a species belongs to.
2. **erl**: European Red List (Kalkman et al. 2010);
3. **irl**: Italian Red List (Riservato et al. 2014b). For the red lists, the IUCN category a species belongs to is given. The categories used are:
CR: Critically endangered;
EN: Endangered
VU: Vulnerable;
NT: Near threatened;
LC: Least concern.

Symbols used in the lists

- * species recorded only before 2000. This year was chosen as a threshold for consistency with the Provisional Atlas of Italian dragonflies and damselflies (Riservato et al. 2014c)
- R** reproduction confirmed in the study area
- R?** reproduction probable, but not confirmed in the study area
- CMT** specimen referred to the collection of MUSE (Trento; Assandri et al. 2019)

CONFIRMED SPECIES

1. Lestidae

1. *Chalcolestes viridis* (Vander Linden, 1825) R
erl: LC; **irl**: LC

2. *Lestes barbarus* (Fabricius, 1798) *
erl: LC; **irl**: LC

Although apparently widespread in Trentino in the 19th century (Ausserer 1869b), it was reported for only three localities in the 20th century, and the last observation occurred in 1947 (Nielsen 1932; CMT; Museo Civico di Storia Naturale di Verona collection). In the neighbouring Alto Adige, a population was recorded in a single locality and in a single year after the 2000 (Nössing et al. 2012).

Lestes barbarus is a migrant and highly erratic species, which undertakes periodic invasions and colonizes early successional stages of aquatic ecosystems (frequently temporary), often resulting in isolated and short-lived populations (Boudot & Kalkman 2015; Wildermuth et al. 2005). This possibly explains the occasional records known for the study area, in which no evidence of past reproduction is known.

3. *Lestes dryas* (Kirby, 1890) * R
erl: LC; **irl**: LC

Reported sporadically in the course of the 20th century until 1987 (Daiano; “Federico Landi” collection). A recent record in Maiolini & Carolli (2009) should be discarded, as referred to *Lestes sponsa* (evaluation based on photographic evidence).

Although it appears to be extremely rare in North-eastern Italy (Riservato et al. 2014c), the species is possibly still part of the fauna of Trentino. Further research is needed to clarify its status.

4. *Lestes sponsa* (Hanseemann, 1823) R
erl: LC; **irl**: LC

5. *Lestes virens* (Charpentier, 1825) * R
erl: LC; **irl**: LC

In the study area is reported the subspecies *L. v. vestalis* (Charpentier, 1825).

Only few old records are available for this species in Trentino, referred to the valley floor of Vallagarina (Conci & Nielsen 1956; CMT) and to Lago di S. Colomba (CMT). The most recent record dates back to 1987 (Laggetti di Marco; “Federico Landi” collection).

Although it appears to be extremely rare in North-eastern Italy (Riservato et al. 2014c), the lack of more recent confirmations for Trentino is possibly due to the lack of specific surveys, and probably also to the ecology of the species, which exploits effemeral and often temporary wetlands with very variable environmental conditions (Boudot & Kalkman 2015; Deliry 2008).

6. *Sympecma fusca* (Vander Linden, 1820) R
erl: LC; **irl**: LC

7. *Sympecma paedisca* (Brauer, 1877) * R
hd: II, IV; **grl**: LC; **erl**: LC; **irl**: CR

The first circumstantiated data on the distribution of this taxon in Italy date back to 1944 (Conci & Galvagni 1944) and referred to the Vallagarina (Trentino) and Adige valley (Alto Adige) valley floors, in a period spanning from 1927 to 1943. Subsequent research (Conci & Galvagni 1946) allowed to conclude that the species was “abundant and far more common than the congeneric *Sympecma fusca*” in the Vallagarina, in particular at Paludi dell’Adige where hundreds of individuals were reported to spend the summer (Conci & Galvagni 1946), using as winter quarters the adjacent West-facing warm slopes of the valley. At that time, these marshlands were the last extensive wetlands occurring in the Adige Valley in Trentino, since the others had been reclaimed for agriculture from the Austrian domination onward. The disappearance of these last wetlands (reclaimed during the second half of the 20th century) is the most likely cause for local extinction of this species in the study area.

As in Trentino, *Sympecma paedisca* disappeared or se-

verely declined in both western Europe and the Alps in the second half of the 20th century (Boudot & Kalkman 2015). In Italy it still occurs in Piedmont (Battisti & Pavesi 2017) and was recently rediscovered in Lombardy (Canovi et al. 2014; Gheza 2016).

2. Calopterygidae

8. *Calopteryx splendens* (Harris, 1780) R
erl: LC; *irl*: LC

For the study area the subspecies *C. s. caprai* (Conci, 1956) has been indicated, although further research is needed to confirm the taxonomic identity of the populations of the *Calopteryx splendens*-complex occurring in the study area.

9. *Calopteryx virgo* (Linnaeus, 1758) R
erl: LC; *irl*: LC

For northern Italy was described the ‘form’ *padana* (Conci, 1956) based on material from Trentino (Rio Cameras, Loppio). This taxon present intermediate features between the northern *C. v. virgo* (Linnaeus, 1758) and the southern *C. v. meridionalis* (Selys, 1873). Further research is needed to clarify the taxonomic status of this form and the identity of the populations occurring in the study area.

3. Platycnemididae

10. *Platycnemis pennipes* (Pallas, 1771) R
erl: LC; *irl*: LC

4. Coenagrionidae

11. *Coenagrion hastulatum* (Charpentier, 1825) R
erl: LC; *irl*: LC

12. *Coenagrion puella* (Linnaeus, 1758) R
erl: LC; *irl*: LC

13. *Coenagrion pulchellum* (Vander Linden, 1825) R
erl: LC; *irl*: LC

14. *Coenagrion scitulum* (Rambur, 1842) * R
erl: LC; *irl*: LC

The only specimen available from the study area is conserved in the CMT (a male from Mattarello collected on July 1936). The only other mention for this species was given by Conci & Galvagni (1944). They reported the presence of the species at Laghetti di Marco between 1938 and 1943. It was considered “not uncommon” from June to the beginning of August. These records confirm the occurrence, at least historically, of the species in Trentino, which was considered doubtful by Riservato et al. (2014c). The site Laghetti di Marco is today strongly degraded, and this might explain the lack of recent confirmations; however, the presence of the species elsewhere in Trentino seems possible, also considering the recent climatic-driv-

en northward expansion undertaken by this damselfly in Europe (Boudot & Kalkman 2015).

15. *Enallagma cyathigerum* (Charpentier, 1840) R
erl: LC; *irl*: LC

16. *Erythromma lindenii* (Selys, 1840) R
erl: LC; *irl*: LC

17. *Erythromma najas* (Hansemann, 1823) R
erl: LC; *irl*: EN

Historically, the species was considered very rare in Trentino and reported for three localities (Lago di Garda, Laghetti di Marco, and Lago di Toblino) (Ausserer 1869b); subsequently, between 1945 and 1948, it was confirmed for Laghetti di Marco, and newly reported for Laghi di Cei (where was deemed as “very abundant”) and for the Paludi dell’Adige in Volano (Conci & Galvagni 1946).

Recent surveys allowed to confirm, after almost seventy years, the persistence of a viable population at Laghi di Cei, and lead to the discovery of a new population in 2017 (Laghestel di Pinè; Assandri, unpub.).

It is to note that in the other sites, where the species has not been confirmed recently, environmental perturbations strongly modified (or destroyed) its habitats, almost certainly leading to the local extinction of the species.

In Italy *Erythromma najas* occurs mainly in the North, where its population declined during the last decades, worsening the isolation of the few (less than ten) populations known to date (Boudot & Kalkman 2015; Riservato et al. 2014c). This further increases the conservation relevance of the two relict populations occurring in Trentino.

18. *Erythromma viridulum* (Charpentier, 1840) R
erl: LC; *irl*: LC

19. *Ischnura elegans* (Vander Linden, 1820) R
erl: LC; *irl*: LC

20. *Ischnura pumilio* (Charpentier, 1825) R
erl: LC; *irl*: LC

21. *Pyrrhosoma nymphula* (Sulzer, 1776) R
erl: LC; *irl*: LC

5. Aeshnidae

22. *Aeshna affinis* Vander Linden, 1820 R?
erl: LC; *irl*: LC

Ausserer (1869b) reported this species at four localities; three of these, Lago di Molveno, Lago di Tenno (referred as “Lago di S. Antonio Ballino”) and Lago di Toblino are nowadays likely unsuitable for its presence, due to important anthropogenic perturbations, which deeply modified the characteristics of the sites. Subsequently, the species

was reported only twice, in Lavarone (1930; Nielsen 1932) and at Lago di S. Colomba (1951; CMT).

The only “modern” records of the species refer to Castello di Fiemme, where individual males of the species were encountered twice in 2015 and 2017 (Ancarani & Assandri unpub.) in a habitat suitable for reproduction: a pond with a dense helophytes belt, subject to strong variations of the water level. The site is located at 1000 m a.s.l., which is near to the European altitudinal limits known for the species (Boudot & Kalkman 2015; Deliry 2008; Papazian et al. 2017).

23. *Aeshna caerulea* Ström, 1783 R

erl: LC; *irl*: NT

With the exception of an old record, certainly erroneous, reported by Navas (1932) of an individual found in a house in the city of Trento, the first report for the species in Trentino dates back to 1971 (Baita Segantini; Bucciarelli 1972).

In recent years (2008-2018) the species has been confirmed in Baita Segantini and reported at other seven localities, all located East to the Adige valley and, all except one, inside the Avisio river basin. In 2018 the species was confirmed to be autochthonous at a peat bog in Valfloriana located at a latitude of 46.23° N (Assandri, unpub.), which represents the most southern breeding site of this species in Europe to date (Boudot & Kalkman 2015; Riservato et al. 2014c).

Within the study area, the species is likely to be more frequent and widespread than what is known today; however, its alpine populations are scattered and fragmented (Boudot & Kalkman 2015). In Italy, *Aeshna caerulea* occurs only in the northernmost part of the country, in strictly Alpine ecosystems and at high altitudes (Riservato et al. 2014c). Despite being threatened by climatic and environmental changes, little is known about its actual distribution and ecology.

24. *Aeshna cyanea* (Müller, 1764) R

erl: LC; *irl*: LC

25. *Aeshna grandis* (Linnaeus, 1758) R?

erl: LC; *irl*: VU

Cited historically by Ambrosi (1851) and Ausserer (1869 b); the subsequent available records referred to five localities in a period spanning between 1929 and 1954 (Conci, 1948, 1957; Conci and Nielsen 1956; CMT). All those occurrences referred to isolated individuals, and no evidences for reproduction was provided; however, in several sites (i.e. Cei area and Lago di S. Colomba), the presence of the species was confirmed in different years, with also a “modern” record in Cei in 1996 (Tagliapietra & Zanocco 1998).

Recent surveys allowed to confirm the presence of the species at two new localities: 2 males in Zambana between 30 July and 3 Aug 2017; 3-4 males at Lago di Lases in

both August 2017 and 2018 (Assandri, unpub.). Although reproduction was not ascertained, it could have occurred at least in the second site, also in consideration of the suitability of the habitat and the occurrence in two subsequent years.

Aeshna grandis is rare in Italy and confirmed as autochthonous only at few localities in Valtournenche (Aosta; Riservato et al. 2014a), and Alto Adige (A. Festi, pers. com.). Further research is needed to better define the distribution and reproductive status of the species in the study area.

26. *Aeshna isoceles* (Müller, 1767) R

erl: LC; *irl*: LC

27. *Aeshna juncea* (Linnaeus, 1758) R

erl: LC; *irl*: LC

28. *Aeshna mixta* (Latreille, 1805) R

erl: LC; *irl*: LC

29. *Aeshna subarctica* Walker, 1908 R

erl: LC; *irl*: VU

In the study area, as in the rest of Europe, is reported the subspecies *A. s. elisabethae* (Djakonov, 1922).

This species is a recent addition to the Italian fauna, as it was first reported for Trentino (Lago Nero di Monte Corno) in 2009. Subsequent research led to the discovery of three new sites (in two of which reproduction was confirmed) in the neighbouring Alto Adige, although one of them is located at just 700 m from the site of the first discovery (Festi 2011). Further recent investigations allowed to confirm its presence for three new sites in Trentino (and Italy): in 2017 at Palù Longa and Lac del Vedes and in 2018 in Valfloriana. In the latter two sites the reproduction was confirmed (Assandri, unpub.; Fig. 3). These sites are near to the other known localities (respectively about six, four and eight kilometres far from Lago Nero di Monte Corno). The Valfloriana site, to date, represents the most southern breeding site of this species in Europe (Boudot & Kalkman 2015), although being only slightly further South than other two sites in Slovenia and Romania (Bedjanič 1999; Flenker 2011), considering an old Bulgarian record as doubtful (M. Marinov, pers. com.).

A further recent record regards an isolated male on 16 Sep 2018 at Lago delle Buse (F. Grazioli, unpub.). This site is located about 8 km South-East from the Valfloriana site. Here the reproduction of the species needs to be confirmed in order to exclude the possibility of a wandering individual.

In Europe, *A. subarctica* is mainly found in the North-eastern part of the continent, with scattered and isolated populations in the Alps (Boudot & Kalkman 2015). Thus, the data presented in Festi (2011) and here shed new light onto the distribution of this largely overlooked species at the southernmost border of its European distribution.



Fig. 3 – *Aeshna subarctica* female ovipositing in a raised bog. Lac del Vedes. 01 Aug 2017. Photo: G. Assandri.

30. *Anax ephippiger* (Burmeister, 1839)

erl: LC; *irl*: LC

Anax ephippiger is a migrant species, its presence in Europe (often invasive) largely depends on movements from Africa. In Europe, its breeding attempts are sporadic, although regularly increasing in the southern part of the continent (Boudot & Kalkman 2015). In Trentino, there were only two known historical records referred to Lago di Loppio and Laghetti di Marco, reported by Ausserer (1869b) and cited again by Heymer (1967); however, recently, a female was recorded in Bocca di Caset bird ringing station (Ledro) on 16 Sep 2018 (A. Franzoi/MUSE, unpub.).

Although in eastern Italy the species appears to be rarer than in the western part, it is likely that further research could lead to new sightings of this species in the study area.

31. *Anax imperator* Leach, 1815 R

erl: LC; *irl*: LC

32. *Anax parthenope* Selys, 1839 R

erl: LC; *irl*: LC

33. *Brachytron pratense* (Müller, 1764) *

erl: LC; *irl*: LC

The species was historically reported by Ausserer (1869b) for Castelfondo, although the note “not very common, in August” is incompatible with the flight period of the species, which in Europe is always found in spring (Boudot & Kalkman 2015). This considered, the only confirmed record for the study area is a male collected in Zam-

bana (CMT), where today the habitat of the species is lost due to the massive anthropogenic changes occurred in the Adige floodplain.

6. Gomphidae

34. *Gomphus vulgatissimus* (Linnaeus, 1758) R

erl: LC; *irl*: LC

35. *Onychogomphus forcipatus* (Linnaeus, 1758) R

erl: LC; *irl*: LC

In the study area occurs the nominal subspecies *forcipatus* and Trentino represents the Western limit of its distribution in Northern Italy; however, in Nielsen’s collection (Museo Civico di Storia Naturale di Milano) are present two individuals attributable to the subspecies *O. f. unguiculatus* (Vander Linden, 1820) (M. Pavesi, pers. com.) collected at Lago di Caldonazzo in 1930 and 1934, where the nominal subspecies used to be found.

This considered, further research is definitely needed to clarify the distribution of these two taxa in the study area, that could represent a contact zone between the two.

7. Cordulegastridae

36. *Cordulegaster bidentata* Selys, 1843 R

erl: NT; *irl*: LC

37. *Cordulegaster boltonii* (Donovan, 1807) R

erl: LC; *irl*: LC

In the study area is reported the nominal subspecies.

8. Corduliidae

38. *Cordulia aenea* (Linnaeus, 1758) R
erl: LC; *irl*: LC
39. *Somatochlora alpestris* (Selys, 1840) R
erl: LC; *irl*: LC
40. *Somatochlora arctica* (Zetterstedt, 1840) R
erl: LC; *irl*: NT
41. *Somatochlora flavomaculata* (Vander Linden, 1825) R
erl: LC; *irl*: LC
42. *Somatochlora metallica* (Vander Linden, 1825) R
erl: LC; *irl*: LC

9. Libellulidae

43. *Crocothemis erythraea* (Brullé, 1832) R
erl: LC; *irl*: LC
44. *Leucorrhinia dubia* (Vander Linden, 1825) R
erl: LC; *irl*: LC
45. *Leucorrhinia pectoralis* (Charpentier, 1825) R
hd: II, IV; *erl*: LC; *irl*: EN

The first mention of this species for Trentino (and Italy), a male at Torbiera del Lagabrun in 1942 (Conci & Galvagni 1946; Marcuzzi 1948), resulted to be erroneous, as the record was subsequently referred to the congeneric *Leu-*

corrhinia dubia (Conci & Nielsen 1956). The following mention for the study area was based on three nymphs collected at Torbiera di Fiaavè in 1972 and conserved at the Natural History Museum of Venice (Macagno et al. 2012). Extensive research carried out in the last few years seem to suggest that the species is most likely extinct there (Macagno et al. 2012; Assandri, unpub.).

Besides the Fiaavè occurrence, before 2012 the species was sporadically reported in Italy, specifically in: Lombardia (one site, last records in 2003; Riservato et al. 2014c), Veneto (two sites, last record in 1970; Bucciarelli 1978), Alto Adige (one site, last records in 1984; Festi 2012), and Friuli-Venezia-Giulia (two sites, last record in 1982; Zandigiaco et al. 2014).

In Trentino (in 2012) an autochthonous and quite big population was discovered in the transition mire of Palù di Fornace (Macagno et al. 2012), and in 2013 a further reproductive population was found at another ecologically similar site in Alto Adige, 30 km north from Fornace, following an isolated individual further 7 km North, found the year before (Festi 2012, 2013).

Recent research lead to the discovery in 2017 of a small population in a -suboptimal- site 1 km far from Fornace (Torbiera di Santa Colomba; Assandri & Bazzi, unpub.; Fig. 4) where the reproduction of the species was confirmed in 2018. Moreover, further two males were observed in another site 2.7 km far from Fornace in 2017 (Palù Gross; Assandri, unpub.). Additionally, the study of the CMT collection allowed the discovery of a male specimen, overlooked until today, coming from Santa Colomba, dated 18.07.1951, possibly suggesting that the



Fig. 4 – *Leucorrhinia pectoralis* male. Torbiera di S. Colomba. 20 Jun 2017. Photo: G. Assandri.

site has been inhabited by the species for at least several decades.

It is to be remarked that the Trentino population(s) of this declining species, included in the Annexes II and IV of the Habitat directive and in the list of priority invertebrate species for the Trento Province (Gobbi et al. 2013), has a remarkable conservation value, as, with the one recently discovered in Alto Adige, they are the only known to occur in Italy.

46. *Libellula depressa* Linnaeus, 1758 R
erl: LC; *irl*: LC

47. *Libellula fulva* (Müller, 1764) R
erl: LC; *irl*: LC

48. *Libellula quadrimaculata* Linnaeus, 1758 R
erl: LC; *irl*: LC

49. *Orthetrum albistylum* (Selys, 1848) R?
erl: LC; *irl*: LC

This species was historically considered as very rare in Trentino by Ausserer (1869b), who reported its presence for Rovereto and Civezzano. A further historical specimen referred to Trento and presumably to the second half of the XIX century was conserved in the collection “G. Strobl” (Admont, Austria; Kiauta 2003). These historic records were later confirmed by a female collected at Lago di Caldonazzo (23.08.1932; CMT), and a pair at “Paludi dell’Adige” (19.05.1946; Collezione “C. Conci” - Museo Civico di Storia Naturale di Milano). Recent research allowed to confirm the presence of the species in Vallagarina (Taio di Nomi, Assandri, unpub.), where a male and a female were observed on 15 Jun 2017. The reproduction at this site was not confirmed, but seems likely, considering the habitat characteristics.

Orthetrum albistylum is a widespread and locally very abundant species in northern Italy, although its presence is mostly limited to the lowland (Riservato et al. 2014c), this possibly explains its rarity in Trentino. In its European range it showed a marked northward expansion in the last forty years, being favoured by the higher summer temperature and its adaptability and pioneer habits (Boudot & Kalkman 2015). This considered, it is possible that in the near future the species will be found at new sites in the study area, possibly also at higher altitudes.

50. *Orthetrum brunneum* (Fonscolombe, 1837) R
erl: LC; *irl*: LC

51. *Orthetrum cancellatum* (Linnaeus, 1758) R
erl: LC; *irl*: LC

52. *Orthetrum coerulescens* (Fabricius, 1798) R
erl: LC; *irl*: LC

In the study area is reported the nominal subspecies.

53. *Sympetrum danae* (Sulzer, 1776) R
erl: LC; *irl*: LC

54. *Sympetrum depressiusculum* (Selys, 1841) R
erl: VU; *irl*: EN

55. *Sympetrum flaveolum* (Linnaeus, 1758) * R
erl: LC; *irl*: VU

According to the available literature and the collections, the species was quite regularly reported from the XIX century (Ausserer 1869b) to 1985 (Terzani & Mascagni 2005) but lacks recent confirmations. Although modern studies in Trentino were scarce, this pattern seem to be consistent with what is reported for the rest of Italy, where the species was recently found only on the Apennines and the Western Alps (Riservato et al. 2014c). This could be explained by the fact that, at the limits of its range, *S. flaveolum* is subjected to important population fluctuations, due to irregular waves of immigrations (Boudot & Kalkman 2015).

56. *Sympetrum fonscolombii* (Selys, 1840) R
erl: LC; *irl*: LC

57. *Sympetrum meridionale* (Selys, 1841)
erl: LC; *irl*: LC

Already cited historically by Ausserer (1869b), this strongly migratory species was later sporadically reported in the course of the XX century until 1949 (CMT, Morton 1928). Most of these records referred to migrant/vagrant individuals, often collected at high elevations (as in other sectors of the Alps, see e.g. Wildermuth et al. 2005) and in habitats not suitable for reproduction. To this category also belong the few recent mentions available for the study area: an individual reported at Paneveggio (Negrisolo 2008); a male at Bocca di Caset ringing station (Ledro) on 21 Aug 2018 (A. Franzoi/MUSE, unpub.); a female and a male at Foci dell’Avisio on 29-30 Sep 2018 (M. Cadin, G. Assandri, unpub.).

58. *Sympetrum pedemontanum* (Müller in Allioni, 1766) R
erl: LC; *irl*: LC

According to the historical data, until the first half of the XX century, the species was quite common and widespread in Trentino at low altitudes (Ausserer 1869a; Morton 1928, 1926; Nielsen 1932; CMT). Subsequently, it became rarer, most probably due to the wide disappearance of the periodically flooded lowland meadows and natural wetlands, to the point that the only recent record of the species refers to a pair found in Dimaro in 2007 (Carolli and Maiolini, unpub.).

59. *Sympetrum sanguineum* (Müller, 1764) R
erl: LC; *irl*: LC

60. *Sympetrum striolatum* (Charpentier, 1840) R
erl: LC; *irl*: LC

61. *Sympetrum vulgatum* (Linnaeus, 1758) R
erl: LC; *irl*: LC

SPECIES NOT CONFIRMED OR DOUBTFUL

1. *Ceriagrion tenellum* (Villers, 1789) *
erl: LC; *irl*: LC

Historically cited by Ausserer (1869b) for two localities (Lago di Garda and Lago di Loppio); a female conserved in Collezione “C. Conci” - Museo Civico di Storia Naturale di Milano (Laghetto di Marco; 18.06.1943) resulted to be an *Erythromma viridulum* (M. Pavesi, *pers. com.*).

The only ‘modern’ record of this species refers to a female reported on 22 Jun 1988 in an area with sparse herbaceous riparian vegetation, on the shore of the Avisio (Cavalese, 950 m; Terzani & Mascagni 2005), a rushing stream located in an inner Alpine valley with a strict continental climate. In Italy the species is generally absent from the Alps (Riservato et al. 2014c), and in Europe rarely reaches altitudes above 1000 a.s.l. (Boudot & Kalkman 2015). In the continental portion of its European range, *C. tenellum* colonizes mainly acidic peat bogs and various flooded *Cyperaceae* grasslands, although in its Mediterranean range it is found also at seepages, stream and small river with rich low aquatic vegetation (Boudot & Kalkman 2015; Wildermuth et al. 2005). This considered, the cited record appears to be inconsistent with the known ecology of the species, and thus need further confirmations.

2. *Coenagrion lunulatum* (Charpentier, 1840) *
erl: LC

Historically considered as “rare” in Trentino by Ausserer (1869b), this species was cited for four localities at altitudes spanning from 200 to 915 m a.s.l.; the species was never subsequently cited for the study area nor included in the Italian fauna (Conci & Nielsen 1956; Riservato et al. 2014c). The closest localities where it is still found are located in Tyrol (Austria), where it dramatically declined in the last decades and is still declining, as in the majority of the southern part of the bulk of its European range (Boudot & Kalkman 2015; Landmann et al. 2005). The causes of this decline are poorly understood, although climate change could be playing a fundamental role (Boudot & Kalkman 2015; Wildermuth et al. 2005).

In the absence of a voucher specimen, it is difficult to judge whether in the XIX century *Coenagrion lunulatum* was actually present on the Southern Alps, and has subsequently become extinct, as in other parts of southern Europe (e.g. in Switzerland, Wildermuth et al. 2005), or whether Ausserer’s identifications were wrong. In his work, Ausserer (1869b) included a detailed identification key demonstrating a perfect knowledge of the species; however, due to the high variability of the sister species *Coenagrion hastulatum* (Deliry, 2008), it is difficult to be persuaded about the reliability of the records presented above. However, it is to be remarked that the first

half of the XIX century was characterized by the end of the so-called Little Ice Age, a period marked by a considerably low temperature. During the course of the XX century, the rise of the temperatures (Casty et al. 2005; Lüthi 2014) possibly determined the disappearance of cold-adapted species at the lower elevations. Additionally, although several of the sites for which the species was cited could harbour or have harboured favourable habitats for the species, the reported phenology (July-August) appears inconsistent for a taxon strictly found in spring, at least in the southern part of its range (Deliry 2008; Wildermuth et al. 2005).

This considered, the past presence of this species in Trentino (and Italy) should be considered as unlikely.

3. *Coenagrion ornatum* (Selys, 1850) *
hd: II; *erl*: NT; *irl*: DD

Historically considered as very rare in Trentino by Ausserer (1869b), it was reported for three localities (Lago di Garda, Lago di Loppio and Laghetto di Marco) in July. Those data, along with another record for the Lago di Garda near Verona (Assenza, in August, Garbini 1897) were subsequently considered as doubtful by Conci & Nielsen (1951), but were maintained in Riservato et al. (2014c) and Boudot and Kalkman (2015). The closest localities to Trentino where the species is found are Slovenia and Bavaria (Boudot & Kalkman 2015).

In the absence of voucher specimens, it is difficult to judge whether in the XIX century *Coenagrion ornatum* was actually present in the study area and had subsequently become extinct, as in other parts of Europe (e.g. in Switzerland, Wildermuth et al. 2005), or whether Ausserer’s and Garbini’s identifications were wrong. Due to the high resemblance with congeneric species, it is difficult to be completely persuaded about the reliability of these records; additionally, the reported phenology, with records restricted to July and August, is quite inconsistent with the known flying period of the species, which generally has an abundance peak in June (Boudot & Kalkman 2015). This considered, the historic presence of this species in Trentino should be considered as doubtful, thus the only confirmed records for Italy refer to Friuli-Venezia-Giulia and Puglia (Zandigiacomo et al. 2014; Mastropasqua & Liuzzi 2016).

4. *Ophiogomphus cecilia* (Geoffroy in Fourcroy, 1785) *
hd: II, IV; *erl*: NT; *irl*: LC

Historically reported by Ausserer (1869b), as “very rare, in July”, for two localities in Vallagarina (Laghetto di Marco and Calliano); subsequently, Maiolini & Carolli (2009) stated that other evidences were available until 1951, referring to specimens conserved at CMT, on which bases the species was entered in the list of priority invertebrate species for the Trento Province (Gobbi et al. 2013). A recent revision of this collection allowed to clarify that all the *Ophiogomphus cecilia* here conserved, coming from

Lago di Caldonazzo in a period spanning between 1938 and 1951, were misidentified, as they are *Onychogomphus forcipatus*.

In the southern part of its range, the species mostly occurs along the major river basins (Boudot & Kalkman 2015); for example, in Italy the species is substantially confined to the Po plain (Riservato et al. 2014c). This considered, the past presence of the species in the Adige valley should be taken as unlikely, though it could not be completely ruled out, since Ausserer's description seems to be convincing.

5. *Epitheca bimaculata* (Charpentier, 1825) *
erl: LC; *irl*: RE

In Italy, *Epitheca bimaculata* was reported historically by Ausserer (1869b) for Trentino (Lago di Garda, Laghetti di Marco and Lago di Loppio), where the species was considered as "rare" and "found in June and at the beginning of July"; and by Garbini (1897; erroneously cited as 1906 by Conci & Nielsen 1956), who reported a single individual collected on 24.06.1897 at Navene, on Lago di Garda, a few kilometres south from Trentino border. The record of 1985 reported in Maiolini & Carolli (2009) is erroneous, as refers to a synthesis only reporting Ausserer's data. No other occurrences of the specie were subsequently reported, thus today the species is considered extinct in Italy (Riservato et al. 2014c). It should be highlighted that no voucher specimens supporting the past occurrence of the species are available; however, Ausserer's and Garbini's reports seem consistent with the species habitat requirements (mainly medium to large standing waters with rich helophytes, often in forested landscapes; Boudot & Kalkman 2015) and flight period. *Epitheca bimaculata* went through a steep decline through the 20th century, probably due to management changes of lakes and ponds and decrease in water quality (Boudot & Kalkman 2015). Massive environmental changes, determined by human exploitations, also affected the three Italian wetlands at which the species was recorded in the past, possibly determining the local extinction of the species in the study area. However, the past occurrence of the species in Italy should be conservatively considered as not confirmed.

SPECIES EXCLUDED

1. *Platycnemis latipes* Rambur, 1842 *
erl: LC

Species endemic to France and Iberian Peninsula (Boudot & Kalkman 2015), not included in the Italian fauna (Riservato et al. 2014c). Historically, the species was cited for two localities in Trentino (Ausserer 1869b); however, Nielsen & Conci (1951) judged these and other Italian literature records as unlikely, considering its known distribution and the fact that it can be easily confused with teneral individuals of the congeneric *Platycnemis pennipes* (Conci & Nielsen 1956).

2. *Onychogomphus uncatus* (Charpentier, 1840) *
erl: LC; *irl*: LC

Historically reported by Ausserer (1869b) for two localities in Trentino (Lago di Loppio and Lago di Garda) but subsequently never confirmed. According to the description and tables of the original German version of the study (Ausserer 1869a), it is likely that the author confused this species with the congeneric *Onychogomphus forcipatus unguiculatus*, the south-western subspecies of this taxon (Balestrazzi & Pavesi 2008). This hypothesis is supported by the known distribution of *Onychogomphus uncatus*, which in Northern Italy is confined West to the river Oglio basin (Lombardy; Riservato et al. 2014c). According to this evidence, the species should not be considered as part of the odonatofauna of the study area.

The updated and comprehensive odonatological bibliography for Trentino, which consist of 38 references, is provided (see references section). Apart from the publications already cited in the text, also the following publications are part of the odonatological bibliography of Trentino: Balestrazzi et al. 1983; Casellato & Zanfei 1987; D'Antonio 1997, 1999; Festi et al. 2009; Golfieri et al. 2016; Lampo et al. 2011; Marcuzzi 1956; Marcuzzi et al. 1975; Utzeri et al. 1994.

Discussion

Sixty-one Odonate species were confirmed to occur (or have occurred) in Trentino; five more (i.e. *Ceriagrion tenellum*, *Coenagrion lunulatum*, *Coenagrion ornatum*, *Ophiogomphus cecilia*, and *Epitheca bimaculata*) are not confirmed or doubtful.

Further two (i.e. *Platycnemis latipes* and *Onychogomphus uncatus*) were excluded from the fauna of the study area. Not confirmed and excluded species all referred to years before 2000 (but mostly to much older records).

Fifty-four species were confirmed also after 2000, and 54 species (49 after 2000) reproduce/reproduced in the study area; for three species (*Aeshna affinis*, *Aeshna grandis*, *Orthetrum albistylum*) reproduction is doubtful or to be confirmed.

Considering only the confirmed species, these represent the 64% of the 95 species recorded at least once in Italy (<http://www.odonata.it/libe-italiane/>) and the 43% of the 143 species recorded in Europe (Boudot & Kalkman 2015). This is a noticeably high diversity, considering the small extent of the study area, and confirms that the Alps represent a hotspot of dragonfly diversity at a European scale (Kalkman et al. 2018).

For five species, this review highlighted the importance of the study region at a national, and, in several cases, Alpine scale. Namely, *Leucorrhinia pectoralis* was known to occur at only two sites in Italy (one in Trentino and the other in Alto-Adige). The present study reports the discov-

ery of a new reproductive site in Trentino, pointing out the importance of the area for the conservation of this endangered species.

The discovery of *Aeshna subarctica* in Italy, less than ten years ago (Festi 2011), represented an important odonatological novelty for Italy. To date, the species is known for eight localities (reproduction confirmed at six sites), five in Trentino and three in Alto Adige. Similarly, the numerous sites of occurrence of *Aeshna caerulea* found in eastern Trentino, along with those occurring in the neighbouring Alto-Adige and North-Eastern Veneto are of biogeographical importance, as these represent the last glacial relict populations at the southernmost European range of the species.

Although further research is needed to clarify the status of *Aeshna grandis* in Trentino, the numerous bibliographic references and specimens in collections, along with the recent reports, suggest that the species might be more frequent in northern Italy than previously believed.

For *Erythromma najas* Trentino hosts two of the less than ten thus far known Italian populations, and the recent discovery of the second population suggests that further discoveries at new sites might be possible.

In addition, the study area hosts numerous and often conspicuous populations of several common species that elsewhere in Italy are found only in the Alps, and often occur very scattered: *Coenagrion hastulatum*, *Somatochlora alpestris*, *Somatochlora arctica*, *Leucorrhinia dubia* and *Sympetrum danae*.

Considering conservation categories, two species confirmed for Trentino are included in the Annexes II and IV of the Habitats Directive (*Leucorrhinia pectoralis* and *Sympetma paedisca*); however, the latter, which is also listed as critically endangered in the Italian Red List, is most likely extinct in Trentino. Additionally, two species are categorized in a risk category of the European Red List (*Cordulegaster bidentata* as Near Threatened and *Sympetrum depressiusculum* as Vulnerable) and nine species in the Italian Red List (*Aeshna caerulea* and *Somatochlora arctica* as Near Threatened; *Aeshna grandis*, *Aeshna subarctica*, *Sympetrum flaveolum* as Vulnerable; *Erythromma najas*, *Leucorrhinia pectoralis*, *Sympetrum depressiusculum* as Endangered). The other species are considered of Least Concern in the red lists and not are listed in the annexes of the Habitats Directive. This should not diminish the concern for the conservation of the dragonflies in the study region, as “only considering the species confirmed”, seven were not reported after the 2000; of these, five used to breed in the study area (i.e. *Lestes dryas*, *Lestes virens*, *Sympetma paedisca*, *Coenagrion scitulum*, and *Sympetrum flaveolum*). Although it is not possible to rule out that some of these species could be found in the future, at least two (i.e. *Sympetma paedisca*, *Brachytron pratense*) are likely extinct in the study area. Additionally, it should be noted that, according to historic literature and collections, it seems that many populations of formerly common

species disappeared from many sites, in particular in the valley bottoms, suggesting an important impoverishment in the biodiversity of the Trentino wetlands.

In conclusion, we are still far from considering exhaustive the knowledge on dragonfly distribution, diversity, and basic ecology in the study area; however, this study will hopefully set a solid baseline on which to further build increasingly accurate knowledge on the Odonatofauna of the region.

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