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Survey of selected beetle families in a floodplain remnant in northern Italy

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Abstract

The highly fragmented floodplain forest remnants of the river Po (Italy) are protected at the European level, but surprisingly little is known about their ecology and in particular their invertebrate fauna. The present work investigates 11 selected beetle families sampled in the reserve of Isola Boscone (Lombardy Region, Mantua Province), which is situated inside the embankments of the Po. Twelve window traps were attached to dead trees, either in open and sun-exposed situations (n = 6) or in the understorey of small forest patches (n = 6), and were active from 16 June to 3 November 2009. The following 11 beetle families were studied: Histeridae, Lucanidae, Scarabaeidae, Lissomidae, Elateridae, Buprestidae, Cleridae, Aderidae, Tenebrionidae, Cerambycidae, Anthribidae. A total of 495 individuals belonging to 53 species were collected, including five species of particular faunistic interest. The species *Aegosoma scabricorne* (Scopoli) and *Dissoleucas niveirostris* (F.) were associated with the forest habitat, while *Chlorophorus varius* (Muller), *Dorcus parallelipipedus* (L.) and *Nalassus dryadophilus* (Mulsant) were associated with the open habitat. Analyses of the abundance data revealed that the traps from the two habitat types differed in their community composition and that more species were caught in the open habitat. However, individual-based rarefaction curves showed that species richness did not differ when the number of species was plotted in relation to the number of individuals caught. This finding shows that richness estimates need to be interpreted with caution. The study also highlights that monitoring of beetles in floodplain forest remnants is complicated by recurrent floods.

Key words: Coleoptera, floodplain forest, Italy, species richness, Po River, saproxylics, window traps.

Introduction

Floodplain forests are highly dynamic ecosystems which depend on particular flood regimes for their continued existence. They are considered to be one of Europe's most threatened natural ecosystems (Arizpe *et al.*, 2008), as approximately 90% of their original area has disappeared and remaining fragments are often in critical condition (Hughes, 2003); they have been called "linear oases" since they harbour scarce resources and conditions found nowhere else in the surrounding landscape (Arizpe *et al.*, 2008). Fluvial systems in the Mediterranean region have been greatly altered by human activity and these alterations have directly or indirectly affected the natural riverside vegetation by reducing its biodiversity and, in some cases, making it disappear from large stretches of rivers (Prada and Arizpe, 2008). The construction of embankments separated many of the remaining forests from the direct effects of fluvial processes, which are of fundamental importance for the ecology of these forests. Research in Slovakia and in France has shown that flood regimes structure snail assemblages (Čejak *et al.*, 2007) and the composition of woody plants (Deiller *et al.*, 2001).

In Italy, the river Po was dyked from Cremona to the delta already at the end of the 12th century. Over the following centuries engineering works continued and most forests were isolated from the river channel by embankments (Hughes, 2003). As a result, the riparian forests in the Po Valley are highly fragmented today (Ruffo, 2002). In the Mantua province the *Salici-Populetum nigrae* is the dominant association along the river Po. This forest type, which is of high ecological importance, is protected by the Habitats Directive (Code 91E0). In Italy the importance of floodplain forests is widely recognized and their bird communities are relatively well documented and include many protected species (Montanari, 1991; Longhi *et al.*, 2010). However, surprisingly little is known about the invertebrate fauna of riparian forest patches along the largest Italian river, the Po. In particular, invertebrate communities of forests exposed to flood regimes have received limited attention (Rastelli *et al.*, 2003; Fabbri and Corazza, 2009; Camerini, 2009).

Each flood event destroys a patch of floodplain forest but facilitates regeneration of new forest. These dynamics have been well documented for the period 1889-2005 for the nature reserve Isola Boscone (Cuizzi, 2010), where the present study was carried out. Specifically, the total density of softwood forests (*Salici-Populetum*) varies with flooding conditions and only parts of the reserve are forested at any point in time (Schnitzler, 1997; Hughes, 2003; Cuizzi, 2010). Therefore, dead trees are present in the reserve in various ecological conditions and the extremes are: trees entirely surrounded by closed canopy forest and single trees in open areas, fully exposed to the sun.

The amount of dead wood present in a forest is highly important for species richness of saproxylic Coleoptera (Müller and Bussler, 2008; Brin *et al.*, 2009). More specifically, numerous saproxylic beetle species are attracted to sun-exposed dead wood (Lindhe *et al.*, 2005; Vodka *et al*., 2009; Pradella *et al*., 2010) and many species of Cerambycidae and Buprestidae prefer sun-exposed wood (Vodka *et al*., 2009), while other beetle species favour shady conditions (Hammond *et al.*, 2004; Brunet and Isacsson, 2009; Vodka *et al*., 2009). For the floodplain remnants in northern Italy it is not known which beetle species live there and what are their preferred habitats, and if open forest habitats or closed canopy situations have higher species richness.

The aims of this study were:

- to characterize the fauna of selected beetle families of the reserve Isola Boscone;
- to determine whether abundances of beetle species vary between open and closed habitats;
- to investigate whether the composition of the species collected varies with the sun-exposure of the dead tree used to position the window trap;
- to compare the species richness of open and closed habitats.

Materials and methods

Study area

The study was carried out in the nature reserve Isola Boscone, which is located in the Lombardy region, Mantua province (UTM 32T 676445 E, 4989857 N, 14 m a.s.l). It covers an area of 131.5 ha, with a maximum length of approximately 2,500 m and a maximum width of approximately 550 m. The presence of a forest on Isola Boscone, which is situated inside the embankments of the river Po, has been confirmed from the year 1953 onwards (Cuizzi, 2010). Currently, the vegetation is dominated by "softwood" floodplain forest, the prevailing tree species being poplar (*Populus* spp.), willow (*Salix* spp.) and mulberry (*Morus* spp.). High discharge volumes of the river in autumn and spring often cause floods, which regularly inundate the entire reserve. These dynamics have a great impact on forest structure creating a patchwork of closed forest and large open areas (Hughes, 2003; Cuizzi, 2010).

Beetle sampling and determination

Window traps directly attached to trunks of dead trees are considered to be the most effective trapping method for saproxylic beetle assemblages (Økland, 1996; Hyvärinen *et al*., 2006), have been shown to be effective in riparian forests in Italy (Audisio *et al.*, 2008), are efficient in catching rare beetles in forests (Martikeinen and Kouki, 2003), and show less variability than other sampling methods (Hammond *et al*., 2004). In the year 2009 the beetle fauna of the reserve was monitored with a total of 12 window flight traps. These consisted of two intersecting Plexiglas panels (60 × 40 cm) positioned above a plastic funnel (diameter, 41 cm) connected to a 500 ml flask containing 70% ethanol as an attractant and preservative (see Atkinson *et al.*, 1988; Audisio *et al.*, 2008). An upside-down funnel served as a cover for the traps. The traps were attached to large dead trees at a height of about 2.5 m. This set-up is efficient in collecting beetle species in alluvial forests (Audisio *et al*., 2008) and it is known that ethanol is an attractant to a number of beetle families (Salpingidae, Scolytidae) (Roling and Kearby, 1975; Montgomery and Wargo, 1983) and increases the percentage of saproxylic beetles collected (Bouget *et al.*, 2009). A total of 12 large dead trees (*Salix* spp. and *Populus* spp.) were selected in two different habitat types; six traps were attached to sun-exposed and isolated trunks (open habitat traps). In an area of 380 m^2 surrounding the trap, on average only a single small live tree was present. Six further traps were hung from trunks located in the understorey of small forests (forest traps). In these sites on average 42 trees were present in the area of 380 m^2 surrounding the trap and canopy closure was higher than 75%. The traps set in the two habitat types were spatially interspersed and the forest traps were separated as widely as possible, utilizing five separate forest patches. Average diameters of the tree trunks used for trapping were 45 cm for the open habitat traps and 48 cm for the forest traps, respectively. The traps were active from 16 June to 3 November 2009. It had been planned to initiate the study earlier, but a flood of the river Po, which inundated the entire reserve, made it impossible to place the traps before this date. Samples were collected every two weeks.

In trunk sections which had been submerged we were unable to find larvae of saproxylic beetles 10 days after they had re-emerged from the water in early June 2009. In contrast, when we searched above the maximum water level, beetle larvae were found in the dead wood.

The following beetle families were chosen for this study, as at least part of the species belonging to these, are saproxylic in the sense of Speight (1989). The species were identified by the specialists indicated in brackets: Anthribidae, Cerambycidae, Cleridae, Lucanidae (Paolo Cornacchia); Buprestidae (Gianfranco Curletti); Tenebrionidae (Piero Leo); Aderidae (Gianluca Nardi); Histeridae (Fabio Penati); Scarabaeidae (Emanuele Piattella); Lissomidae, Elateridae (Giuseppe Platia).

The nomenclature of the beetle families follows: Mazur, (2004) (Histeridae); Bartolozzi and Sprecher-Uebersax, (2006) (Lucanidae); Löbl and Smetana, (2006) (Scarabaeidae); Mertlik and Platia, (2008) (Lissomidae); Sànchez-Ruiz, (1996) (Elateridae); Schaefer, (1949) (Buprestidae); Löbl *et al.*, (2007) (Cleridae), Nardi (2008) (Aderidae), Löbl and Smetana, (2008) (Tenebrionidae); Löbl and Smetana, (2010) (Cerambycidae); Alonso-Zarazaga, (2004) (Anthribidae).

Statistical analyses

For the analyses, temporal data were pooled for single traps. The package indicspecies for R (version 2.10.1, http://www.r-project.org/) was used to study the association of the beetle species caught in both habitat types, employing the function multipatt (De Cáceres and Legendre, 2009). The community compositions of the two habitats was analysed by two-dimensional Nonmetric Multidimensional Scaling (NMDS) of the abundance data employing the function metaMDS, which is incorporated in the statistical package Vegan (Oksanen *et al.*, 2010). Here, Bray-Curtis similarity was used to calculate pairwise distances among samples. In the resulting plot the groups were connected to the cluster centroids by a line using the function 'ordispider' present in the same package. To test for differences in species composition between the two habitats, a non-parametric multivariate ANOVA was performed using the method described by Anderson (2001) and implemented in Vegan's adonis function.

Sample-based and individual-based rarefaction curves were calculated using the programme EstimateS 8.20 (http://viceroy.eeb.uconn.edu/EstimateS). Total species richness was estimated with the same programme, employing the methods ACE and Jackknife 1, which are considered accurate and not sensitive to statistical problems (Hortal *et al.*, 2006). Completeness of the survey data was calculated in relation to these richness estimators.

All statistical tests were carried out using the software package R (version 2.10.1, http://www.r-project.org/), if not stated otherwise.

Results

A total of 495 individuals belonging to 53 species were collected (table 1). The open habitat traps collected a total of 355 individuals, while the forest traps caught 140.

Five of the species collected are of faunistic interest, as they are considered rare or are new to the regional fauna: *Cyclobacanius medvidovici* (Reitter) (Histeridae), *Anidorus sanguinolentus* (von Kiesenwetter) (Aderidae), *Diaclina fagi* (Panzer) (Tenebrionidae), *Platydema violaceum* (F.) (Tenebrionidae) and *Eusphyrus vasconicus* (Hoffmann et Tempere) (Anthribidae). Only two species, *Synaptus filiformis* (F.) (Elateridae) and *Chlorophorus varius* (Muller) (Cerambycidae), were caught in relatively high numbers (≥ 50 specimens).

Five species were found to be significantly associated with one of the two habitats investigated (table 1). *Aegosoma scabricorne* (Scopoli) (Cerambycidae) and *Dissoleucas niveirostris* (F.) (Anthribidae) were significantly associated with forest habitat, while *Chlorophorus varius* (Muller) (Cerambycidae), *Dorcus parallelipipedus* (L.) (Lucanidae) and *Nalassus dryadophilus* (Mulsant) (Tenebrionidae) were significantly associated with open habitat. For one species, *Drasterius bimaculatus* (Rossi) (Elateridae), the test returned a marginally significant result ($p = 0.053$), and this species was exclusively found in the open habitat. NMDS (figure 1) showed that the communities collected in the two habitats were distinct and the nonparametric multivariate ANOVA based on 999 permutations showed that the communities from the two habitats were significantly different ($F_{1, 10} = 4.108$, $P = 0.004$).

The numbers of species and specimens collected were higher in the open habitat (table 1) but only the difference in the number of specimens was significant (Wilcoxon rank sum test, $p < 0.01$), while for the number of species the difference was not significant (Wilcoxon rank sum test, $p = 0.13$). Sample based rarefaction curves (figure 2) indicate that species richness was significantly higher (non-overlapping confidence limits) for the open habitats, when single traps were considered. However, the individual-based rarefaction curves (figure 3) show that species richness was not lower in the forest habitats if richness is plotted in relation to the number of individuals caught. The estimates for total species richness of both habitats investigated (table 2) show that the traps in the open habitat should at least reach between 63 and 81 species (table 2), while the six traps together collected 43 species. Thus, their total catch can be estimated to represent between 52% and 67% of all species which it would have been possible to sample. For the traps exposed in the forest it was estimated that rarefaction curves should at least reach 46 to 59 species (table 2), while the six traps employed collected 31 species. These represent between 51% and 65% of all species which it would have been possible to catch. Thus, the six window traps exposed in the respective habitats caught at most 51-67% of the estimated total species richness.

Discussion

This study is the first to investigate the fauna of many beetle families from floodplain forests directly exposed to flood regimes of the river Po, which are ecologically important and protected. In the present study the fauna trapped at sun-exposed dead trees differed from that in the understorey of small forest patches. Such differences in community composition and preferences of single species have also been found by other authors (Kaila *et al.*, 1997; Lindhe *et al.*, 2005; Sverdrup-Thygeson and Birkemoe, 2009; Vodka *et al.*, 2009). Sun exposure should therefore be considered an important environmental factor for saproxylic beetles.

The few entomological studies carried out in comparable forests along the river Po employed different methods, took place during different periods of the year, and investigated exclusively Cerambycidae and Buprestidae (Rastelli *et al.*, 2003) or Cerambycidae (Fabbri *et al.*, 2005). Therefore, it is currently only possible to state that the Cerambycidae species reported for other riparian forests of the river Po are similar to those observed in the present study.

Recurring floods can make it difficult to apply standard sampling methods over many months in fluvial ecosystems, as in the case of this study. These difficulties are well illustrated by the fact that prior to this investigation, Isola Boscone had been completely inundated six times in the years 2008 and 2009 (D. Cuizzi, personal communication) and the April-May flood of the year 2009 is among the 10 most important maximal discharges of the last 100 years (W2A, 2011). Each flood uproots a number of standing dead trees, completely saturates with water the lower parts of all standing dead trees and moves a number of lying tree-trunks. It seems that each flood eliminates a part of the saproxylic fauna present in the

Table 1. List of beetles collected with 12 window traps at Isola Boscone from June 16 to November 3, 2009 (O: open habitat trap, F: forest trap, numbers indicate trap numbers). Species marked with asterisk were significantly associated with one of the habitats (* < 0.05, ** < 0.01). Figures in brackets are standard deviations.

	O1	O2	O3	O4	O5	O6	F1	F2	F3	F4	F5	F6
Histeridae												
Acritus minutus (Herbst)				5			2	2		5		
Carcinops pumilio (Erichson)		1										
Cyclobacanius medvidovici (Reitter)					1					1		
Haeterius ferrugineus (Olivier)										1		
Platylomalus complanatus (Panzer)	1											
Lucanidae												
Dorcus parallelipipedus (L.)*	1	2		3	3	1		1				
Scarabaeidae												
Anomala vitis (F.)		1		1	2	3		1				
Cetonia aurata pisana Heer				4	1							
Oxythyrea funesta (Poda)			1	9								
Pleurophorus caesus (Creutzer)		1										
Tropinota squalida squalida (Scopoli)			20		8	9						
Valgus hemipterus (L.)			1	2		1	1					
Lissomidae												
Drapetes mordelloides (Host)	1											
Elateridae												
Adrastus limbatus (F.)					1							
Adrastus rachifer (Fourcroy)		1		4	1			4		1		
Agriotes litigiosus (Rossi)		1										
Ampedus sanguinolentus (Schrank)		1					1					
Drasterius bimaculatus (Rossi)		2	1		2	7						
Melanotus dichrous (Erichson)	2		2	2	5			1	1	1		
Synaptus filiformis (F.)	12	80	13	7		4	6	4	2	2	2	25
Buprestidae												
Acmaeoderella flavofasciata (Piller et Mitterpacher)					1							
Melanophila picta decastigma (F.)						1						
Cleridae												
Trichodes apiarius (L.)			1	8				1				
Aderidae												
Aderus populneus (Creutzer in Panzer)						1				1		
Anidorus sanguinolentus (von Kiesenwetter)			1									
Tenebrionidae												
Alphitobius diaperinus (Panzer)					1							
Corticeus bicolor (Olivier)										1		
Diaclina fagi (Panzer)				1								
Diaperis boleti (L.)	2			1				1	1			
Hymenalia rufipes (F.)		1								1		
Lagria hirta (L.)				1						1		
Latheticus oryzae Waterhouse					1							
Nalassus dryadophilus (Mulsant)**	6	1	2	3	9	2						
Palorus depressus (F.)	1				1			1				
Platydema violaceum (F.)												1
Prionychus melanarius (Germar)								1				
Tribolium castaneum (Herbst)		2		5				2				
Cerambycidae												
Aegosoma scabricorne (Scopoli)*	2			3			3	3	2	7	3	9
Agapanthia villosoviridescens (De Geer)			1			1						
Chlorophorus pilosus glabromaculatus (Goeze)												1
Chlorophorus varius (Muller)*	2		2	18	21	7						
Grammoptera ruficornis (F.)										1		
Leiopus nebulosus (L.)							1			5		
Neoclytus acuminatus (F.)	3						1		3			1
Stenopterus rufus L.				1								
Stictoleptura cordigera (Fuessly)				2	2	2						
Xylotrechus stebbingi Gahan	1								2	2		2
Anthribidae												
Choragus sheppardi Kirby								1			1	1
Eusphyrus vasconicus (Hoffmann et Tempere)							1				2	
Dissoleucas niveirostris (F.)*					1		1	2	1		2	1
Phaenotherion fasciculatum Reitter												1
Platystomos albinus (L.)				1			1		1		2	
Ulorhinus bilineatus (Germar)	1											
Number of specimens	35	94	45	81	61	39	18	25	13	30	12	42
Number of species	13	12	11	20	17	12	10	14	8	14	6	9
Average number of specimens			59.2	(24)				23.3		(11.5)		
Average number of species			14.2	(3.5)				10.2		(3.3)		

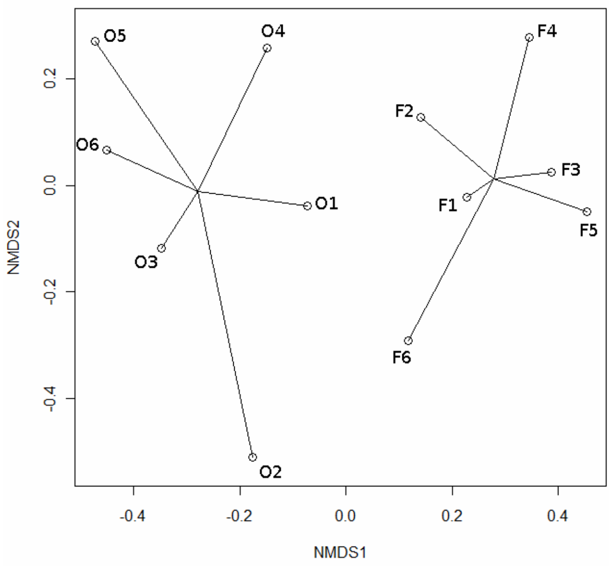

Figure 1. Two-dimensional Nonmetric Multidimensional Scaling (NMDS) of the abundance data (O: open habitat trap, F: forest trap, numbers indicate trap numbers). Groups are connected to the cluster centroids by a line using the function 'ordispider' (statistical package Vegan).

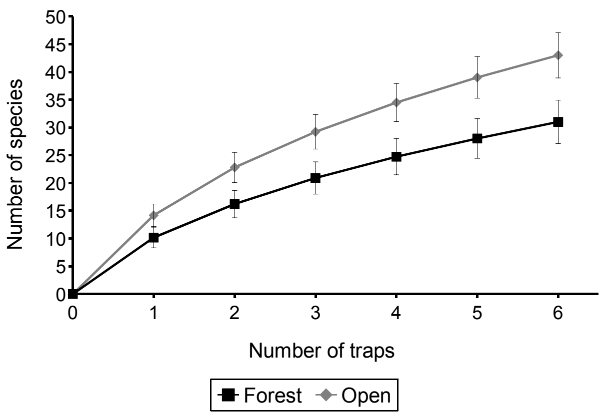

Figure 2. Sample-based rarefaction curves for forest and open habitat traps.

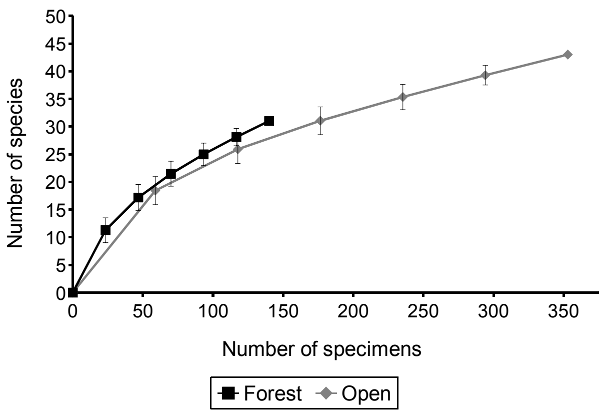

Figure 3. Individual based rarefaction curves for forest and open habitat traps.

Table 2. Total species richness, estimated employing the methods ACE Mean (Abundance-based Coverage Estimator of species richness) and Jackknife 1 (First-order Jackknife richness estimator), for the traps "Forest" (n = 6) and "Open" (n = 6).

Species richness estimator	Traps "Forest"	Traps "Open"
ACE Mean	58.7	81.3
Jackknife 1	46.0	63.0

reserve and this is likely to be one important reason for the relatively low number of beetle species (53) collected during the study. This number is low even if one considers that only some families were studied, that the traps were only exposed from 16 June 2009 and that many species that emerge early in the season could not be sampled. A further probable cause for the low species richness observed is the fact that the reserve is small and relatively isolated, as small and isolated islands of habitats host relatively low species richness (Hunter, 2002). Forests similar to Isola Boscone are present along the river Po, but they are all restricted in size and are generally separated from each other by some kilometres of habitats not suitable for saproxylics.

It was estimated that at least 33-49% of the beetle species of the selected families, which are collectable with window traps, were not caught. This means that at least 20 Coleoptera species, belonging to the families investigated, were not collected. Additionally, beetle diversity is often high early in the season (e.g. Ulyshen and Hanula, 2007) and as this part of the season could not be investigated due to a flood. It is clear that the coleopteran fauna of the reserve is still not well known and that more research is needed to understand the distribution, composition and ecology of the beetle fauna of the floodplain remnants along the river Po.

Species of faunistic interest and common species

E. vasconicus (Anthribidae) has only recently been reported from Italy (Trýzna and Valentine, 2011) and is currently known from three nature reserves in the Lombardy region (Cornacchia and Colonnelli, 2012). The species almost certainly originates from America and is likely to have arrived in Europe with imported wood. *E. vasconicus* was described by Hoffmann and Tempère (1954) from specimens collected in the Pyrénées-Atlantiques department (France) on branches of *Quercus pedunculata* (Ehr.). The specimens of *C. medvidovici* (Histeridae) collected represent the third and westernmost record of this species for Italy. Vienna (1980) reported that this taxon lives in rotten wood of several hardwood species (mostly oaks), in the debris of tree hollows. *D. fagi* (Tenebrionidae), a species that mainly lives in dead wood colonised by fungi, has only recently been reported from Italy (Scupola, 2000) and is currently expanding (Aliquò *et al.*, 2006; P. Leo, personal observation). *P. violaceum* (Tenebrionidae), a rare species that mainly lives in humid forests, has been found under bark and inside polypore mushrooms living on deciduous trees (Aliquò *et al.*, 2006). A single female of

A. sanguinolentus (Aderidae) was collected, which is the first record of this species for Lombardy. This beetle was previously known for Italy from the following regions: Liguria, Piedmont, Emilia-Romagna, Tuscany, Latium, Sicily and Sardinia (Luigioni, 1929; Porta, 1929; Vitale, 1934; Zangheri, 1969; Lundberg *et al.*, 1987; Contarini, 1992; Nardi, 1997; Poggi 2001) and is considered uncommon, generally collected by beating trees (Caillol, 1914; Gompel and Barrau, 2002). Little is known about the biology of this species. Perris (1864 as *Xylophilus sanguinolentus*) found the pupa of *A. sanguinolentus* in a silky cocoon under the bark of a pine, while Poggi (2001) collected adults on the mycelium of an unidentified Polyporacea within a stump of *Pinus radiata* D. Don in Sardinia.

The two species that were caught in relatively high numbers are both considered common. *S. filiformis* is a common species in Italy and in Europe. Its larvae live in the soil, mainly in wetlands (e.g. river banks, swamps) (Platia, 1994). *C. varius* is widely distributed in Europe and its larvae develop in branches of many broadleaved trees (Müller, 1949-1953).

Species trapped mainly in the shady forest environment

The fact that *A. scabricorne* (Cerambycidae) is significantly associated with the forest habitat has so far not been reported in the literature. What is known is that adults hide in galleries or under bark during the daytime and are active during the night (Pesarini and Sabbadini, 1995). The larvae develop in old, non-resinous trees (e.g. *Quercus*, *Juglans*, *Fagus*, *Ulmus*, *Populus*, *Acer*, *Prunus*, *Alnus*, *Salix*) (Sama, 1988). Contarini (1984) reported that *A. scabricorne* is a good disperser and quickly colonises suitable habitats, even those heavily influenced by man. The second species with a preference for the forest environment was *D. niveirostris* (Anthribidae); its association with forest habitats had also not been reported before. Recently, it has been found that window traps exposed at ground level at Bosco Fontana (Mantua Province) caught significantly more *D. niveirostris* when compared to catches from the canopy (P. Cornacchia, unpublished data). This observation coincides well with the preference for the forest observed at Isola Boscone. It is known that adults of *D. niveirostris* can be found amongst mosses, under bark or on branches of trees (Riti and Osella, 1997).

Species trapped mainly in the open habitat

So far no study has statistically compared habitat preferences of *C. varius* (Cerambycidae). However, it is known that adults can often be found on flowers of Apiaceae (Pesarini and Sabbadini, 1995) and Asteraceae, and on *Verbascum* spp. (Müller, 1949-1953). This behaviour coincides well with the observed preference for the open habitat presented here. *C. varius* has also been reported by Rastelli *et al.* (2003) for a riparian forest along the river Po in the province of Turin. The behaviour of adults of *D. parallelipipedus* (Lucanidae) is not well known and a significant preference for open habitats is here reported for the first time. Adults of *D. parallelipipedus* are believed to be active mainly during the night and to fly only reluctantly (Franciscolo, 1997). However, the total catch of 11 adults in the window traps and the fact that also Brunet and Isacsson (2009) trapped many specimens of this beetle with small window traps, show a certain propensity for flying by this beetle, particularly in open areas. *N. dryadophilus* (Tenebrionidae) was associated with the open habitat and this observation coincides well with the fact that in the Po Valley it has commonly been observed in rows of deciduous trees (*Populus*, *Ulmus*, *Platanus*, etc.), but the species is also common in remnants of lowland forests and is generally found under the bark of trees (P. Leo, personal observation). The specimens of *D. bimaculatus* (Elateridae) were exclusively found in the open habitat and the association with this habitat was almost significant. This preference for open habitats has so far not been reported and generally it has been found that *D. bimaculatus* lives in a large number of terrestrial habitats, where the adults live on the ground, while the larvae are rhizophagous (G. Platia, personal observation).

Influence of sun exposure on species composition

The two-dimensional ordination (figure 1) showed that the communities collected in the open habitats differed from those caught within the closed forest sections. This result was expected, as numerous saproxylic beetle species are attracted to sun-exposed dead wood (e.g. Lindhe and Lindelöw, 2002; Hammond *et al.*, 2004; Lindhe *et al.*, 2005; Brunet and Isacsson, 2009; Vodka *et al.*, 2009), and open, sun-exposed stands generally show higher species richness (Ranius and Jansson, 2000; Brunet and Isacsson, 2009; Vodka *et al.*, 2009). Adult beetles of many species of the families Cerambycidae and Buprestidae prefer sun-exposed oak wood for breeding (Vodka *et al.*, 2009), while a number of saproxylic beetle species prefer shady conditions (Hammond *et al.*, 2004; Brunet and Isacsson, 2009; Vodka *et al.*, 2009).

The sample based rarefaction curves (figure 2) indicated that species richness was higher in the open habitats. However, as the activity of beetles generally increases with increased temperatures (Ranius and Jansson, 2000), the observed difference might be related more to catchability (or density) than to higher species richness. This view is supported by the individual-based rarefaction curves (figure 3), which showed that species richness was not lower in the forest habitats when richness was plotted in relation to the number of individuals caught. This finding underlines that catches of window traps are not a direct representation of the local communities, but are the result of the activity patterns of the single species in this particular environment (Nageleisen and Bouget, 2009). This limits the comparability of trapping results between different habitats (Lindhe *et al.*, 2005). Species richness counts can be validly compared only when accumulation curves have reached a clear asymptote (Gotelli and Colwell, 2001). As the rarefaction curves in both habitats are clearly a long way from reaching an asymptote (figures 2 and 3), the comparison of richness estimates has to be done with caution. However, the failure to reach an asymptote is not uncommon (Hammond *et al*., 2004; Audisio *et al*., 2008) and the curves might not level off even at 1,000 individuals. The different results obtained with the two versions of rarefaction curves are a good example that the interpretation of richness estimates is fraught with problems (Gotelli and Colwell, 2001; Magurran, 2004).

The beetle fauna collected in the two different habitats showed clear differences when considering single species and when analysing the community composition and this finding is important for future studies. This shows that sun exposure is an important factor in floodplain forests. If the aim of a study is to compile a faunistic list, the traps should be positioned in a variety of habitats. If, however, the aim of the study is to provide data for comparisons (with other habitats or with future data), the traps should be exposed in homogeneous and well defined situations, in order to reduce the variability of the results. Monitoring of beetle communities is difficult and in floodplain remnants is further complicated by recurrent floods. This episodic and important ecological factor needs to be considered when planning sampling designs.

Conclusions

Numerous studies have highlighted the link between the distribution of saproxylic species and characteristics of dead wood (Lindhe *et al*., 2005; Brunet and Isacsson, 2009; Vodka *et al*., 2009). Similarly, in this study we showed that sun exposure is important for the distribution of single species and for community composition. These insights are important for the management of nature reserves and indicate that only maintaining a "mosaic" of different dead wood types and different levels of sun exposure (e.g. open and closed forests) will ensure the survival of a large number of saproxylic species (Vodka *et al*., 2009; Pradella *et al*., 2010). The management of riparian forests exposed to the effects of fluvial processes differs from that of most other forests, as lying trunks are episodically moved or carried away during floods. Standing trees are probably the main source of dead wood allowing for permanent populations of saproxylic species to survive in riparian forests, and should thus be given particular attention by managers.

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