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The Odonate fauna of Val Grande National Park (Insecta: Odonata)

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Abstract
The results of a survey aimed at describing the Odonate fauna of Val Grande National Park are presented, which was carried out in the framework of the project "Animal Biodiversity Monitoring in Alpine Habitat". Relevant literature was examined and data collected intensively in summer 2016 and extensively in the period 2014-2019. Prior to this research specific knowledge on dragonfly and damselfly presence and distribution accounted for 6 species for the study area, which were recorded near the northern border but outside the park. The first Odonate checklist here provided is based on 188 records (1173 individuals), of which 137 are recent and unpublished. Comprehensively 25 species were recorded (14 breeding), which represent 26% of the Italian fauna, 36% of Piedmont and 58% of the province of Verbano Cusio Ossola, whereas three species were not confirmed; 10 species were found inside the park (4 breeding). Odonate diversity was remarkable, thanks to Val Grande geographical position between the Alps and the Insubric region and to high rainfall coupled with a complex orography. The study area hosts populations of the boreo-alpine species *Somatochlora alpestris* and *Sympetrum danae*, which are scattered and isolated in Italian Alps, and of the endemic European *Cordulegaster bidentata*; it hosts lotic *taxa* which are concentrated in SW Europe where they are under pressure because of droughts and exploitation of freshwater. Conservation and status issues of observed dragonflies and damselflies are discussed in the light of the growing interest gained by odonates as ecological indicators. The study proposes to use this knowledge to guide the future expansions of the protected area.

Key words: dragonflies, damselflies, Alps, biodiversity monitoring, conservation, national park.

Introduction

Odonates (Insecta: Odonata) are an ancient group of insects demonstrating an aquatic larval lifestage and an aerial adult lifestage. Because of their moderate to large size, brilliant colours, attractive flying patterns, reproductive strategies and their apex position in the trophic web, odonates are one of the most popular and studied groups of insects both among researchers and amateurs, and a draw for photographers.

In Italy, odonatological research dates as far back as 19th century and Piedmont represents one of the best known and surveyed regions. The first published regional Atlas on the distribution of dragonflies and damselflies was that of Piedmont and Valle d'Aosta (Boano et al. 2007), followed shortly after by the first Atlas for one of its provinces, Novara (Riservato 2009). As in many other European countries, Italian odonatological knowledge and research greatly benefited from the implementation of citizen science databases which have occurred over the past decade, leading to the publication of a national preliminary Atlas describing 93 species recorded at least once (Riservato et al. 2014c). Since its publication, another three dragonfly species have been added to the Italian odonate fauna (Viganò et al. 2017; Corso & Penna 2020). Despite these advances, knowledge on the distribution of many Odonata species is still scarce and fragmented in large parts of the country, including mountainous regions where surveys are more difficult to conduct and suitable habitat, even when numerous, are small and scattered.

Odonates are well established ecological indicators (Chovanec & Waringer 2001; Golfieri et al. 2016; Šigutová et al. 2019; Cardoso et al. 2020; Vorster et al. 2020): being apex predators at both larval and adult lifestages (Bo et al. 2012), they convey information on aerial and aquatic communities in which they hunt. Recently, dragonflies have gained interest as indicators of climate change as their distributions can change rapidly (McNeely 2010; Ott 2010; Parr 2010; Termaat et al. 2010; Termaat et al. 2019). In the last few decades several warm-adapted species have expanded their distributions both north and south in response to climate change; this trend was confirmed also on a European

continental scale (Termaat et al. 2019). On the other hand, cold-adapted species with a fragmented, boreo-alpine distribution, may face the risk of contraction of their ranges, as they cannot move further to higher latitudes or altitudes. Recent data demonstrates how climate change affects ecosystems and biological communities at a faster rate in montane and high-latitude contexts compared with areas at lower elevations (Viterbi et al. 2013; Rogora et al. 2018; Viterbi et al. 2020), and how invertebrates are more sensitive to climatic variations than vertebrates (Viterbi et al. 2013, 2020). Mountain ecosystems and their invertebrate communities may thus be studied as "early warning systems" or sentinels of climate change induced effects (Oertli 2010).

To date, odonates of Val Grande National Park (VGNP) (province of Verbano Cusio Ossola, Piedmont, Italy) have not been the subject of specific studies. Some scattered data was collected during limnological research carried out on small mountain lakes (Boggero et al. 2006). The Atlas on the distribution of dragonflies and damselflies of Piedmont and Valle d'Aosta does not contain a single observation for the park (Boano et al. 2007). After its publication, Odonata records increased in north eastern Piedmont, thanks to an increase in citizen science sampling effort, leading to the first checklist for the province of Verbano Cusio Ossola (VCO) which listed a total of 43 species (Clemente et al. 2011), thus almost doubling the 23 taxa reported in Boano et al. (2007) for the area. Between 2013 and 2015 a few more records were collected during surveys carried out in the framework of the project "Animal Biodiversity Monitoring in Alpine Habitat" (Viterbi et al. 2014; Baroni et al. 2018). Nevertheless, comprehensive and systematic research on dragonflies and damselflies in VGNP was missing before this study.

Thanks to its mountainous but not fully Alpine characteristics, high rainfall and vicinity to a large lake which leads to an insubric-oceanic climate, VGNP might host more dragonfly species than current data suggests.

This paper presents the results of the first survey aimed at describing the odonate fauna of the park; some preliminary data were already presented by Pompilio & Mosini (2017). Existing information was gathered and critically examined and the resulting checklist represents the current knowledge of the status of dragonflies and damselflies of VGNP. This provides a basis to which future records and surveys can be added to improve our knowledge of odonate communities. Our results may also be used as a reference for future comparisons, provided they are collected following the same methodology.

Study area

VGNP (46.03528N 8.282070E) lies in the southern sector of the Italian Lepontine Alps in the north eastern portion of Piedmont, province of VCO, Italy (Fig. 1). The park was established in 1992, covers 146 km^2 and encompasses a wide array of deep valleys belonging to two main hydrographic basins, Pogallo and Val Grande rivers, surrounded by mountain ridges with the highest peaks reaching 2300 m. Seventy-nine % of its surface is included in Natura 2000 Sites of Community Interest/Special Conservation Area (SCI/SCA) IT1140011, according to the European Habitat and Birds Directives.

Due to its complex orography there is no road access and most of the park is uninhabited. VGNP lies between the main Alpine ridge towards the north and west and Lake Maggiore and Insubric region towards the south and east and ranges between 200 and 2300 m in elevation, thus offering suitable climatic and environmental conditions both for cold and warm-adapted species. The main habitats include deciduous (mainly beech and chestnut) and coniferous forests, rocky outcrops and alpine heathlands and grasslands (Sindaco et al. 2009). Natural habitats are predominantly in good conservation status except for secondary grasslands, which have been progressively invaded by shrubs and pioneer woodland because of the abandonment of traditional agriculture and of cattle grazing after the Second World War. Primary and secondary grasslands were traditionally used as pastures and for hay production.

The park experiences one of the highest amounts of rainfall in Italy, with 2500 mm/year (Biancotti & Costamagna 2001); its climate is oceanic at lower altitudes and montane-subalpine at higher elevations. High rainfall and steep slopes mean that the park is especially rich in lotic habitats, although small lakes and ponds can be found in the northern and western sectors where glacial morphology prevails.

Odonates were surveyed in all suitable and accessible aquatic habitats in the park. Surveyed sites were grouped into three study areas falling inside VGNP (Loana Portaiola, Laghi del Proman e Cicogna Pian di Boit) and three lying along its administrative borders (Pian dei Sali, Laghi del Geccio e Costa dei Bagnoli); we also included the future expansion of the park towards the south and Lake Maggiore (Fig. 1). Some additional records were collected during visits not targeted at odonates and are listed under "Other". The study areas were spread over a total of 8,91 km^2 and included approximately two km^2 of riverine habitats, alpine lakes and peat bogs; altitudes ranged from 293 m to 2109 m (overall mean=1350, DS=610, Table 1). Main habitat and environment are as follows (specific information on surveyed sites and habitat characteristics are provided in Table 1).

1. Expansion (EXP)

It includes a stretch of San Bernardino river, formed by the merging of the Val Grande and Pogallo streams, which discharge into Lake Maggiore along with some small ponds and wetlands of the lower Val Grande. The upper portion of the valley has a complex and harsh orography with several

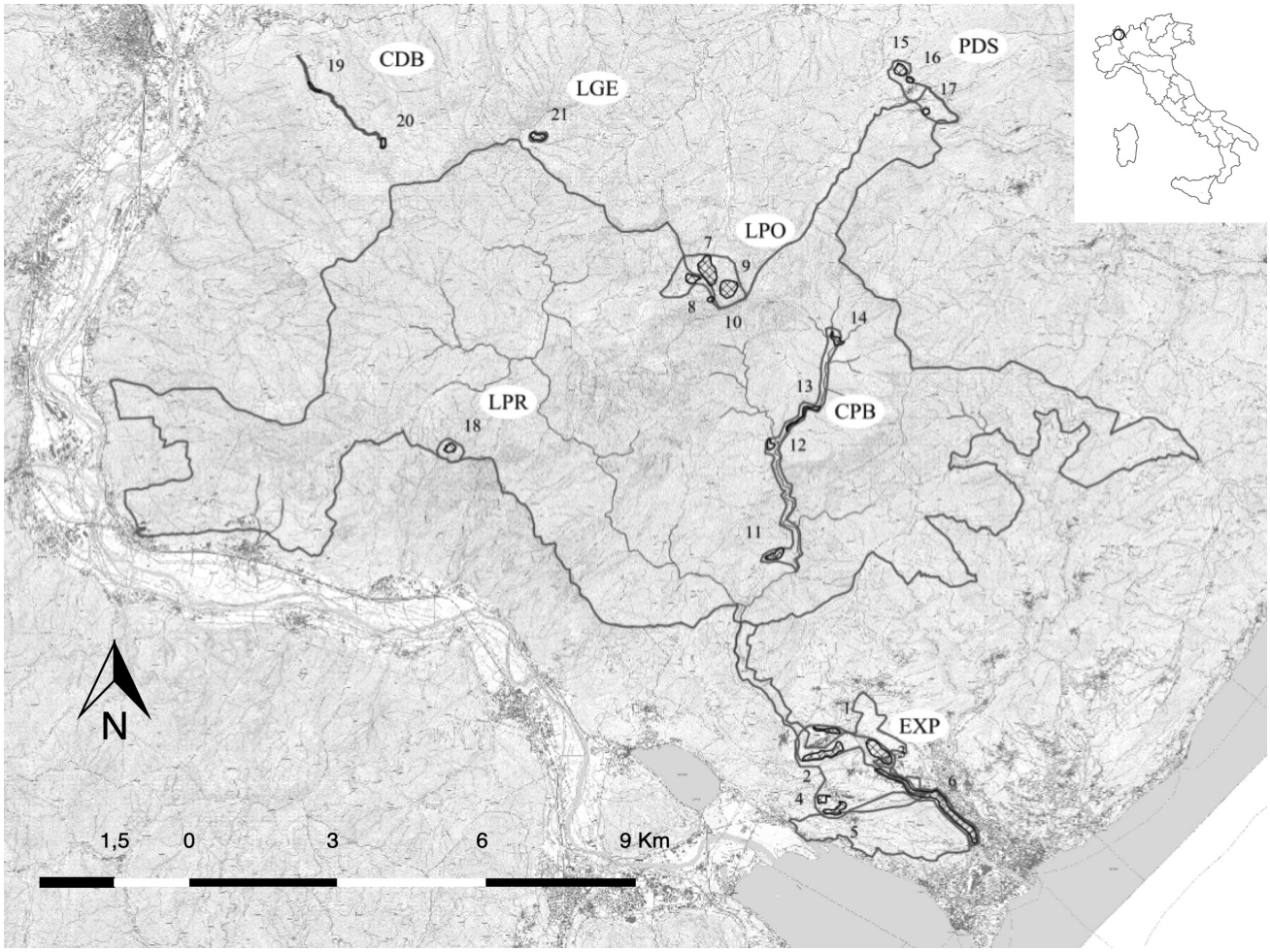

Fig. 1 – Val Grande National Park and its location in Italy (top right inset). Labels and site codes as in Table 1.

Table 1 – Monitored study areas (EXP=Expansion, LPO=Loana Portaiola, CPB=Cicogna-Pian di Boit, PDS=Pian dei Sali, LPR=Laghi Proman, CDB=Costa dei Bagnoli, LGE=Lago Geccio) and total surface, for each study area name and code of investigated sites are provided, aquatic habitat surface, minimum and maximum altitude, coordinates, vegetation (Pentcheva F. 2011. Parco Nazionale della Val Grande. Flora e vegetazione delle zone umide. Master degree dissertation in Natural Sciences [tutor: M. Caccianiga], University of Milan: 110 pp. (unpublished); Roberto Dellavedova *pers. comm.*) and survey dates.

Study Area (km²)	**Site Name and Code**	**Aquatic habitat (km²)**	**Altitude (m)**		**Coordinates**	**Vegetation (phytosociological alliances)**	**Survey dates**
			Min	**Max**			
EXP (4,4)	1. Cossogno Aurelio stream	0.05	380	420	45.964972N 8.504806E	Small stream in a deciduos forest (*Fraxinion, Alnion glutinosae*), some small abandoned meadows	1 Jul 2015, 14 and 24 Jul 2016, 11 Aug 2016
	2. Cossogno San Bernardino River	0.16	220	360	45.959972N 8.506556E	Narrow stream gorge and hydroelectric power plant's adduction channel in an alluvial forest (*Lunario-Acerion, Fraxinion*)	14 and 24 Jul 2016, 11 Aug 2016
	3. Unchio peat bog	0.18	300	400	45.960917N 8.525833E	Small peat bog sorrounded by forest *(Molinion, Alnion glutinosae, Quercion robori-petraea)*	24 Jul 2016, 18 Aug 2016

Study Area (km^2)	Site Name and Code	Aquatic habitat (km^2)	Altitude (m)		Coordinates	Vegetation (phytosociological alliances)	Survey dates
			Min	Max			
EXP (4,4)	4. Bieno sewage treatment plant	0.04	320	320	45.949944N 8.508528E	Abandoned sewage treatment plant with common reed surrounded by forest *(Alnion glutinosae)*	27 Aug 2012, 18 Jul 2016, 20 Jul 2016
	5. Cavandone lake and wet forest	0.07	330	400	45.946444N 8.512028E	Small lake and few streams in a deciduos forest *(Quercion robori-petraea)*	18 Jul 2016, 20 Jul 2016
	6. San Bernardino River	0.43	200	250	45.951278N 8.542222E	Different observation's sites along a stream; both sides of it are forested with deciduos trees and shrubs *(Alnion glutinosae; Robinion; Salicion albae; Salicion elaeagni)*	27 Aug 2012, 7 and 25 Aug 2016, 6 Sep 2016
LPO (1,6)	7. Torbiere e pozze Cortnuovo	0.20	1700	1850	46.067742N 8.476178E	Ponds and bogs with bank vegetation and wet meadows, surrounded by alpine pastures, shrublands and stony ground	11 Aug 2013, 14 Sep 2014, 8 and 19 Aug 2016
	8. Pozze Alta Val Portaiola	0.05	1730	1850	46.064667N 8.472417E	Ponds and bogs with vegetated banks and submerged vegetation *(Caricion fuscae)* surrounded by natural grassland and stony slopes.	11 Aug 2013, 8 Jul 2014, 14 and 21 Aug 2014, 1 Sep 2015, 18 and 19 Aug 2016
	9. Lago Marmo	0.14	1870	1980	46.062572N 8.479331E	Small alpine lake with vegetated banks *(Caricion fuscae)* surrounded by natural grassland, shrublands and stony slopes.	4 Aug 2013, 5 Jul 2013, 18 and 19 Aug 2016
	10. Laghetto Scaredi	0.01	1950	2000	46.059846N 8.473011E	Small alpine lake with vegetated banks *(Caricion fuscae)* surrounded by natural grassland, shrublands and stony slopes.	4 and 11 Aug 2013, 18 and 19 Aug 2016
CPB (1,53)	11. Cicogna	0.07	700	770	46.003333N 8.491639E	Different observation's sites along a stream in a slope forest *(Lunario-Acerion)*	15 Jul 2015, 18 Aug 2015, 6, 7 and 14 Aug 2016, 23 Jul 2019
	12. Pogallo	0.03	700	740	46.027972N 8.491583E	*Molinia* meadow, partially mowed (*Molinion)*	1 Sep 2015, 6, 7 and 14 Aug 2016
	13. Pianezzoli stream	0.02	730	830	46.031583N 8.496750E	Stream in an alluvial forest *(Alnion glutinosae; Alnion incanae; Fraxinion)*	6, 7 and 14 Aug 2016
	14. Pian di Boit - Alpe Terza	0.04	1070	1150	46.051667N 8.512139E	Streams and a small meadow surrounded by beech forest *(Luzulo-Fagenion)*	1 Sep 2015, 6, 7 and 14 Aug 2016
PDS (0,89)	15. Pian dei Sali	0.06	940	970	46.111253N 8.530533 E	Wet meadow with small streams and a pond with vegetated banks (*Caricion fuscae; Caricion lasiocarpae; Molinion);* the plain is surrounded by pine forest *(Dicrano-pinion)*	7 Jul 2013, 29 Aug 2013, 11 Jul and 27 Jul 2016, 19 Aug 2016 and 9 Sep 2016
	16. Finero	0.02	900	910	46.108664N 8.534000 E	Wet meadow crossed by a small stream	28 Jul 2016, 19 Aug 2016 and 9 Sep 2016
	17. Provola	0.02	900	930	46.101917N 8.539389E	*Caricion fuscae; Caricion lasiocarpae; Dicrano-pinion; Molinion*	27 Jul 2016, 19 Aug 2016 and 9 Sep 2016

Study Area (km²)	Site Name and Code	Aquatic habitat (km²)	Altitude (m)		Coordinates	Vegetation (phytosociological alliances)	Survey dates
			Min	Max			
LPR (0,26)	18. Laghetti Proman	0.04	1820	1846	46.027621N 8.386898 E	Alpine lakes with vegetated banks *(Caricion fuscae)* surrounded by natural grassland, shrublands and stony slopes.	12 Aug 2016
CDB (0,14)	19. Parpinasca	0.02	1100	1150	46.101917N 8.386222E	Streams and a small meadow surrounded by beech forest *(Luzulo-Fagenion)*	7 Aug 2016
	20. Costa dei Bagnoli	0.02	1700	1750	46.093986N 8.370389E	Alpine pools with vegetated banks *(Caricion fuscae)* surrounded by natural grassland, shrublands and stony slopes.	7 Aug 2016
LGE (0,09)	21. Laghi del Geccio	0.05	2106	2113	46.095664N 8.419028E	Two Alpine lakes with vegetated banks and submerged vegetation *(Caricion fuscae; Littorellion)* surrounded by natural grassland and stony slopes.	28 Jul 2016

ravines. Dominant habitat types are *Tilio-Acerion* ravine woods along rivers and streams and chestnut woods in the lower portion, where they are fragmented by urban areas; in the latter, San Bernardino river flows within a belt of willow and allochthonous black locust (*Robinia pseudoacacia*) shrubs.

2. Loana Portaiola (LPO)

It expands over Loana and Portaiola valley headwaters embracing a vast system of natural alpine lakes, bogs, wet meadows, permanent and ephemeral ponds of glacial origin above woodland. Rocks are both siliceous and calcareous.

3. Cicogna Pian di Boit (CPB)

It includes part of Pogallo hydrographic basin. Monitored habitats are mainly lotic, along with a pond and some secondary pastures. The main habitat type is ravine forests and beech woods in the highest part of the valley.

4. Pian dei Sali (PDS)

This area includes some wetlands and a pond surrounded predominantly by a beech wood matrix.

5. Lago Geccio (LGE)

Geccio two lakes and bog lie in a vast alpine rocky grassland.

6. Costa dei Bagnoli (CDB)

It consists of a small brook and two natural alpine ponds.

7. Laghi Proman (LPR)

It consists of a small lake and three ponds scattered in a vast alpine rocky basin.

Materials and Methods

All available previously existing information was gathered and critically examined. Scarce and scattered information prior to 2007 has been retrieved, systematically revised and published by Boano et al. 2007; it consists of historic records collected at the end of 19th century by De Carlini (1892, three records) and reported in Capra & Galletti (1978), along with a few more recent observations made during a survey of odonates of Canton Tessin (De Marmels & Schiess 1978, 4 records). Our main source of recent records was Clemente et al. (2011), which was based on approximately 1800 data collected in the province between 2007 and 2011 on a volunteer basis by local experts affiliated to Società di Scienze Naturali del VCO, an association aimed at promoting knowledge and research on natural sciences; among these, 25 records were collected in the area we investigated. Some information on larvae occurrence were drawn from Bonizzoni (2011)[1].

In 2013 we started collecting records on a volunteer basis and in 2014 during an extensive monitoring programme on numerous animal *taxa* within the "Animal Biodiversity Monitoring in Alpine Environment" project (Viterbi et al. 2014). Thanks to VGNP financial support aimed at building knowledge on the status and distribution of odonates in the park, systematic surveys were conducted in summer 2016. Dragonflies and damselflies were monitored during peak periods of adult flying activity and

[1] Bonizzoni A. 2011. Laghetti alpini del Parco Nazionale della Val Grande: analisi della fauna macrobentonica. Master degree dissertation in Natural Sciences [tutor: A. Boggero], University of Milan: 155 pp. (unpublished).

suitable weather: from 10:00 to 16:00, air temperature higher than 17 °C, no wind or light breeze and cloud cover less than 50%. Because of the prevalent mountainous characteristics of our study areas and in order to maximize the number of species detection, surveys were concentrated on imaginal stages in July and August; data were also collected in September (30% of records). All suitable areas were visited at least once in the season; easily accessible sites were visited monthly where possible. Additional records were collected in 2019.

Adults were monitored through visual counts, using 10x40 binoculars, and by entomological hand nets (Ketelar & Plate 2001); individuals were counted and identified to species level in the field by observing diagnostic characteristics following Dijkstra & Lewington (2006); taxonomic uncertainties were resolved using digital images and later examination, avoiding specimen collection. Individuals were released immediately after handling. Breeding behaviour was recorded following criteria provided in Chovanec & Waringer (2001). *Exuviae* were searched for by walking slowly along suitable habitat, collected and stored in plastic boxes. Larvae were also sampled using an opportunistic approach, whenever possible and where water was easily accessible, using a dip-net single sweep and stored in a 70% ethanol solution. *Exuviae* and larval stages were identified with the aid of a stereoscope in the laboratory following Carchini (2016). A few observations drawn from cited sources referred to uncounted samples, to which a standard minimum number of 1 was given.

All records were archived in open-source QGIS. Observations collected by the authors were used to implement a national citizen science odonate database (www.ornitho.it), contributing to the increasing knowledge on this order of insects.

Results

The first odonate checklist for VGNP and surrounding areas is based on a total of 188 records relative to a minimum of 1173 individuals; 128 records (69% of total) were collected by the authors between 2013 and 2019, 25 came from published literature (Clemente et al. 2011; Riservato et al. 2014c) and 35 from unpublished sources.

The list includes 25 species, 6 belonging to the suborder Zygoptera and 19 to Anisoptera; 10 species (2 Zygoptera and 8 Anisoptera) were found within VGNP boundaries (Table 2). Breeding was confirmed for 14 species comprehensively and for 4 species inside VGNP (Table 3). The most frequent and abundant dragonfly was by far *Aeshna juncea* (21% of observations and 53% of abundance); as for frequency, a further group of 4 species made up for half of the collected records, namely *Aeshna cyanea*, *Somatochlora metallica, Somatochlora alpestris* and *Aeshna mixta* (Fig. 2). Zygoptera accounted for 19% of frequency and 13% of abundance: *Calopteryx virgo*, *Ischnura pumilio* and *Chalcolestes viridis* were the most frequent and abundant damselflies (Fig. 2).

Information on the occurrence, distribution, abundance and breeding status of dragonflies and damselflies in VGNP and surrounding study areas are provided (Fig. 1, Tables 2 and 3). Survey dates, codes and coordinates of observation sites are provided in Table 1. The list follows the nomenclature and systematic order given by the preliminary Atlas of Italian dragonflies and damselflies (Riservato et al. 2014c); chorotypes refer to Riservato et al. (2014c) and Siesa (2017). Lentic or lotic habitat preference follow Kalkman et al. (2018); these authors chose to include species occurring in both lotic and lentic habitats in the lentic group, so that the lotic group only includes species strictly dependent on habitats with running water. For this reason, some species recorded during this study are described as lentic even if they were also observed in running water environments.

Below, for each species, conservation status following European (EU), Italian (IT) and Mediterranean (MED) Red Lists (Kalkman et al. 2010; Riservato et al. 2014b; Boudot et al. 2009), breeding status, namely confirmed breeding (B), likely breeding (B?) and breeding not confirmed (NB) and sites of occurrence are provided (site code in parenthesis, codes are provided in Table 1). Some comments and a comparison with national, regional, transboundary and local distributions, where relevant, are also provided.

Calopterigidae

1. *Calopteryx virgo* (Harris, 1780)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This European lotic damselfly was recorded in EXP (2) as breeding and in PDS (16) where reproduction was not confirmed. The nearest to VGNP published record comes from De Marmels & Schiess 1978 and was collected at a distance of 3 km at 231 m. Boano et al. (2007) did not report it as frequent in the alpine region of Piedmont and Valle d'Aosta because of lack of relevant data at that time; in fact, Clemente et al. 2011 observed it along the main bottom of Val d'Ossola, where it occurred as high as 1200 m (the latter being the highest record in Piedmont, Bionda et al. 2013). In Piedmont the nominal subspecies *C. virgo virgo* and *C. virgo meridionalis* are both recognized and overlap with individuals with intermediate characters (Boano et al. 2007; Siesa 2017). The same pattern is observed in the adjacent Swiss Canton Tessin (Wildermuth et al. 2005).

2. Calopteryx splendens (Harris, 1780)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

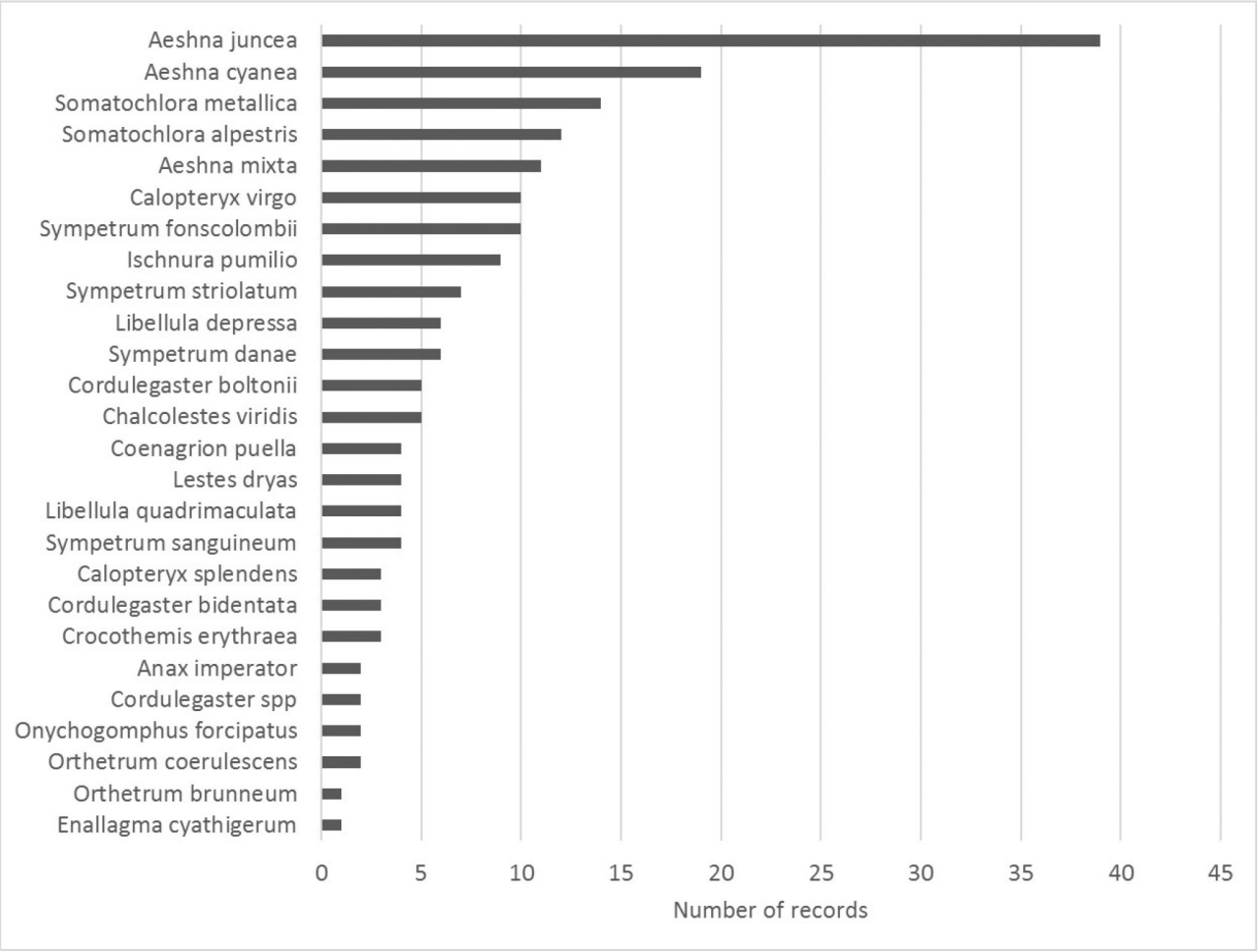

Fig. 2 – Frequency of records of odonates in VGNP.

This European lotic damselfly was observed along San Bernardino river in EXP (6). No further records came from higher sites, due to it being characteristic of lowlands, main valley bottoms and hills in Piedmont and Valle d'Aosta (Boano et al. 2007) and of its larvae not suited to inhabiting cold mountain streams (Riservato et al. 2014c). In Piedmont and in the adjacent Canton Tessin the subspecies *C. s. caprai* is reported (Boano et al. 2007; Wildermuth et al. 2005).

Lestidae

3. Chalcolestes viridis (Vander Linden, 1825)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This atlantic-mediterranean lentic damselfly was found in EXP (4,6) and PDS (15); in the latter a small breeding population was observed at around 1000 m, demonstrating a rather high elevation for reproduction. *C. viridis* occurs in the Alps, though it is more frequent below 600 m (Wildermuth 2005; Boano et al. 2007; Riservato et al. 2014c; Siesa 2017).

4. Lestes dryas (Kirby, 1890)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), NB

This holarctic lentic damselfly was recorded in LPO (10) and PDS (15); breeding was not confirmed, though observation of up to 4 males during three consecutive counts in PDS (11 and 27 Jul 2016, 19 Aug 2016) makes reproduction likely. Though considered quite common in the Western Italian Alps (Siesa 2017), Boano et al. (2007) reported a rather fragmented occurrence in Piedmont, which was confirmed by the preliminary Italian Atlas (Riservato et al. 2014c). A similar pattern of distribution was recorded in Switzerland, where *L. dryas* was not observed in the adjacent Canton Tessin (Wildermuth et al. 2005).

Coenagrionidae

5. Ischnura pumilio (Charpentier, 1825)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This palearctic lentic damselfly was observed in EXP (6) as breeding, and in LPO (8,9) and PDS (15) where reproduction was not confirmed. Boano et al. (2007) did not report it for the alpine area of Piedmont because of a lack of relevant data at the time; as a matter of fact, later surveys successfully recorded its presence in several sites of VCO, with some occurrences and breeding events reaching the highest elevations for the region (2050 m in Pompilio 2012; over 2200 m in Bionda et al. 2013). Further surveys are required in order to ascertain successful reproduction in VGNP.

6. Enallagma cyathigerum (Charpentier, 1840)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), NB

Two individuals belonging to this palearctic lentic species were observed in LPO (9). Breeding was not confirmed and further surveys are needed to confirm reproduction. This damselfly is frequent in mountainous areas of Italy, Piedmont and Swiss Canton Tessin (Riservato et al. 2014c; Boano et al. 2007; Wildermuth et al. 2005).

7. Coenagrion puella (Linnaeus, 1758)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This palearctic lentic species was recorded in EXP (6) and in PDS (15). It is reported as one of the most widespread and abundant damselflies in the plains and hilly areas in Italy, Piedmont, VCO and Canton Tessin, but it becomes less frequent in mountainous regions (Riservato et al. 2014c; Boano et al. 2007; Clemente et al. 2010; Wildermuth et al. 2005). Its occurrence and abundance seem scarce in VGNP, though further and earlier seasonal surveys are needed to define its distribution.

Aeshnidae

8. Aeshna juncea (Linnaeus, 1758)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This holarctic lentic dragonfly was widespread and abundant in VGNP, being recorded in 5 out of the 7 study areas (LPR, 18; LGE, 21; LPO, 7,8,9,10; CDB, 20; PDS, 15); it was missing from EXP, as this area predominantly lies at a low altitude, and from CPB where suitable standing water habitats are scarce. Reproduction was confirmed in 4 study areas; only in CDB it was not confirmed, despite the site containing a small natural pond lying at suitable altitude, and further visits would be required to establish reproduction. Larvae and *exuviae* were found in most ponds and lakes surveyed in LPO and LPR, where up to 300 larvae were observed in a single visit (LPO, 9, 28 Aug 2011, Clemente et al. 2011). *A. juncea* was reported as the most common and widespread dragonfly for the alpine area by Boano et al. (2007), though at the time only one unpublished record was available for VCO and two further observations had been retrieved from De Marmels & Schiess (1978), of which one was collected in Pian dei Sali. Later improved surveys allowed this species to be recorded in north eastern Piedmont and provided 11 new records for VGNP until 2013 (Clemente et al. 2011; Riservato et al. 2014c). This study added another 28 records, confirming *A. juncea* as the most abundant and widespread dragonfly in the park. Similar results have been observed in other alpine parks, including from west to east Mont Avic (Aosta Valley, Sindaco et al. 2008), Maritime Alps and Veglia Devero (Piedmont, provinces of Cuneo and VCO, Bionda et al. 2013; Pettavino 2015), Stelvio (Lombardy, province of Sondrio, Trentino and South Tyrol) and Texelgruppe (South Tyrol, Lösch et al. 2013).

9. Aeshna cyanea (Latrelle, 1805)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This eurosibiric lentic species was frequent, being reported in 5 out of 7 study areas (EXP, 2; LPO, 8,9,10; CPB, 13; PDS, 15; LPR, 18) and breeding in three (LPO, 8,9; PDS, 15; LPR, 18), with a further couple of records coming from non-systematic surveys. This dragonfly shows a wide ecological amplitude and can be seen flying from lowlands and valley bottoms up to altitudes in excess of 2000 m, though it is most abundant below 700 m; records become scarcer and isolated at high altitudes. In this study reproduction and metamorphosis were observed up to 1900 m. Breeding was reported also in other sites of the province of VCO, in adjacent Swiss Canton Grisons and in the Natural Park of Maritime Alps (Pompilio 2012; Pettavino 2015; Wildermuth et al. 2005).

De Marmels & Schiess (1978) observed it at Pian dei Sali; their record was reported by Boano et al. 2007, who described *A. cyanea* as one of the most widespread and frequent dragonflies of Piedmont, though at the time only one unpublished record was available for VCO. During subsequent surveys *A. cyanea* occurrence was confirmed in large parts of the province and 4 records were collected in VGNP (Clemente et al. 2011; Riservato et al. 2014c). During this research another 15 records were collected and this species was confirmed as frequent in the park.

10. Aeshna mixta (Mueller, 1764)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), NB

A. mixta is a palearctic lentic dragonfly which was recorded in EXP (2,4,6) and CPB (12); 2 further records were collected during surveys not targeted on odonates (municipality of Premosello Chiovenda, In La Piana, 46.056100 N 8.419550 E, 950 m, 21 Aug 2014). Breeding of this species was not confirmed in the study areas. Half of the observations refers to adults, single or in groups up

to 15 individuals, hunting over grasslands a long way from water bodies up to 1120 m. This dragonfly was reported as new for the Canton Tessin by De Marmels & Schiess (1978) and as uncommon for Piedmont and Valle d'Aosta by Boano et al. (2007), with only two records located in the alpine region at altitudes not exceeding 530 m. The preliminary Atlas of Italian dragonflies and damselflies reported a wider distribution in Piedmont, including 4 observations for VGNP and surrounding areas, all below 400 m (Riservato et al. 2014c). Seven additional records were collected during this survey. In Switzerland this dragonfly was not reported over 700 m (Wildermuth et al. 2005)

11. Anax imperator (Leach, 1815)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This large and powerful holomediterranean lentic dragonfly was recorded twice in EXP (3), where breeding was also confirmed.

A. imperator is mainly distributed in lowlands, plains and bottom valleys in Piedmont, Valle d'Aosta and Canton Tessin, though sporadic populations have been recorded at 1200 m in VCO (Boano et al. 2007; Bionda et al. 2013) and at 1425 m in Canton Tessin (Wildermuth et al. 2005). Thus, breeding inside VGNP cannot be excluded and further targeted surveys are needed.

Gomphidae

12. Onychogomphus forcipatus (Linnaeus, 1758)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), NB

Two mature males were observed in EXP (6). This euromediterranean lotic dragonfly is widely distributed in Piedmont where the subspecies *O. forcipatus unguiculatus* occurs (Riservato et al. 2014c; Boano et al. 2007), but it is scarce in the alpine valleys of the province of VCO (Clemente et al. 2011; Wildermuth et al. 2005; authors unpublished data). This subspecies was reported as new for Canton Tessin by De Marmels & Schiess (1978) and its presence was confirmed only in this area of Switzerland by Wildermuth et al. (2005).

Cordulegastridae

13. Cordulegaster boltonii (Donovan, 1807)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

Records relative to this central European – Atlantic lotic species were collected in EXP (1,6) where breeding was confirmed, and in CPB (11). This dragonfly is widespread in Piedmont and can also be found in the Alps, though its occurrence there is more scattered than at lower altitudes (Riservato et al. 2014c); the same pattern was observed in Canton Tessin (Wildermuth et al. 2005). A few higher records are reported for Piedmont, relative to altitudes of 1370 m and 1545 m in the provinces of Cuneo and VCO (Boano et al. 2007; Clemente et al. 2011), though reproductive sites are probably at lower altitudes. In the province of Torino, a likely breeding population was found at approximately 670 m (Giuliano 2017). For this reason, reproduction of this species seems possible inside VGNP and further research is required.

14. Cordulegaster bidentata (Selys, 1843)
Conservation and breeding status: NT (EU), LC (IT), NT (MED), B?

This endemic European lotic dragonfly was recorded in EXP (4), CPB (11) and CDB (19) study areas. No previous records are known for VGNP and the surrounding areas.

Breeding was not confirmed, although observation of territorial behaviour in CDB at 1200 m makes this a possibility. In Piedmont it was considered localized by Boano et al. (2007), who reported only one record for VCO taken from Capra & Galletti (1978). In the same period only two records were collected in Canton Tessin (De Marmels & Schiess 1978). The large database on which the Italian preliminary Atlas of dragonflies and damselflies is based confirms this conclusion (Riservato et al. 2014c); in Switzerland also, the records for this species are rare in the Alps (Wildermuth et al. 2005). Due to its habitat preference, small rivers, streams, brooks and seepages in wooded and shaded mountainous sites, *C. bidentata* may easily go undetected. Therefore, its distribution in VGNP could be greater and deserves further targeted research to ascertain distribution and confirm reproduction.

Four individuals of *Cordulegaster* spp. could not be caught and identified, of which, two were mating, thus one of the two species of *Cordulegaster* is certainly breeding in VGNP.

Corduliidae

15. Somatochlora alpestris (Selys, 1840)
Conservation and breeding status: LC (EU), LC (IT), NT (MED), B

This boreo-alpine lentic dragonfly was reported in 4 out of 7 study areas: namely LPO (8,10), LPR (18), CDB (20) and LGE (21); breeding was confirmed in CDB and LGE and deemed likely in the remaining two. *S. alpestris* was considered rare in Piedmont and Valle d'Aosta by Boano et al. (2007) and Sindaco et al. (2008) and no records were available for VCO at that time. Later surveys confirmed its presence along the alpine border of north eastern Piedmont (Bionda et al. 2013; Riservato et al. 2014c). Records collected during this study are the first to confirm its presence in PNVG and are spatially separated from the main Alpine ridge by Vigezzo valley. De Marmels & Schiess (1978)

also reported the occurrence of *S. alpestris* as new in Canton Tessin (apart from an old record dating back to 1880), though they immediately recognized it as the most frequent corduliid; however, they did not collect any observations further south than Vigezzo valley; the same geographic distribution was confirmed by Wildermuth et al. (2005).

The autocthony of *S. alpestris* in the Orobian Prealps (province of Brescia, Lombardy) was described as an interesting record by Gheza (2015) on the basis of its boreo-alpine chorology and Italian distribution, which is limited to the inner part of the Alps, with only a few records coming from the Prealps. Though its occurrence was reported in all Italian alpine regions and despite it being a generalist dragonfly (Riservato et al. 2014c), many of its isolated populations are considered at risk of substantial alterations due to anthropic intervention or significant changes in climate, because they are scattered and found only in the Alps (Zandigiacomo et al. 2014; Wildermuth et al. 2005; Assandri 2019). *S. alpestris* distribution may be underestimated because suitable habitats are often located in remote high-altitude sites and populations are accounted for by a few individuals (Wildermuth et al. 2005; Sindaco et al. 2008; Pettavino 2015).

16. Somatochlora metallica (Vander Linden, 1825)
Conservation and breeding status: LC (EU), LC (IT), NT (MED), B?

The congeneric euro-sibiric lentic *S. metallica* is a lowland species which was observed frequently in EXP in slow running water habitats (4,6); breeding was not confirmed, although it seems likely. Boano et al. (2007) reported it as the most common and widespread corduliid in Piedmont, though records from VCO were still missing at the time; *S. metallica* was later reported to be common also in north eastern Piedmont, mostly at low altitudes and in the central and southern part of the province, including one record from EXP (Clemente et al. 2011). All data collected in this survey represent new sites of occurrence for VGNP and VCO. *S. metallica* was the third most abundant species in the park.

Libellulidae

17. Libellula depressa (Linnaeus, 1758)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), NB

L. depressa is a central Asian - European lentic dragonfly which was recorded in EXP (4,6) and PDS (15); breeding however was not confirmed. It is a dragonfly characteristic of altitudes below 700 m in the Alps (Siesa 2017). Boano et al. (2007) reported it as widely distributed and common up to 600 m in the Piedmont plains and lowlands, whereas its occurrence in the Alps was limited to some records from Ligurian and Maritime Alps; the same pattern of altitudinal distribution was observed in Switzerland (Wildermuth et al. 2005). Later surveys revealed more observations for Piedmont, including some records penetrating the main alpine valleys (Riservato et al. 2014c). In VGNP the highest record was collected in PDS at 937 m (7 Jul 2013, two individuals); here, the species was not recorded again during the course of repeated surveys in 2016. Further research is thus needed to confirm its distribution and reproduction status around and inside VGNP, which cannot be excluded considering the observation of a metamorphosis at 1132 m and of a territorial male at 1750 m in VCO (Clemente et al. 2011).

18. Libellula quadrimaculata (Linnaeus, 1758)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

L. quadrimaculata is a holarctic lentic dragonfly which was observed in PDS (15) where up to 20 individuals were seen to congregate (11 Jul 2016) and breeding was confirmed. This species was considered locally common and well distributed in the Alpine valleys of Piedmont (Boano et al. 2007), a pattern confirmed by the Italian preliminary Atlas (Riservato et al. 2014c). Territorial males were observed over 2000 m and breeding up to 1890 m in VCO, Maritime Alps (province of Cuneo, Piedmont) and Mont Avic (Val d'Aosta) Natural Parks (Clemente et al. 2011; Pompilio 2012; Bionda et al. 2013; Pettavino 2015; Sindaco et al. 2008); thus, further surveys would be needed to ascertain its occurrence at higher altitudes in VGNP.

19. Orthetrum coerulescens (Fabricius, 1798)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), NB

Two records relative to this palearctic lentic species were collected in EXP in habitats of slowly running water (4,6); breeding was not confirmed. Until 2007 *O. coerulescens* was reported as widely occurring in plains and hilly areas of Piedmont, but lack of data relative to its presence in the alpine valleys at the time led authors to consider its occurrence unlikely in the Alps (Boano et al. 2007). Later improved data collection confirmed its presence in the valleys (Riservato et al. 2014c), including the province of VCO where 5 records came from altitudes ranging from 700 m to 1975 m (Clemente et al. 2011; authors unpublished data). Thus, further surveys are needed to ascertain its presence at higher altitudes inside and around VGNP.

20. Orthetrum brunneum (Fonscolombe, 1837)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), NB

Only one record relative to this palearctic lentic dragonfly was collected in EXP (6) and breeding was not confirmed. Until 2007 this species was reported as evenly distributed in plains and hills in Piedmont (Boano et al. 2007); later surveys confirmed a wider area of occurrence, which

expands over the rice growing districts and penetrates the alpine valleys, including the province of VCO where a couple of records were collected over 1300 m (Riservato et al. 2014c; Clemente et al. 2011).

21. Crocothemis erythraea (Brullé, 1832)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B?

This afro-mediterranean lentic dragonfly was recorded in EXP (6) and PDS (15); in the latter, reproduction was considered likely in a pond at around 1000 m. Two historic records were reported for the municipality of Villette in Vigezzo valley, which lies near Pian dei Sali, by De Carlini (1892) and Bentivoglio (1908a, in Capra & Galletti 1978), but they were considered doubtful by Boano et al. 2007. The Atlas of Piedmont reported *C. erythraea* as widespread and abundant in the plains and hills of Piedmont below 600 m and its population trend was reported as increasing. As for other species, further surveys confirmed a wider distribution in the Alps (Clemente et al. 2011; Riservato et al. 2014c), although most populations reproduce below 500 m and records as high as 2000 m refer to dispersing individuals (Bionda et al. 2013; Pettavino 2015; Siesa 2017). In Switzerland its distribution is limited to low elevations also and the species is absent from Alpine highlands (Wildermuth et al. 2005).

Due to their quick response to global warming, dragonflies are good indicators of climate change (McNeely 2010); thus, increasing records of this thermophilic species at high altitudes in the Alps could really be linked to a genuine expansion on a 10-15 year time span, rather than to an earlier lack of relevant data and further surveys are needed to confirm reproduction in PNVG and surrounding areas. Indeed, *C. erythraea* expansion was already well documented north of the Alps 10 years ago (Krokhalo 2010, Ott 2010, Parr 2010) and has been recently confirmed as moderate on a European scale (Termaat et al. 2019).

22. Sympetrum fonscolombii (Selys, 1840)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), NB

S. fonscolombii is a holarctic lentic dragonfly that was recorded in LPO (8,9) and CPB (11,12,14); breeding was not confirmed although two immature individuals were observed in CPB, but this does not provide solid evidence of reproduction. This dragonfly tends to be gregarious at the end of summer, when large swarms may be observed. It was the fifth most abundant species in VGNP and surrounding areas and its numbers may have been underestimated, as 4 records refer to groups of uncounted individuals. *S. fonscolombii* is a migrant and can be found at high altitudes during migration (Borisov et al. 2020). In Piedmont it is widespread and abundant and it can be observed from the plains up to the Alps; the majority of records come from sites below 600 m, although reproduction was reported as exceptionally high at 2200 m (Wildermuth et al. 2005; Boano et al. 2007). Later surveys revealed that this species occurs in almost the whole alpine area of Piedmont (Riservato et al. 2014c); due to its migratory behaviour, most records coming from high elevations refer to either isolated or groups of dispersing individuals (Bionda et al. 2013; Pettavino 2015).

23. Sympetrum striolatum (Charpentier, 1840)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This palearctic lentic species was recorded and breeding confirmed in EXP (4,6) and PDS (15). Two historic records were reported for the municipality of Craveggia in Vigezzo valley, which lies on the northern slope opposite to the VGNP boundary, by De Carlini (1892) and Bentivoglio (1908a, in Capra & Galletti 1978); this data were cited by Boano et al. (2007), who reported it as widespread in low hilly areas and plains in Piedmont but missing from the rice growing district and localized in alpine valleys. This evaluation was probably influenced by the limited availability of data at the time, as later surveys showed that its distribution includes many alpine valleys in Piedmont, except in the south of the region (Riservato et al. 2014c). Most breeding populations are reported below 800 m in Switzerland (Wildermuth et al. 2005) and records are concentrated below 500 m in VCO. Therefore, the breeding population that was observed in PDS at ca 950 m is at a rather high and unusual elevation for the region.

24. Sympetrum sanguineum (Mueller, 1764)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This palearctic lentic dragonfly was reported in EXP (4,6), where breeding was confirmed, and in PDS (15). Boano et al. (2007) reported it as one of the most common dragonflies in Piedmont, widespread in low hills and lowlands but apparently localized and less frequent on inner reliefs and rarely penetrating alpine valleys over 1000 m. Later surveys carried out in the region confirmed a wider distribution which includes alpine valleys (Riservato et al. 2014c). Still, reproduction is not common above 900 m (Siesa 2017; Wildermuth et al. 2005). In the province of VCO few observations come from sites at altitudes above 1200 m and some of these records provide evidence for breeding (Clemente et al. 2011), thus further surveys are needed to ascertain the occurrence and reproduction of this species within VGNP.

25. Sympetrum danae (Sulzer, 1776)
Conservation and breeding status: LC (EU), LC (IT), LC (MED), B

This circumboreal lentic dragonfly was recorded and observed as breeding in LPO (7) and PDS (15); in

the latter, two groups of 20 and 30 individuals were observed in two sites 135 m apart (9 Sep 2016) and an intense period of copulation and oviposition was recorded. De Marmels & Schiess (1978) reported this species for the Vigezzo valley, in the municipality of Santa Maria Maggiore which is situated ca 5 km from VGNP boundary. It was the second most abundant species for the park and surrounding areas. In Italy the occurrence of *S. danae* is limited to the Alps (Riservato et al. 2014c). In Piedmont it is rather localized in a few alpine valleys, including Val d'Ossola (Boano et al. 2007) where later surveys revealed it to be more widely distributed (Clemente et al. 2011; Bionda et al. 2013). A similar pattern relative to distribution and elevation was observed in adjacent Swiss Cantons Tessin and Valais (Wildermuth et al. 2005). Though occurring in all Italian Alpine regions and not being listed in any red list, *S. danae* shows a scattered distribution and is often represented by small populations which may suffer from climate change and desiccation of suitable habitats in the future (Assandri 2019; Boudot et al. 2009; Gheza 2013; Sindaco et al. 2008; Zandigiacomo et al. 2015).

Discussion

Prior to this study, existing knowledge on dragonfly and damselfly fauna was limited to 6 species for the VGNP area, which were recorded in Vigezzo valley (municipalities of Santa Maria Maggiore, Craveggia and Re) close to the park's northern border but not within it.

The odonate checklist for VGNP and surrounding areas presented here consists of 25 species, which represent 26% of the 96 species recorded in Italy, 36% of the 69 species of Piedmont and 58% of the 43 species reported for VCO (Clemente et al. 2011; Corso & Penna 2020; Piretta & Assandri 2019; Riservato et al. 2014c; Viganò et al. 2017). Species richness is high considering that it refers to an area of approximately 152 km^2, which was surveyed opportunistically concentrating visits in accessible suitable wetlands and aquatic habitats. Our results agree with recent research on diversity of European odonates, which demonstrates that the Alps are a hotspot for diversity due to the co-occurrence of Mediterranean species in the lowland and boreal species at higher altitudes (Kalkman et al. 2018). Bearing this in mind, VGNP and surrounding areas are favourable sites as they span from the main Alpine ridge in the north to the Insubric region in the south. High rainfall coupled with moderate mean temperatures (Biancotti & Costamagna 2001) and a complex orography also determine a wide availability of small suitable vegetated aquatic habitats. When considering exclusively the study areas within VGNP, species richness decreased to 10 *taxa* and breeding was confirmed for only four species and was considered likely for further two (Table 2).

Other Italian alpine protected areas show odonate communities of lower to similar richness. In Stelvio National Park and surroundings (Lombardy region) Sindaco et al. (2017) recorded 18 species (4 damselflies and 14 dragonflies), 6 inside the protected area; in Dolomiti Bellunesi National Park and surroundings (Veneto region), Leandri (2017) reported the occurrence of 25 species (9 damselflies and 16 dragonflies) of which 13 occurred inside the park. As for regional parks, Sindaco et al. (2008) reported 9 species (3 damselflies and 6 dragonflies) in Mont Avic (Valle d'Aosta region), whereas Pettavino (2015) and Bionda et al. (2013) observed 15 species (4 damselflies and 11 dragonflies in both checklists) in Maritime Alps and Veglia-Devero (Piedmont region, provinces of Cuneo and VCO); in the latter, 17 *taxa* were recorded if additional suitable sites lying outside were included. Moving further east to South Tyrol (province of Bolzano), in Texelgruppe Natural Park a total of 15 species were recorded, of which 10 inside the park boundaries (Lösch et al. 2013), whereas in Monte Corno Natural Park a total of 22 species were observed (Festi et al. 2009). Finally, as for non-protected areas, 13 species (3 damselflies and 9 dragonflies) on Borno plateau (Lombardy region, province of Brescia, Gheza 2013, 2015) and 19 species on Schlern Massif (South Tyrol, province of Bolzano, Haller et al. 2008).

As for conservation status, three species occurring in VGNP and surrounding areas are of concern: *Cordulegaster bidentata* is listed as Near Threatened by the European and Mediterranean red lists (Kalkman et al. 2010; Riservato et al. 2009), whereas *Somatochlora alpestris* and *S. metallica* are listed as Near Threatened by the Mediterranean red list. None of the other species are included in a category of threat by the European, Mediterranean or Italian red lists (Riservato et al. 2014b) or in the European Habitat Directive.

Nevertheless, we highlight the importance of our results from a regional perspective. Firstly, they provide evidence to the key role played by alpine sites as reservoirs of high odonate species diversity, especially those areas consisting of inner reliefs, shaped by harsh weather, along with mountainous and hilly landscapes enjoying milder climatic conditions, as is the case of this study area. Secondly, VGNP and surroundings areas host 5 lotic species; running water dragonflies and damselflies are concentrated in south-western Europe and are under particular pressure in large parts of the Mediterranean because of prolonged droughts and increased human exploitation of freshwater (Boudot et al. 2015); being mostly habitat specialists, their colonization potential is limited by wide fragmentation of suitable habitats (Kalkman et al. 2018). Some studies carried out at regional to local scale in the southern Alps highlighted their conservation value and or reported decreasing trends (Riservato et al. 2014a; Pettavino 2015; Lösch et al. 2018). Thirdly, VGNP and surrounding areas host boreal species such as *Somatochlora*

Table 2 – List of dragonflies and damselflies observed in VGNP and surrounding areas and relative abundance. Study areas labels as in Table 1, besides OTH=other. For each *taxon* the number of individuals counted per study area and in total (Tot) is reported, VGNP column lists species observed inside the park (*). Nomenclature and taxonomic order follow Riservato et al. (2014c).

	Abundance									
	EXP	LPO	CPB	PDS	LPR	CDB	LGE	OTH	**Tot**	**VGNP**
Calopteryx virgo	47			5					**52**	
Calopteryx splendens	15								**15**	
Chalcolestes viridis	15			9					**24**	
Lestes dryas		1		8					**9**	*
Ischnura pumilio	11	12		2					**25**	*
Enallagma cyathigerum		2							**2**	
Coenagrion puella	8			13					**21**	
Aeshna juncea		571		13	28	1	6	2	**621**	*
Aeshna cyanea	14	5	1	19	3				**42**	*
Aeshna mixta	17		16					2	**35**	*
Anax imperator	2								**2**	
Onychogomphus forcipatus	2								**2**	
Calopteryx virgo	47			5					**52**	
Calopteryx splendens	15								**15**	
Chalcolestes viridis	15			9					**24**	
Lestes dryas		1		8					**9**	*
Ischnura pumilio	11	12		2					**25**	*
Enallagma cyathigerum		2							**2**	
Coenagrion puella	8			13					**21**	
Aeshna juncea		571		13	28	1	6	2	**621**	*
Aeshna cyanea	14	5	1	19	3				**42**	*
Aeshna mixta	17		16					2	**35**	*
Anax imperator	2								**2**	
Onychogomphus forcipatus	2								**2**	
Cordulegaster bidentata	1		2			2			**5**	*
Cordulegaster boltonii	14		1						**15**	*
Cordulegaster spp			3					1	**4**	*
Somatochlora alpestris		13			5	1	2		**21**	*
Somatochlora metallica	28								**28**	

	Abundance									
	EXP	LPO	CPB	PDS	LPR	CDB	LGE	OTH	**Tot**	**VGNP**
Crocothemis erythraea	1			4					**5**	
Libellula depressa	12			2					**14**	
Libellula quadrimaculata				30					**30**	
Orthetrum brunneum	1								**1**	
Orthetrum coerulescens	3								**3**	
Sympetrum fonscolombii		3	42						**45**	*
Sympetrum striolatum	18			40					**58**	
Sympetrum sanguineum	21			1					**22**	
Sympetrum danae		2		70					**72**	*
Total abundance	**230**	**609**	**65**	**216**	**36**	**4**	**8**	**5**	**1173**	
Number of species	**18**	**8**	**5**	**13**	**3**	**3**	**2**	**3**	**25**	**10**
Number of counts	19	17	8	6	2	1	1	3	58	
Number of records	72	49	12	37	7	3	4	3	187	
Inds/count	12.11	35.82	8.13	36.00	18.00	4.00	8.00	1.67	20.58	
Species/count	0.95	0.47	0.63	2.17	1.50	3.00	2.00	1	0.44	
Records/count	3.79	2.88	1.50	6.17	3.50	3.00	4.00	1	3.28	

alpestris and *Sympetrum danae* that, although classified as Least Concern on a European scale, possess a genuine conservation value on a regional scale where they may not enjoy a comparable status (Assandri 2019; Gheza 2013 and 2015; Pettavino 2015; Sindaco et al. 2008). Many populations of these cold-dwelling dragonflies breed in small to very small high-altitude peatbogs and wetlands, which are threatened by natural siltation, disturbance by cattle or uncontrolled tourism activities. Furthermore, many populations may face threats due to marginal or relict distributions in low-quality habitats and because of sensitivity to global warming and desiccation of breeding habitats (De Knijf et al. 2011; Riservato et al. 2009; Suhonen et al. 2010; Termaat et al. 2018). Even a very common dragonfly in Piedmont and northern Italy such as eurosibiric *Somatochlora metallica* may face conservation threats in the Mediterranean soon and already shows a decline at the south-western and south-eastern edges of its alpine range (Lambret et al. 2017; Riservato et al. 2009; Siesa 2017).

This research fills a gap in the knowledge of VGNP fauna in terms of an important group of insects. Insect conservation and status have received increasing public attention in recent years due of the awareness of declines in populations; still, invertebrates are largely neglected in conservation effort where "vertebratism" prevails (Cardoso et al. 2020). Parks and protected areas have traditionally promoted studies and research first on mammals and birds and only later on other vertebrates, which may appeal less to visitors; following the evolutionary line in reverse, invertebrates and insects come last, apart from *taxa* which are listed in Habitats Directive or are endemics (Vigna Taglianti et al. 1998). Indeed, in VGNP, studies have been published on mammals (AA.VV. 2014; Torretta et al. 2017), birds (Movalli & Grimaldi 1996; Laiolo et al. 2004a, 2004b; Casale et al. 2014) and reptiles and amphibians (Laddaga 2019).

Apart from possessing an intrinsic value that all species share as unique combinations of evolutionary events, odonate systematic monitoring is also important to track global warming and consequent habitat and biodiversity alterations. This study reinforces and supports that monitoring this taxonomic group may be advanced by citizen science. Furthermore, odonates respond more quickly to

Table 3 – Breeding status of dragonflies and damselflies observed in VGNP and surrounding areas. For each *taxon*, comprehensive (Total) and study area status is reported (labels as in Table 1, besides OTH=other; B=breeding, B?=likely breeding, blank=breeding not confirmed), VGNP column lists species breeding inside the park (*). Nomenclature and taxonomic order follow Riservato et al. (2014c).

	Reproduction									
	EXP	LPO	CPB	PDS	LPR	CDB	LGE	OTH	**Total**	**VGNP**
Calopteryx virgo	B								**B**	
Calopteryx splendens	B								**B**	
Chalcolestes viridis	B?			B					**B**	
Lestes dryas										
Ischnura pumilio	B								**B**	
Enallagma cyathigerum										
Calopteryx virgo	B								**B**	
Calopteryx splendens	B								**B**	
Chalcolestes viridis	B?			B					**B**	
Lestes dryas										
Ischnura pumilio	B								**B**	
Enallagma cyathigerum										
Coenagrion puella	B			B					**B**	
Aeshna juncea		B		B	B	B?	B		**B**	*
Aeshna cyanea		B		B	B				**B**	*
Aeshna mixta										
Anax imperator	B								**B**	
Onychogomphus forcipatus										
Cordulegaster bidentata						B?			**B?**	
Cordulegaster boltonii	B								**B**	
Cordulegaster spp			B							
Somatochlora alpestris		B			B	B?	B?		**B**	*
Somatochlora metallica	B?								**B?**	
Crocothemis erythraea				B?					**B?**	
Libellula depressa										
Libellula quadrimaculata				B					**B**	
Orthetrum brunneum										
Orthetrum coerulescens										
Sympetrum fonscolombii										
Sympetrum striolatum	B			B					**B**	
Sympetrum sanguineum	B								**B**	
Sympetrum danae		B		B					**B**	*
Number of breeding species	**8**	**4**	**1**	**7**	**3**	**0**	**1**	**0**	**14**	**4**

climate change than other faunistic groups and freshwater invertebrates (Termaat et al. 2019) and are demonstrated indicators of terrestrial habitat degradation, at least in tropical rainforest (Dolný et al. 2012). Thus, standardized monitoring should be repeated frequently in order to track any ongoing trends and volunteering becomes an invaluable tool for conservation efforts.

Results presented here are certainly not exhaustive and further surveys are needed to confirm the occurrence of additional species which have been recorded in the past in VGNP and surrounding areas (*Somatochlora flavomaculata* and *Sympetrum vulgatum,* De Marmels & Schiess 1978; *Sympetrum pedemontanum*, Boano et al. 2007)

This study results could also be used to inform and guide future decisions concerning potential enlargement of the protected area, that VGNP administrative authorities and politicians might assume. For example, EXP study area falls outside the administrative boundaries but hosts the largest odonate species diversity, so its inclusion in the park is evaluated as a positive move forward by our survey. PDS too hosts a rich diversity along with high numbers of individuals of 7 *taxa*; furthermore, *Libellula quadrimaculata* was reported solely in this site and *Sympetrum danae* was represented by an abundant breeding population; thus, future expansion to include it would increase VGNP biodiversity and favour the conservation of odonates and other freshwater *taxa*.

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