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The diversity of Cerambycidae in the protected Mediterranean landscape of the Natural Park of Carrascal de La Font Roja, Spain

Francisco Javier PERIS-FELIPO, Jose Vicente FALCÓ-GARÍ, Ricardo JIMÉNEZ-PEYDRÓ
Laboratorio de Entomología y Control de Plagas, Instituto Cavanilles de Biodiversidad y Biología Evolutiva, Universidad de Valencia (Estudio General), Valencia, Spain

Abstract

The present work offers new information about the faunistic diversity of Cerambycidae (Coleoptera) in the Natural Park of Carrascal de La Font Roja, along with data on the family's ecology. A total of 27 species were identified during the sampling period (2004-2009), the adult activity of which spans from early May to late August. *Stenurella melanura* (L.) and *Chlorophorus trifasciatus* (F.) were the most abundant species. Ecological studies were carried out in four different habitats (*Quercus* forest, *Pinus* forest, mixed forest and herbaceous), and identified *Pinus* forest as the most diverse habitat (Shannon Index = 2.467), and *Quercus* forest as the least diverse (Shannon Index = 1.068). Correspondence and neighbour joining analyses showed that certain Cerambycidae species are associated with certain habitats, although some species may be present in more than one habitat due to their lower plant specificity.

Key words: Coleoptera, Cerambycidae, Natural Park of Carrascal de La Font Roja, Spain.

Introduction

Mediterranean forest landscapes that are rich in evergreen species frequently intersect with areas of brushwood, pasture, farming and ranching. In close proximity to these areas, however, it is often possible to identify zones that have regained their highly diverse natural communities after the cessation of human intervention. This favours the proliferation of hotspots in Mediterranean ecosystems (Myers *et al*., 2000). Despite the huge resistance posed by Mediterranean biotopes to human pressure, isolation and fragmentation are unavoidable (Pungetti, 2003), resulting in the emergence of isolated patches within the landscape.

The death and decay of woodlands, however, offers a broad range of potential microhabitats for the spatial segregation of different saproxylic insects, according to the tree species, tissue type and position within the tree. Saproxylic insects are associated with dead wood tissue or with the fungi and microorganisms responsible for decomposition (Speight, 1989; Mendez Iglesias, 2009), and can be classified as wood or fungus feeders (primary saproxylics), predators or parasitoids (secondary saproxylics) or commensals (tertiary saproxylics). All major insect orders are present in each of these groups, but Coleoptera and Diptera are especially well represented. Other groups of invertebrates, for example mites, pseudoscorpions and onychophorans, also include many saproxylic species. Although saproxylic insect assemblages are functionally highly dominant (Elton, 1966) and speciose (Siitonen, 1994), they frequently include naturally rare species (Stork and Hammond, 1997). In the light of current human pressure on woodland landscapes, saproxylic insects must be given greater priority in research since they are by definition dependent on the very resource – wood – the removal of which from the ecosystem is the usual object of forest management (Grove and Nigel, 1999).

The Cerambycidae is one of the richest families of saproxylic beetles, with around 35,000 catalogued species (Grimaldi *et al*., 2005). Some of these species are frequently significant for the declaration of internationally important forests (Speight, 1989). Spain is rich in catalogued Cerambycidae, offering an important contribution to knowledge of the group at the European level. However, diversity studies, habitat-comparative analysis and the preferences of Cerambycidae in protected natural landscapes have received less attention. In this context, the aim of this study was to analyse the Cerambycidae fauna present in the Natural Park of Carrascal de La Font Roja (Alicante, eastern Spain), which, due to bioclimatic conditions, is extremely diverse. Abundance, phenological and specific richness analyses were also carried out.

Materials and methods

Samples were taken in the Natural Park of Carrascal de La Font Roja. This area, located in the north of the province of Alicante (38°38'51"N 0°32'46"W), extends over 2,298 ha, with an elevation of 1,356 m and is known for its low level of anthropogenic disturbance. The orientation of the hill range favours cool, moist winds from the northeast, resulting in retention of rainfall. This, along with the steep slopes and the predominance of limestone, fosters the existence of different landscape units, including deciduous forests, brushwood, scrub rock vegetation, pine forests and agricultural areas. Each face in the range enjoys different climatic conditions. The precipitation regime on the north face is upper sub-humid, with an annual rainfall of 600 to 1,000 mm, while the south face is dry, with an annual rainfall of 350 to 600 mm. Due to the high average temperatures recorded throughout the year (15-20 °C) and the low average rainfall, the precipitation regime is dry and thermo-Mediterranean.

Specimen capture was carried out by both direct collection on plants in the sampling areas and by indirect collection using light traps and Malaise traps (Townes model) distributed across the park (Alcoy and Ibi localities). Sampling took place weekly between 2004 and 2009, with a few exceptions due to unforeseeable circumstances, and captured specimens were preserved in ice (direct and light trap collection) or ethanol 70% (Malaise trap collection) until final preparation. Prepared specimens were identified according to Vives (2000) and Sama and Löbl (2010) criteria, and are housed in the UVEG (Universidad de Valencia - Estudio General) entomological collection. Taxa are listed in alphabetical order.

The data were organised according to the presence of species, an approach that is particularly suited to interspecific comparisons (Tavares *et al*., 2001). Data on the habitat type of each specimen were also collected. The park supports four different habitats: *Quercus* forest (mainly populated by *Quercus ilex rotundifolia* Lam.), *Pinus* forest (populated by *Pinus halepensis* Miller), mixed forest (populated by *Fraxinus ornus* L., *Acer opalus granatensis* Boiss., *Sorbus aria* (L.) Crantz, *Taxus baccata* (L.) and *Quercus ilex rotundifolia*, among others) and herbaceous. The data were used in species richness analyses, diversity indices and correspondence analyses to identify possible relationships between species distribution within each habitat; similarity/dissimilarity analyses to identify the relationship between species; and phenological analyses. All analyses were carried out using the R statistical package (R Development Core and Team, 2003) and SPSS (SPSS15, 2006).

Results

During our 5-year research programme, a total of 390 beetles belonging to the Cerambycidae family, representing 27 different species, were captured. The figures shown in table 1 reflect the species abundance, average abundance and abundance per habitat.

Analysis of captured specimens revealed the prevalence of certain species, such as *Stenurella melanura* (L.), with 176 specimens collected, amounting to 45.13% of the total, and *Chlorophorus trifasciatus* (F.), with 62 specimens (15.90%). Other species were much rarer, with only one specimen captured during the 5 years of sampling. The latter included *Ergates faber* (L.), *Stictoleptura cordigera* (Fuessly), *Stictoleptura otini* (Peyerimhoff), *Stictoleptura scutellata* (F.), *Stromatium unicolor* (Olivier) and *Trichoferus fasciculatus* (Faldermann).

Phenological studies were based on the number of specimens in monthly catches and other data collected during their capture (figure 1). Figure 1 shows that adult Cerambycidae typically appeared in the Natural Park of Carrascal de La Font Roja in spring and summer, with no activity during autumn and winter.

Each of the four differentiated habitats (*Quercus* forest, *Pinus* forest, mixed forest and herbaceous) was also considered separately with regards the abundance and phenology data. Table 1 shows data on the specific abundance for each habitat, which led to a separate di-

Table 1. List of species captured and global and habitat abundance.

Species	Abundance	Average abundance	Habitat			
			Quercus forest	*Pinus* forest	Mix forest	Herbaceous
Agapanthia asphodeli	13	3.33	0	2	1	10
Agapanthia cardui	21	5.38	0	5	4	12
Albana m-griseum	4	1.03	0	4	0	0
Arhopalus ferus	8	2.05	0	8	0	0
Arhopalus rusticus	6	1.54	0	6	0	0
Calamobius filum	6	1.54	0	2	0	3
Cerambyx cerdo	3	0.77	3	0	0	0
Certallum ebulinum	6	1.54	0	0	0	6
Chlorophorus glaucus	13	3.33	13	0	0	0
Chlorophorus sartor	2	0.51	1	0	0	1
Chlorophorus trifasciatus	62	15.90	48	2	4	8
Ergates faber	1	0.26	0	1	0	0
Hylotrupes bajulus	2	0.51	0	2	0	0
Monochamus galloprovincialis	2	0.51	0	2	0	0
Opsilia caerulescens	16	4.10	0	5	0	11
Penichroa fasciata	2	0.51	0	2	0	0
Phymatodes testaceus	2	0.51	0	2	0	0
Phytoecia virgula	4	1.03	0	0	0	4
Pseudovadonia livida	15	3.85	0	3	7	5
Stenopterus ater	12	3.08	4	0	2	6
Stenurella melanura	176	45.13	96	20	24	36
Stictoleptura cordigera	1	0.26	0	0	1	0
Stictoleptura otini	1	0.26	0	0	0	1
Stictoleptura scutellata	1	0.26	0	1	0	0
Stromatium unicolor	1	0.26	0	1	0	0
Trichoferus fasciculatus	1	0.26	0	1	0	0
Vesperus xatarti	9	2.31	0	0	0	9

versity analysis (table 2). *Pinus* forest presented the widest specific diversity, with 18 species, followed by herbaceous (13), mixed forest (7) and *Quercus* forest (6). According to the Shannon Index, the most diverse habitat was again the *Pinus* forest, with a value of 2.467, followed by herbaceous (2.191), mixed forest (1.38) and finally *Quercus* forest (1.068).

Subsequent analyses were aimed at ascertaining the specific spatial distribution within habitats. This was done through correspondence analyses (figure 2) and led to the conclusion that *Quercus* forest and *Pinus* forest show significant differences while *Quercus* forest and mixed forest are very similar, because of the abundance of *Quercus* species in the latter. Herbaceous habitats, on the other hand, occupy a middle position, hosting different species from those detected in forested habitats. Some species, such as *S. melanura*, appear in different habitats, in this case *Quercus* forest and mixed forest.

Finally, similarity/dissimilarity analysis aimed at showing distribution patterns did not reveal clustering according to habitat (figure 3), while neighbour-joining analysis (figure 4) showed such clustering. This kind of analysis, however, blurred specific differences between *Quercus* and mixed forests, because all species were grouped within the same branch.

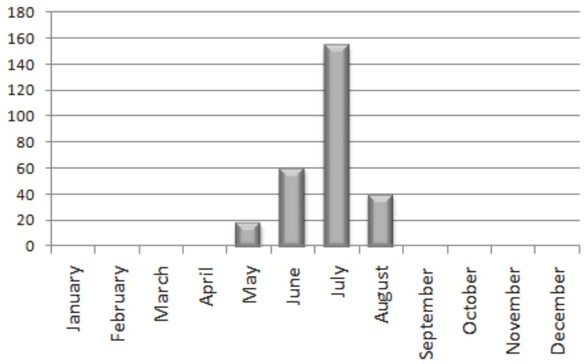

Figure 1. Phenology of Cerambycidae from Natural Park of Carrascal de La Font Roja.

Table 2. Results of diversity analyses.

	Quercus forest	*Pinus* forest	Mix forest	Herbaceous
Taxa S	6	18	7	13
Individuals	165	69	43	112
Dominance D	0.4303	0.1275	0.3586	0.1539
Shannon H	1.068	2.467	1.38	2.191
Simpson 1-D	0.5697	0.8725	0.8461	0.8461
Evenness e^H/S	0.4852	0.6547	0.5681	0.6883
Menhinick	0.4671	2.167	1.067	1.228
Margalef	0.9793	4.015	1.595	2.543
Equitability J	0.5963	0.8535	0.7094	0.8544
Fisher alpha	1.221	7.916	2.372	3.806
Berger-Parker	0.5818	0.2899	0.5581	0.3214

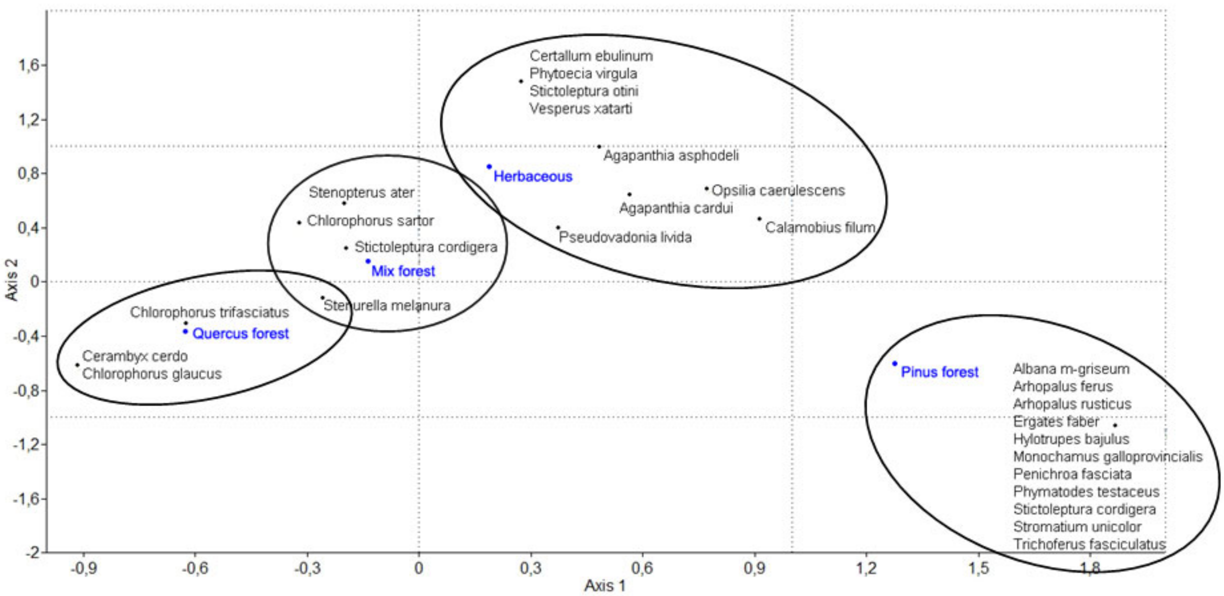

Figure 2. Distribution of Cerambycidae species per habitat.

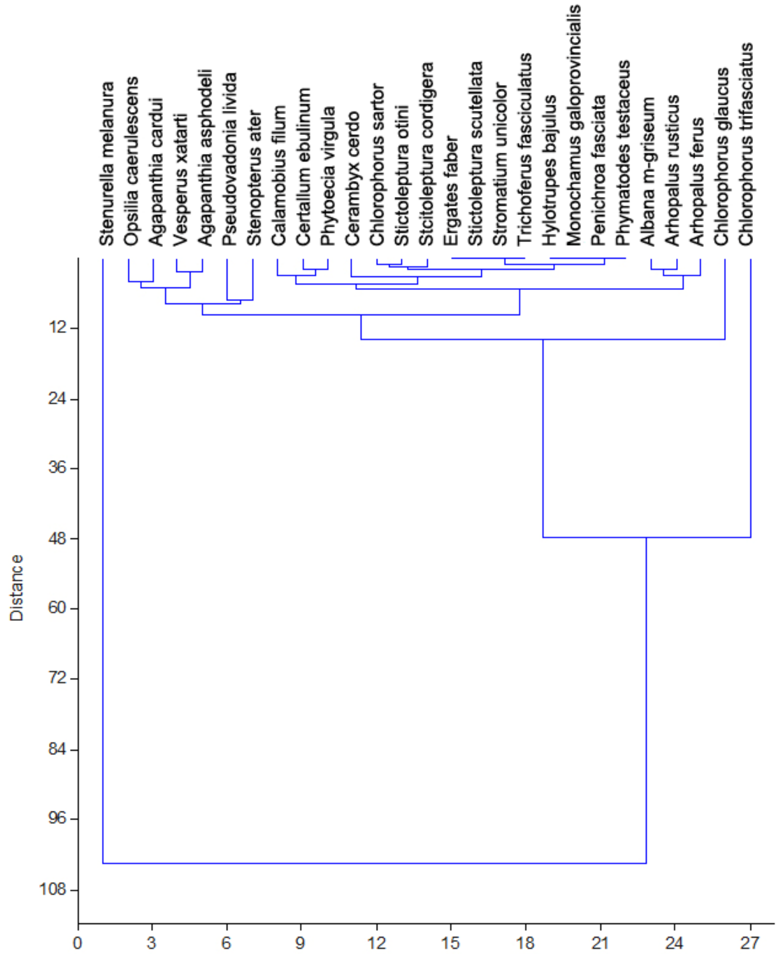

Figure 3. Cluster of similarity-dissimilarity of Cerambycidae species from Natural Park of Carrascal de La Font Roja.

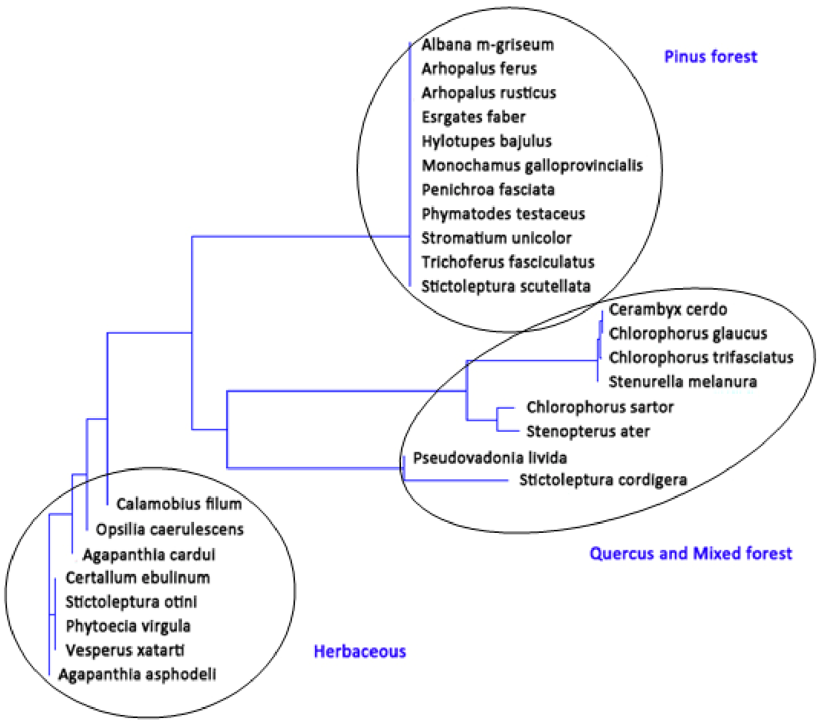

Figure 4. Distribution of Cerambycidae species with Neighbour-joining analyses.

List of collected specimens

Subfamily *PRIONINAE* Latreille 1802
Ergates faber (L. 1761)
IBI: 8.VII.2009 1♀.

Subfamily *SPONDYLIDINAE* Serville 1832
Arhopalus ferus (Mulsant 1839)
IBI: 1.VIII.2009 3♂ 1♀; 14.VIII.2009 2♂ 2♀.
Arhopalus rusticus (L. 1758)
ALCOY: 1.VIII.2009 1♀; 14.VIII.2009 1♀. IBI: 15.VII.2009 3♀ 1♂.

Subfamily *CERAMBYCINAE* Latreille 1802
Cerambyx cerdo spp. *cerdo* (Lucas 1842)
Alcoy: 29.VI.2004 1♀; 21.VII.2005 1♂; 10.VII.2007 1♀.
Penichroa fasciata (Stephens 1831)
IBI: 1.VIII.2009 1♂; 14.VIII.2009 1♂.
Trichoferus fasciculatus (Faldermann 1837)
IBI: 1.VIII.2009 1♀.
Stromatium unicolor (Olivier 1795)
ALCOY: 14.VIII.2009 1♀.
Certallum ebulinum (L. 1767)
ALCOY: 27.V.2005 3♀ 1♂; 3.VI.2008 1♀ 1♂.
Stenopterus ater (L. 1767)
ALCOY: 10.VII.2006 1♀; 6.VIII.2007 1♂; 8.VII.2008 1♀ 3♂; 15.VII.2009 2♀; 25.VII.2009 1♂. IBI: 15.VII.2009 2♀; 25.VII.2009 1♀.
Hylotrupes bajulus (L. 1758)
IBI: 8.VII.2009 1♂; 1.VIII.2009 1♂.
Phymatodes testaceus (L.1758)
ALCOY: 3.VII.2007 1♀; 10.VI.2009 1♀.
Chlorophorus glaucus (F. 1781)
ALCOY: 10.VI.2004 1♀; 22.VII.2004 2♀; 13.VI.2005 1♂; 27.VI.2005 1♀; 12.VI.2006 1♀; 3.VII.2006 1♀ 1♂; 17.VII.2006 2♂; 31.VII.2006 1♀; 6.VIII.2007 1♂; 17.VI.2009 1♀.
Chlorophorus trifasciatus (F. 1781)
ALCOY: 17.VII.2006 4♀; 1.VII.2007 3♀ 4♂; 15.VII.2008 1♀ 3♂; 1.VII.2008 2♀; 8.VII.2009 4♀; 15.VII.2009 4♀ 2♂; 25.VII.2009 10♀ 5♂. IBI: 15.VII.2009 5♀ 6♂; 25.VII.2009 5♀ 4♂.
Chlorophorus sartor (Muller 1766)
ALCOY: 24.VI.2009 2♀.

Subfamily *LEPTURINAE* Latreille 1802
Pseudovadonia livida (F. 1777)
ALCOY: 17.VI.2006 3♂; 24.VI.2008 2♀ 3♂; 1.VII.2009 2♀. IBI: 24.VI.2009 2♀ 2♂; 1.VII.2009 1♀.
Stictoleptura scutellata (F. 1781)
ALCOY: 1.VII.2008 1♀.
Stictoleptura cordigera (Fuessly 1775)
ALCOY: 1.VII.2004 1♀.
Stictoleptura otini (Peyerimhoff 1949)
ALCOY: 1.VIII.2008 1♀.
Stenurella melanura (L. 1758)
ALCOY: 10.VI.2004 4♀ 2♂; 27.VI.2004 3♀; 1.VII.2004 2♀ 4♂; 15.VII.2004 3♂; 22.VII.2004 15♀ 7♂; 29.VII.2004 2♀ 2♂; 2.VIII.2004 3♀ 1♂; 20.VI.2005 1♀; 27.VI.2005 1♂; 4.VII.2005 3♀; 11.VII.2005 1♀ 1♂; 18.VII.2005 2♀ 3♂; 26.VI.2006 5♀ 1♂; 3.VII.2006 6♀ 4♂; 10.VII.2006 3♀ 7♂; 17.VII.2006 1♀; 25.VII.2006 2♀; 31.VII.2006 1♂; 6.VIII.2007 1♀; 10.VIII.2008 2♂; 10.VI.2009 1♀; 17.VI.2009 1♀; 24.VI.2009 1♀ 1♂; 1.VII.2009 8♀ 7♂; 8.VII.2009 4♀ 4♂; 15.VII.2009 5♀ 4♂. IBI: 1.VII.2009 20♀ 10♂; 8.VII.2009 2♀ 2♂; 15.VII.2009 6♀ 7♂.

Subfamily *VESPERINAE* Mulsant 1839
Vesperus xatarti Dufour 1839
ALCOY: 1.VIII.2008 3♂; 14.VIII.2009 1♀ 5♂.

Subfamily *LAMIINAE* Latreille 1825
Albana m-griseum Mulsant 1846
ALCOY: 17.VI.2009 1♀; 1.VII.2009 1♀. IBI: 24.VI.2009 1♀; 1.VII.2009 1♀.
Calamobius filum (Rossi 1790)
ALCOY: 3.VI.2009 1♂; 10.VI.2009 2♀ 1♂; 17.VI.2009 2♀.
Agapanthia cardui (L. 1767)
ALCOY: 27.V.2009 3♀; 3.VI.2009 5♀ 2♂; 17.VI.2009 2♀ 2♂. IBI: 27.V.2009 2♀; 3.VI.2009 3♀ 1♂; 17.VI.2009 1♂.
Agapanthia asphodeli (Latreille 1804)
ALCOY: 27.V.2009 5♀; 3.VI.2009 1♀ 3♂; 10.VI.2009 3♀; 17.VI.2009 1♀ 1♂.
Monochamus galloprovincialis (Olivier 1795)
IBI: 14.VIII.2009 1♂.
Opsilia coerulescens (Scopoli 1763)
ALCOY: 25.VII.2009 4♀ 1♂; 1.VIII.2009 3♀ 2♂; 14.VIII.2009 1♀ 1♂. IBI: 1.VIII.2009 2♀ 1♂; 14.VIII.2009 1♀.
Phytoecia virgula (Charpentier 1825)
ALCOY: 27.V.2009 3♀; 10.VI.2009 1♂.

Discussion and conclusions

Although saproxylic coleoptera have often been catalogued in the Iberian Peninsula, faunistic and ecological studies allowing a better understanding of the biology and distribution of species of the Cerambycidae family are a recent development; these include studies in Mediterranean ecosystems, for example in the natural parks of Tinença de Benifassà (Peris-Felipo *et al*., 2008) and Lagunas de la Mata-Torrevieja (Peris-Felipo *et al*., 2009).

Sampling was carried out in the above-mentioned parks and also in the Natural Park of Carrascal de La Font Roja, all of which are protected bioclimatic areas. During the sampling period, 390 specimens were collected, representing 27 different species. Of these, the most common were *S. melanura* and *C. trifasciatus* with an abundance of 45.13% and 15.90% respectively. The sampling strategy also permitted the study of the family's phenology, leading to the conclusion that adult activity in the park is restricted to the spring and summer months, specifically from early May to late August. This is also the case in the Natural Park of Tinença de Benifassà (Peris-Felipo *et al*., 2008). In the Natural Park of Las Lagunas de la Mata-Torrevieja, however, adult activity spans from February to June, due to its higher average temperatures (Peris-Felipo *et al*., 2009).

Diversity analyses carried out in the Natural Park of Carrascal de La Font Roja showed variations according to habitat. The most diverse was *Pinus* forest, with a Shannon Index score of 2.467, followed by herbaceous habitats (2.191). *Quercus* forest (1.068) was the least diverse of all habitats considered. This could be due to the small number of Cerambycidae species that require plant species of the genus *Quercus* to complete their life cycle. On the other hand, the correspondence analyses, aimed at exploring the distribution of Cerambycidae species according to vegetal species, showed the occurrence of habitat specificity, hence favouring plant specificity. However, species such as *S. melanura* appeared in both *Quercus* forest and mixed forest habitats, probably because of the existence of plants of the genus *Quercus* in both, though less abundantly in the latter. This was also reflected in specific association clusters, showing that species present in *Pinus* forest and herbaceous habitats form two separate groups, whereas those present in *Quercus* and mixed forests intersect.

We must conclude by highlighting the importance of this kind of ecological and faunistic study, given that Cerambycidae play a prominent role in decomposition processes and hence in the nutrient cycle in natural ecosystems, through interaction with other groups of living organisms such as mites, nematodes, bacteria and fungi, and are essential for the well being of ecosystems and their economic status (Nieto and Keith, 2010). In addition, some species of saprolyxic Coleoptera are highly significant in the declaration of wooded areas as internationally important forests (Speight, 1989). In this context, the position of *Cerambyx cerdo* L. must be emphasised, because its status as a protected species (Council Directive, 1992) may help in the declaration of the Natural Park of Carrascal de La Font Roja as an internationally important forest.

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Authors' addresses: Francisco Javier PERIS-FELIPO (corresponding author: francisco.peris@uv.es), José Vicente FALCÓ-GARÍ, Ricardo JIMÉNEZ-PEYDRÓ, Laboratorio de Entomología y Control de Plagas, Instituto Cavanilles de Biodiversidad y Biología Evolutiva, Universidad de Valencia, Apartado Oficial 22085, 46071 Valencia, Spain.

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