Sommario

ISSN 1121-1423

ASSOCIAZIONE NATURALISTICA PIEMONTESE

Rivista Piemontese di Storia Naturale

Volume XXXVIII - Anno 2017

ANP

Museo Civico F. Eusebio - Alba
Museo Civico Craveri di Storia Naturale - Bra
Museo Civico di Storia Naturale - Carmagnola

ISSN 1121-1423

ASSOCIAZIONE NATURALISTICA PIEMONTESE

Rivista Piemontese di Storia Naturale

Volume XXXVIII - Anno 2017

ANP

Museo Civico F. Eusebio - Alba
Museo Civico Craveri di Storia Naturale - Bra
Museo Civico di Storia Naturale - Carmagnola

Davide Giuliano* - Cristiana Cerrato*/**
Ramona Viterbi** - Paolo Savoldelli***

The Orthopterans (Insecta: Orthoptera) of the Orsiera-Rocciavré Natural Park and the Orrido di Foresto Natural Reserve (Piedmont, NW Italy)

ABSTRACT - In this paper we present the currently available information about the orthopterans of the Orsiera-Rocciavré Natural Park and the Orrido di Foresto Natural Reserve (Piedmont, NW Italy), reporting some bibliographic and unpublished data.

Field research were carried out during the Animal Biodiversity Monitoring Project in these two alpine protected areas. The sampling activities occurred in accordance with a standardized method in 2007-2008 and in 2012-2013, in 20 sampling plots along 4 altitudinal transects.

Overall, 53 species were recorded, with the first report of *Stenobothrus fischeri* (Eversmann, 1848) in Piedmont.

Ecological analyses were performed to characterize the orthopteran assemblages along the altitudinal gradient, identifying the typical and most abundant species in each elevational belt. We found the most exclusive assemblages in the alpine belt and in the sub-montane belt (xerothermic area), while at the intermediate elevations the high habitat diversification prevent from finding specific communities and indicator species.

KEYWORDS - Orthoptera, checklist, altitudinal gradient, Orsiera-Rocciavré Natural Park, Orrido di Foresto Natural Reserve.

RIASSUNTO - *Gli ortotteri (Insecta: Orthoptera) del Parco Naturale Orsiera-Rocciavré e della Riserva Naturale dell'Orrido di Foresto.*

In questo lavoro si presenta la *checklist* degli ortotteri noti del Parco Naturale Orsiera-Rocciavré e della Riserva Naturale dell'Orrido di Foresto. L'elenco delle specie è stato stilato mediante la raccolta di dati bibliografici e grazie alle informazioni inedite derivanti dalle ricerche sul campo realizzate nell'ambito del Progetto di Monitoraggio della Biodiversità Animale nei bienni 2007-2008 e 2012-2013. La

* CNR, Institute of Atmospheric Sciences and Climate, c.so Fiume 4 - 10133 Torino.
** Gran Paradiso National Park, via Pio VII 9 - 10135 Torino.
*** IPLA S.p.A., c.so Casale 476 - 10132 Torino. davide.giuliano@alice.it

raccolta degli individui è stata effettuata con tecniche standardizzate in 20 stazioni di campionamento, collocate lungo 4 transetti altitudinali.

Nell'area di studio è stata accertata la presenza di 53 specie, tra le quali si segnala *Stenobothrus fischeri* (Eversmann, 1848) per la prima volta in Piemonte.

Sono state effettuate analisi ecologiche esplorative per caratterizzare le comunità delle diverse fasce altitudinali, individuando le specie caratteristiche e i *taxa* più abbondanti. L'orizzonte alpino e la fascia sub-montana (oasi xerotermica) ospitano le comunità più esclusive, mentre alle quote intermedie la maggiore eterogeneità ambientale impedisce la presenza di specie caratteristiche e di comunità specifiche.

INTRODUCTION

In the last few decades, species extinction and biodiversity decline have reached an alarming rate (Thomas *et al.*, 2004; Butchart *et al.*, 2010). These processes point out the urgent need to study and monitor factors that influence biodiversity variations, identifying priority areas and sensitive taxonomic groups for conservation purposes (Yoccoz *et al.*, 2001; Magurran *et al.*, 2010).

In this framework, alpine ecosystems are of particular interest. Mountain landscapes, owing to their physical, topographic and climatic heterogeneity, are characterized by a mosaic of habitats along the altitudinal gradients (Körner, 2000; Beniston, 2003), allowing the presence of a rich biodiversity (Viterbi *et al.*, 2013).

For these reasons, a long-term Animal Biodiversity Monitoring Project (ABMP) has been started in 2006 in the Western Italian Alps, involving some protected areas in Piedmont (Gran Paradiso National Park, Val Grande National Park, Orsiera-Rocciavré Natural Park, Orrido di Foresto Natural Reserve and Alpe Veglia-Alpe Devero-Alta Valle Antrona Natural Park). This monitoring program is based on a multi-*taxa* approach, investigating the diversity of several animal groups along altitudinal gradients repeatedly in time. The aim of this research is to observe and monitor on the long period the variations in animal communities, as a probable consequence of climatic and environmental changes.

Orthopterans (Orthoptera: Ensifera, Caelifera) are included between the animal groups selected for the ABMP and in the last years a large amount of data about these insects were collected in the parks involved in the project (see also Battisti *et al.*, 2016). Therefore, the information obtained may provide an important contribution to the knowledge of the alpine orthopteran fauna, concerning in particular the Orsiera-Rocciavré

Natural Park (ORNP) and the Orrido di Foresto Natural Reserve (FNR), for which a grasshopper checklist is currently lacking.

To date, the information about the orthopterans in the ORNP and the FNR were limited to occasional research by various authors and to specimens preserved in public (Carmagnola Natural History Museum; Verona Natural History Museum) and private (Coll. Fontana; Coll. Goidanich) collections. La Greca (1986) published a checklist for the Western Italian Alps, in which some data for the ORNP are reported. Nevertheless, they are referred only to 4 localities in the Chisone Valley, therefore without a thorough description of the overall fauna of the Park.

Recently, an orthopteran checklist for North-West Italy was published by Sindaco *et al.* (2012), providing an overall description of the distribution of these insects at regional level and including some of the data collected in the ABMP in 2007-2008. Although they were formerly included in this publication, these data are considered also in the present paper, in order to provide a complete description of the orthopteran fauna in the study area.

The aim of this research is to collect all the currently available information about the grasshoppers of the ORNP and the FNR, reporting bibliographic and unpublished data. Moreover, the orthopteran assemblages within each elevational belt will be described in detail, identifying the typical and the most abundant species in the different habitats.

MATERIALS AND METHODS

Study area

The ORNP covers a surface of about 11.000 ha on the mountain ridge between the Susa Valley, the Chisone Valley and the Sangone Valley (Western Italian Alps), between 1200 to 2890 m a.s.l. (Mt. Orsiera peak). Instead, the FNR is placed on the left hydrographic side of the Susa Valley, between 500 and 900 m a.s.l., covering a surface of about 200 ha around the canyon created by the Rocciamelone Stream. The FNR is also included within the S.C.I. IT1110030 *Oasi xerotermiche della Valle di Susa - Orrido di Chianocco e Foresto*, occupying a little portion of this larger protected area (fig. 1).

The data collection was performed along 4 altitudinal transects, 3 in the ORNP (*Chisone*, *Sangone* and *Susa*) and 1 in the FNR (*Foresto*) (fig. 1), selected with the purpose of investigate all the habitats present in the two protected areas. Therefore, a wide elevational range was investigated, between the montane and the alpine belts in the ORNP (1400-2600 m a.s.l.)

and between the sub-montane and the montane belts in the FNR, where elevation is lower (560-1300 m a.s.l.).

Within each altitudinal transect 4 or 6 sampling stations (*plot*) were selected, each one separated by the others by about 200 m in altitude. In every *plot*, all the sampling activities were performed along a linear transect (200 m in length).

Data collection

Samplings were performed monthly in 2007-2008 and in 2012-2013, between July and September. Data collection in June was avoided due to the presence of a large proportion of immature individuals (nymphs) in mountain ecosystems.

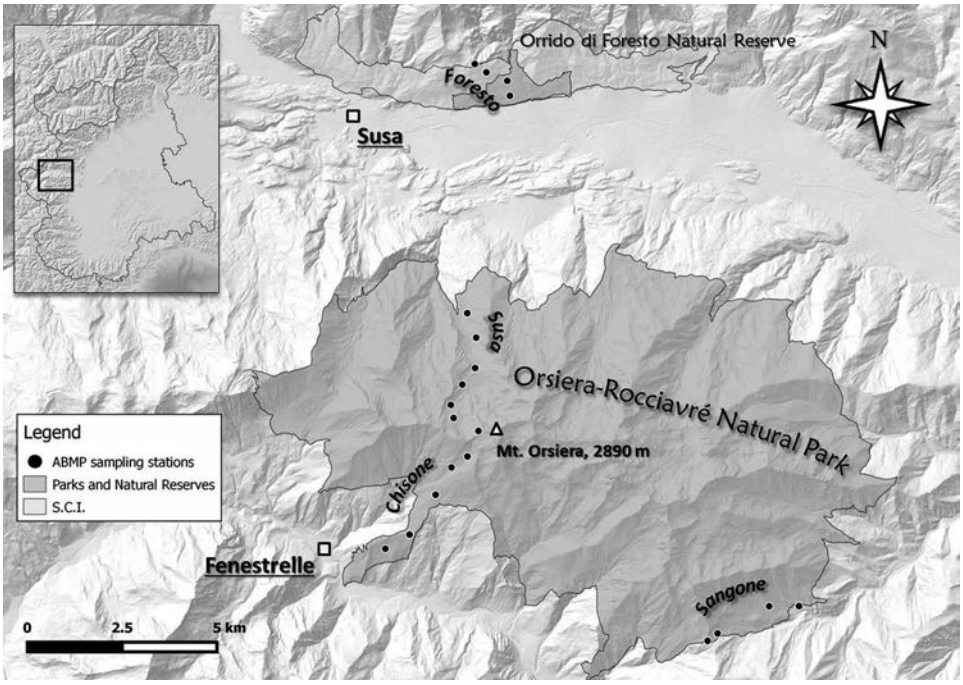

Fig. 1 - Map of the study area, including the Orsiera-Rocciavré Natural Park and the Orrido di Foresto Natural Reserve. The black points identify the position of the ABMP sampling stations, with the name of the altitudinal transects reported in italic.

The collecting method was based on a standard sampling surface of 0.18 m^2, defined in the field by a plastic cylinder (*ring counts*). This instrument was placed randomly on the ground 30 times in each *plot*, counting and collecting all the trapped orthopterans.

The use of a fixed sampling unit allowed the standardized grasshopper collection in different habitats, even if this method alone is not enough to study the overall orthopteran assemblage. Indeed, this technique is not effective to collect arboreal and shrub species, that normally require other sampling systems not applied in this study. Notwithstanding, the choice of this technique was driven by the ABMP requirements, that suggest the application of standardized sampling methods in order to simplify the long-term repetition of the surveys and the data analysis.

Species identification was carried out in the field only for some distinctive *taxa*, while the other individuals were suppressed and examined in laboratory, using a binocular and the identification keys by Coray & Thorens (2001), Baur *et al.* (2006), Massa *et al.* (2012) and Sardet *et al.* (2015). The collected individuals were dried and included in a reference collection (now preserved at Gran Paradiso National Park headquarters, Torino), concerning in particular the species of difficult identification.

The bibliographical data were collected through a critical analysis of the available literature for the study area, using in particular *CkMap* (Fontana *et al.*, 2005) and the *Piemonte Region Faunistic Database* as information sources. Due to the frequent imprecision in the localities reported, in this paper we considered only the data certainly included in the two protected areas (basing on place name and altitude). Therefore, we did not include data in which only the municipality is shown as locality, in particular if the elevation reported indicates a site outside the ORNP or the FNR borders.

In the checklist we also included some data collected randomly by the authors in the study area, concerning in particular species not found during the ABMP.

Data analysis

Thanks to the availability of standardized data, we performed some ecological analyses, including the calculation of biodiversity indices (Shannon-Wiener Index). Moreover, in order to show how species richness and diversity are distributed along the altitudinal gradient, we applied a non-parametric regression method (*loess*). This technique permits a graphical visualization of the orthopteran diversity distribution within the different elevational belts.

The ecological preferences of species, concerning in particular their distribution along the altitudinal gradient, were tested using an *Indicator*

Species Analysis (ISA), through the calculation of the *IndVal* (Indicator Value) index (Dufrêne & Legendre, 1997). This parameter measures the specificity and the fidelity of species to a defined group of sampling stations or habitats, allowing the identification of the characteristic species for each elevational belt. The species that obtain index values higher or equal to 0.5 can be considered typical of a given habitat type; nevertheless, a proper interpretation of the results is subjected to a statistical significance, in particular when the values are close to 0.95.

The *IndVal* statistical significance is calculated through a random reallocation procedure of sites among site groups, performing a high number of permutations (in this case 999), in which the index is re-calculated. On these data, the significance is evaluated by the difference between the observed value and the mean of those obtained from the random permutations, weighted by the standard deviation of the values obtained randomly, turning it into a regular *z* statistic, assuming approximate normality of the distribution of the permuted statistics. Moreover, the rank of the observed value in the randomly generated distribution ordered in decreasing order is noted, producing a regular permutational probability (Dufrêne & Legendre, 1997). The elevational belts considered for the *IndVal* are: alpine belt (2000-2600 m a.s.l.), sub-alpine belt (1600-2000 m a.s.l.), montane belt (1000-1600 m a.s.l.) and sub-montane belt (500-1000 m a.s.l.); the last including only sampling plots in the FNR.

These analyses were performed using the software *R* (version 3.1.0) (R Core Team, 2014), packages *vegan* (version 2.0-10) (Oksanen *et al.*, 2013) and *indicspecies* (version 1.7.1) (De Caceres & Legendre, 2009).

RESULTS

During the monitoring period in the ORNP and the FNR, we collected 867 individuals (305 in 2007-2008 and 562 in 2012-2013), belonging to 45 species. Due to their identification complexity, the individuals ascribed to the genus *Anonconotus* and to the *Chorthippus* (*Glyptobothrus)* gr. *biguttulus* group were identified only as a species complex (Massa *et al.*, 2012).

The data of presence in the study area of *Phaneroptera nana*, *Leptophyes boscii*, *Podisma pedestris*, *Aiolopus strepens*, *Mecostethus parapleurus* and *Pararcyptera alzonai* were obtained from literature and faunistic databases, while *Dolichopoda azami* (sensu Allegrucci *et al.*, 2014) and *Chorthippus (Glyptobothrus) cialancensis* were observed by the authors outside the standardized sampling areas (Giuliano D. & Savoldelli P., pers. obs.).

Overall, at present 53 orthopteran species are reported for the ORNP and the FNR. Nevertheless, the presence of *Podisma pedestris* and *Mecostethus parapleurus*, reported by Griffini (1897) in the surroundings of Colle delle Finestre, lacks of recent confirmations and therefore must to be considered uncertain.

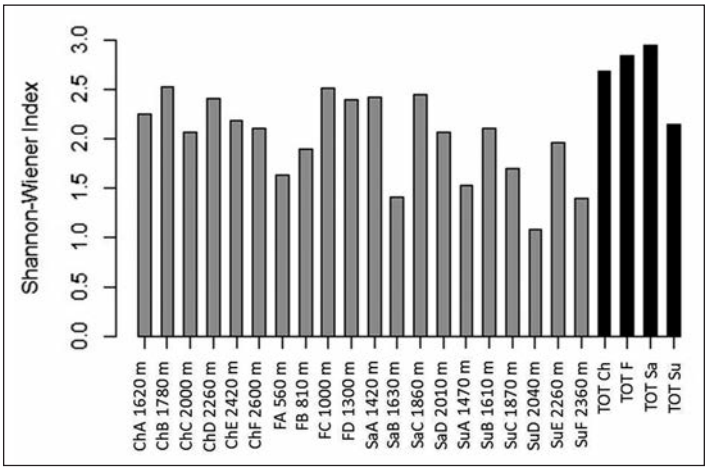

Fig. 2 - Shannon-Wiener Index values calculated in each ABMP sampling station (grey bars) and as a whole in the 4 altitudinal transects (black bars) (Ch = *Chisone*; F = *Foresto*; Sa = *Sangone*; Su = *Susa*). The altitude of every sampling *plot* is also reported.

Concerning standardized samplings, we recorded the highest species richness along the *Sangone* transect (29), followed by *Foresto* (27) and *Chisone* (26). Instead, *Susa* is the area with the lowest number of species, only 16 (tab. 1). The community data analysis, through the calculation of the Shannon-Wiener Index, allowed the description of the orthopteran diversity in the study area (fig. 2). The sampling station *FB* (FNR, 810 m a.s.l.) is the *plot* with the highest diversity (2.53), followed by *SaB* (Sangone Valley, 1630 m a.s.l.; 2.52), *ChC* (Chisone Valley, 2000 m a.s.l.; 2.45) and *SaC* (Sangone Valley, 1860 m a.s.l.; 2.42). Between transects, *Sangone* (2.94) shows the highest value of the Shannon-Wiener Index, followed by *Foresto* (2.84), *Chisone* (2.69) and *Susa* (2.14).

The analysis of species chorology revealed the prevalence of Euro-Siberian (6) and Eurasian species (4) in the FNR. Nevertheless, a large amount of the other species found in this site is distributed in the Mediterranean area. Euro-Siberian (10) and Eurasian species (9) are the prevalent *taxa* in the ORNP as well, where 7 Alpine endemic species are also present, highlighting the importance of the area from a conservation point of view.

Tab. 1 - Checklist of the orthopteran species collected in the ORNP and in the FNR. The table reports information about the species distribution in the 4 ABMP transects (CH = *Chisone*; F = *Foresto*; SA = *Sangone*; SU = *Susa*), indicating the altitudinal range of presence and the observation period (PHE; months in latin numbers). Moreover, we provide information about species chorology (according with Stoch & Vigna Taglianti, 2005) (CHO) and bibliographical data. For the species not observed during the ABMP only the bibliographical source of the data is reported. Species nomenclature and taxonomic order follow Massa *et al.* (2012).

Species	CHO	Transect				Elevational range (m)	PHE	Bibliographical data
		CH	F	SA	SU			
Phaneroptera nana Fieber, 1853	WPA					600-700	-	Sindaco, 2002, *Piemonte Region Faunistic Database*
Barbitistes alpinus Fruhstorfer, 1920	AWNA			+	+	1420-1610	VIII	
Leptophyes boscii Fieber, 1853	SEU					1200	-	Sindaco, 2005, *Piemonte Region Faunistic Database*
Leptophyes laticauda (Frivaldsky, 1867)	CEU		+			810	VII	
Polysarcus denticauda (Charpentier, 1825)	SEU	+		+		1850-2420	VII-VIII-IX	Nadig, 1987; Coll. Fontana, 1996, *CkMap*.
Tettigonia cantans (Fuessly, 1775)	ASE	+		+	+	1420-1800	VII-VIII-IX	La Greca, 1986.
Tettigonia viridissima Linnaeus, 1758	PAL		+			810	VII	
Decticus verrucivorus (Linnaeus, 1758)	ASE	+		+	+	1800-2260	VIII-IX	La Greca, 1986.
Platycleis grisea (Fabricius, 1781)	CAE	+	+			560-1620	VII-VIII-IX	
Metrioptera saussuriana (Frey-Gessner, 1872)	CEU	+		+		1420-2010	VII-VIII-IX	
Bicolorana bicolor (Philippi, 1830)	SIE	+				2000-2600	VII-VIII	
Pholidoptera aptera (Fabricius, 1793)	CEU			+	+	1420-1610	VII-VIII-IX	
Pholidoptera griseoaptera (De Geer, 1773)	EUR		+	+	+	1250-1670	VII-VIII-IX	
Anonconotus sp.	ALP	+		+	+	1630-2600	VII-VIII-IX	Coll. Goidanich, *CkMap* (*A. occidentalis*); Nadig (1987) & La Greca (1986) (*A. ghilianii*).
Chopardius pedestris (Fabricius, 1787)	CEU		+	+		1300-1420	VII-VIII	
Saga pedo (Pallas, 1771)	SIE		+			560-810	VII-VIII-IX	
Ephippiger terrestris (Yersin, 1854)	ALSW	+				1780	IX	
Dolichopoda asami Sauley, 1893	ALPW					1300	-	Giuliano D., *unpublished data.*
Nemobius sylvestris (Bosc, 1792)	CEU		+	+		810-1420	VII-VIII-IX	
Oecanthus pellucens (Scopoli, 1763)	CAM		+			810	IX	
Tetrix bipunctata (Linnaeus, 1758)	SIE		+			1300	IX	
Tetrix tenuicornis (Sahlberg, 1893)	TUE	+				1620	IX	
Podisma pedestris (Linnaeus, 1758)	ASE					2100	-	Griffini, 1897.
Epipodisma pedemontana (Brunner von Wattenwyl, 1882)	ALPW	+		+	+	1860-2600	VII-VIII-IX	Coll. Fontana, 1972, *CkMap*; La Greca, 1986.
Pezotettix giornae (Rossi, 1794)	EUM		+			810-1000	VII-VIII-IX	
Calliptamus italicus (Linnaeus, 1758)	ASE		+	+		560-1630	VII-VIII-IX	

ISSN 1121-1423

Calliptamus siciliae Ramme, 1927	MED		+			560-1000	VIII-IX	
Psophus stridulus (Linnaeus, 1758)	PAL	+		+		1630-2000	VIII-IX	
Oedaleus decorus (Germar, 1826)	CAM		+			560	VII-VIII-IX	
Oedipoda caerulescens (Linnaeus, 1758)	CEM	+	+	+		560-2420	VII-VIII-IX	Coll. Museum of Verona, 1919, *CkMap*.
Oedipoda germanica (Latreille, 1804)	EUR	+	+	+		560-2000	VII-VIII-IX	
Aiolopus strepens (Latreille, 1804)	EUM					-	-	Griffini, 1897; Mangini & Bonicelli, 2002, *Piemonte Region Faunistic Database*
Mecostethus parapleurus (Hagenbach, 1822)	SIE					2100	-	Griffini, 1897.
Arcyptera fusca (Pallas, 1773)	SIE	+		+	+	1630-2420	VII-VIII-IX	La Greca, 1986; Coll. Fontana, 1996, *CkMap*.
Pararcyptera alzonai Capra, 1938	ALPW					1850	-	Coll. Fontana, 1996, *CkMap*.
Euthystira brachyptera Ocskay, 1826	ASE	+	+	+		810-2260	VII-VIII-IX	La Greca, 1986; Coll. Fontana, 1996, *CkMap*.
Omocestus (Omocestus) rufipes (Zetterstedt, 1821)	CEM		+			810-1300	VII-VIII-IX	
Omocestus (Omocestus) viridulus (Linnaeus, 1758)	ASE	+		+	+	1420-2600	VII-VIII-IX	La Greca, 1986.
Omocestus (Dirshius) haemorrhoidalis (Charpentier, 1825)	ASE	+	+	+		560-2260	VII-VIII-IX	
Stenobothrus fischeri (Eversmann, 1848)	CAM		+			560	VII	
Stenobothrus lineatus (Panzer, 1796)	SIE	+	+	+		1300-2420	VII-VIII-IX	
Stenobothrus nigromaculatus (Herrich-Schaeffer, 1840)	SIE	+	+	+	+	810-2420	VII-VIII-IX	La Greca, 1986.
Aeropus sibiricus (Linnaeus, 1767)	SIE	+		+	+	1860-2600	VII-VIII-IX	La Greca, 1986; Coll. Fontana, 1996, *CkMap*.
Gomphocerippus rufus (Linnaeus, 1758)	SIE			+		1420-1630	VII-VIII-IX	
Myrmeleotettix maculatus (Thunberg, 1815)	SIE			+		1630	IX	Nadig, 1987.
Staurodesus scalaris (Fischer de Waldheim, 1846)	ASE	+	+	+	+	1300-2420	VII-VIII-IX	La Greca, 1986; Coll. Fontana, 1996, *CkMap*.
Chorthippus (Chorthippus) dorsatus (Zetterstedt, 1821)	SIE	+	+		+	1300-2260	IX	
Chorthippus (Chorthippus) parallelus (Zetterstedt, 1821)	SIE	+	+	+	+	1300-2000	VII-VIII-IX	

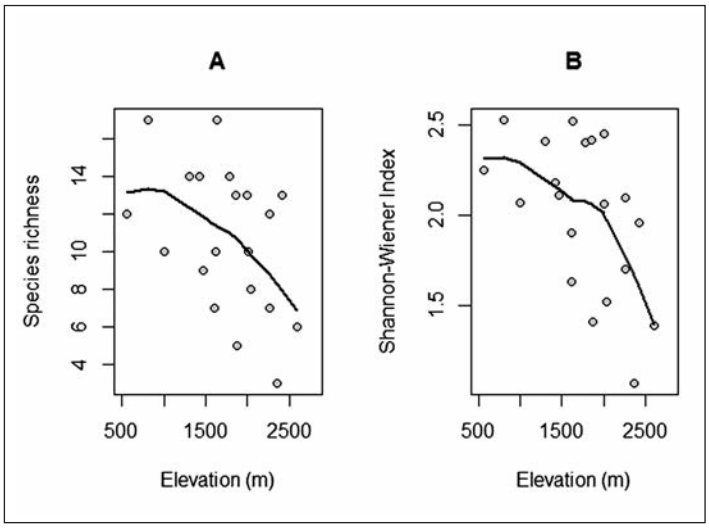

Fig. 3 - Scatter plots with a trend line (*loess*) representing species richness and diversity distribution along the altitudinal gradient within the study area. In **A** the species richness trend against elevation is reported, while in **B** the curve shows how the Shannon-Wiener Index declines along the altitudinal gradient. The points identify the values recorded in each ABMP sampling station.

In order to describe the variation of orthopteran assemblages along the altitudinal gradient, we analyzed the relationship between elevation, species richness and diversity (as a Shannon-Wiener Index value). The results of these analyses are reported in figure 3, where is possible to note that species richness and diversity decrease with increasing elevation.

The community composition in the 4 elevational belts and in the ABMP transects is reported in the figures 4-7. In the alpine belt *Aeropus sibiricus* is the most abundant species, representing the 9.69% of the sample. *Anonconotus* sp. (7.50%) and *Epipodisma pedemontana* (6.92%) are the other predominant species in this area. These three *taxa* were collected mainly in the *Chisone* and *Susa* transects (fig. 4).

Instead, the most frequent species in the sub-alpine belt are *Chorthippus (Glyptobothrus) apricarius* (3.00%) and *Stauroderus scalaris* (2.77%), sampled mainly in the Chisone Valley (fig. 5).

In the montane belt *S. scalaris* (3.00%) and *Chorthippus (Chorthippus) parallelus* (2.19%) are the most represented *taxa*. Within this belt, along the *Sangone* transect we found the highest number of species (fig. 6).

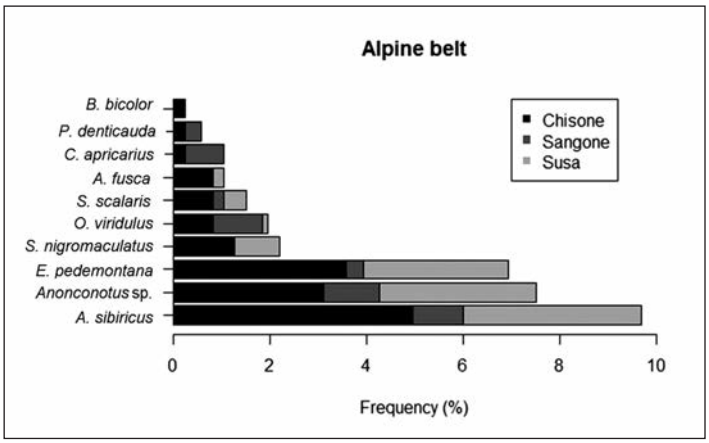

Fig. 4 - Percentage frequency of the 10 most abundant species collected in the alpine belt (2000-2600 m a.s.l.). The values obtained in each altitudinal transect are reported with different colors.

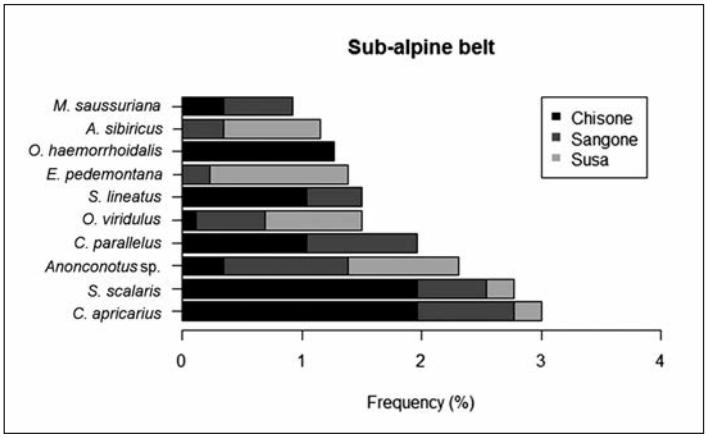

Fig. 5 - Percentage frequency of the 10 most abundant species collected in the sub-alpine belt (1600-2000 m a.s.l.). The values obtained in each altitudinal transect are reported with different colors.

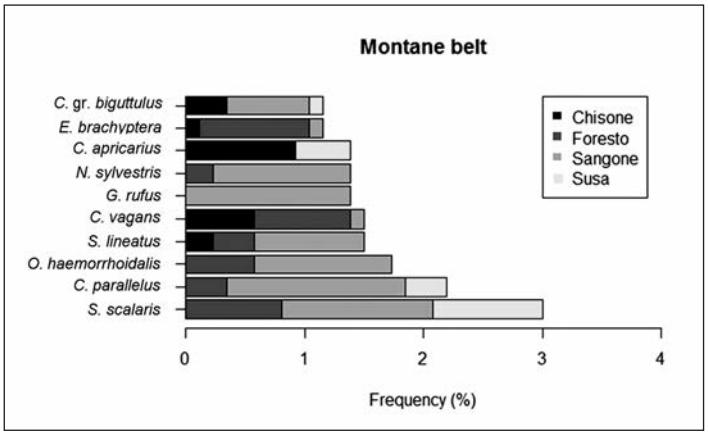

Fig. 6 - Percentage frequency of the 10 most abundant species collected in the montane belt (1000-1600 m a.s.l.). The values obtained in each altitudinal transect are reported with different colors.

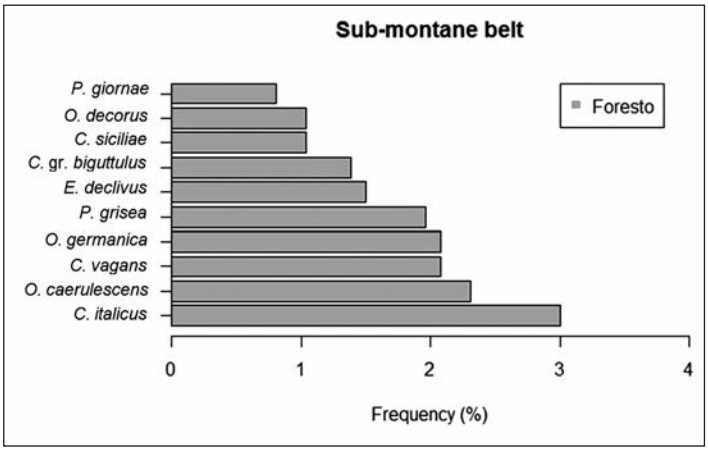

Fig. 7 - Percentage frequency of the 10 most abundant species collected in the sub-montane belt (500-1000 m a.s.l.). The values reported are only referred to the *Foresto* transect.

Tab. 2 - *IndVal* results regarding the elevational belts monitored during the ABMP. *Stat* reports the values of the index, while in the column *p value* the significance of the results is calculated through 999 permutations.

Elevational belt	Stat	*p* value
Alpine (2000-2600 m)		
Aeropus sibiricus (Linnaeus, 1767)	0.926	0.001
Epipodisma pedemontana (Brunner von Wattenwyl, 1882)	0.884	0.001
Anonconotus sp.	0.806	0.001
Sub-alpine (1600-2000 m)		
-	-	-
Montane (1000-1600 m)		
Pholidoptera griseoaptera (De Geer, 1773)	0.746	0.028
Sub-montane (500-1000 m)		
Calliptamus siciliae Ramme, 1927	1.000	0.003
Platycleis grisea (Fabricius, 1781)	1.000	0.003
Calliptamus italicus (Linnaeus, 1758)	0.989	0.003
Oedipoda germanica (Latreille, 1804)	0.939	0.005
Oedipoda caerulescens (Linnaeus, 1758)	0.936	0.004
Chorthippus (Glyptobothrus) vagans (Eversmann, 1848)	0.835	0.007
Pezotettix giornai (Rossi, 1794)	0.816	0.019
Euchorthippus declivus (Brisout, 1848)	0.750	0.047
Chorthippus (Glyptobothrus) gr. *biguttulus*	0.741	0.026

In the FNR, included in the sub-montane belt, the orthopteran assemblage is dominated by *Calliptamus italicus* (3.00%), *Oedipoda caerulescens* (2.31%), *Oedipoda germanica* (2.08%) and *Chorthippus (Glyptobothrus) vagans* (2.08%) (fig. 7).

The results obtained from *IndVal* showed values higher than 0.8 only for the alpine and sub-montane belts (tab. 2). *A. sibiricus*, *E. pedemontana* and *Anonconotus* sp. are the typical high altitude species, while *Calliptamus siciliae*, *Platycleis grisea* and *Calliptamus italicus* are characteristic *taxa* for lower elevations.

DISCUSSION

To date, 349 orthopteran species are reported for Italy (Massa *et al.*, 2012), while 147 are present in North-West Italy (Piedmont, Liguria and Aosta Valley), with 136 *taxa* in the Alps only (Sindaco *et al.*, 2012). Our research demonstrated the presence of 53 species in the ORNP and the FNR, representing more than a third (39%) of the species reported for the Western Italian Alps.

Although the results obtained in this paper provide an important contribute to the knowledge of orthopteran distribution in the study area, some information gaps are still present, concerning in particular the genus *Anonconotus* and the *C. (G.)* gr. *biguttulus* group. Moreover, the application of a single sampling method, not effective for collecting arboreal and shrub species, probably led to an underestimation of the presence of these *taxa*, suggesting the execution of further research in these protected areas.

The genus *Anonconotus* was considered monotypic until 1987 (Sindaco *et al.*, 2012), when many new *taxa* started to be described in North-West Italy. According to the revisions of Carron *et al.* (2002), Galvagni (2002, 2003, 2005) and Galvagni & Fontana (2006), the species known for the Western Alps are 6, but, due to the variability in the diagnostic characters, the identification of these *taxa* on morphological basis is particularly difficult (Sindaco *et al.*, 2012).

Analyzing the literature data (La Greca, 1986; Nadig, 1987; Sindaco *et al.* 2012) and specimens in private collections (Coll. Goidanich, *CkMap*), the species probably present in the ORNP are two: *A. ghilianii* and *A. occidentalis*.

Instead, the *C. (G.)* gr. *biguttulus* group includes morphologically similar species, in many cases impossible to identify without a stridulation analysis (Ingrisch, 1995). The lack of a specific sampling method, based on song listening and registration, prevented the identification of the individuals belonging to this group. Moreover, the absence of bibliographical data makes impossible to formulate hypothesis on which species are present in the ORNP and FNR.

Between the species observed in the study area, *Saga pedo* is the most important one, concerning biodiversity conservation. This Ensifera is the biggest orthopteran of Europe and it is included in the Annex IV of the Habitat Directive (92/43/CEE), being rare and related to particular habitats. Indeed, *S. pedo* is a thermophilous species and is considered one of the best indicators for the xerothermic areas of Northern Italy (Massa *et al.*, 2012). Its distribution in Piedmont is extremely restricted, limited to some xerothermic sites in the alpine valleys and in the Capanne di Marcarolo Natural Park (Northern Apennines, Alessandria Province) (Sindaco *et al.*, 2012).

Within the study area, the 13.2% of the orthopteran fauna is composed by endemic species. Between them, *Ephippiger terrestris* (ssp. *bormansi*), *Dolichopoda azami*, *Epipodisma pedemontana*, *Pararcyptera alzonai* and *Chorthippus (Glyptobothrus) cialancensis* are Western Alps endemics (Massa *et al.*, 2012; Sindaco *et al.*, 2012).

D. azami (sensu Allegrucci *et al.*, 2014) is a troglophilous species, observed in the ORNP outside the standardized samplings areas (Giuliano D., pers. obs.) in a little cave on the left side of the Gravio Valley (*Barma Chita*, municipality of S. Giorio di Susa). Similarly, the data about *C. cialancensis* has been collected during a random sampling session in the Balma Valley (municipality of Coazze) (Savoldelli P., pers. obs.), now representing the northernmost observation site for this endemic species.

P. alzonai has not been observed during the ABMP as well, but its presence in the ORNP is confirmed by specimens preserved in a private collection (Coll. Fontana 1996, *CkMap*; Sindaco *et al.*, 2012). The presence in the ORNP of *P. alzonai* is an interesting data, since the distribution of this species is extremely restricted (Sindaco *et al.*, 2012). Similarly to *P. alzonai*, the presence in the FNR of *Oedaleus decorus* is an important data, because this species is extremely rare in Piedmont (Sindaco *et al.*, 2012), even if it is not an endemic *taxon*.

Nevertheless, the most important information collected during our research on the orthopterans of this alpine area concerns *Stenobothrus fischeri*, found during the standardized samplings in the FNR. This species is distributed in Southern Europe and in Central Asia (Massa *et al.*, 2012), while in Italy it is known only for several isolated localities, mainly located in Southern Apennines (Massa *et al.*, 2012). In North-West Italy *S. fischeri* has been found only in two sites in the Aosta Valley (Baroni, 2015), while in Piedmont its presence has never been noticed (Sindaco *et al.*, 2012).

The only one individual collected of *S. fischeri* (a female) (fig. 8), was found at the beginning of July 2013 in the *FA* sampling station (FNR, 560 m). This species was sampled in a xerothermic prairie, with many rock

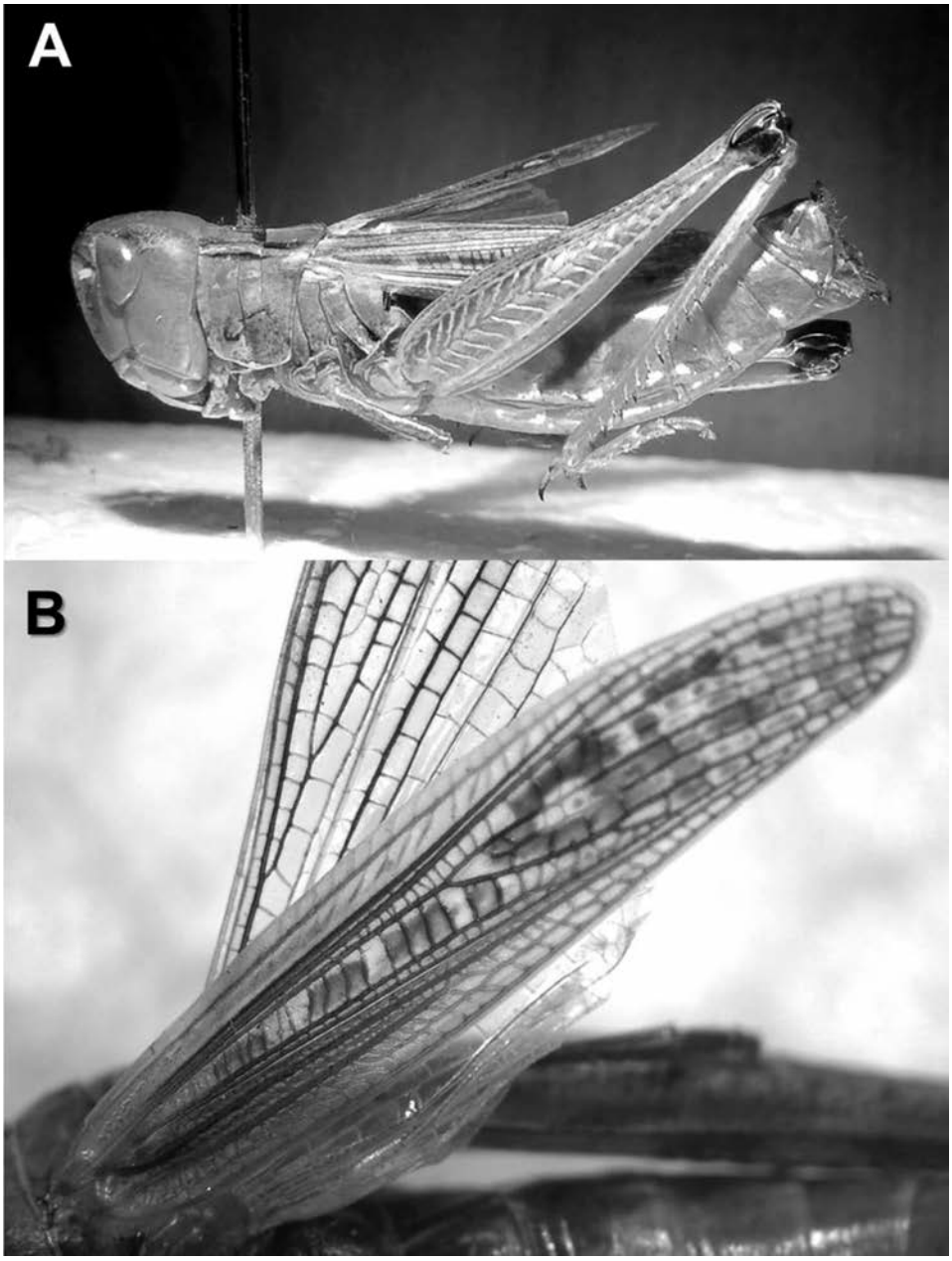

Fig. 8 - Female of *Stenobothrus fischeri* collected in the FNR (**A**), with a detail on *tegminae* morphology (**B**). Total body length: 28 mm; right *tegmina* length: 14.4 mm; left post-femur length: 14.9 mm (Photo: D. Giuliano).

outcrops and dry stone walls, all surrounded by shrubs and small woodland patches (fig. 9).

The high orthopteran diversity described in this paper is mainly due to the results obtained in the FNR. Although the *Foresto* transect is not the richest of the study area in terms of species richness, it provides a large proportion of the total number of species found in this study. The peculiarity of habitats (xerothermic area with dry prairies and rock outcrops) permits the presence of a large number of orthopterans species, also with particular ecological requirements (e.g. *Saga pedo*). Indeed, 10 of the species hosted in the FNR are exclusive of this area.

An additional evidence of the FNR's peculiarity is the presence of a large amount of species adapted to steppic and dry habitats, which in many cases are distributed mainly in the Mediterranean region. Therefore, the orthopteran assemblage observed here is completely different from communities normally present in the alpine valleys. Instead, the ORNP area hosts many species adapted to cold climatic conditions (Euro-Siberian distribution), able to survive at the highest elevations.

Fig. 9 - Habitat where *Stenobothrus fischeri* was collected in the FNR (*FA* sampling station, 560 m a.s.l.), characterized by xerothermic prairies, rock outcrops, dry stone walls and small woodland patches. The other species found in this *plot* are: *P. grisea*, *S. pedo*, *C. italicus*, *C. siciliae*, *O. decorus*, *O. caerulescens*, *O. germanica*, *O. haemorrhoidalis*, *C.* gr. *biguttulus*, *C. vagans* and *E. declivus* (Photo: D. Giuliano).

The *IndVal* shows high values only for the alpine and sub-montane belts (tab. 2), demonstrating again the peculiarity of the orthopteran assemblage in the FNR, but also highlighting the importance of the high elevation communities. In the intermediate elevational belts (montane and sub-alpine), the index values for the characteristic species are lower, probably due to the high habitat heterogeneity in this portion of the altitudinal gradient that permits the coexistence of many ecological niches. In these belts the assemblages can change as a consequence of many factors, including for example habitat type and exposure, while in alpine grasslands and in xerothermic areas the extreme climatic conditions allow the presence of orthopteran communities exclusive of these habitats.

Aeropus sibiricus, *Epipodisma pedemontana* and *Anonconotus* sp. are the typical high altitude species. Indeed, these *taxa* are adapted to survive in the alpine grasslands and shrubs (Baur *et al.*, 2006) (fig. 10), being also important for conservation purposes since *E. pedemontana* and many species of the genus *Anonconotus* are Western Alps endemics (Massa *et al.*, 2012). In the FNR, that includes the sampling station at the lowest elevations, the highest *IndVal* values were recorded for *Calliptamus siciliae*, *Platycleis grisea* and *Calliptamus italicus*. These *taxa* are typically thermophilous (Baur *et al.*, 2006), adapted to rocky and steppic habitats, often present in the alpine xerothermic areas.

The analysis of the abundances distribution along the altitudinal gradient shows a substantial predominance of *A. sibiricus*, *Anonconotus* sp. and *E. pedemontana* in the alpine belt (fig. 4). These species are the best adapted to the alpine climatic conditions and they are rarely found below 2000 m, as demonstrated by *IndVal* results.

At the intermediate elevations (sub-alpine and montane belts) the abundances are better distributed between species, with some *taxa* being abundant in both the elevational belts (e.g. *S. scalaris*) (figg. 5-6). Habitat heterogeneity explains again this result, allowing the coexistence of many individuals of different species.

In the sub-montane belt, the 10 most abundant species are all typically thermophilous and they correspond with the characteristic *taxa* indicated by *IndVal*, demonstrating their exclusive and abundant presence in the FNR.

In the end, we observed that species richness and diversity (Shannon-Wiener index) decrease with increasing elevation (fig. 3). This result is in accordance with those reported in literature (Sindaco *et al.*, 2012; Battisti *et al.*, 2016), where a higher species richness was observed at lower altitudes, with a substantial reduction of the number of *taxa* in the high elevation belts.

Indeed, orthopterans are mainly adapted to sunny and warm habitats (Massa *et al.*, 2012), with a restricted number of species able to live in extreme high elevation conditions, as reported before in this paper and in literature (Baur *et al.*, 2006). Moreover, in this study we observed that habitat heterogeneity and the presence of particular habitats at lower elevations can permit the coexistence of species with a wide range of ecological requirements, explaining the reduction of orthopteran diversity with increasing elevation.

CONCLUSIONS

In this paper we provide some important information about orthopteran distribution and ecology. In particular, the *Stenobothrus fischeri* discover in the FNR is a new data for Piedmont, improving our knowledge on the distribution of this species particularly rare in Italy. Moreover, this

Fig. 10 - Typical landscape in the alpine belt within the ORNP (*SuF* sampling station, 2360 m a.s.l.), characterized by high altitude grasslands and alpine shrubs. *Anonconotus* sp., *E. pedemontana* and *A. sibiricus* are exclusive species of this habitat (Photo: D. Giuliano).

research confirmed the presence of *Saga pedo* in the FNR, an important *taxon* for conservation purposes that need a strict protection, according to the Habitat Directive (Annex IV).

Overall, the observation of more than a third of the species known for the Western Italian Alps, including 7 Alpine endemic *taxa*, underlines the importance of the ORNP and the FNR in a biogeographical point of view. In a rather restricted area it is possible to observe a variety of habitats and a wide range of climatic conditions (from the dry prairies of the xerothermic areas, to alpine grasslands). This promotes the presence of a diverse orthopteran fauna that contributes in maintaining high biodiversity rates in the area.

The ecological analyses presented in this paper highlight the exclusivity of the orthopteran assemblages in the alpine belt and in the xerothermic areas. These information can be useful to identify priority habitats for biodiversity conservation, focusing in particular where endemic species are present.

ACKNOWLEDGEMENTS

We acknowledge Roberto Sindaco who, in the framework of the ABMP, carried out an important work in training some of the authors in orthopteran species identification, also validating the data for some specimens collected.

Moreover, we are grateful to two anonymous referees for their useful suggestions in improving the earlier version of the manuscript.

We also thank all the students and collaborators that helped us in the fieldwork, being in many cases essential for samplings fulfillment: Chiara Flora Bassignana, Andrea Battisti, Massimo Brunetti, Matteo Gabaglio, Silvia Ghidotti, Alessandro Girodo, Giulia Marangoni, Luca Pejretti, Elena Piano, Loredana Polello and Emanuel Rocchia.

REFERENCES

Allegrucci G., Rampini M., Di Russo C., Lana E., Cocchi S., Sbordoni V., 2014 – Phylogeography and systematics of the westernmost Italian *Dolichopoda* species (Orthoptera, Rhaphidophoridae). ZooKeys, 437: 1-23.

Baroni D., 2015 – Gli ortotteri della Valle di Cogne (Valle d'Aosta) (Insecta, Orthoptera). Revue Valdôtaine d'Histoire Naturelle, 69: 79-98.

Battisti A., Cerrato C., Viterbi R., Bionda R., Savoldelli P., 2016 – Gli ortotteri dei Parchi Naturali Veglia-Devero e Alta Valle Antrona. Rivista Piemontese di Storia Naturale, 37: 93-115.

BAUR B., BAUR H., ROESTI C., ROESTI D., THORENS P., 2006 – Sauterelles, grillons et criquets de Suisse. Haupt, Berne: 352 pages.

BENISTON M., 2003 – Climatic change in mountain regions: a review of possible impacts. Climatic Change, 59: 5-31.

BUTCHART S.H.M., WALPOLE M., COLLEN B., VAN STRIEN A., SCHARLEMANN J.P.W., ALMOND R.E.A., BAILLIE J.E.M., BOMHARD B., BROWN C., BRUNO J., CARPENTER K.E., CARR G.M., CHANSON J., CHENERY A.M., CSIRKE J., DAVIDSON N.C., DENTENER F., FOSTER M., GALLI A., GALLOWAY J.N., GENOVESI P., GREGORY R.D., HOCKINGS M., KAPOS V., LAMARQUE J.F., LEVERINGTON F., LOH J., MCGEOCH M.A., MCRAE L., MINASYAN A., HERNÁNDEZ MORCILLO M., OLDFIELD T.E.E., PAULY D., QUADER S., REVENGA C., SAUER J.R., SKOLNIK B., SPEAR D., STANWELL-SMITH D., STUART S.N., SYMES A., TIERNEY M., TYRRELL T.D., VIÉ J.C., WATSON R., 2010 – Global biodiversity: indicators of recent declines. Science, 328: 1164-1168.

CARRON G., SARDET E., WERMEILLE E., 2002 – Revision of the genus *Anonconotus* Camerano, 1878 with description of *A. pusillus* sp. n. and *A. baracunensis occidentalis* ssp. n.. Revue Suisse de Zoologie, 109 (4): 879-918.

CORAY A., THORENS P., 2001 – Ortotteri della Svizzera: chiave di determinazione. Fauna Helvetica, 5 Centre Suisse de Cartografie de la Faune - Schweizerische Entomologische Gesellschaft: 235 pages.

DE CACERES M., LEGENDRE P., 2009 – Associations between species and groups of sites: indices and statistical inference. Ecology, URL http://sites.google.com/site/miqueldecaceres/

DUFRÊNE M., LEGENDRE P., 1997 – Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs, 67: 345-366.

FONTANA P., LA GRECA M., KLEUKERS R., 2005 – Insecta Orthoptera. In: RUFFO S., STOCH F. (eds); Checklist e distribuzione della fauna italiana. Memorie del Museo Civico di Storia Naturale di Verona, 2.serie, Sezione Scienze della Vita, 16: 25-28.

GALVAGNI A., 2002 – Nuove specie italiane del genere *Anonconotus* Camerano, 1878: *A. ligustinus* n. sp. e *A. sibyllinus* n. sp. (Insecta Orthoptera Tettigoniidae). Atti dell'Accademia Roveretana degli Agiati, a. 252, ser. VIII, vol. II (B): 17-28.

GALVAGNI A., 2003 – Su due specie del genere *Anonconotus* Camerano, 1878, delle Alpi Occidentali italiane: *A. alpinus alpinus* (Yersin, 1858) e *A. ghilianii* Camerano, 1878 (Insecta Orthoptera Tettigoniidae). Atti dell'Accademia Roveretana degli Agiati, a. 253, ser. VIII, vol. III (B): 105-127.

GALVAGNI A., 2005 – Ulteriore contributo alla conoscenza del genere *Anonconotus* Camerano, 1878, sulle Alpi Occidentali italiane (Insecta Orthoptera Tettigoniidae). Atti dell'Accademia Roveretana degli Agiati, a. 255, ser. VIII, vol. V (B): 215-289.

GALVAGNI A., FONTANA P., 2006 – Contributo alla conoscenza del genere *Anonconotus* Camerano, 1878, sulle Alpi di Francia (Insecta Orthoptera Tettigoniidae). Atti dell'Accademia Roveretana degli Agiati, a. 256, ser. VIII, vol. VI (B): 85-108.

GRIFFINI A., 1897 – Imenotteri, neurotteri, pseudoneurotteri, ortotteri e rincoti italiani. Ulrico Hoepli, Milano: 687 pages.

INGRISCH S., 1995 – Evolution of the *Chorthippus biguttulus* group (Orthoptera, Acrididae) in the Alps, based on morphology and stridulation. Revue Suisse de Zoologie, 102 (2): 475-535.

KÖRNER C., 2000 – Why are there global gradients in species richness? Mountains may hold the answer. Trends in Ecology and Evolution, 15(12): 513-514.

LA GRECA M., 1986 – Contributo alla conoscenza degli ortotteri delle Alpi Occidentali piemontesi con descrizione di una nuova specie di *Stenobothrus*. Animalia, 12 (1/3) (1985): 215-244.

MAGURRAN A.E., BAILLIE S.R., BUCKLAND S.T., DICK J.M., ELSTON D.A., SCOTT E.M., SMITH R.L., SOMERFIELD P.J., WAT A.D., 2010 – Long-term datasets in biodiversity research and monitoring: assessing change in ecological communities through time. Trends in Ecology and Evolution, 25(10): 574-582.

MASSA B., FONTANA P., BUZZETTI F. M., KLEUKERS R., ODÉ B., 2012 – Orthoptera. Fauna d'Italia vol. XLVIII: 563 pages.

NADIG A., 1987 – Saltatoria (Insecta) der Süd- und Südostabdachung der Alpen zwischen der Provence im W, dem pannonischen Raum im NE und Istrien im SE (mit Verzeichnissen det Fundorte und Tiere meiner Sammlung). Revue Suisse de Zoologie, 94 (2): 257-356.

OKSANEN J., GUILLAUME BLANCHET F., KINDT R., LEGENDRE P., MINCHIN P.R., O'HARA R.B., SIMPSON G.L., SOLYMOS P., STEVENS M.H.H., WAGNER H., 2013 – vegan: Community Ecology Package (version 2.0-10). http://vegan.r-forge.r-project.org/.

R CORE TEAM, 2014 – R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. URL http://www.R-project.org.

SARDET E., ROESTI C., BRAUD Y., 2015 – Cahier d'identification des orthoptères de France, Belgique, Luxembourg & Suisse. Biotope Editorial : 304 pp.

SINDACO R., SAVOLDELLI P., EVANGELISTA M., 2012 – Ortotteri, mantidi e fasmidi dell'Italia nord-occidentale (Piemonte, Valle d'Aosta, Liguria) (Insecta: Orthoptera, Mantodea, Phasmatodea). Rivista Piemontese di Storia Naturale, 33: 111-160.

STOCH F., VIGNA TAGLIANTI A., 2005 – I corotipi della fauna italiana. In: RUFFO S., STOCH F. (eds); Checklist e distribuzione della fauna italiana. Memorie del Museo Civico di Storia Naturale di Verona, 2.serie, Sezione Scienze della Vita, 16: 25-28.

THOMAS C.D., CAMERON A., GREEN R.E., BAKKENES M., BEAUMONT L.J., COLLINGHAM Y.C., ERASMUS B.F.N., FERREIRA DE SIQUEIRA M., GRAINGER A., HANNAH L., HUGHES L., HUNTLEY B., VAN JAARSVELD A.S., MIDGLEY G.F., MILES L., ORTEGA-HUERTA M.A., TOWNSEND PETERSON A., PHILLIPS O.L., WILLIAMS S.E., 2004 – Extinction risk for climate change. Nature, 427: 145-148.

VITERBI R., CERRATO C., BASSANO B., BIONDA R., VON HARDENBERG A., PROVENZALE A., BOGLIANI G., 2013 – Patterns of biodiversity in the northwestern Italian Alps: a multi-*taxa* approach. Community Ecology, 14: 18-30.

YOCCOZ N.G., NICHOLS J.D., BOULINIER T., 2001 – Monitoring of biological diversity in space and time. Trends in Ecology and Evolution, 16(8): 446-453.

SOMMARIO