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Orthopteran diversity and distribution in the Monviso Natural Park (Western Italian Alps) (Orthoptera)

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Abstract
The Alps represent a biodiversity hotspot in Europe, especially due to the occurrence of many endemic plant and animal species. In particular, the southwestern portions of the Alpine range have been identified as a centre of endemism for many taxa, including Orthoptera, thanks to the peculiar biogeographical history of this area. In this research, the orthopteran fauna living in one of the main massifs of the Italian western Alps (Monviso massif, Cottian Alps) was investigated, focusing on the Monviso Natural Park and the SAC/SPA IT1160058 "Gruppo del Monviso e Bosco dell'Alevé" territories. Merging field data with information gathered from bibliographical sources, public and private databases, a checklist of 51 species was compiled for the study area, including 7 W-Alpine endemic species and 4 *Near-threatened taxa* according to the European IUCN orthopteran Red List. Species distribution has been mapped in detail within the park, identifying core areas for endemic and near-threatened species, as well as for the overall orthopteran diversity, where desirable research and conservation efforts should be focused in future. In addition, combining field data with the information obtained by means of a little systematic review, the known elevation extremes of 43 orthopteran species observed in the study area are updated for the W-Alpine region, significantly improving the current knowledge on their altitudinal distribution in this area, especially in view of the upward range shifts expected in the ongoing climate change scenario.

Key words: Checklist; endemic species; near-threatened species; elevation; systematic review; Cottian Alps.

Introduction

Mountain systems have been recognised at global scale as hotspots of biological diversity (Lomolino 2001; Körner & Spehn 2003), especially because they often encompass different biomes (and the associated biodiversity) along the altitudinal gradient, enclosing in a relatively small area many habitats otherwise distributed across a broader latitudinal cline (Körner & Spehn 2003). In addition, high elevation areas are frequently subjected to geographic isolation, which can facilitate the occurrence of speciation processes, including the differentiation of endemic species (Lomolino 2001).

The Alps represent a significant example of biodiversity hotspot in Europe (Nagy et al. 2012), encompassing a wide elevation range (0-4810 m) in the transition area between the Mediterranean and the continental biogeographical regions. Numerous endemic species evolved in this mountain range, resulting from speciation events triggered by geographic isolation, biogeographical history (i.e. Pleistocene glaciations), species' ecological requirements and dispersal capacity (Smyčka et al. 2017). Accordingly, endemic species are not randomly distributed in the Alps, mostly showing distribution patterns which roughly correspond to the extent of glacial refugia occurred during the Quaternary ice ages (Schönswetter et al. 2005; Smyčka et al. 2017). For instance, a phylogeographical study demonstrated that one of these refugia was probably located in the southwestern Alps (Schönswetter et al. 2005), a region today characterized by a high number of endemic plants (Aeschimann et al. 2011) and animals (Minelli et al. 2005), making this area one of the most biodiversity-rich in Europe (Médail & Myers 2004). In particular, the western Alps represent a centre of endemism for many insect groups, such as butterflies (Van Swaay et al. 2010), saproxylic beetles (Nieto et al. 2010), wild bees (Nieto et al. 2014) and orthopterans (Kenyeres et al. 2009; Hochkirch et al. 2016).

Focusing on Orthoptera, this order is represented in the western Alps by at least 164 species (Sardet et al. 2015; Sindaco et al. 2012), among which 18 (11%) show a distribution restricted to this sector of the alpine range. Overall, the relatively high orthopteran diversity observed in the alpine region (e.g. 97 species occur in the western Po plane, while 70 are known in the northern Apennines; Sindaco et al. 2012) is largely due to the co-occurrence in the same geographical area of several thermophilus species,

mainly distributed at low elevations, and taxa specifically adapted to survive to the high-altitude harsh climatic conditions. In this context, the orthopteran species richness generally declines with increasing elevation (Battisti et al. 2016; Giuliano et al. 2017; Pitteloud et al. 2020), resulting in species-poor assemblages at high elevation often composed by exclusive taxa (i.e. distributed in the alpine and subalpine belts only; Giuliano et al. 2017) and by a high proportion of endemic species (61% of the W-Alpine endemic Orthoptera primarily lives above 2000 m; Sardet et al. 2015; Sindaco et al. 2012), as observed in other animal groups (Viterbi et al. 2013).

Unfortunately, the restricted distribution and the specific ecological requirements of many high-altitude species may increase their vulnerability to environmental alterations, either due to land use modifications or to climate change effects, making these Orthoptera among the most threatened of extinction in Europe (Hochkirch et al. 2016). Since the biology, ecology and distribution of many of these species are relatively little known, further research on alpine orthopterans has therefore to be promoted, in order to obtain useful data for conservation purposes, especially in the framework of protected areas and in the Natura 2000 network.

The Monviso massif (Cottian Alps) is one of the most biodiversity-rich areas in the western Alps, thanks to its particular bioclimatic conditions and to the occurrence of several endemic plant and animal species, among which the Lanza's Salamander (*Salamandra lanzai*) is definitely the most emblematic. In 2016, the Italian slopes of the Monviso peak have been included in a new protected area, the Monviso Natural Park, mostly corresponding to the previously established Natura 2000 site SAC/SPA IT1160058 "Gruppo del Monviso e Bosco dell'Alevé". Despite the biogeographical significance of the area for orthopteran diversity (i.e. western Alps; see Hochkirch et al. 2016), no detailed studies on these insects have been performed in the newly-established park territory so far, except for few data concerning the occurrence of 18 species only, among which 5 are W-alpine endemics (Ruffo & Stoch 2005; Sindaco 2006).

In this research, a detailed description of the orthopteran fauna living in the Monviso Natural Park and in the SAC/SPA IT1160058 "Gruppo del Monviso e Bosco dell'Alevé" is provided, in order to fill the existing knowledge gaps about these insects in the protected area, focusing in particular on endemic and threatened taxa. Besides the compilation of a simple checklist, this study aims to map the distribution of each species in the study area, providing a basic tool for the future implementation of management strategies addressed to achieve Orthoptera conservation in the park.

Since a wide elevational range has been explored in this research, a further objective of this work is to update the current knowledge about the orthopteran altitudinal distribution in Italy and in the neighbouring W-Alpine countries (at least concerning the species observed in the Monviso Natural Park), integrating the data collected in the field with the information gathered from a systematic review of recent literature.

Material and methods

The Monviso Natural Park and the SAC/SPA IT1160058 "Gruppo del Monviso e Bosco dell'Alevé" (hereafter "MNP") cover together an area of 9623 ha in the Cottian Alps (Cuneo, Piedmont, northwestern Italy), between 770 m and 3841 m, including part of the territory of 7 municipalities in the upper Po and Varaita valleys (Casteldelfino, Crissolo, Oncino, Ostana, Paesana, Pontechianale and Sampeyre; Fig. 1). A relatively high habitat diversity occurs along the altitudinal gradient within the protected area, ranging from meadows and mixed broadleaved woodlands at low elevations, to subalpine coniferous forests and shrublands, until high-altitude alpine grasslands, screes, perennial snows and glaciers (the latter only near the top of the Monviso peak). In particular, the "Bosco dell'Alevé" Swiss pine forest covers about 825 ha in the Varaita valley, representing one of the most significant examples of this habitat in the whole alpine range.

Furthermore, an additional contribution to the environmental heterogeneity in the MNP is provided by the different climatic conditions that occur on the two opposite slopes on the Monviso massif (North-East and South-West), especially concerning precipitation regimes. Indeed, a high amount of precipitations is observed in the upper Po valley (1076.8 mm/year; Crissolo, 1422 m; 2001-2011; ARPA Piemonte database), while the upper Varaita valley is characterized by a drier climate (699.7 mm/year; Pontechianale, 1575 m; 2001-2011; ARPA Piemonte database), although similar temperatures are recorded in these two sectors of the study area (average 2001-2011, Crissolo: 6.34°C; Pontechianale: 6.07°C; ARPA Piemonte database).

In order to simplify a systematic and exhaustive exploration of the MNP during the research, the protected area has been subdivided in 139 1x1 km cells, basing on the UTM grid (zone 32 N) (Fig. 1). The resulting lattice (13900 ha) has been considered as study area, also including some territories adjacent to the park/SAC/SPA. Field surveys were carried out with the aim to explore many 1x1 km cells as possible, even if sampling locations were strongly influenced by their accessibility, often depending from the availability of paths or roads. Each cell has been explored aiming to investigate all the available environmental units, focusing in particular on open and ecotone areas (i.e. habitats generally preferred by orthopterans).

Data were collected in sunny days (time slot: 10 A.M. - 5 P.M.) between May and November in 2019 and 2020, but

focusing in the period of maximum orthopteran activity in alpine ecosystems (i.e. July-September). In each locality, the orthopteran community was investigated by means of a non-standardized survey around a georeferenced point, combining two sampling methods known to optimise species detection in alpine grassland habitats (Mourguiart et al. 2020): listening and visual census. In particular, each sampling site was explored without a fixed time or surface limits, taking note of elevation, habitat, and species heard or observed, until the overall orthopteran assemblage appeared to be detected.

Species identification was first achieved without capturing individuals, by listening the species-specific stridulations and comparing them directly in the field with the recordings provided by Odé (2012). However, this technique alone is not sufficient to detect all the orthopteran species in a given area, since some taxa do not produce any audible sound or their occurrence might be missed in high background noise conditions (e.g. co-occurrence of many singing individuals, a close waterfall, etc.). Therefore, orthopterans were also visually searched and captured by hand in each surveyed locality, examining directly in the field the morphological traits required for a correct species recognition, following the keys provided by Massa et al. (2012) and Sardet et al. (2015). Despite most specimens were released after identification, in some cases the collected individuals were suppressed in a 95% alcohol solution, examined in laboratory (especially when a stereomicroscope or a dissection were required to notice key morphological characters, e.g. for *Tetrix* sp. or *Anonconotus* sp. specimens), and included in a reference collection preserved by the author.

The completeness of the 2019-2020 field surveys has been visually checked by means of a species-sample rarefaction curve (Gotelli & Colwell 2001), calculated using the *specaccum* function of the *vegan* package (version 2.5-6; Oksanen et al. 2019) in the *R* software (ver. 4.0.2; R Core Team 2020). This analysis is commonly used in biotic inventories, since it provides an estimate of the species richness observed in a given area applying an infinite sampling effort. When the curve tends to an asymptote, the species pool sampled is close to the statistically expected values, thus in theory corresponding to an exhaustive survey.

In addition to field surveys, the orthopteran checklist has been integrated with some bibliographical information concerning the study area, as well as with data from public and private databases, all updated at October 2020. In particular, the *CkMap* database (Ruffo & Stoch 2005) and the *Piemonte Region Naturalistic Database* (PRND; http://www.regione.piemonte.it/bdnol/RicercaAction.do) were consulted, together with the data uploaded by some authors on the *iNaturalist* website (https://www.inaturalist.org). Furthermore, Marco Bonifacino (MB) and Roberto Sindaco (RS) made kindly available some recent data included in their archives.

Once a final orthopteran list was available, each species was assigned to a chorological category, following Vigna Taglianti et al. (1992, 1999) and basing on the available data about their global distribution, as reported by Cigliano et al. (2020), Massa et al. (2012), and the IUCN Red List website (www.iucnredlist.org). In addition, the conservation status of each taxon has been considered, referring to the European IUCN Red List of grasshoppers, crickets and bush-crickets (Hochkirch et al. 2016).

Lastly, in order to update the current knowledge about the orthopteran altitudinal distribution in Italy and in the neighbouring W-Alpine countries (i.e. France and Switzerland), the elevational range of each species found in the MNP has been compared with the data reported in the publications resulted from a systematic review of recent literature, updated at January 2021. Accordingly, a list of suitable bibliographical sources was compiled by means of a three-steps process: (1) first, a search in the *Web of Science*, *Scopus* (including secondary documents) and *Google Scholar* (first 30 pages, patents and citations excluded, with items ordered by relevance) databases was performed, using the key words reported in Tab. 1, from which (2) each paper reporting elevation data was selected and (3) finally inspected to verify the availability of information regarding the target species. Concerning Italy, only items published after 2012 were included in the review (i.e. after Massa et al. 2012), while only *post*-2015 publications were considered regarding the French and Swiss territories (i.e. after Sardet et al. 2015).

Results

In 2019-2020, the orthopteran fauna in the MNP has been investigated in 395 localities, scattered in almost the whole territory covered by the protected area (Fig. 1). Twenty-eight additional sampling sites were reported in literature or in the consulted databases (Fig. 2), overall resulting in 423 survey points, in which a total number of 1290 observations were recorded (1200 collected by the author; 32 gathered from the available literature or *CkMap*; 11 from the PRND; 10 from *iNaturalist*; 17 from MB; 20 from RS). Ninety-five out of 139 1x1 km cells were investigated, corresponding to the 68.3% of the study area (Fig. 3).

Overall, the MNP's orthopteran checklist includes 51 species (20 ensifera and 31 caelifera), 49 of which were observed by the author in 2019-2020, while the occurrence of 2 taxa was reported in literature or in the consulted databases only. According to the species-sample rarefaction curve (Fig. 4), this species richness closely resembles the statistically expected values in the study area (about 50 species), allowing to assume that an adequate sampling effort has been applied in this research.

The southernmost and north-eastern sectors of the study area proved to host the higher orthopteran diversity (Fig.

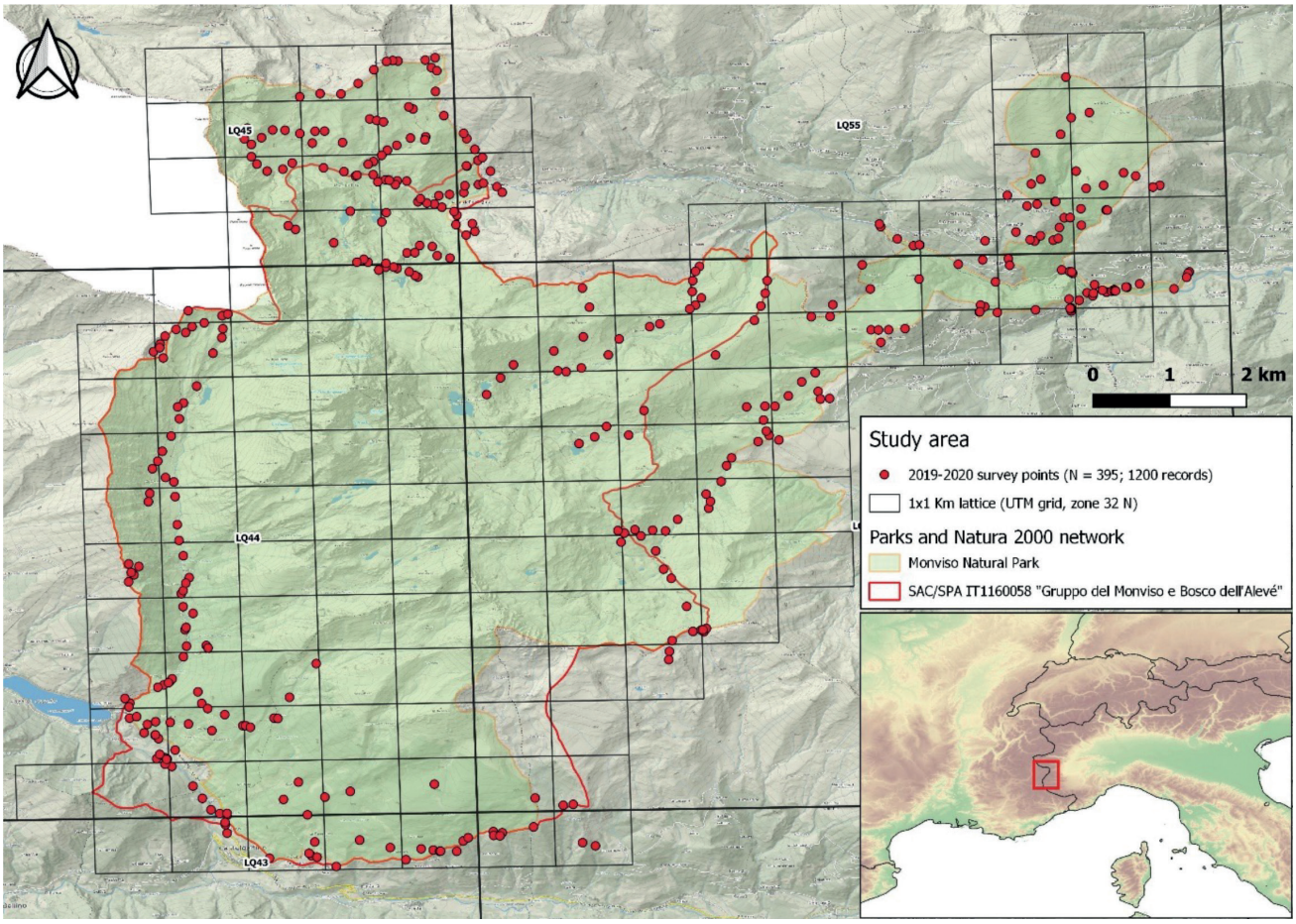

Fig. 1 – Map showing the geographical position of the study area (Monviso massif, Cottian Alps, Piedmont, Italy). The Monviso Natural Park (yellow line, pale green area) and the SAC/SPA IT1160058 "Gruppo del Monviso e Bosco dell'Alevé" (red line) borders are reported, together with the 1x1 km lattice (UTM grid, zone 32 N) used as spatial reference during this research (in black). Red dots identify the 395 survey points (1200 records) investigated by the author in 2019-2020.

5), corresponding to the low-elevation portions of the main south-facing slopes of the Po and Varaita valleys. In particular, a maximum of 26 taxa were recorded in the surroundings of S. Nicolao and Pian Charm (Ostana, LQ55_008 1x1 km cell), while other species-rich areas were identified around Pian Regina (20 species; Crissolo, LQ55_011) and in the vicinity of Bivio di Oncino (19 species; Oncino, LQ54_098). Concerning the altitudinal distribution, orthopterans were observed between 770 m (Ponte della Cunsignà, Paesana) and 3050 m (Punta Losetta, Pontechianale), showing a general decline in species richness with increasing elevation. Indeed, only 10 species were recorded above 2600 m, while the occurrence of 43 taxa was noticed between 1400 m and 2000 m (37 species in the 1600-1800 m belt; Fig. 6A). Most species were observed in their adult life stage in August and September, in the period when the highest sampling effort was applied (Fig. 6B).

Stauroderus scalaris resulted as the most common species in the MNP, occurring in the 33.8% of the 1x1 km cells that constitute the study area. In addition, other widespread taxa are *Epipodisma pedemontana* (30.2%), *Pseudochorthippus parallelus* (28.1%), *Tettigonia cantans* (27.3%), *Omocestus viridulus* (25.9%), *Gomphocerus sibiricus* (23.0%), and *Stenobothrus lineatus* (21.6%).

The most represented chorological categories among the orthopterans observed in the MNP are the Endemic (ALAP, ALPS, ALPW, ALSW, AWNA) and the Sibero-European (SIE) ones (both with 10 species), followed by S-European (SEU; 9 taxa) and Asiatic-European (ASE; 7 taxa) species. In this context, 7 endemic taxa show a distribution restricted to the western Alps, with four of them (*Anonconotus baracunensis*, *Epipodisma pedemontana*, *Chorthippus cialancensis* and *Chorthippus sampeyrensis*) included in the *Near-threatened* (NT) category in the European IUCN Red List (Hochkirch et al. 2016). *Least concern* (LC) is the category assigned by Hochkirch et al. (2016) to the other species observed in the MNP, except for *Platycleis grisea*, *Tetrix kraussi* (assessment carried out together with *P. albopunctata* and *T. bipunctata* respectively, both LC) and *Roeseliana azami* (*Data deficient* - DD; the *Vulnerable* - VU category reported in the Red List is referred to the French endemic ssp. *azami* only; Braud et al. 2016).

According to the systematic review, 40 publications were selected among the 847 documents resulted from the search in literature databases (Tab. 1; a complete publication list is available from the author): 27 concerning the Italian territory, while 5 and 8 papers regarded France and Switzerland respectively. In Italy, the comparison with Massa et al. (2012) revealed the occurrence of new data on species' elevation range in 9 articles, regarding 43 of the taxa observed in the MNP. On the other hand, only 3 *post*-2015 publications contributed to an update of the known altitudinal range of 5 species in the French and Swiss territories, as resulted from the comparison with Sardet et al. (2015). In this context, the elevation data recorded in the MNP include new altitude extremes for 16 orthopteran taxa in Italy, also updating the altitudinal range of 11 species considering the whole W-Alpine region.

The orthopteran fauna of the Monviso Natural Park

In the following lines, an annotated checklist of the orthopteran fauna observed in the MNP is provided, together with concise information about species distribution in the study area (detailed maps and additional data are available from the author). For each *taxon*, the following codes are used:

Ch: chorotype, according to Vigna Taglianti et al. (1992, 1999). Endemic chorotypes are highlighted in bold;
ERL: conservation status, according to the European IUCN Red List of grasshoppers, crickets and bush-crickets (Hochkirch et al. 2016). LC = Least concern, **NT** = Near-threatened, DD = Data deficient, NA= Not assessed;
P: occurrence in the Po Valley confirmed. The asterisk (*) identifies first reports for this valley, according to Sindaco et al. (2012);
V: occurrence in the Varaita Valley confirmed. The asterisk (*) identifies first reports for this valley, according to Sindaco et al. (2012);
%C: percentage of 1x1 km cells in which the species has been observed within the study area (139 cells in total);
ER: elevation range observed in the study area;
Ph: adult phenology observed in the study area (months in Roman numerals).

In addition, when mentioning single observations in the text, the following codes are used to identify the authors (DG= D. Giuliano; RS= R. Sindaco). Nomenclature and taxonomic order are in accordance with Cigliano et al. (2020).

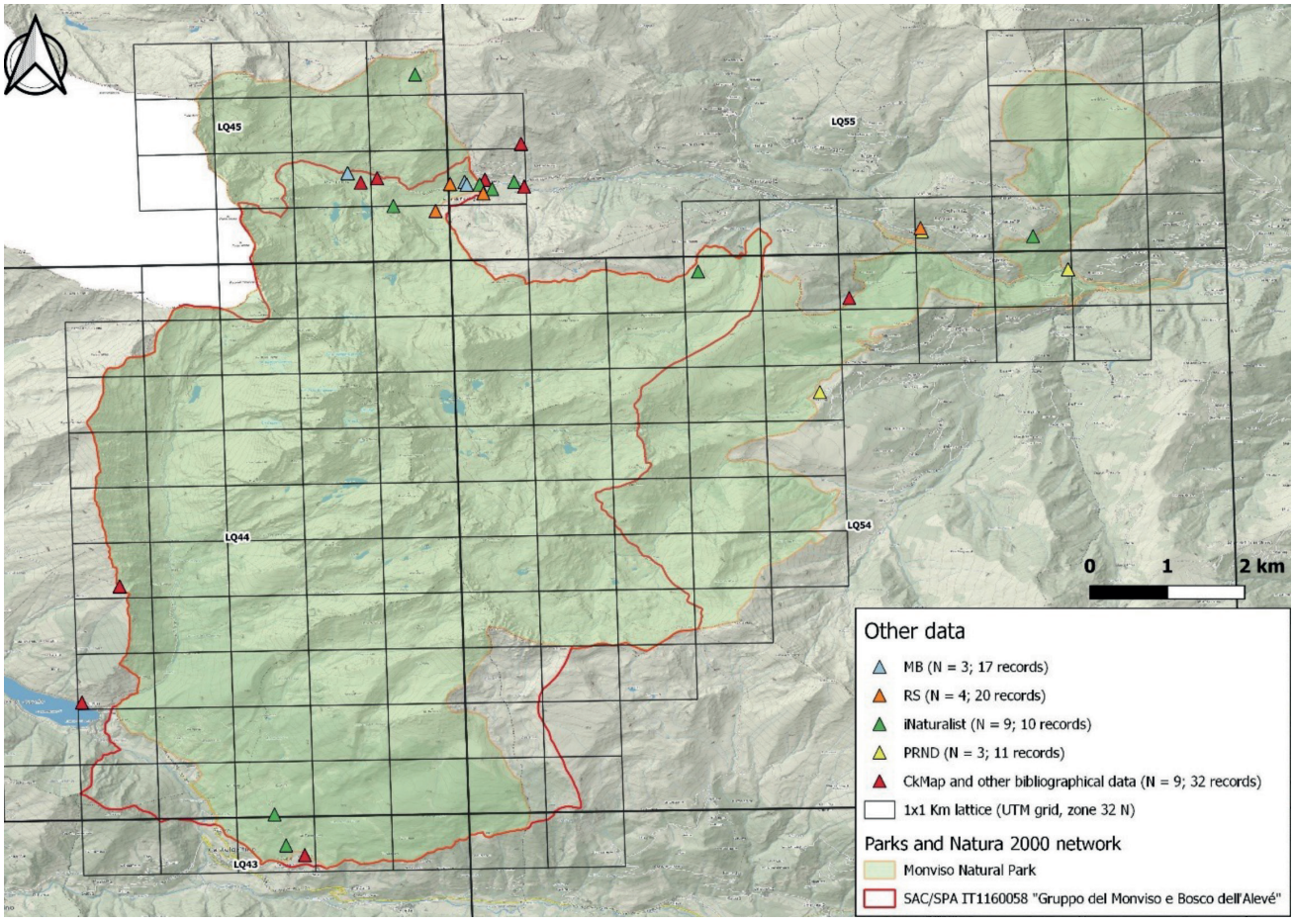

Fig. 2 – Map of the study area showing the position of the 28 additional survey points (90 records) reported in literature or in the considered databases (MB = M. Bonifacino's archive; RS = R. Sindaco's archive; PRND = Piemonte Region Naturalistic Database).

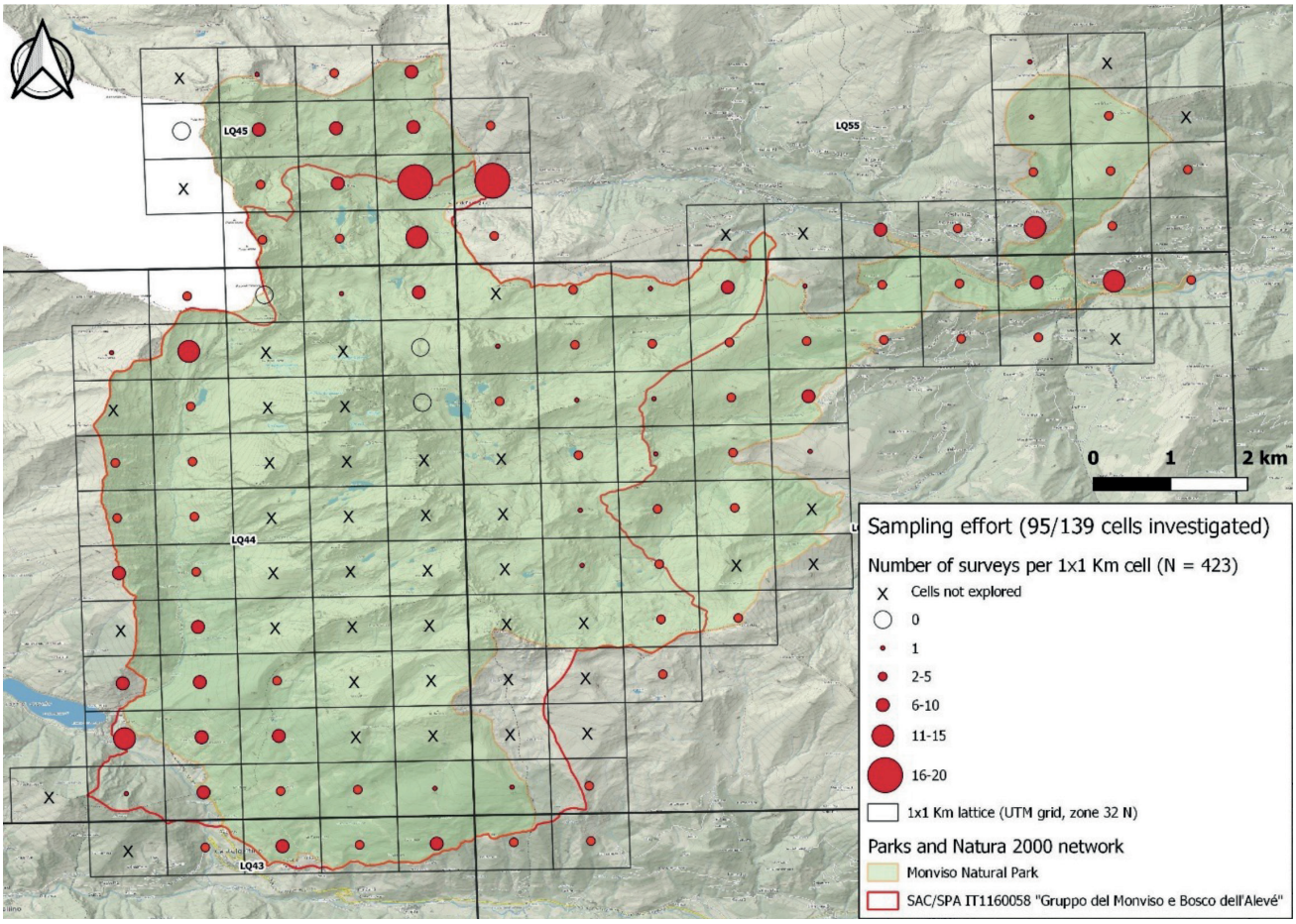

Fig. 3 – Map of the study area reporting the number of survey points in each 1x1 km cell (N = 423; red circles). The unexplored cells are identified with a "X", while unfilled circles indicate cells where no surveys were carried out, due to the absence of orthoptera.

1. Tettigoniidae

1.1 *Phaneroptera* sp.
Ch: -; ERL: -; P; %C: 0.72; ER: 890 m; Ph: VIII
A specimen of this genus has been observed in a single locality in the Po Valley (Ponte di Oncino, Paesana, 890 m; 25/08/2005; RS in PRND). According to the data provided by Sindaco et al. (2012), the occurrence of *P. nana* in the study area is more likely than *P. falcata*, since the latter appears to be distributed mainly in the northern sectors of the Piedmont region.

1.2 *Barbitistes alpinus* Fruhstorfer, 1920
Ch: **ALAP**; ERL: LC; P*-V; %C: 6.47; ER: 1075-1710 m; Ph: VII-IX
B. alpinus is a S-Alpine-Apenninic endemic. In the study area, this species has been mainly observed in forest margins at low elevations.

1.3 *Leptophyes laticauda* (Frivaldszky, 1868)
Ch: SEU; ERL: LC; P*; %C: 0.72; ER: 875 m; Ph: IX
This species has been observed in a single locality in the Po Valley, in the surroundings of the Po-Lenta rivers confluence (Oncino, 875 m; 18/09/2019; DG).

1.4 *Polysarcus denticauda* (Charpentier, 1825)
Ch: SEU; ERL: LC; P-V; %C: 11.51; ER: 1620-2430 m; Ph: VII-IX
P. denticauda proved to occur in most subalpine and alpine grasslands within the MNP, preferring those with

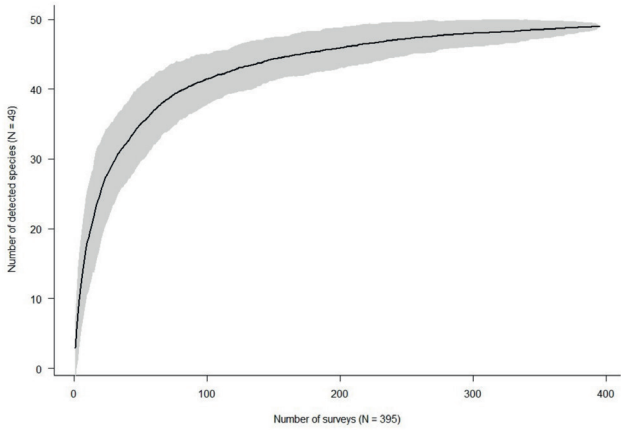

Fig. 4 – Plot representing the species-sample rarefaction curve, calculated using the 2019-2020 surveys data (1200 records in 395 survey points, 49 species). The grey area identifies the 95% confidence interval.

a south-facing exposition. According to the available data, the specimen recorded at 2430 m (Le Conce, Pontechianale; 05/08/2019; DG) represents a new elevation record for this species in Italy and in the whole W-Alpine region.

1.5 *Ruspolia nitidula* (Scopoli, 1786)
Ch: TEM; ERL: LC; P*; %C: 3.60; ER: 770-1070 m; Ph: IX-X
This *taxon* has been observed only at low elevations in the Po Valley, especially in warm open and ecotone habitats.

1.6 *Tettigonia cantans* (Fuessly, 1775)
Ch: SIE; ERL: LC; P-V; %C: 27.34; ER: 785-1980 m; Ph: VII-X
T. cantans is one of the most common species in the study area, preferring ecotone and shrubby areas at low elevation.

1.7 *Tettigonia viridissima* (Linnaeus, 1758)
Ch: CEM; ERL: LC; V*; %C: 0.72; ER: 1750 m; Ph: X
This species has been observed in a single locality in the Varaita Valley (Grange Cruset, Casteldelfino, 1750 m; 26/10/2019; DG), almost at its altitudinal extreme in the western Italian Alps.

1.8 *Decticus verrucivorus* (Linnaeus, 1758)
Ch: ASE; ERL: LC; V; %C: 6.47; ER: 1390-2470 m; Ph: VII-IX
The occurrence of *D. verrucivorus* has been confirmed in the Varaita Valley only, where it has been mainly observed in warm open areas, from montane meadows until alpine grasslands.

1.9 *Platycleis grisea* (Fabricius, 1781)
Ch: SEU; ERL: NA (LC); P*-V; %C: 6.47; ER: 830-1830 m; Ph: VII-IX
P. grisea has been mainly observed in open and ecotone habitats at low elevations, preferring south-facing slopes.

1.10 *Metrioptera saussuriana* (Frey-Gessner, 1872)
Ch: SEU; ERL: LC; P; %C: 7.19; ER: 1520-2150 m; Ph: VII-X
This species has been observed in the Po Valley only, mainly close to small bushes or in well-developed grassy vegetation in alpine grasslands.

1.11 *Roeseliana azami* (Finot, 1892)
Ch: SEU; ERL: DD; P*; %C: 2.88; ER: 1075-1415 m; Ph: VIII-IX
This *taxon*, ascribed to the ssp. *minor*, proved to occur only in relatively fresh montane meadows at low elevations in the Po Valley, preferring areas with well-developed vegetation.

1.12 *Pholidoptera aptera* (Fabricius, 1793)
Ch: SEU; ERL: LC; P-V*; %C: 14.39; ER: 820-1840 m; Ph: VII-IX
In the study area, *P. aptera* is mainly distributed in ecotone habitats and in green alder shrublands, preferring the MNP low elevations sectors.

1.13 *Pholidoptera griseoaptera* (De Geer, 1773)
Ch: EUR; ERL: LC; P-V; %C: 10.79; ER: 770-1735 m; Ph: VIII-X
This species has been mainly observed in ecotone habitats at low elevations.

1.14 *Anonconotus baracunensis* Nadig, 1987
Ch: **ALSW**; ERL: **NT**; P; %C: 15.83; ER: 1620-2730 m; Ph: VII-XI
Perhaps the most relevant orthopteran species in the MNP, *A. baracunensis* is a steno-endemic *taxon*, distributed only at high elevations in a restricted area on the Monviso massif (Sindaco et al. 2012; Sardet et al. 2015). In the park, this species has been observed in the Po Valley only, mostly living in alpine and subalpine grasslands, often close to small shrubs. According to these data, the occurrence of this *taxon* in the Varaita Valley reported by Sindaco et al. (2012) has to be confirmed (maybe referred to *A. baracunensis* ssp. *occidentalis*, now *A. occidentalis*), since the Monviso peak likely constituted an insurmountable barrier in the biogeographical history of this species. *A. baracunensis* is classified as *Near-threatened* by Hochkirch et al. (2016) due to its expected vulnerability to climate change, thus representing a conservation priority in the MNP, especially because the protected area includes about a third of the known global range of this *taxon*.

In this paper, the distribution of *A. baracunensis* has been carefully mapped for the first time on a vast area (i.e. 13900 ha), enhancing the information previously based on few occurrence data, collected in a limited number of easy-accessible localities. In particular, new extremes were identified concerning the altitudinal range of this species, thanks to the specimens observed at 1620 m (Pian Charm-S. Lucia della Vardetta path, Ostana; 16/08/2019; DG) and at 2730 m (in the surroundings of Colle Armoine, Crissolo; 17/09/2020; DG).

1.15 *Anonconotus occidentalis* Carron & Wermeille, 2002
Ch: **ALSW**; ERL: LC; P-V; %C: 8.63; ER: 1930-2780 m; Ph: VIII-X
A. occidentalis is an endemic species of the southwestern sectors of the Alpine range, with a distribution restricted to the high elevations of Cottian and northern Maritime Alps (Sindaco et al. 2012; Sardet et al. 2015). In the study area, this Tettigoniidae proved to occur mainly in the Varaita Valley, while only one observation has been collected in the Po Valley (Vallone Bulé, Oncino, 1930 m; 12/09/2020; DG). Alpine grasslands are the preferred habitat by this species, especially when small shrubs are available. According to

the available data, the observation of *A. occidentalis* at 2780 m (Passo della Losetta, Casermetta, Pontechianale; 27/08/2020; DG) represents a new altitudinal extreme for this species in its distribution range.

1.16 *Antaxius* (*Chopardius*) *pedestris* (Fabricius, 1787)
Ch: SEU; ERL: LC; P-V*; %C: 4.32; ER: 820-1785 m; Ph: VIII-IX
This species has been observed at low elevations, mainly occurring in warm ecotone and shrubby habitats.

1.17 *Ephippiger terrestris* Yersin, 1854
Ch: **ALPW**; ERL: LC; P-V; %C: 2.16; ER: 1610-1770 m; Ph: IX-X
E. terrestris is a W-Alpine endemic, occurring in the study area with the ssp. *bormansi*. This species has been observed in the Varaita Valley only, where it prefers shrubby areas on warm and dry slopes.

2. Rhaphidophoridae

2.1 *Dolichopoda* (*Dolichopoda*) *azami* Saulcy, 1893
Ch: **ALSW**; ERL: LC; P-V; %C: 1.44; ER: 1440-1580 m; Ph: IX
D. azami show a distribution restricted to the southwestern Alps, occurring in the MNP with the ssp. *ligustica*. This species is well-adapted to live in subterranean habitats, with only two records in the study area: one in an abandoned mine (Croce d'Alie, Sampeyre, 1580 m; 07/09/2019; DG), while a second occurrence locality is reported for the Buco di Valenza cave (Crissolo, 1440 m; Balbiano D'Aramengo & Bonelli 1975). Moreover, *D. azami* is mentioned for the Buco del Maestro cave (Calcinere, Paesana, 750 m; Allegrucci et al. 2014), situated a few hundred meters outside the MNP in the Po Valley.

3. Trigonidiidae

3.1 *Nemobius sylvestris* (Bosc, 1792)
Ch: EUR; ERL: LC; P*-V*; %C: 14.39; ER: 770-1850 m; Ph: VII-XI
This species has been observed in most MNP's broadleaved forests, especially on warmer slopes. *N. sylvestris* proved also to occur in some subalpine shrublands, up to 1850 m in the Po Valley (L'Arp, Ostana; 04/11/2019; DG). According to the available data, this latter locality represents a new altitudinal record for this cricket in Italy.

4. Gryllidae

4.1 *Gryllus* (*Gryllus*) *campestris* Linnaeus, 1758
Ch: TEM; ERL: LC; P*-V; %C: 7.91; ER: 780-1600 m; Ph: V-VII
G. campestris has been observed only in open habitats at low elevations, preferring south-facing meadows.

5. Tetrigidae

5.1 *Tetrix depressa* Brisout de Barneville, 1848
Ch: TEM; ERL: LC; P*-V*; %C: 4.32; ER: 1170-1770 m; Ph: V-X
This species has been observed mainly at low elevations, preferring dry and warm open areas with scattered vegetation, bare ground and rocks.

5.2 *Tetrix kraussi* Saulcy, 1888
Ch: SEU; ERL: NA; P-V; %C: 2.88; ER: 1485-1955 m; Ph: V-IX
The occurrence of *T. kraussi* in the MNP has been confirmed in four localities only, mainly in warm and dry open habitats with scarce vegetation, rocks and bare ground spots.

5.3 *Tetrix subulata* (Linnaeus, 1758)
Ch: OLA; ERL: LC; V*; %C: 0.72; ER: 1485 m; Ph: V
T. subulata has been observed in a single locality in the study area (downstream of the Castello dam, Pontechianale, 1485 m; 30/05/2020; DG), with a small population living in a little wetland habitat.

6. Acrididae

6.1 *Podisma dechambrei* Leproux, 1951
Ch: **AWNA**; ERL: LC; V; %C: 0.72; ER: 2420-2470 m; Ph: VIII
P. dechambrei is an endemic species, ranging at high elevations from the southwestern Alps to the northern Apennines (Iorio et al. 2019). In the study area, the occurrence of this species (ssp. *dechambrei*) has been ascertained in a single locality (Le Conce, Pontechianale, 2420-2470 m; 05/08/2019; DG), where *P. dechambrei* proved to prefer alpine grassland habitats. According to the available data, the specimen observed at 2470 m represents an altitudinal record for this *taxon* in Italy.

6.2 *Epipodisma pedemontana* (Brunner von Wattenwyl, 1882)
Ch: **ALPW**; ERL: **NT**; P-V; %C: 30.22; ER: 1785-2920 m; Ph: VII-XI
Although the distribution range of *E. pedemontana* is restricted to high elevations in the Cottian and Graian Alps (Sindaco et al. 2012; Sardet et al. 2015), this species is one on the most common orthopterans in the MNP, occurring in most alpine grasslands and shrublands. According to the available data, the specimen observed at 2920 m in the Varaita Valley (Punta Losetta, Pontechianale; 27/08/2020; DG) represents an altitudinal record throughout the *E. pedemontana*'s range. Due to its expected vulnerability to climate change, this species has been classified as *Near-threatened* by Hochkirch et al. (2016).

6.3 *Pezotettix giornae* (Rossi, 1794)
Ch: EUM; ERL: LC; V; %C: 0.72; ER: 1570-1690 m; Ph: IX-X
This species has been recorded only in few localities in the Varaita Valley, on the south-facing slopes between

Grange Arbre and Grange Cruset (Casteldelfino), preferring warm and dry grassland habitats with scattered shrubs or ecotone areas. According to the available data, the specimen observed at 1690 m (Grange Cruset, Casteldelfino; 26/10/2019; DG) represents a new altitudinal record for *P. giornae* in Italy and in the whole W-Alpine region.

6.4 *Calliptamus italicus* (Linnaeus, 1758)
Ch: CAE; ERL: LC; P-V; %C: 9.35; ER: 890-3050 m; Ph: VIII-IX
In the MNP, *C. italicus* has been mainly observed at low elevations (i.e. up to 2020 m), especially in warm and dry open areas. The only exception is the specimen collected at 3050 m in the Varaita Valley (Punta Losetta, Pontechianale; 27/08/2020; DG), that, according to the available data, represents an altitudinal record throughout the whole species range (form the Iberian Peninsula to northwestern China), perhaps providing a first evidence of a dispersal behaviour of this *taxon* across the Alpine range (Giuliano 2021).

6.5 *Psophus stridulus* (Linnaeus, 1758)
Ch: ASE; ERL: LC; P*; %C: 6.47; ER: 1600-2290 m; Ph: VIII-X
This species has been observed in the Po Valley only, preferring alpine and subalpine grasslands on warm and dry slopes.

6.6 *Oedipoda caerulescens* (Linnaeus, 1758)
Ch: CEM; ERL: LC; P*-V; %C: 10.79; ER: 840-2415 m; Ph: VIII-X
In the MNP, *O. caerulescens* has been observed in open areas at low elevations, especially in warm and dry grasslands with scattered rock outcrops.

6.7 *Oedipoda germanica* (Latreille, 1804)
Ch: SEU; ERL: LC; V; %C: 6.47; ER: 1480-2820 m; Ph: VIII-IX
Most *O. germanica* individuals have been observed at low elevations in the study area (i.e. up to 1920 m), preferring warm and dry rocky grasslands. A single exception is provided by the specimen collected at 2820 in the Varaita Valley (Passo della Losetta-Passo Vallanta path, Pontechianale; 27/08/2020; DG), representing, according to the available data, a new altitudinal record for this *taxon* in Italy and in the whole W-Alpine region.

6.8 *Aiolopus strepens* (Latreille, 1804)
Ch: TEM; ERL: LC; P*; %C: 2.16; ER: 825-1350 m; Ph: X-V
A. strepens has been observed in the Po Valley only, preferring south-facing open areas at low elevations.

6.9 *Mecostethus parapleurus* (Hagenbach, 1822)
Ch: ASE; ERL: LC; P; %C: 1.44; ER: 770-825 m; Ph: IX-X
This species proved to occur only at low elevations in relatively moist meadows near the Po river, especially in the surroundings of Calcinere (Paesana). *M. parapleurus* is considered in decline in Italian lowlands, due in particular to wetland habitats loss (Massa et al. 2012).

6.10 *Arcyptera* (*Arcyptera*) *fusca* (Pallas, 1773)
Ch: SIE; ERL: LC; P; %C: 0.72; ER: 1700 m; Ph: ?
The occurrence of *A. fusca* in the MNP has not been confirmed in the 2019-2020 surveys, but an historical record is available for Pian Regina (Crissolo, 1700 m; *CkMap*, Coll. La Greca, 1981).

6.11 *Euthystira brachyptera* (Ocskay, 1826)
Ch: SIE; ERL: LC; P-V; %C: 8.63; ER: 1075-2025 m; Ph: VII-IX
This species has been observed only at low elevations, in relatively warm grassland habitats.

6.12 *Omocestus* (*Omocestus*) *haemorrhoidalis* (Charpentier, 1825)
Ch: ASE; ERL: LC; P*-V; %C: 5.75; ER: 1750-2350 m; Ph: VII-X
In the study area, *O. haemorrhoidalis* proved to prefer grassland habitats on warm and dry slopes, especially in the subalpine belt.

6.13 *Omocestus* (*Omocestus*) *rufipes* (Zetterstedt, 1821)
Ch: CEM; ERL: LC; P; %C: 2.88; ER: 895-1420 m; Ph: IX
This species has been observed only at low elevations in the Po Valley, where it proved to prefer relatively warm south-facing meadows.

6.14 *Omocestus* (*Omocestus*) *viridulus* (Linnaeus, 1758)
Ch: ASE; ERL: LC; P-V; %C: 25.90; ER: 1430-2800 m; Ph: VII-XI
O. viridulus is one of the most common orthopterans in the study area, living in most alpine and subalpine grasslands (above 1400 m).

6.15 *Stenobothrus lineatus* (Panzer, 1796)
Ch: SIE; ERL: LC; P-V; %C: 21.58; ER: 1595-2415 m; Ph: VII-XI
This species is one of the commonest grasshoppers in the MNP's alpine and subalpine grasslands, mostly preferring south-facing slopes.

6.16 *Stenobothrus nigromaculatus* (Herrich-Schäffer, 1840)
Ch: SIE; ERL: LC; P; %C: 2.88; ER: 1600-1630 m; Ph: VIII
The occurrence of *S. nigromaculatus* in the study area proved to be limited at the warm subalpine grasslands above the Ostana village, in the Po Valley. Although

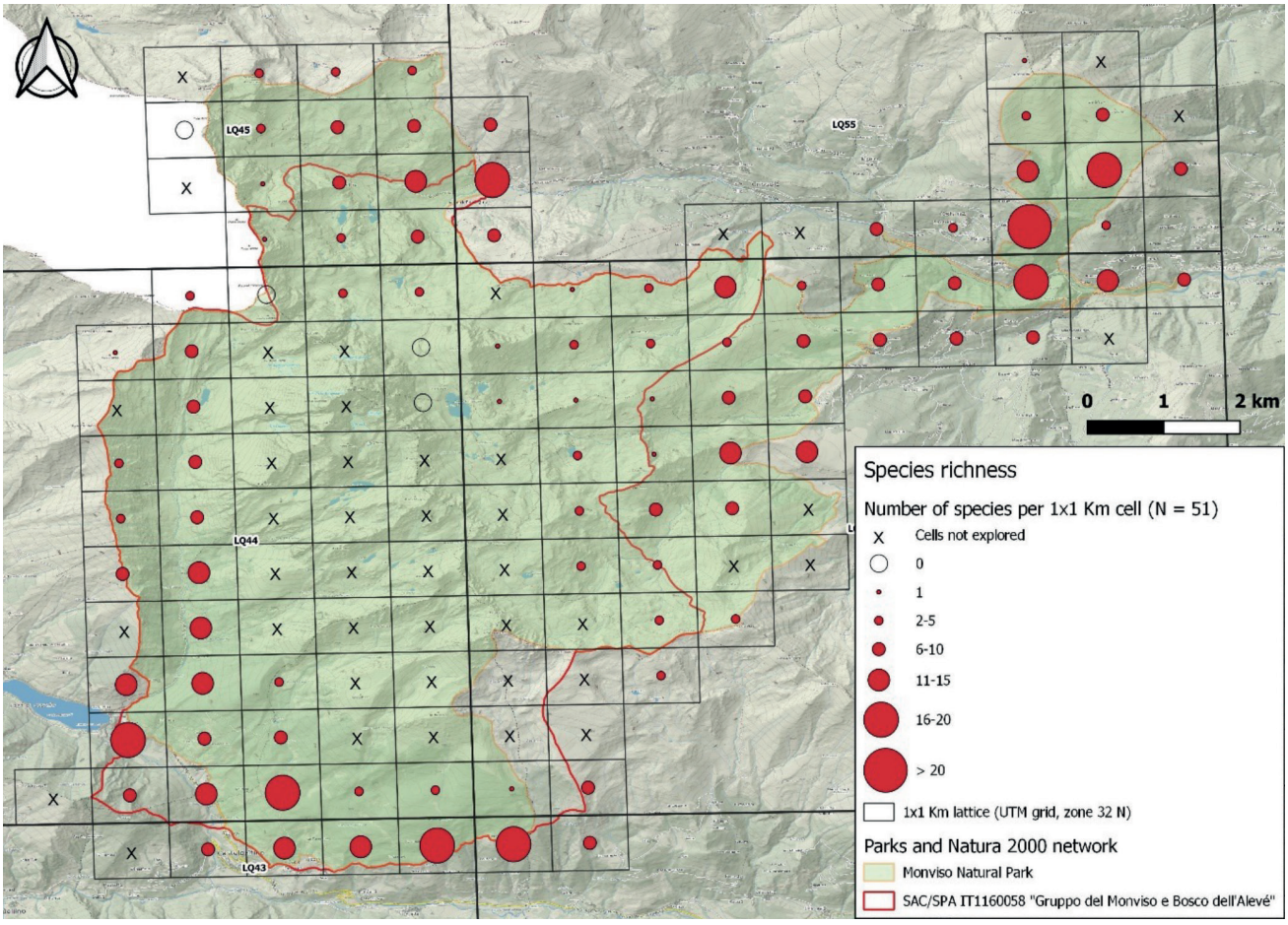

Fig. 5 – Map of the study area reporting the number of species observed in each 1x1 km cell (N = 51; red circles). The unexplored cells are identified with a "X", while unfilled circles indicate cells where no orthopterans were found.

this species is not included in any threat category by Hochkirch et al. (2016), *S. nigromaculatus* is considered threatened in Switzerland due to both intensive meadows management and land abandonment (Baur et al. 2006).

6.17 *Gomphocerus sibiricus* (Linnaeus, 1767)
Ch: ASE; ERL: LC; P-V; %C: 23.02; ER: 1620-2780 m; Ph: VII-IX
G. sibiricus is one of the most common orthopterans in the alpine grasslands of the study area, preferring in particular those on south-facing slopes.

6.18 *Gomphocerippus rufus* (Linnaeus, 1758)
Ch: SIE; ERL: LC; P-V; %C: 7.91; ER: 770-2065 m; Ph: VIII-X
This species has been observed at low elevations in the MNP, mainly occurring in woodland clearings, shrubby and in ecotone areas on south-facing slopes.

6.19 *Myrmeleotettix maculatus* (Thunberg, 1815)
Ch: SIE; ERL: LC; P-V; %C: 13.67; ER: 1600-3050 m; Ph: VII-XI
Although *M. maculatus* showed a patchy distribution in the study area, this species proved to occur in most high-altitude sectors of the MNP, preferring dry and rocky alpine grasslands. According to the available data, the specimen observed at 3050 m in the Varaita Valley (Punta Losetta, Pontechianale; 27/08/2020; DG) represents a new altitudinal record for *M. maculatus* in Italy.

6.20 *Stauroderus scalaris* (Fischer von Waldheim, 1846)
Ch: SIE; ERL: LC; P-V; %C: 33.81; ER: 890-2840 m; Ph: VII-X
S. scalaris is the most common orthopteran species in the MNP, occurring in about a third of the whole study area. This *taxon* is widespread in warm montane and subalpine grasslands, with only some individuals recorded at high elevations (> 2600 m). According to the available data, the specimen observed at 2840 m (Passo Vallanta, Pontechianale; 27/08/2020; DG) represents a new altitudinal record for *S. scalaris* in Italy and in the whole W-Alpine region.

6.21 *Pseudochorthippus parallelus* (Zetterstedt, 1821)
Ch: SIE; ERL: LC; P-V; %C: 28.06; ER: 825-2250 m; Ph: VII-XI

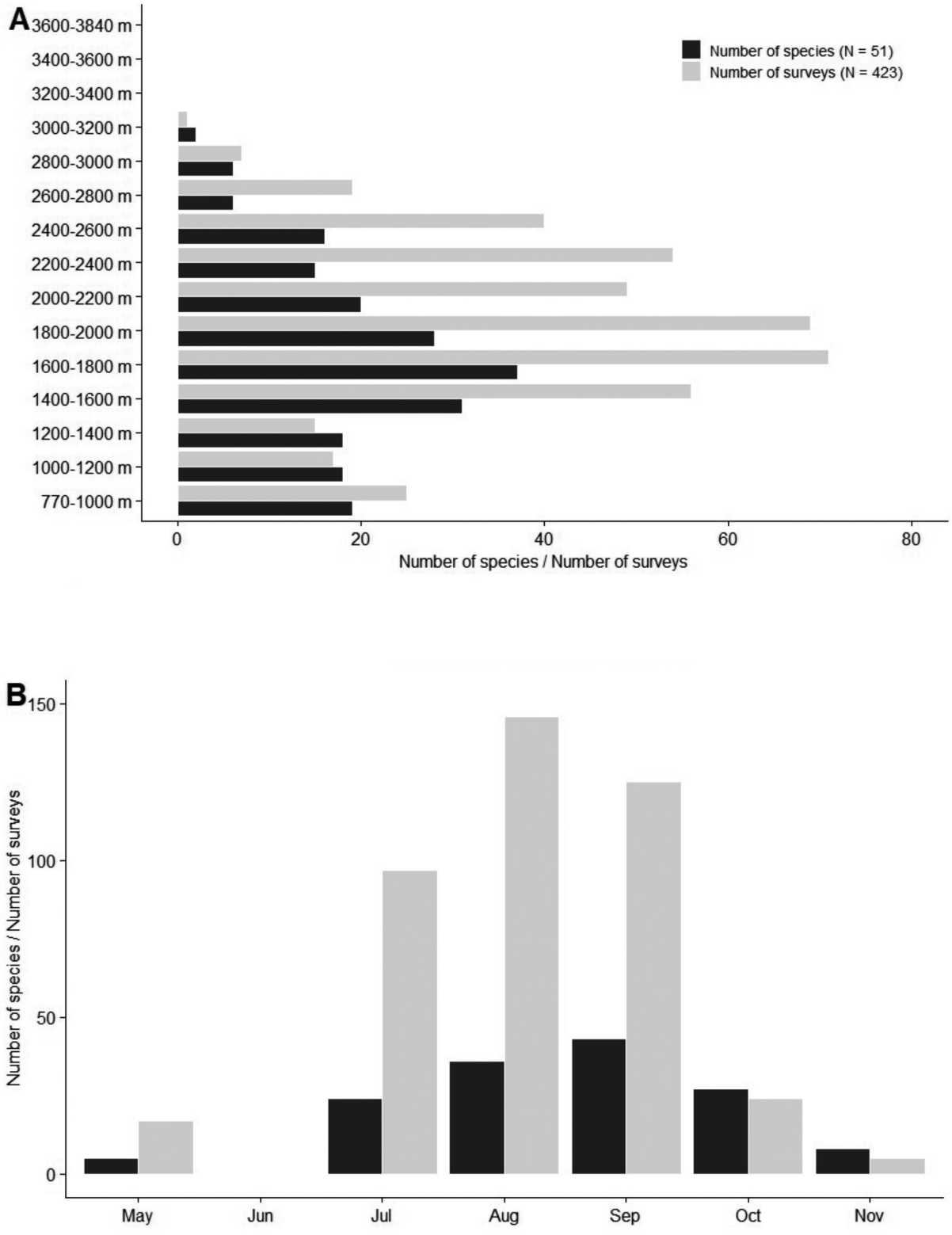

Fig. 6 – Barplots showing the distribution of survey points (grey bars) and observed species richness (black bars) along A, the altitudinal gradient within the study area, and B, in each month during the research period.

This species is one of the commonest grasshoppers in the MNP, mostly occurring in montane meadows and in subalpine grasslands.

6.22 *Chorthippus* (*Chorthippus*) *dorsatus* (Zetterstedt, 1821)
Ch: CAE; ERL: LC; P-V; %C: 17.99; ER: 825-2100 m; Ph: VIII-X
In the MNP, *C. dorsatus* has been mostly observed at low elevations, preferring warm montane and subalpine grasslands.

6.23 *Chorthippus* (*Glyptobothrus*) *apricarius* (Linnaeus, 1758)
Ch: ASE; ERL: LC; P-V; %C: 15.11; ER: 1390-2470 m; Ph: VII-IX
In 2019-2020 surveys, this species has been observed in the Varaita Valley only, failing to confirm some historical occurrence records in the Po Valley (Pian Regina, Crissolo, 1700 m; *CkMap*, Coll. La Greca, 1967, 1981). *C. apricarius* is a typical species of the montane and subalpine belts in the study area, where it prefers warm grassland habitats, including forest clearings. According to the available data, the specimen observed at 2470 m (Le Conce, Pontechianale; 05/08/2019; DG) represents a new altitudinal record for this species in Italy.

Tab. 1 – Summary of the bibliographical search results. For each database (**DB**; **WoS** = Web of Science; **Sc** = Scopus; **GS** = Google Scholar), the typed key words are reported, together with the respective outcomes (**N_doc** = number of documents found; **N_sui** = number of suitable documents; **N_dup** = number documents already found in previous searches; **N_sel** = number of selected documents). The number of "secondary documents" found in Scopus is identified by "s.d.". The time spans considered are 2012-2021 for Italy and 2015-2021 for France and Switzerland.

DB	Key words	N_ doc	N_ sui	N_ dup	N_ sel
WoS	(Orthoptera OR Ortotter*) AND Ital*	48	5	-	5
	(Orthoptera OR Orthoptères OR Heuschrecken OR Ortotteri) AND (France OR Switzerland OR Schweiz OR Suisse OR Svizzera)	27	4	0	4
Sc	(Orthoptera OR Ortotter*) AND Ital*	71 +20 s.d.	5 +3 s.d.	4 +0 s.d.	4
	(Orthoptera OR Orthoptères OR Heuschrecken OR Ortotteri) AND (France OR Switzerland OR Schweiz OR Suisse OR Svizzera)	68 +13 s.d.	6 +0 s.d.	3 +0 s.d.	3
GS	(Orthoptera OR Ortottero OR Ortotteri) AND (Italia OR Italy)	300	22	5	17
	(Orthoptera OR Orthoptère OR Orthoptères OR Heuschrecke OR Heuschrecken OR Ortottero OR Ortotteri) AND (France OR Switzerland OR Schweiz OR Suisse OR Svizzera)	300	16	9	7

6.24 *Chorthippus* (*Glyptobothrus*) *brunneus* (Thunberg, 1815)
Ch: SIE; ERL: LC; P*-V*; %C: 4.32; ER: 1010-2815 m; Ph: VII-X
C. brunneus has been mainly observed at low elevations in the study area (i.e. up to 1595 m), occurring in various warm and dry open habitats. A single specimen has been exceptionally recorded at 2815 m (Passo della Losetta-Passo Vallanta path, Pontechianale; 27/08/2020; DG), representing, according to the available data, a new altitudinal record for this species in Italy and in the whole W-Alpine region.

6.25 *Chorthippus* (*Glyptobothrus*) *cialancensis* Nadig, 1986
Ch: **ALSW**; ERL: **NT**; P; %C: 2.88; ER: 2020-2580 m; Ph: VIII-X
C. cialancensis is an endemic grasshopper with a distribution restricted to high elevations in the northern Cottian Alps (Sindaco et al. 2012; Sardet et al. 2015). The MNP includes the southernmost portions of its range, with only some localised populations occurring in the upper Po Valley. This species proved to prefer alpine grassland habitats, especially in the proximity of screes or other rocky areas on south-east-facing slopes. According to the available data, the specimen observed at 2020 m (Pian del Re, Crissolo; 14/10/2019; DG; Bellmann 1993) represents a low-elevation record in the whole *C. cialancensis* range, while the individual collected at 2580 m (Vallone delle Traversette, Crissolo; 10/08/2019; DG) updates the known upper altitudinal extreme for this species in Italy. This *taxon* should represent a conservation priority in the MNP, since the observed localised populations are apparently composed by a low number of individuals, making them particularly vulnerable to detrimental human pressures (e.g. intensive grazing, collecting, etc.) or other stochastic events. In addition, *C. cialancensis* is considered among the species which may suffer of ongoing climatic alterations in alpine ecosystems, thus justifying its inclusion in the *Near-threatened* category by Hochkirch et al. (2016).

6.26 *Chorthippus* (*Glyptobothrus*) *eisentrauti* (Ramme, 1931)
Ch: **ALPS**; ERL: LC; P*-V*; %C: 12.23; ER: 1570-2470 m; Ph: VII-X
C. eisentrauti is a S-Alpine endemic, occurring in the MNP mainly in alpine and subalpine grasslands, with a marked preference for warm and dry slopes.

Tab. 2 – List of the orthopteran taxa observed in the MNP (N = 51), ordered following their altitudinal distribution in the study area (from high-altitude to lowland species). For each *taxon*, the elevation range observed in this study is compared with the altitudinal extremes reported in literature for Italy and in the neighbouring W-Alpine countries (i.e. France and Switzerland), as resulted from the publications review. Concerning Italy, substantial elevation data are provided by (ordered by year): [1] Massa et al. (2012); [2] Sindaco et al. (2012); [3] Tami et al. (2013); [4] Allegrucci et al. (2014); [5] Baroni (2015); [6] Giuliano et al. (2017); [7] Baroni et al. (2018a); [8] Baroni et al. (2018b); [9] Iorio et al. (2018); [10] Tami & Fontana (2019). Instead, relevant elevation data for France and Switzerland were found in (ordered by year): [11] Morichon & Morin (2010); [12] Sardet et al. (2015); [13] Noël & Vannucci (2015); [14] Bonifait (2019); [15] Mourguiart et al. (2020). The overall elevation extremes known for each species in the W-Alpine countries are highlighted in bold, while the minimum-maximum values for Italy are underlined.

Species	Elevation range Min-Max (m)			Source (Italy)	Source (France & Switzerland)
	MNP	Italy	France & Switzerland		
Myrmeleotettix maculatus (Thunberg, 1815)	1600-3050	1100-2810	**0-3070**	[1,2]-[5]	[12]-[12]
Calliptamus italicus (Linnaeus, 1758)	890-**3050**	**0**-2000	**0**-2100	[2]-[2]	[12]-[12]
Epipodisma pedemontana (Brunner von Wattenwyl, 1882)	1785-**2920**	**1550**-2834	1700-2800	[2]-[5]	[12]-[12]
Stauroderus scalaris (Fischer von Waldheim, 1846)	890-**2840**	242-2700	**190**-2700	[2]-[2]	[12]-[12]
Oedipoda germanica (Latreille, 1804)	1480-**2820**	**0**-2435	**0**-2650	[1]-[2]	[12]-[12]
Chorthippus (Glyptobothrus) brunneus (Thunberg, 1815)	1010-**2815**	**0**-2550	**0**-2680	[1]-[1]	[12]-[12]
Omocestus (Omocestus) viridulus (Linnaeus, 1758)	1430-2800	802-2900	**100-2910**	[5]-[1]	[13]-[12]
Anonconotus occidentalis Carron & Wermeille, 2002	1930-**2780**	**1250**-2700	1300-2700	[2]-[2]	[12]-[12]
Gomphocerus sibiricus (Linnaeus, 1767)	1620-2780	1400-**3021**	**1070-**2920	[8]-[5]	[12]-[12]
Anonconotus baracunensis Nadig, 1987	**1620-2730**	1750-2400	1900-2400	[2]-[2]	[12]-[12]
Chorthippus (Glyptobothrus) cialancensis Nadig, 1986	**2020**-2580	2100-2550	**2640**	[6]-[2]	[12]-[12]
Chorthippus (Glyptobothrus) sampeyrensis Nadig, 1986	2420-**2535**	**2020**-2450	2200-2320	[2]-[2]	[12]-[11]
Podisma dechambrei Leproux, 1951	2420-2470	1350-2450	**1300-2621**	[2]-[2]	[12]-[15]
Chorthippus (Glyptobothrus) eisentrauti (Ramme, 1931)	1570-2470	645-**2792**	**290**-2120	[5]-[5]	[12]-[12]
Decticus verrucivorus (Linnaeus, 1758)	1390-2470	650-**2706**	**50**-2700	[3]-[2]	[12]-[12]
Chorthippus (Glyptobothrus) apricarius (Linnaeus, 1758)	1390-2470	900-2370	**400-2570**	[10]-[2]	[12]-[12]
Polysarcus denticauda (Charpentier, 1825)	1620-**2430**	**0**-2420	500-2300	[1]-[6]	[12]-[12]

Species	Elevation range Min-Max (m)			Source (Italy)	Source (France & Switzerland)
	MNP	Italy	France & Switzerland		
Stenobothrus lineatus (Panzer, 1796)	1595-2415	300-2631	**50-2890**	[8]-[7]	[12]-[12]
Oedipoda caerulescens (Linnaeus, 1758)	840-2415	**0-2531**	**0**-2200	[2]-[5]	[12]-[12]
Omocestus (Omocestus) haemorrhoidalis (Charpentier, 1825)	1750-2350	560-2688	**140-3000**	[6]-[5]	[12]-[12]
Psophus stridulus (Linnaeus, 1758)	1600-2290	600-2450	**70-2600**	[2]-[7]	[14]-[12]
Pseudochorthippus parallelus (Zetterstedt, 1821)	825-2250	**0**-2500	**0-2740**	[1]-[1,2]	[12]-[12]
Metrioptera saussuriana (Frey-Gessner, 1872)	1520-2150	850-2200	**100-2500**	[2]-[2]	[12]-[12]
Chorthippus (Chorthippus) dorsatus (Zetterstedt, 1821)	825-2100	**0**-2370	**0-2500**	[1]-[2]	[12]-[12]
Gomphocerippus rufus (Linnaeus, 1758)	770-2065	**0**-2400	10-**2480**	[1]-[1]	[12]-[12]
Euthystira brachyptera Ocskay, 1826)	1075-2025	**0**-2380	180-**2600**	[1]-[5]	[12]-[12]
Tettigonia cantans (Fuessly, 1775)	785-1980	340-2300	**180-2350**	[2]-[2]	[12]-[12]
Chorthippus (Glyptobothrus) mollis (Charpentier, 1825)	1010-1970	**0**-1925	90-**2600**	[1]-[5]	[12]-[12]
Tetrix kraussi Saulcy, 1888	1485-1955	**0-2436**	250-2000	[1]-[7]	[12]-[12]
Nemobius sylvestris (Bosc, 1792)	770-1850	240-1660	**0-2100**	[8]-[2]	[12]-[12]
Pholidoptera aptera (Fabricius, 1793)	820-1840	**0**-2142	250-**2360**	[1]-[2]	[12]-[12]
Platycleis grisea (Fabricius, 1781)	830-1830	**0-2531**	200-2200	[1]-[7]	[12]-[12]
Antaxius (Chopardius) pedestris (Fabricius, 1787)	820-1785	**0**-2200	**0-2350**	[1]-[2]	[12]-[12]
Ephippiger terrestris Yersin, 1854	1610-1770	**200**-2000	840-**2109**	[2]-[1]	[12]-[15]
Tetrix depressa Brisout de Barneville, 1848	1170-1770	**0**-2000	**0-2500**	[1]-[1]	[12]-[12]
Tettigonia viridissima (Linnaeus, 1758)	1750	**0**-1790	**0-2100**	[1]-[5]	[12]-[12]
Pholidoptera griseoaptera (De Geer, 1773)	770-1735	**0**-2000	**0-2100**	[1]-[1]	[12]-[12]

Species	Elevation range Min-Max (m)			Source (Italy)	Source (France & Switzerland)
	MNP	Italy	France & Switzerland		
Barbitistes alpinus Fruhstorfer, 1920	1075-1710	275-**2000**	**250**-1815	[8]-[1]	[12]-[12]
Arcyptera (Arcyptera) fusca (Pallas, 1773)	1700	**0**-**2790**	100-2650	[1]-[5]	[12]-[12]
Pezotettix giornae (Rossi, 1794)	1570-**1690**	**0**-1350	**0**-1550	[1]-[2]	[12]-[15]
Stenobothrus nigromaculatus (Herrich-Schäffer, 1840)	1600-1630	**52**-2484	300-**2650**	[10]-[5]	[12]-[12]
Gryllus (Gryllus) campestris Linnaeus, 1758	780-1600	**0**-**2470**	**0**-1850	[1]-[1]	[12]-[12]
Dolichopoda (Dolichopoda) azami Saulcy, 1893	1440-1580	**194**-**1900**	500-1500	[4]-[2]	[12]-[12]
Tetrix subulata (Linnaeus, 1758)	1485	**0**-1700	**0**-**1970**	[1]-[1]	[12]-[12]
Omocestus (Omocestus) rufipes (Zetterstedt, 1821)	895-1420	**0**-**2300**	**0**-2000	[1]-[1,2]	[12]-[12]
Roeseliana azami (ssp. *minor*) Nadig, 1961	1075-1415	**70**-**1700**	200-**1700**	[1]-[2]	[12]-[12]
Aiolopus strepens (Latreille, 1804)	825-1350	**0**-1400	**0**-**1750**	[1]-[2]	[12]-[12]
Ruspolia nitidula (Scopoli, 1786)	770-1070	**0**-**1600**	**0**-1300	[1]-[2]	[12]-[12]
Phaneroptera (Phaneroptera) sp. (*P. nana* & *P. falcata*)	890	**0**-1400	**0**-**1620**	[1]-[2]	[12]-[12]
Leptophyes laticauda (Frivaldszky, 1868)	875	150-1400	**0**-**1500**	[9]-[2]	[12]-[12]
Mecostethus parapleurus (Hagenbach, 1822)	770-825	**0**-1418	**0**-**1850**	[1]-[2]	[12]-[12]

6.27 *Chorthippus* (*Glyptobothrus*) *mollis* (Charpentier, 1825)
Ch: CAE; ERL: LC; P*-V*; %C: 19.42; ER: 1010-1970 m; Ph: VIII-XI
This species, ascribed to the ssp. *ignifer* in the study area, has been mainly observed at low elevations, being sometimes abundant in warm and dry montane meadows and subalpine grasslands. According to the available data, the specimen collected at 1970 m (Pian Caval-Costa La Charmo path, Pontechianale; 11/08/2019; DG) represents a new altitudinal record for *C. mollis* in Italy.

6.28 *Chorthippus* (*Glyptobothrus*) *sampeyrensis* Nadig, 1986
Ch: **ALSW**; ERL: **NT**; V; %C: 2.16; ER: 2420-2535 m; Ph: IX-X
Although the taxonomic status of this species is still debated (possible synonymy with *C. cialancensis*; Massa et al. 2012), recent biometric data seem to support the specific identity of this endemic *taxon* (Morichon & Morin 2010), therefore treated separately in this checklist. *C. sampeyrensis* show a distribution restricted to high altitudes in the southern Cottian Alps (Sindaco et al. 2012; Sardet et al. 2015), occurring in only one sector of the study area, in the surroundings of Colle di Luca (Sampeyre). This population was previously unknown (Morichon & Morin 2010), extending of about 8 km northwards the known distribution range of this species. Its preferred habitat proved to

be south-facing alpine grasslands, even with small shrubs, in the proximity of screes of other rocky areas. According to the available data, the specimen observed at 2535 (Colle di Luca-Lago di Luca path, Sampeyre; 12/09/2020; DG) represents a new altitudinal record in the whole *C. sampeyrensis* range. Despite the Colle di Luca population is only marginally included in the protected area, this *taxon* should represent a conservation priority in the MNP, due to the limited number of individuals and its expected vulnerability to climate change effects (Hochkirch et al. 2016).

Discussion

Thanks to the large amount of new data collected in the field, integrated with the information gathered from literature, public and private databases, this research provides a substantial improvement to the knowledge of the orthopteran fauna in the MNP, not only enhancing the previous checklist from 18 to 51 taxa, but also giving a detailed picture of species distribution within the protected area. In addition, several new records for the Po and the Varaita valleys are here reported (15 and 9 new species respectively; Sindaco et al. 2012), thus also contributing in the update of the orthopteran distribution data in this sector of the western Italian Alps.

Although the sampling effort appeared to be adequate to survey the whole species pool occurring in the MNP, some gaps might be contained in the checklist and the distribution maps provided in this study, due in particular to the intrinsic detection limits of the sampling techniques applied (i.e. listening + visual census), a not accounted variable in the calculation of the species-sample rarefaction curve. For instance, the sighting and listening methods, whatever alone or combined, may underestimate the occurrence of some orthopteran taxa that primarily live on the tree canopy or in bushy areas, otherwise detected using an entomological umbrella, especially if no audible stridulations are produced. This is the case of *Meconema thalassinum*, observed by the author few kilometres outside the study area in the Po Valley (Bric Lumbatera, Paesana, 1380 m; 06/09/2018), but not found in similar habitats within the MNP. Moreover, other detection issues might have occurred with *Bohemanella frigida*, *Stenobothrus rubicundulus* and *Chorthippus vagans*, all reported in localities close to the study area (*B. frigida*: Colle dell'Agnello, Pontechianale, 2700 m; Sindaco et al. 2012. *S. rubicundulus*: LQ44 UTM 10x10 km cell, Pontechianale; Sindaco 2006. *C. vagans*: LQ55 UTM 10x10 km cell, Crissolo; Sindaco 2006), but not observed during field surveys.

Nevertheless, the 51 species observed in the MNP represent the 31% of the orthopteran taxa known to occur in the western Alps (Sardet et al. 2015; Sindaco et al. 2012), with a species richness comparable or even higher than what reported for other W-Alpine areas, as for instance the Mercantour National Park (56 species between 928 m and 2614 m; Mourguiart et al. 2020), the Orsiera-Rocciavré Natural Park and the Orrido di Foresto Natural Reserve (53 species, 560-2600 m; Giuliano et al. 2017), the Cogne Valley (48 species, 602-4061 m; Baroni 2015), the Mont Avic Natural Park (37 species, 1200-2700 m; Sindaco et al. 2007-2008), and the Alpe Veglia-Alpe Devero and Alta Valle Antrona Natural Parks (20 species, 1150-2700 m; Battisti et al. 2016). Moreover, the biogeographic relevance of the MNP territory for orthopteran diversity is particularly highlighted by the high number of endemic taxa observed (10), even representing the most common chorological category in the study area, together with the Sibero-European species. Indeed, more than a third (39%; Sardet et al. 2015; Sindaco et al. 2012) of the W-Alpine endemic Orthoptera proved to occur in the MNP, confirming the role of the Monviso massif as a biodiversity hotspot for these insects.

In this context, alpine ecosystems play a major role in supporting endemic orthopterans in the study area, since they host 5 of the 11 W-Alpine endemic taxa known to primarily occur above 2000 m, namely *Anonconotus baracunensis*, *Anonconotus occidentalis*, *Epipodisma pedemontana*, *Chorthippus cialancensis* and *Chorthippus sampeyrensis* (Sardet et al. 2015; Sindaco et al. 2012). For this reason, high-altitude orthopteran assemblages should represent a conservation priority in the MNP, especially because *A. baracunensis*, *E. pedemontana*, *C. cialancensis* and *C. sampeyrensis* are included in the *Near threatened* category by Hochkirch et al. (2016), due to their restricted global distribution and their expected vulnerability to climate change effects in alpine ecosystems. Together with these species, other widespread taxa compose the alpine orthopteran community in the MNP, among which *Omocestus viridulus*, *Gomphocerus sibiricus* and *Myrmeleotettix maculatus* resulted as the most common ones.

However, as highlighted by the 43 species recorded between 1400 m and 2000 m, most of the orthopteran diversity observed in the study area occurs in the subalpine and montane belts, where a high habitat heterogeneity is able to support the diverse ecological requirements of many taxa. Meadows, pastures, shrublands and ecotones proved to be species-rich habitats at these elevations, especially those with south-facing exposition, suggesting that the maintenance of open and transitional areas should represent the focus of future orthopteran conservation strategies in the lower sectors of the MNP. In particular, a high species richness was found in subalpine grasslands, with *Polysarcus denticauda*, *Metrioptera saussuriana*, *Calliptamus italicus*, *Psophus stridulus*, *Omocestus haemorrhoidalis*, *Omocestus viridulus*, *Stenobothrus lineatus*, *Stauroderus scalaris*, *Chorthippus dorsatus*, *Chorthippus apricarius* and *Chorthippus eisentrauti* as most common taxa; while montane meadows proved to host abundant *Gryllus campestris*, *Oedipoda caerulescens*, *Euthystira brachyptera*,

Pseudochorthippus parallelus and *Chorthippus mollis* populations, also including some species considered in decline in Italy or in other Alpine countries, as *Mecostethus parapleurus* and *Stenobothrus nigromaculatus* (Baur et al. 2006; Massa et al. 2012). Furthermore, *Barbitistes alpinus*, *Tettigonia cantans*, *Pholidoptera aptera*, *Pholidoptera griseoaptera*, *Antaxius pedestris*, *Gomphocerippus rufus* and the W-Alpine endemic *Ephippiger terrestris* resulted as the most common shrubland and ecotone taxa, although this ecological guild might require further investigations in the study area with a proper sampling method.

The importance of open and transitional habitats in supporting orthopteran diversity is further highlighted by their limited extent in the MNP, especially in the montane belt, where most of the protected area is covered by woodlands. Indeed, closed forests represent an unsuitable habitat for most species in the study area, except for *Nemobius sylvestris*, a widespread cricket in well-exposed broadleaved woods at low elevations. Furthermore, other minor habitats contribute in enhancing orthopteran species richness below 2000 m, as in the case of the few available wetlands and caves, where *Tetrix subulata* and *Dolichopoda azami* (a W-Alpine endemic) respectively are exclusive species, thus deserving attention in future plans for orthopteran diversity conservation in the MNP.

Besides the substantial contribution in knowing the MNP's biodiversity, this paper also provides important information on orthopteran distribution in Italy and in the neighbouring W-Alpine countries (i.e. France and Switzerland), especially concerning species' elevation range. Through a systematic review of recent publications and the new data collected in the study area, the altitudinal extremes of 43 taxa are here updated for Italy, completing not only the information provided by Massa et al. (2012), but also those contained in the last national field guide published by Iorio et al. (2019); while the update concerning the whole W-Alpine region concerns 15 species only. In particular, a new absolute elevation record for orthopterans in Italy has been documented in the MNP, thanks to the *Calliptamus italicus* and *Myrmeleotettix maculatus* specimens observed at 3050 m on Punta Losetta (Pontechianale), where particular environmental and short-term meteorological conditions might have supported an upslope movement of these individuals (Giuliano 2021). Conversely, this extreme elevation does not represent a record considering the whole western Alps, where *Aeropedellus variegatus* and *Myrmeleotettix maculatus* are reported until 3100 m and 3070 m respectively (Sardet et al. 2015).

Conclusions

In this research, the biogeographical relevance of the Monviso massif for orthopteran diversity has been confirmed, thanks to the overall species richness observed and to the high proportion of endemic taxa. Fortunately, most species are of least conservation concern, with only 4 endemic taxa classified as *Near-threatened* which has to be considered as a conservation priority in the MNP (Hochkirch et al. 2016).

Hopefully, the information provided in this paper may represent a baseline for future research, monitoring, and management activities in the park, identifying species-rich localities and outlining the areas where conservation efforts for near-threatened taxa should be focused. Indeed, mapping species distribution is an essential first step towards the development of an effective conservation strategy, although further studies are needed, especially concerning the biology, ecology, and interactions with human activities (e.g. livestock grazing, tourism, etc.) of high-altitude endemic Orthoptera.

Since alpine grasslands, subalpine pastures and montane meadows were identified as key habitats for many species in the MNP (including those of conservation concern), the adoption of management solutions based on extensive livestock grazing might represent an effective strategy to preserve the orthopteran diversity in the study area. Indeed, extensive grazing is generally recognised as a suitable practice to maintain biodiversity in open areas (Sartorello et al. 2020), hindering the progressive shrub encroachment and tree recolonization in grasslands, while avoiding over-grazing conditions, with verified considerable benefits for orthopterans as well (Hochkirch et al. 2016). In this context, the yearly creation of non-grazed areas in alpine grasslands might be experimented, in order to evaluate the suitability of this practice as a possible specific management solution to preserve high-altitude endemic species in the current climate change scenario.

Lastly, although examining a limited number of species, this paper provides a first summary about the current knowledge on orthopteran elevation ranges in the three W-Alpine countries, merging Italian, French and Swiss bibliographical data with those collected in the study area. This allowed to update the known altitudinal extremes of some taxa beyond political borders, covering a wide geographical area and including most of the Alpine biogeographical region. However, a huge work has still to be done to outline as precisely as possible the elevational range of all the orthopteran species living in the area reviewed by this paper (especially in Italy), with particular attention to the Alpine fauna, which is expected to undergo considerable upward range shifts in the foreseeable future due to climate change.

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