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Research article

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Hoverfly diversity in Mareschi alluvial alder forest (Piedmont, Italy), and "Syrph the Net" ecological analysis (Diptera: Syrphidae)

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Abstract

This paper presents the results of the one-year field research into the hoverfly (Diptera: Syrphidae) in Mareschi, in Sant'Antonino di Susa municipality. The sampling activities were performed with Malaise trap, emerging trap, and entomological net. Monitoring was carried out from March to October 2018 in the over-mature alder forest, classified under the Natura 2000 Habitat code 91E0, considered as a priority in EU 92/43 Habitats Directive. Preliminary data from July to October 2017 are also included. Overall, 74 species were recorded, with the first records of 7 species for Piedmont. Some of the observed species in Mareschi are of primary conservation importance, such as *Arctophila superbiens* (Müller, 1776)*, Sphiximorpha subsessilis* (Illiger in Rossi, 1807) and *Temnostoma bombylans* (Fabricius, 1805). The use of Syrph the Net analysis and the comparison with other woods in Po Plain confirm the high naturalistic value of the studied area.

Key words: Diptera Syrphidae, Mareschi forest, Hoverfly, Piedmont, Susa Valley, Syrph the Net.

Introduction

Natural forests are fundamental elements for biodiversity conservation. In Europe, forests have been enormously affected by human activity (Hermy & Verheyen 2007). According to Peterken (1996), few remnants of the original natural forests remain in Europe, mainly in its northern parts. The poor condition of natural forests is especially dramatic in lowland areas of northern Italy. The Po Plain represents 71% of all plain areas in Italy (Pellegrini 1979), and plays a key role in Italian agriculture; thus, the increasing human population and the ever-increasing demand for areas to be dedicated to agriculture have strongly modified this plain since the Bronze Age (Ruffo 2002). Before this period the Po Valley and the main adjacent valleys were probably covered by an extensive alluvial forest, of which there are only a few remnants. In any case, even these areas have been affected by man, as in the case of Bosco della Fontana (province of Mantua) considered one of the best examples of lowland forest in the Po Plain (Mason 2004). The problems afflicting these natural remnants include small size, the changes endured, and the high fragmentation of the habitat. In particular, the phenomena linked with the drastic fragmentation of the habitat are likely to isolate the populations of those species closely associated with forests, finally leading to the local extinction of such species (Haila 2002; Henle et al. 2004). Therefore, not only can the presence of small areas of alluvial forests be particularly important for increasing the total area with this type of vegetation, but it can also significantly improve the interconnections between the few remnants of natural areas, acting as a metapopulation (Hanski & Gilpin 1997).

Since the second half of the 19th century an increase in forest cover has been observed in Piedmont: in 1870 the woody index was 17% and by 2016 it had risen to 37% (Camerano et al. 2017). This trend is however more evident in the mountain woods; in fact, the improved economic conditions of the human population have led to a progressive abandonment of land use in disadvantaged areas. In Piedmont the lowland forests cover a total area of 90.000 hectares, with a woody index of only 10% (Camerano et al. 2009). Furthermore, many of these forests have been extensively modified by man; for example, just under half of the lowland forest area is occupied by *Robinia* woods, planted by man to increase forest productivity. Among the woods of particular interest, it is worth mentioning *Alnus* woods, the importance of which is recognised by the inclusion of this habitat (91E0) as a priority in the Directive 92/43 EEC. *Alnus* woods faced several problems, such as fragmentation, reduced dimensions and invasion of alien species. In Piedmont, contrary to the general trend, a contraction of *Alnus* forest cover has been observed in recent years; from 2011 to 2016 an 11% reduction was observed in the area covered by this type of wood (Camerano et al. 2017). Only 47% of 91E0 habitat is protected in Piedmont (Camerano et al. 2009). In this scenario, it is fundamental, on the one hand, to favor the diffusion of this habitat, and, on the other, to implement all possible actions to promote the protection of alluvial wood remnants.

The use of Syrphidae as a bioindicator has been widely shared by the scientific community (Sommaggio 1999; Speight & Castella 2001; Speight 2012; Burgio et al. 2015). Hoverfly larvae show such evident ecological differences that even small variations in habitat conservation can modify Syrphidae populations. Therefore, the use of Syrphidae to assess the ecosystem conservation has proved very useful. In the nineties, in order to standardise and facilitate the use of Syrphidae as bioindicators, the Syrph the Net (StN) database was developed (Speight 2008; 2012). Even if some limitations still exist, mainly due to a reduced knowledge of species distribution (especially in southern European countries), StN has been an efficient and useful tool to evaluate the conservation condition of both natural and rural ecosystems (e.g. Speight et al. 2002; Gittings et al. 2006; Burgio & Sommaggio 2007; Velli et al. 2010; Sommaggio & Burgio 2014; Popov et al. 2017).

This current research aims to study the Syrphidae fauna of the Mareschi of Sant'Antonino di Susa (MAR) alluvial wood area to assess its conservation condition and to provide useful information for a proper management of the site. Thus the research represents a case study for the evaluation of alluvial forest conservation (with particular reference to northern Italy), and for improved protection of these important habitats.

Materials and methods

Study area

The study area MAR is approximately 10 ha wide and is located on the right hydrographic side of the Susa Valley, 390 m a.s.l., in the middle of the valley floor (Fig. 1). This MAR site is a natural depression with respect to the bed of the main river of the valley (Dora Riparia). This land is characterised by the presence of slow-flowing surface water in ditches or stagnation for virtually the whole year. It is a mosaic of different habitats: the main alluvial forest is downgraded towards the higher part of the mountain into a chestnut forest, whereas on the other side we can identify unimproved grassland and occasional meadow pasture. Further to the east side (near the small village of Borgata Codrei) the sampling area (Fig. 2) also comprises the wood portion that is usually more flooded. MAR is characterised by alluvial forest of *Alnus glutinosa* (Linnaeus), the dominant species, and *Fraxinus excelsior* (Linnaeus) – a habitat considered as priority in EU 92/43 Directive. Galleries of *Salix alba* (Linnaeus) and *Populus* sp. become a subdominant layer. Very few *Alnus incana* (Linnaeus) are present in the sampling area.

Over half of the total extension of the woodland area under examination is in a wild state, characterised by *Alnus* over-mature and dead wood on the ground. In the 20th Century, some lots of the remaining parts were cut to give way to poplar crops, which two decades ago were partially removed by the municipal administration to allow the regrowth of the alder. Two-thirds of the land is owned by the municipal authorities, for which conservation actions are being undertaken, also thanks to the construction of water wells and the identification of a rolling basin as an expansion bank of the nearby Dora Riparia. The site (Fig. 3) is not currently part of the nearby Orsiera Rocciavrè Natural Park (a regionally protected area that extends over most of the contiguous mountain area), and is not currently established as a European Natural Reserve.

Sampling methods

The area was sampled in 2017 and 2018. From July to October 2017 a few samplings with an entomological net were performed in order to locate the best transects for the following season. In 2018 three sampling methods were applied: entomological net, Malaise trap, and emergence trap. The use of a Malaise trap proved particularly effective for sampling Diptera and Hymenoptera, but this sampling device was demonstrated to be selective (e.g. Burgio & Sommaggio 2007) and less efficient in forests (Birtele & Handersen 2012, Marcos-García et al. 2012). One Malaise trap was activated inside alder wood (45°06'10"N; 7°15'50"E) (Fig. 2). The trap was active from 10 March 2018 to 15 October 2018 and was supplied with a 70% solution of ethyl alcohol; the sample was collected approximately once a week. Sampling by entomological net was performed twice a week; each sampling lasted almost 2 hours and 7 transects were used inside the alder wood or at its margin, as shown in Fig. 2. Each transect was on average 100 m long and took 15 minutes. The entomological net was used on days without rain and wind, in a rotary way from 10:00 until 12:00, from 14:00 until 16:00, and from 16:00 until 18:00. An emergency trap was activated from April to October on a stump of *Alnus glutinosa* (full dimension 30 × 20 cm) which has been dead for several years. This trap allowed detection of specimens that completed their biological cycle inside a specific substrate. In the present research it was used only to sample saproxylic species, which are usually very rare.

The collected specimens were partly pinned and partly preserved in 80° ethyl alcohol. Van Veen (2010), Bertollo & Sommaggio (2012) and Speight & Sarthou (2015) were used for species identification. All the material was carefully identified and reviewed by both authors. Specimens are deposited in the Civic Museum of Natural History of Carmagnola and the most representative ones in the personal collection of one of the authors (UM). The systematics and nomenclature used in this paper follow those proposed by Burgio et al. (2015).

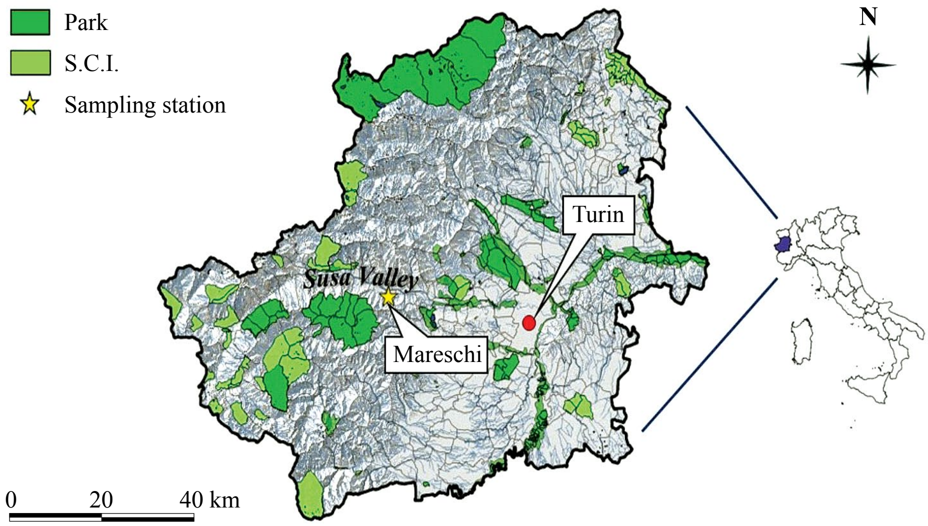

Fig. 1 – Turin province with Natura 2000 sites (S.C.I.) and position of MAR. http://www.geoportale.piemonte.it/geocatalogorp/?sezione=catalogo.

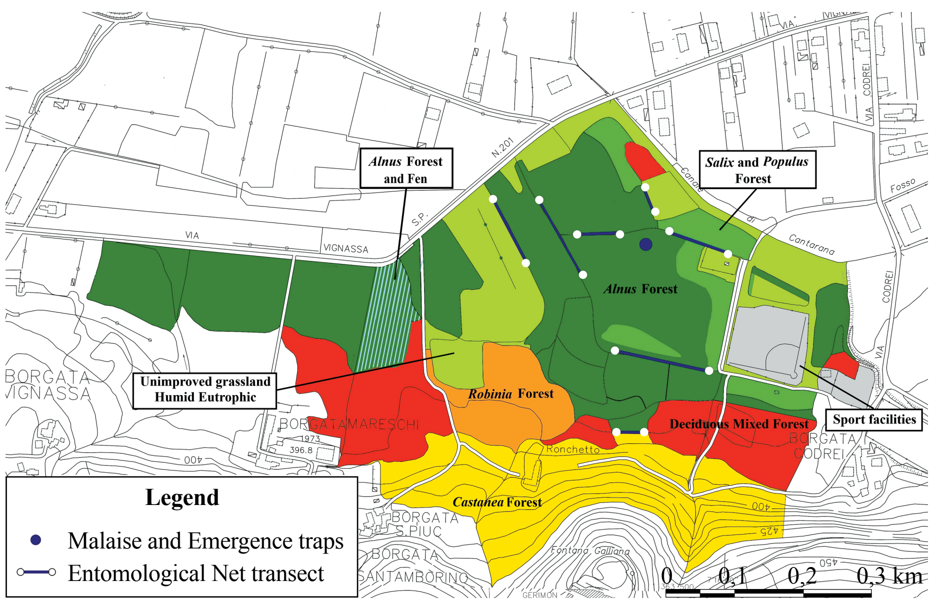

Fig. 2 – Study area. Location of sampling sites.

Data analysis

Individual-based rarefaction curves were performed to evaluate whether the sampling effort was sufficient; rarefaction curves were elaborated separately for the two main sampling devices (Malaise trap, entomological net). The iNEXT Online Software was used to elaborate the rarefaction curve (Hsieh et al. 2013).

The Syrphidae fauna of MAR was compared with alluvial lowland forests in northern Italy, sampled in previous research (Birtele et al. 2002; Sommaggio & Corazza 2006; Whitmore et al. 2008; Bertollo et al. 2012). The multivariate analysis was applied to a species matrix including only presence/absence data. A non-metric multidimensional scaling (NMDS) with Bray-Curtis dissimilarity index and a cluster analysis based on Ward's method were used as a multivariate technique (Shaw 2003). Species collected in MAR and other lowland woods were characterised according to ecological categories, found in the StN database (Speight 2016). Correspondence analysis was applied to the matrix with the number of species collected in each wood, divided according to their ecological categories. NMDS and cluster analysis were performed using Past 3.04 (Hammer et al. 2001), and correspondence analysis using STATISTICA Ver. 7.1 (Statsoft©). The cluster

Fig. 3 – Study area. Typical aspect of the Mareschi alder forest, May 2018.

tree was projected on a map of northern Italy to highlight the peculiarity of MAR. This projection of the cluster was performed using GenGIS 2.3 (Parks et al. 2013).

The Syrph the Net ecological analysis
The use of Syrph the Net as a tool to evaluate natural conservation of ecosystems has been widely tested in Europe (e.g. Burgio & Sommaggio 2007; Velli et al. 2010; Speight 2012; Burgio et al. 2015).

The use of hoverflies as bioindicators is based on the great differences in ecological requirements, mainly of larvae. The StN database is an important source concerning the characteristics of most European Syrphidae species (Speight 2012; Speight 2016). Thanks to this tool we can assess several kinds of ecological categories, such as those species that need submerged detritus or timber to complete their life cycle.

StN has also been used to elaborate the Biodiversity Maintenance Function (BDMF), understood as the relationship between observed species and species expected in a given habitat (e.g. as detailed in Speight 2012). For each species included in the database, StN provides an association with different ecosystems. To elaborate the list of expected species, a regional checklist is required. Since a checklist of Syrphidae from Piedmont is not yet available the list has been elaborated starting from the most representative papers in the literature (Sommaggio 2005, 2007; Delmastro & Sommaggio 2003), integrated with Witek et al. (2012) for the presence of *Microdon myrmicae* Schonrogge et al. 2002. Even if sampling was performed in the alder wood, the dimension of this area is too small (considering the mobility of hoverflies). For this reason, other habitats have been considered in addition to the alder wood; hence, one Macrohabitat Aggregate has been used to include all kinds of alluvial forest present in the sampling area. The qualitative assessment of the habitat has been calculated for each type present in MAR with a coverage above 5 %, except for urban (Tab. 1).

Tab. 1 shows the habitat present in a buffer zone of 300 m from the centre of the alder wood. The habitats follow what is reported in the Coordination of Information on the Environment (CORINE) system, but with a univocal StN code, following the example of Speight & Castella (2016). The list of expected species has been compared with the list of observed species, using only presence/absence data. This procedure has been repeated for the main ecological groups, and specifically for:

- Larval trophic habitus: phytophagous, predators, detritivores, xilosaprophagous
- Voltinism.

The habitats were further analysed to determine which parts (i.e. which microhabitats) could be identified as being in a worse state of conservation. We proceeded in a similar way to calculate the total BDMF for macrohabitats, but this time selecting from the database the main microhabitats (Tab. 4) on which the larvae develop.

Results

A total of 170 specimens, belonging to 74 species, have been collected in MAR in years 2017 and 2018. Tab. 2 lists all the species collected, reporting the number of in-

Table 1 – Habitat type in a 300 m buffer from the centre of the sampling area.

Habitat	CORINE Code	StN Code	Percentage of coverage (%)
Alnus forest	44.9/44.33	11261/113241	36
Salix alba/*Populus* forest	44.1	11311	8
Lowland unimproved grassland	37.2	231131	23
Mixed deciduous forest (*Juglans*/*Robinia*)	-	-	12
Castanea forest	41.9	11117	11
Urban	85.2	502	9
Fen	44.9	61	1

Table 2 – Checklist of Syrphidae sampling in Mareschi Sant'Antonino di Susa. * N = Entomological Net, M = Malaise trap, E = Emergence trap. **Female cannot be reliable separated from related species.*** No data available, we considered other species in the same genera.

Faunistic list	Observation period - Catch event	New record for Piedmont	Collected specimens*						Trophic larval category
			N		M		E		
			♂	♀	♂	♀	♂	♀	
Arctophila superbiens (Müller, 1776)	IX-18	X		1					A
Baccha elongata (Fabricius, 1775)	IX-17; V-18			1	2				Z
Brachyopa scutellaris Robineau-Desvoidy, 1844	V-18		2						T
Brachypalpoides lentus (Meigen, 1822)	VI-18			1				1	T
Chalcosyrphus nemorum (Fabricius, 1805)	VI-18					1			A
Cheilosia canicularis (Panzer, 1801)	IX-17; VIII-18		1	1					P
Cheilosia impressa Loew, 1840	VIII-18			1					P
Cheilosia pagana (Meigen, 1822)	VII-17			1					P
Cheilosia scutellata (Fallén, 1817)	IX-17	X		1					P
Cheilosia vulpina (Meigen, 1822)	VII-18			1					P
Chrysogaster solstitialis (Fallén, 1817)	VI-18 ; VII-18; VIII-18		2	1					A
Chrysotoxum bicinctum (Linnaeus, 1758)	VIII-17			1					Z
Chrysotoxum cautum (Harris, 1776)	V-18			1					Z
Chrysotoxum fasciatum (Müller, 1764)	IX-17			1					Z
Chrysotoxum festivum (Linnaeus, 1758)	V-18		1						Z
Chrysotoxum octomaculatum Curtis, 1837	IX-17			1					Z
Criorhina berberina (Fabricius, 1805)	V-18		1						T
Dasysyrphus tricinctus (Fallén, 1817)	IX-17; IX-18			1		1			Z
Didea alneti (Fallén, 1817)	IX-17			1					Z
Epistrophe grossulariae (Meigen, 1822)	IX-17			1					Z
Epistrophe nitidicollis (Meigen, 1822)	IV-18; V-18		1	1		1			Z
Episyrphus balteatus (De Geer, 1776)	V-18; IX-18; X-18			1	1	12			Z
Eristalinus sepulchralis (Linnaeus, 1758)	VII-18		1						A
Eristalis arbustorum (Linnaeus, 1758)	VI-18		1						A
Eristalis horticola (De Geer, 1776)	VII-18	X	1						A
Eristalis interrupta (Poda, 1761)	V-18			1					A
Eristalis pertinax (Scopoli, 1763)	IX-17		1						A
Eristalis tenax (Linnaeus, 1758)	IX-17; VI-18		2						A
Eumerus amoenus Loew, 1848	IX-18			1					P

continued

Faunistic list	Observation period - Catch event	New record for Piedmont	Collected specimens*						Trophic larval category
			N		M		E		
			♂	♀	♂	♀	♂	♀	
Eumerus flavitarsis Zetterstedt, 1843	IX-17; VI-18		1	2					P
Eumerus ornatus Meigen, 1822	IX-18		1						P
Eupeodes corollae (Fabricius, 1794)	IV-18					1			Z
Eupeodes luniger (Meigen, 1822)	IV-18				1				Z
Helophilus pendulus (Linnaeus, 1758)	X-17; IV-18; VII-18		1		25	13			A
Lejogaster tarsata (Meigen, 1822)	VII-18			1					A
Melangyna lasiophthalma (Zetterstedt, 1843)	III-18					1			Z
Melanostoma mellinum (Linnaeus, 1758)	X-17; V-18; VI-18		1	1	2	1			Z
Melanostoma scalare (Fabricius, 1794)	V-18; VI-18		1			1			Z
Meligramma cincta (Fallén, 1817)	IX-17			1					Z
Meliscaeva auricollis (Meigen, 1822)	V-18; VI-18			1		1			Z
Milesia crabroniformis (Fabricius, 1775)	IX-17			1					T
Myathropa florea (Linnaeus, 1758)	IX-17			1					A
Neoascia podagrica (Fabricius, 1775)	V-18; VII-18		1	3					A
Orthonevra nobilis (Fallén, 1817)	VII-18		1						A
Paragus albifrons (Fallén, 1817)	IX-17			1					P***
Paragus haemorrhous Meigen, 1822	VII-17; VII-18		3			2**			Z
Paragus pecchiolii Rondani, 1857	VII-18		1						Z
Paragus quadrifasciatus Meigen, 1822	IX-17			1					Z
Parhelophilus frutetorum (Fabricius, 1775)	VII-18	X	1						A
Pipiza noctiluca (Linnaeus, 1758)	VI-18			1					Z
Pipizella maculipennis (Meigen, 1822)	V-18; VI-18		2						Z***
Pipizella viduata (Linnaeus, 1758)	VII-18; VIII-18		2						Z
Platycheirus albimanus (Fabricius, 1781)	IX-17			1					Z
Platicheirus fulviventris (Macquart, 1829)	V-18			1					Z
Platycheirus scutatus (Meigen, 1822)	IX-17; IV-18			1	1				Z
Sphaerophoria scripta (Linnaeus, 1758)	IX-17; VI-18		2	2					Z
Sphegina elegans (Schummel, 1843)	V-18	X		1					T
Sphiximorpha subsessilis (Illiger in Rossi, 1807)	V-18		1						T
Syritta pipiens (Linnaeus, 1758)	VII-17; V-18		2	1					T
Syrphus ribesii (Linnaeus, 1758)	IX-17; VI-18			1		2			Z
Syrphus torvus Osten-Sacken, 1875	X-17			1					Z
Syrphus vitripennis Meigen, 1822	X-17; VI-18			1	1				Z
Temnostoma bombylans (Fabricius, 1805)	V-18	X		1					T
Volucella inanis (Linnaeus, 1758)	VII-17		1						Z
Volucella inflata (Fabricius, 1794)	V-18			1					T
Volucella pellucens (Linnaeus, 1758)	V-18		1						Z
Volucella zonaria (Poda, 1761)	V-18		1						Z
Xanthandrus comtus (Harris, 1780)	VI-18		1						Z
Xanthogramma laetum (Fabricius, 1794)	VI-18; VIII-18					3			Z***
Xanthogramma stackelbergi Violovitsh, 1975	IX-17	X		1					Z***
Xylota florum (Fabricius, 1805)	VIII-18		1	1					T
Xylota segnis (Linnaeus, 1758)	VII-17; VI-18; VII-18		1	1		1			T
Xylota sylvarum (Linnaeus, 1758)	IX-17; VI-18		1					1	T
Xylota xanthocnema Collin, 1939	VII-17; V-18		2	1					T

dividuals, collection period and other useful information. Comparing the new data with the records known for Piedmont (Sommaggio 2005, 2007; Delmastro & Sommaggio 2003), the following species were first recorded from this region: *Arctophila superbiens*, *Cheilosia scutellata*, *Eristalis horticola, Parhelophilus frutetorum, Sphegina elegans, Temnostoma bombylans* and *Xanthogramma stackelbergi*.

Fig. 4 shows the rarefaction curve, obtained by individuals collected by Malaise and entomological net. The number of species collected by entomological net is clearly higher than those by Malaise trap confirming the low efficiency of Malaise trap in wood habitat (Birtele & Handersen 2012; Marcos-García et al. 2012). The curve obtained by entomological net does not reach asymptote; this is probably due to the high number of singletons collected by this sampling method, which overestimates the rare species. In 2018 more than 100 hours of effective sampling were distributed evenly throughout the day, every week between March and October. For this reason we consider the list of species collected in MAR as representative, even if abundance data are not representative of Syrphidae population in MAR. Therefore, only presence/absence matrix is used in the following analysis.

NMDS applied to the presence/absence matrix of species collected in lowland woods in northern Italy clearly separated a group of woods from north-east Italy on one side and three woods on the other side: MAR, Bosco della Fontana (Birtele et al. 2002) and Vincheto (Whitmore et al. 2008) (Fig. 5). These last three are clearly separated from each other, even if the Vincheto and MAR projections on the first axis, which is the most important factor for explaining variability, are almost the same. Vincheto and MAR are lowland woods located in lateral valleys of the Po Plain, while all the other woods are typical plani-

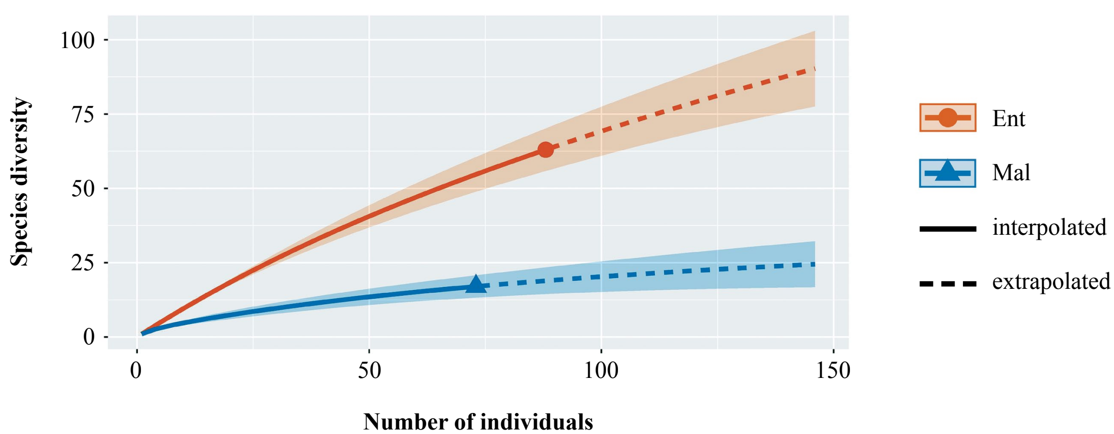

Fig. 4 – Individual-based rarefaction curve. Data from entomological net and Malaise trap are considered separately. Shaded areas represent the 95% confidence interval obtained by a bootstrap method based on 200 replications.

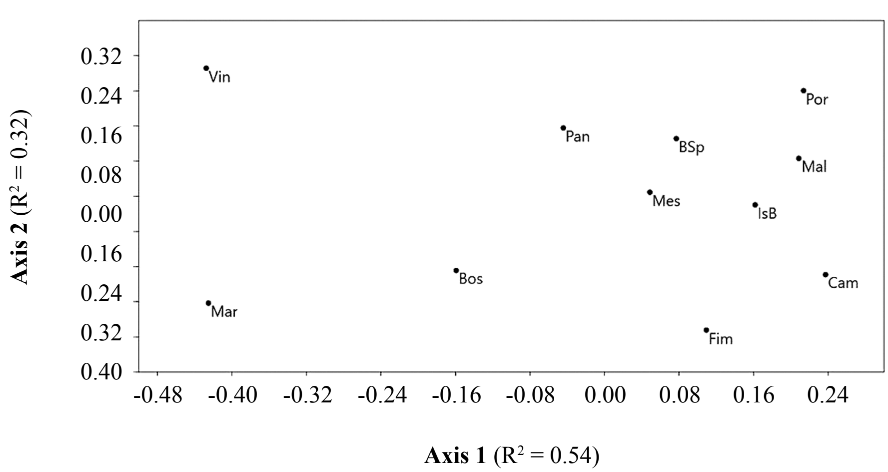

Fig. 5 – Non-metric multidimensional scaling with Bray-Curtis dissimilarity index to lowland woods in North Italy. Legend: Bos: Bosco della Fontana (Birtele et al., 1992); BSp: Spada wood near Codigoro (FE) (unpublished data); Cam: Campotto natural area (FE) (unpublished data); Fim: alluvial wood near Fimon Lake (VI) (Sommaggio, 2017); IsB: Isola Bianca forest (Bertollo et al., 2012); Mal: Malcantone wood near Bondeno (FE) (unpublished data); Mar: Mareschi woods; Mes: Mesola wood (unpublished data); Pan: Panfilia wood (Bertollo et al., 2012); Por: Porporana wood (Bertollo et al., 2012); Vin: Vincheto (Whitmore et al., 2008).

tial woods. The Cluster analysis applied on the same matrix gives similar results; Vincheto, Bosco della Fontana and MAR are well differentiated from other woods, even if Bosco della Fontana and MAR seem to be more similar than Vincheto (Fig. 6). It is worth mentioning that the lowland wood in Berici Hill (Fim) also clearly separates from the other north-eastern woods, as shown in the second axis of the NMDS analysis (Fig. 5) and cluster analysis (Fig. 6).

The use of ecological categories allowed better characterisation of the sampled woods. Fig. 7 shows the results of the correspondence analysis applied to the matrix with the number of species belonging to different ecological categories. On the right, the main axis (50% of total variability explained) separates ecological categories associated with well-preserved woods, in particular those with larvae associated with trees, those that are saproxylic, and those with a long larval development period. The second axis (21.8% of total variability explained) seems to separate the ecological categories associated with underwood (species with larvae developing inside herbs or in submerged detritus) from those developing mainly in the canopy. In this analysis, MAR seems to be intermediate between very well-preserved woods (Vincheto and Bosco della Fontana) and less-preserved woods, i.e. woods that are younger and/or with higher human pressure.

Applying Syrph the Net and considering the Macrohabitat Aggregate as the sum of the three macrohabitats present in the sampling area (migratory species included

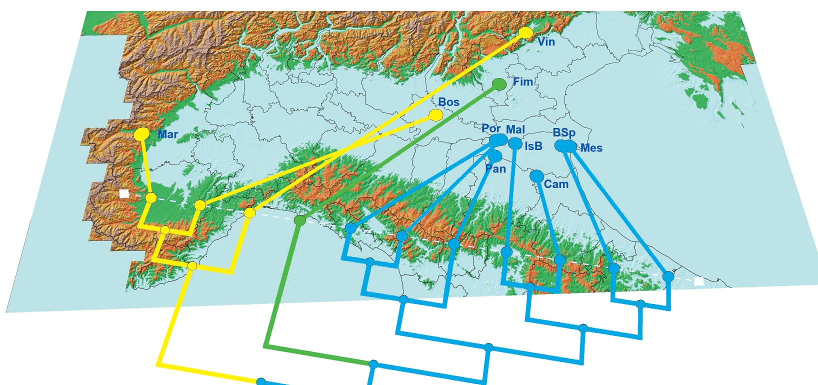

Fig. 6 – Projection of cluster analysis on northern Italy using GenGIS 2.3.

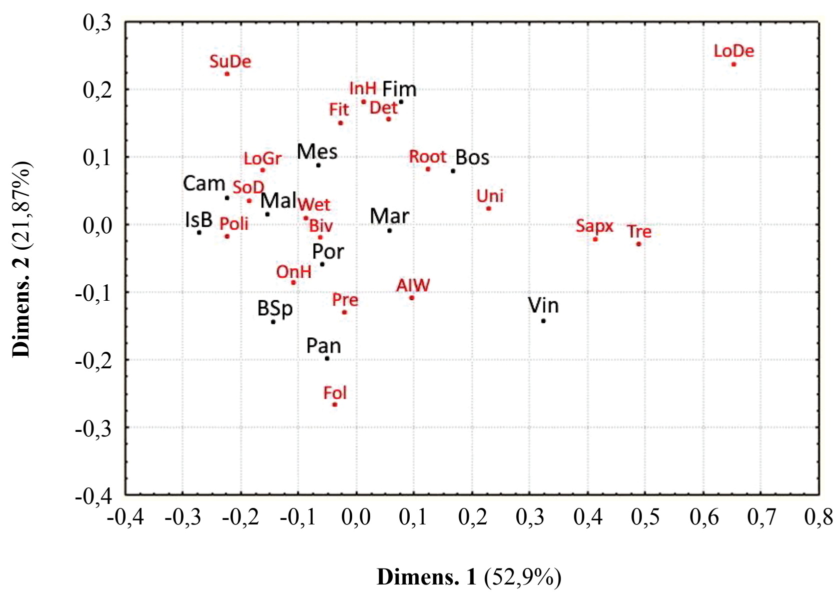

Fig. 7 – Correspondence analysis applied on the species collected in different lowland woods, divided into ecological categories. In black, the wood sites (abbreviations as in Fig. 5). In red, the ecological categories: 1) Larval trophic habitus: Det: detritivores larvae; Fit: phytophagous larvae; Pre: predators; Sapx: saproxylic; 2) Voltinism: Biv: 2 generations/year; LoDe: <1 generation/year; Poli: >2 generations/year; Uni: 1 generation/year; 3) Larval microhabitat: Fol: foliage; InH: larvae developing inside herbs; OnH: larvae on herbs; Root: larvae developing in roots; SoD: soil debris; SuDe: submerged debris; Tre: trees; 4) Adult preference: AlW: alluvial woods; LoG: lowland grassland; Wet: wetland.

and Piedmont checklist as reference), the BDMF value is 56 % (Tab. 3). This denotes an ecosystem in good conservation condition (Speight 2012).

We observed 37 Syrphidae species which were not expected in the three main macrohabitats. If we exclude the migratory species and those coming from macrohabitats outside the study area but present in ecotone (Tab. 3), there were still 17 species which were observed but not expected in MAR. These species (observed but not expected) were: *Arctophila superbiens, Brachypalpoides lentus, Cheilosia canicularis, Chrysotoxum fasciatum, Chrysotoxum festivum*, *Chrysotoxum octomaculatum, Dasysyrphus tricinctus, Eumerus flavitarsis, Eumerus ornatus, Paragus albifrons, Pipiza noctiluca, Pipizella maculipennis, Sphegina elegans, Volucella pellucens, Xanthogramma laetum, Xanthogramma stackelbergi* and *Xylota xanthocnema.*

All these species are mainly associated with woods, except three (*A. superbiens*, *C. canicularis*, and *P. mac-*

Table 3 – BDMF (Biodiversity Maintenance Function) rate for each main habitat in sampling area. StN: Syrph the Net.

Habitat	StN Code	North Italy		Piedmont	
		N	**BDMF** (%)	**N**	**BDMF** (%)
CORE AREA MACROHABITAT		25	68,0	25	68,0
Forest *Alnus* over-mature	11261	57	47,4	57	47,4
Alluvional forest *Alnus glutinosa*/*Fraxinus excelsior*	113241	64	50,0	64	50,0
Alluvional forest *Salix alba*/*Populus* over-mature	11311				
ECOTONAL MACROHABITAT		57	43,9	57	43,9
Lowland unimproved grassland-Humid-Eutrophic	231131	42	47,6	42	47,6
Forest *Castanea* over-mature	111171	87	42,5	87	42,5
MA					
Unpredicted species observed (N)	17				
Unpredicted species observed/total species observed (%)	22,9				

Table 4 – Larval microsite evaluation. MA: Macrohabitat Aggregate.

MA		**Expected species** (N)	**Observed species** (N)	**Observed species** (%)	**Unpredicted species observed** (N)
Larval microsite	foliage/herb	25	15	60,0	4
	timber	17	8	47,0	2
	root/bulbs/litter	8	4	50,0	7
	water-saturated ground	13	9	69,2	2
	dung	1	0	0	0
	nests of social insects	2	1	50,0	2
Food type (larvae)	living plants	6	3	50,0	3
	living animals	27	14	51,9	10
	decomposing organic matter	14	10	71,4	2
	saproxylic	19	10	52,6	2
Number of generations/year		**Expected species** (N)	**Observed species** (N)	**Observed species** (%)	**Unpredicted species observed** (N)
< 1		5	3	60,0	0
1		26	9	34,6	3
2		21	13	61,9	14
> 2		14	13	92,9	0

ulipennis). Four species are common in alluvial forests, but no data are available for association with *Alnus* woods (Speight 2016). Three species are usually found in conifer woods and seven in other type of woods (e.g. *Quercus* and *Fagus).* They are probably common in the surrounding habitats and can occasionally visit adjacent habitats. *C. canicularis* and *P. maculipennis* are common in open habitats, usually dry grasslands. The presence of *A. superbiens* is interesting, because it is generally associated with wetland (Speight 2015), in Italy it is particularly rare and unknown from the Po Plain (Sommaggio 2010, 2017).

Microhabitats associated with aquatic debris and herbal layer seem to be in a very good conservation status (Tab. 5). The component associated with old trees is particularly well preserved; there is a high number of species with preimaginal trophic niche related to senescent standing or old dead trees on the ground. The bivoltine species were the most abundant among those sampled, also because they were the more common species. Species with less than one generation a year are those that require a long period of larval development, usually associated with dead wood. There are relatively few such species, and they are mostly rare in Europe. In MAR, *Brachyopa scutellaris*, *Milesia crabroniformis*, *Sphiximorpha subsessilis* and *Temnostoma bombylans* belong in this category.

A further analysis showed the situation of the MAR with reference to the expected species considered by Speight to be threatened or decreasing (Speight 2016). One species *(Sphiximorpha subsessilis*) is endangered for Europe and is one of the few recent findings for northern Italy (Sommaggio 2017), and another three (*Chrysogaster solstitialis, Paragus albifrons, Pipizella maculipennis*) are added for the Alpine Region. Several species are decreasing for Central Europe: *Chrysotoxum octomaculatum, Eumerus amoenus, Milesia crabroniformis, Parhelophilus frutetorum, Temnostoma bombylans, Volucella inflata* and *Xanthogramma stackelbergi.* Three are decreasing for the Alpine Region (*Paragus quadrifasciatus, Parhelophilus frutetorum* and *Pipizella maculipennis*).

Table 5 – Voltinism.

Number of generations/year	All observed species (N)	%
< 1	4	5,4
1	15	20,3
2	31	41,9
> 2	24	32,4

Conclusions

The present research characterizes the studied site as an environment of considerable naturalistic interest. Despite the small size of the protected area, the number of species collected is high compared with similar habitats in northern Italy (Birtele et al. 2002; Velli et al. 2010; Bertollo et al. 2012; Sommaggio 2017).

In the 20th Century, saproxylic fauna in Europe experienced a great reduction mainly due to the dramatic shrinkage and fragmentation of mature forest (Ranius 2002; Bergman et al. 2012). Saproxylic invertebrates represent an important part of total biodiversity. For example, Vallauri et al. (2005) estimated that about 30% of forest biodiversity is associated with dead-wood. Carpaneto (2015) reported that 2.000 beetle species (almost 15% of Italian beetles) are associated with dead wood. Saproxylic species are an important factor in the protection and conservation of mature forests (Speight 1989; Mason et al. 2003; Johnsson et al. 2005). The presence of rare saproxylic species in MAR is particularly important; this area is limited in extension and has been recently established. Other areas in Piedmont (such as La Mandria and Stupinigi woods) are more important from a naturalistic point of view for their extension or persistence. However, the presence of more recent and reduced areas (such as those in MAR) seems to adequately support an important fauna, because these areas can play a key role in reducing fragmentation between more extended woody areas.

It should be noted that the studied area is located in a territory (the Susa Valley) which, as a whole, can be considered a source of unique data. Other research (e.g. Manino et al. 2010; Giuliano & Piano 2016) has considered the Susa Valley to be one of the main biodiversity local hot spots in Italy, thanks also to its geomorphological conformation with east-west exposure. A particularly interesting indicator of the high complexity in the surrounding landscape is the number of species observed but not expected according to the type of habitats (Burgio et al. 2015).

Comparison of MAR with other woody areas in northern Italy underlines the importance of this site; the conservation of MAR seems to be intermediate between very well-preserved woods such as Bosco della Fontana (Birtele et al. 2002) and recently established woods and/or woods subject to human pressure (Bertollo et al. 2012). Overall, our data suggest that the MAR site should be considered as a well-preserved area, of high naturalistic value, and worthy of conservation and enhancement actions. Our results (integrated with future studies) may also be used to establish a newly-protected area, by merging it with existing or newly-established entities. The high number of species recorded for the first time for Piedmont underscores the poor knowledge of Syrphidae fauna in this region, and highlights the need to increase research into a family that is particularly important for bioindication (Sommaggio 1999; Burgio et al. 2015).

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