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PROCEEDINGS
OF THE 3rd SYMPOSIUM AND WORKSHOP ON THE CONSERVATION OF SAPROXYLIC BEETLES

Rīga / Latvia, 07th – 11th July, 2004

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The Development of an Index of Ecological Continuity for Site Quality Assessment for Saproxylic Coleoptera

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ALEXANDER K.N.A., 2005. THE DEVELOPMENT OF AN INDEX OF ECOLOGICAL CONTINUITY FOR SITE QUALITY ASSESSMENT FOR SAPROXYLIC COLEOPTERA. Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 5-15.

Abstract: An Index of Ecological Continuity (IEC) has been developed as a means of producing a simple statistic which can be used in grading a site for its significance to the conservation of saproxylic Coleoptera, based on ecological considerations rather than rarity. The approach has received good recognition by the UK conservation agencies and several important sites now receive special legal protection as a direct result of this approach. The IEC provides a means of interpreting site species lists as saproxylic assemblages of ecological significance. The Index is based on a listing of the species thought likely to be the remnants of the saproxylic beetle assemblage of Britain's post-glacial forest fauna, and which have survived through a history of wood pasture management systems in certain refugia. The list of qualifying species was originally published in 1986 and has been updated in 2003 to provide a more reliable statement of the range of saproxylic beetles which might be expected on a site with relatively good ecological continuity. The revised list contains 180 of the 700 British native saproxylic beetles. Examples are provided of the application of the IEC to a variety of sites with different management histories. The approach demonstrates the importance of the cultural landscape in the conservation of saproxylic Coleoptera. Current survey work in England continues to identify important refugia in modern farmed landscapes, including networks of ancient trees and old hedgerows, as well as historic parklands.

Key words: site quality assessment, conservation, cultural landscape.

Introduction

Inventories of the species known to occur on a particular site are not very meaningful to the site managers. Most site managers will need help in interpreting such inventories and applying the knowledge gained to prioritisation of conservation management practices. How can a species inventory be translated into something meaningful to a site manager? How might that inventory be transformed into something simple and readily understandable to anyone? How can the inventories of two or more sites be compared in order to assess their relative importance to nature conservation? Simplicity is vital if we are to promote good conservation practice. It was with these questions very much in mind that a first start was made at developing a statistic which aims to provide a meaningful quantitative value for the saproxylic beetle fauna of individual sites (Alexander, 1988). This has subsequently been tweaked a little (Harding, Alexander, 1994) and then fully reappraised and revised (Alexander, 2004).

Site inventories may include species from a wide range of ecological situations. For a site with trees the list may include species which develop in the soil or in field layer plants, as well as foliage feeders on the trees and shrubs. The first need is to identify the assemblages to which the species recorded belong. A full review of the saproxylic invertebrate fauna of Britain and Ireland was presented at the *2nd pan-European conference on Saproxylic Conferences* in 2002 (Alexander, 2002; 2003). This has now fully defined the saproxylic fauna of these islands and enabled a further detailed review to take place, to identify the significance of each species to site assessment.

Site assessment systems in Britain

Two systems have been proposed in Britain for using species inventory data to assess the conservation significance of a particular site or sites. These are the Index of Ecological Continuity (IEC) – the subject of this paper – and the Site Quality Index (SQI – Fowles, 1997; Fowles, Alexander, Key, 1999). There are a number of key differences between the two systems, of which the following three are perhaps the most important.

Firstly, both recognise that different species have different values in site assessment but the IEC scores species based on their known ecological relationships whereas the SQI scores species according to current knowledge of the species rarity status. Thus, a species confined to old forest areas scores most highly in the IEC, whereas species from Red Data lists score most highly in the SQI – irrespective of any known relationship with habitats of high conservation quality.

Secondly, the IEC focuses solely on the native temperate forest fauna of Britain, whereas the SQI has been applied to all native British saproxylic beetles and therefore includes the boreal faunas of northern Scotland.

Thirdly, the IEC is cumulative - continued recording will tend to increase the Index, as species continue to be discovered on a particular site. The return on survey effort however does, of course, decline as the site inventory approaches completeness. Ideally the IEC should be based on survey data that covers all the main seasons in the year and preferably a number of years. Basically, the IEC treats overall species-richness as an important feature. In contrast, the SQI seeks to eliminate this influence of recorder effort. It does this by dividing the overall site score by the number of species recorded, thereby highlighting the proportion of rare species in the inventory. It largely therefore eliminates species-richness from consideration – although it is assumed that a longer site inventory will naturally include more rarities and so species-richness does maintain an influence.

This paper will consider the IEC in greater detail and demonstrate how it is being used in Britain. The SQI will not be further discussed here in detail and the reader is referred to Fowles et al. (1999).

Evidence for ecological continuity

The underlying concept of the IEC is that a particular grouping of saproxylic beetles (Appendix 1) represents the relict fauna of the native forest cover of Britain – forest cover which developed following the last Ice Age - and before that forest cover was extensively modified in structure and composition by the activities of people. These beetles are species which are relatively immobile and which therefore became increasingly confined to suitable areas of surviving native forest as the forest became fragmented, and the fragments increasingly isolated. As these forest fragments became smaller, more isolated, and more modified in structure and plant species composition, then the representation of the IEC species became poorer as species gradually became extinct as the fragments failed to maintain population viability. It is this link with the native post-glacial forest that makes sites which still maintain a relatively rich representation of these beetle species so valuable to nature conservation - and irreplaceable.

The particular mobility capability of each species is obviously very different, and the list of IEC species (Appendix 1) has been split into three categories based on current knowledge. This knowledge is obviously very incomplete and the three categories should be reviewed periodically as new knowledge accumulates – say every 10 years – in order to maintain credibility. Mobility is also likely to vary within each species' range, and so an IEC approach in a different European country would require independent assessment of that country's saproxylic Coleoptera fauna.

But what is the evidence that these particular species are truly relicts of native forest? Strong evidence comes from studies of sub-fossil beetle remains of post-glacial faunas in dated sediments (e.g. Buckland, Dinnin, 1993; Dinnin, Sadler, 1999). The species assemblages found by many such studies are remarkably similar to those of today's fauna in known relict forest areas, such as Sherwood Forest, Windsor Great Park and Forest, and the New Forest. The species concerned are very much those requiring old growth of trees and shrubs in areas with well-documented long and unbroken histories (Alexander et al., 2003; Alexander, Butler, 2004).

Ecological continuity is a very useful concept and has obvious practical implications for managers of conservation sites. In contrast, the SQI approach of analysing the proportion of rarities in the saproxylic Coleoptera fauna of a particular site raises more questions than provides answers. Why are the species concerned actually rare? There are many reasons for rarity and some have practical implications to a site manager, while others do not. Low mobility applies to many of the species concerned, and so the IEC species will tend to score highly in the SQI. Rarity of niche is more of a problem – is that niche naturally rare? Should the site manager try and create more of it? Would this have implications for the conservation of other rare species? Are there other aspects of the species' ecology that result in it being rare on a particular site? More worryingly, does rarity merely reflect under-recording? Are some of the species concerned really established non-native species, perhaps recent colonists, or even accidental introductions? There are probably other reasons for rarity. So, is rarity a useful baseline for site assessment? The IEC approach avoids most of these difficulties and is the favoured approach of the present author.

The IEC concept was first developed for use with epiphytic lichen assemblages (Rose 1974; 1976; 1993). The ecology of epiphytic lichens and saproxylic beetles have much in common, both groups having strong associations with sites with concentrations of large old open-grown trees on historic sites.

Types of site rich in species

It is well known that the sites richest in saproxylic Coleoptera have certain things in common (Alexander, 1998):

- a long documented history of tree cover;
- the management practices have always included retention of trees – or at least their trunks (i.e. pollards or shreds) – beyond their peak commercial usefulness as timber;
- the prime value of the area to the owners/managers has been as hunting preserves – forests, chases and deer parks;
- the land is relatively uncultivable, and best used as rough pasture, with trees often used for providing extra fodder as well as wood products, i.e. wood pastures or wood meadows.

A former UK Government nature conservation agency, The Nature Conservancy Council, commissioned Paul Harding to carry out a review of - what was then referred to as - the mature timber habitat (Harding, 1978). Lists of these rich sites were drawn together for the first time in Britain. A group of national experts was also consulted about developing a list of the key Coleoptera species associated with them. A listing of these Coleoptera was eventually published in 1986 (Harding, Rose, 1986) and drew on the suggestions of A.A. Allen, F.A. Hunter, C. Johnson, P. Skidmore and P.M. Hammond. This list has just been revised and up-dated (Alexander, 2004).

The terminology for the sites rich in saproxylic Coleoptera has been evolving over the years, from "mature timber habitat" (Harding, 1978), through "pasture-woodland" (Harding, Rose, 1986) and "wood-pasture" (UK Biodiversity Action Plan), to "old growth" (Butler et al., 2001; Alexander et al., 2003; Alexander, Butler, 2004). The key things are:

- trees being left to develop naturally, to develop full crowns, to age and decay;
- in an environment with large herbivores, to balance competition from other plants, and to permit open-grown conditions over large areas (Vera, 2000);
- in sufficient numbers to maintain viable populations of dependent organisms;
- with long continuity in time – centuries if not millennia - as well as space.

Old growth does seem the most suitable terminology available.

Calculation of the IEC

The revised version of the old "mature timber habitat" Coleoptera list is presented in Appendix 1. It comprises 180 species, forming more than 25% of the entire native British saproxylic Coleoptera fauna of 700 species. Other species have also been considered for this listing and may be added at the next review (see Alexander, 2004, for the provisional list of potential additions). Each of the 180 species has been assessed in terms of its degree of association with old growth in Britain. Species are given Grade 1 if they are only known from old growth sites; Grade 2 if they are mainly known from such sites; and Grade 3 if they are more widespread but collectively characteristic of such sites.

Each species is then scored three points (if Grade 1), two points (grade 2) and one point (Grade 3), and the scores summed to make the IEC value. As the site inventories need to be built up across seasons and years, and as all sites cannot be surveyed all at the same time, a time limit has been placed on the records which may be used in the calculation. Records prior to 1950 cannot be used – this date was chosen as it provides a long enough time span for sufficient recording of sufficient sites, and follows on from a period of particularly extensive devastation of old growth sites across Europe. Ideally a shorter time span would be much better, eg 1980 onwards, to allow for the subsequent devastation caused by the industrialisation of agriculture and forestry in the latter half of the 20th Century. Unfortunately the available data does not permit this – good coverage of the whole country would not be feasible.

The IEC values by themselves are just meaningless statistics, but, when placed into a framework, provide information of great value to nature conservation. It has been estimated that any site with an IEC of 15 or more has Regional importance in Britain, 25 or more national importance, and 80 or more of European importance. These threshold values are arbitrary values but have been set as a starting point for site assessment. Obviously, until most European countries have begun to carry out similar analyses, European importance remains conjectural.

The approach has received good recognition by the UK conservation agencies and several important sites now receive special legal protection as a direct result of this approach.

Tables 1, 2, and 3 illustrate how the IEC values work out for British sites for these saproxylic Coleoptera.

The IEC values have also proved useful in predicting the evidence from historical documentation. In each case where the IEC value was strongly suggesting a long ecological continuity, but where the historical documentation was suggesting a recent origin, then further historical or archaeological research has subsequently shown that the IEC – and the Coleoptera –

were reliable indications of site history!

Table 1. IEC values calculated for the richest British sites for saproxylic Coleoptera.

British sites of European importance		**Sites of national importance in Britain**	
Windsor Great Park & Forest	249	Hatfield Forest	78
New Forest	194	Ashtead Common	72
Moccas Park	125	Hatchlands Park	72
Bredon Hill	120	Chirk Castle Park	67
Sherwood Forest	100	Knole Park	67
Epping Forest	97	Calke Park	66
Burnham Beeches	83	Croome Park	63
Richmond Park	83	Powis Castle Park	63

Table 2. IEC values calculated for richest sites in the north of England and in Wales.

Most important sites in Northern England		**Most important sites in Wales**	
Sherwood Forest	100	Chirk Castle Park	67
Calke Park	67	Powis Castle Park	63
Clumber Park	61	Dinefwr Park	54
Duncombe Park	59	Llanover Park	39
Dunham Massey	47		
Kedleston Park	45		
Grimsthorpe Park	42		
Studley Royal Park	31		

Table 3. IEC values compared by type of cultural landscape.

Richest historic parklands		**Richest ancient rough pastures**	
Windsor Great Park	249	Bredon Hill	120
Moccas Park	125	Burnham Beeches	83
Richmond Park	83	Ashtead Common	72
Hatchlands Park	72	Esher Commons	62
Chirk Castle Park	67	Bookham Common	49
Knole Park	67		
Calke Park	66		

Future developments

Knowledge is always imperfect and developing. The IEC and SQI approaches to site assessment for nature conservation have been presented as options for moving forward with the present state of knowledge. Working tools are needed now, not some time in the future! The results of such analyses must always be seen as provisional and subject to continual review.

The Coleoptera list used in the calculation of the Index of Ecological Continuity is an artificial assemblage – it contains representations of a wide variety of ecological assemblages. While the commonality is their saproxylic habits, the specific niches of the species are manifold. There is a strong grouping of heartwood decay species; others develop in decaying smaller branchwood; yet others develop in or beneath the bark, with or without spider webs; early or late succession in the decay process; the decaying wood may need to be in sun, dapple shade or deeper shade; and so on.

There are already early signs that the IEC needs to be broken down to reflect these important characteristics, in order to better understand the special importance of a particular site for nature conservation, and hence to refine conservation management practices. A good example is Staverton Park in Suffolk, which has a nationally important IEC value, but where critical examination of the IEC qualifying Coleoptera list shows a large hole in the representation of heartwood decay species. Clearly this site has had a trauma in its history when large hollowing trees were sufficiently scarce for population viability to fail for many of the dependent organisms.

Site definition also presents some problems. Forests tend to be extensive areas, sometimes with diffuse boundaries, whereas historic parklands are relatively small and well-defined. Old orchards are proving to be notably rich in saproxylic Coleoptera in parts of England (Alexander, in press), but each individual orchard is very small, often with a uniform age structure of its trees, and usually only supports a small fraction of the species which may be present within the overall matrix of orchards within the cultural landscape. How should these differences in site size - and even tree density - be taken into account in site assessment?

The other key development which is urgently needed is comparable data collation and analysis from other European countries, to enable refinement of our understanding of which sites are of European importance. Speight (1989) developed a provisional listing of "saproxylic insect species useful in identifying forests of international importance to nature conservation" and collated opinion on which were the best sites in each European country. He did the groundwork for developing a European system for site assessment but this initiative has not been progressed. There is a clear need for an agreed listing of the most important saproxylic Coleoptera at a European level and for the records of these species to be analysed and assessed, to identify the key European sites and to clarify the key conservation aspects. Speight's original listings are now out-of-date and were rather too restrictive taxonomically. He also focussed on "forests" and that terminology may lead us into overlooking the importance of the cultural landscape, with its concentrations of ancient trees and high quality saproxylic habitats within historic parklands, rough pastures, networks of boundary trees, ancient avenues, and even old orchards. We need an objective overview of all of the European saproxylic Coleoptera and a detailed analysis of the types of situation in which they occur before we have the evidence that we can safely ignore large parts of the modern landscape. This would be a major undertaking but the way forward will be to make a start at both national and European levels.

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Appendix 1. Old Growth saproxylic beetles used in the calculation of the Index of Ecological Continuity (from Alexander, 2004).

Grade refers to estimated extent of relict forest status, with Grade 1 species having a high association, 2 moderate, and 3 significant.

Species	**Grade**
Histeridae	
Plegaderus dissectus	2
Abraeus granulum	1
Aeletes atomarius	1
Ptiliidae	
Ptenidium gressneri	2
Ptenidium turgidum	2
Micridium halidaii	1
Ptinella limbata	2
Scydmaenidae	
Eutheia formicetorum	1
Eutheia linearis	1
Stenichnus bicolor	3
Stenichnus godarti	2
Microscydmus minimus	1
Microscydmus nanus	2
Euconnus pragensis	1
Scydmaenus rufus	3
Staphylinidae	
Phyllodrepa nigra	1
Xantholinus angularis	2
Velleius dilatatus	1
Quedius aetolicus	3
Quedius maurus	3
Quedius microps	3
Quedius scitus	2
Quedius truncicola	3
Quedius xanthopus	3
Euryusa optabilis	2
Euryusa sinuata	2
Tachyusida gracilis	1
Pselaphidae	
Bibloporus minutus	2
Euplectus nanus	1
Euplectus punctatus	1
Plectophloeus nitidus	1
Batrisodes adnexus	1
Batrisodes delaporti	1
Batrisodes venustus	1
Scirtidae	
Prionocyphon serricornis	3
Scarabaeidae	
Gnorimus nobilis	1
Gnorimus variabilis	1

Species	**Grade**
Eucnemidae	
Melasis buprestoides	3
Microrhagus pygmaeus	3
Eucnemis capucina	1
Throscidae	
Aulonothroscus brevicollis	1
Elateridae	
Lacon querceus	1
Calambus bipustulatus	3
Limoniscus violaceus	1
Stenagostus rhombeus	3
Ampedus cardinalis	1
Ampedus cinnabarinus	1
Ampedus elongantulus	3
Ampedus nigerrimus	1
Ampedus pomorum	3
Ampedus quercicola	1
Ampedus ruficeps	1
Ampedus rufipennis	1
Ischnodes sanguinicollis	2
Megapenthes lugens	1
Procraerus tibialis	1
Elater ferrugineus	1
Lycidae	
Pyropterus nigroruber	3
Platycis cosnardi	1
Platycis minutus	3
Cantharidae	
Malthodes crassicornis	1
Dermestidae	
Globicornis rufitarsis	1
Trinodes hirtus	1
Bostrichidae	
Lyctus brunneus	3
Anobiidae	
Xestobium rufovillosum	3
Gastrallus immarginatus	1
Dorcatoma ambjoerni	2
Dorcatoma chrysomelina	3
Dorcatoma dresdensis	2
Dorcatoma flavicornis	3
Dorcatoma serra	2
Anitys rubens	1

Species	Grade
Ptininae	
Ptinus subpilosus	2
Lymexylidae	
Hylecoetus dermestoides	3
Lymexylon navale	2
Phloiophilidae	
Phloiophilus edwardsii	3
Trogossitidae	
Thymalus limbatus	2
Cleridae	
Tillus elongates	3
Opilo mollis	3
Thanasimus formicarius	3
Korynetes caeruleus	3
Melyridae	
Aplocnemus impressus	2
Aplocnemus nigricornis	2
Hypebaeus flavipes	1
Nitidulidae	
Carpophilus sexpustulatus	3
Epuraea angustula	3
Rhizophagidae	
Rhizophagus nitidulus	3
Rhizophagus oblongicollis	1
Silvanidae	
Silvanus bidentatus	2
Silvanus unidentatus	3
Uleiota planata	2
Cucujidae	
Pediacus depressus	2
Pediacus dermestoides	3
Laemophloeidae	
Notolaemus unifasciatus	2
Cryptophagidae	
Cryptophagus micaceus	1
Erotylidae	
Triplax lacordairii	3
Triplax russica	3
Triplax scutellaris	3
Tritoma bipustulata	3
Biphyllidae	
Biphyllus lunatus	3
Diplocoelus fagi	3
Cerylonidae	
Cerylon fagi	2
Endomychidae	
Symbiotes latus	3
Lathridiidae	
Lathridius consimilis	1
Enicmus brevicornis	3
Species	**Grade**
Lathridiidae ctd	
Enicmus rugosus	2
Corticaria alleni	1
Mycetophagidae	
Pseudotriphyllus suturalis	3
Triphyllus bicolor	2
Mycetophagus atomarius	3
Mycetophagus piceus	2
Mycetophagus populi	2
Mycetophagus quadriguttatus	2
Ciidae	
Cis coluber	2
Tetratomidae	
Tetratoma ancora	3
Tetratoma desmaresti	3
Melandryidae	
Hallomenus binotatus	3
Orchesia undulata	3
Anisoxya fuscula	3
Abdera biflexuosa	3
Abdera quadrifasciata	1
Phloiotrya vaudoueri	2
Hypulus quercinus	1
Melandrya barbata	1
Melandrya caraboides	3
Conopalpus testaceus	3
Mordellidae	
Tomoxia bucephala	3
Mordellistena neuwaldeggiana	3
Colydiidae	
Synchita humeralis	3
Synchita separanda	3
Cicones variegata	2
Bitoma crenata	3
Teredus cylindricus	1
Oxylaemus variolosus	2
Tenebrionidae	
Eledona agricola	3
Corticeus unicolor	2
Prionychus ater	3
Prionychus melanarius	1
Pseudocistela ceramboides	2
Mycetochara humeralis	2
Oedemeridae	
Ischnomera caerulea	1
Ischnomera cinerascens	3
Ischnomera cyanea	3
Ischnomera sanguinicollis	1
Pyrochroidae	
Pyrochroa coccinea	3

Species	Grade
Aderidae	
Aderus brevicornis	1
Aderus oculatus	3
Scraptiidae	
Scraptia fuscula	1
Scraptia testacea	1
Anaspis septentrionalis	1
Cerambycidae	
Prionus coriarius	3
Grammoptera ustulata	1
Grammoptera abdominalis	3
Stictoleptura scutellata	1
Anoplodera sexguttata	2
Leptura aurulenta	3
Leptura quadrifasciata	3
Pedostrangalia revestita	2
Pyrrhidium sanguineum	1
Phymatodes testaceus	3
Mesosa nebulosa	2
Saperda scalaris	3
Anthribidae	
Platyrhinus resinosus	3
Anthribidae ctd	
Tropideres sepicola	1
Tropideres niveirostris	3
Platystomos albinus	3
Rhynchophoridae	
Dryophthorus corticalis	1
Curculionidae	
Rhopalomesites tardyi	3
Cossonus parallelepipedus	3
Stereocorynes truncorum	1
Trachodes hispidus	3
Scolytinae	
Ernoporicus caucasicus	2
Ernoporicus fagi	3
Ernoporus tiliae	2
Xyleborinus saxeseni	3
Xyleborus dispar	3
Xyleborus dryographus	3
Trypodendron domesticum	3
Trypodendron signatum	3
Platypodidae	
Platypus cylindrus	3

Windthrow Gaps as Dead Wood Islands for Saproxylic Beetles in Managed Deciduous French Forests

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Abstract: In managed French oak-hornbeam forests storm-damaged in 1999, saproxylic beetles were sampled by window-flight traps in 2001. We observed a strong differentiation but only a slight increase in richness of saproxylic assemblage in gaps compared with undisturbed stands. Gap size effect was non linear. Surrounding landscape and local tree species density influenced some species. Saproxylic communities were also distinct in gaps and in fellings. Because of the richness of mid- and large-sized gaps and their faunistic dissimilarity with other open stands and closed-canopy controls, retaining uncleared gaps above 0.5ha in size may enhance saproxylic gamma diversity in forests.

Key words: dead wood, xylophagous, Coleoptera, biodiversity, forest management.

Context

In most temperate deciduous forests, windstorm is the main source of dead wood (Wohlgemuth et al., 2002). In managed forests, windthrow gaps may act as "*kleine Totholzinseln in stehenden Beständen*" (small dead wood islands in living stands) (Pfarr, Schrammel, 1991). The high, concentrated dead wood volumes may be attractive for some saproxylic organisms, but their influence is poorly understood, especially in temperate deciduous forests (Bouget, Duelli, 2004). In gaps resulting from the storm Lothar in 1999, the saproxylic beetle habitat changed drastically. Uprooting and stem breakage increased the volume and diversity of fresh dead wood. The opening of the canopy increased sun exposure and caused the development of flower mats.

Gaps can be considered in the light of island biogeography and landscape ecology concepts. Colonization and local extinction in habitat patches depend on patch characteristics (area) and surrounding landscape (isolation).

Objectives: a snapshot of beetle response

First, we assessed the response of saproxylic assemblages to the short term habitat changes in gaps. For instance, pioneer xylophagous beetles may have benefited from the high volume of sun-exposed fresh dead wood in gaps, whereas secondary xylophagous beetles may have suffered from a deleterious effect of sun exposure.

Secondly, we studied whether this response had been affected by spatial parameters, such as gap size and isolation, or the local micro-environment. From patch-occupancy models, the abundance of gap species might be related to patch isolation, i.e. the density of source patches (such as fellings cut before 1999) in the surrounding landscape (Didham, 1997). What's more, changes in saproxylic environment may increase with gap area. The larger the gap, the higher the volume of dead wood (resource concentration hypothesis ; Tews et al., 2004), and by sampling effect, the higher the heterogeneity of the dead wood (habitat diversity hypothesis ; Tews et al., 2004), the more sun exposed it is (edge effect; Didham, 1997) and the larger the flower mats.

Thirdly, we compared assemblages in natural gaps and man-made openings.

Several management questions underlay this research project. First, is it worth maintaining uncleared gaps from a conservation point of view? Would it be efficient to retain only small scattered gaps? Secondly, how could forest planners adapt the size and spatial pattern of traditional fellings in order to mimic natural disturbances and to enhance biodiversity?

Material and methods

Research area

Three lowland hardwood forests, quite close to each other and 30 km south-east of Paris, covering over 10 thousand hectares, were included in the study: Armainvilliers, Crecy, and Ferrieres in the 'Brie' region. Stands were chosen in oak-hornbeam managed forests that also contain lime, birch and aspen.

Sampling design

We surveyed 24 unlogged gaps, created by the storm in 1999 in 14 plots. Each gap was paired with an adjacent (25-50m distant), closed-canopy control site (*n*=14). Among the 80 gaps inventoried in our study area, the 24 gaps to be surveyed were selected according to size and isolation in order to balance the sampling design. The gaps, ranging from 0.12 to 3.3 ha, were divided into three size classes: small (< 0.3 ha), medium (0.3 to 1 ha) and large (> 1ha). 4 seeding cuts and 8 sapling stands were also sampled near the gaps. These fellings were larger (5 ha on average) and slightly older (1 to 15 years-old) than gaps.

Study group

33 families or subfamilies of saproxylic beetles were determined at the species level (except Ciidae and Melyridae). Due to the poor state of knowledge of life histories of many species, families were assigned to larval trophic groups (tab. 1): (i) pioneer xylophagous, associated with fresh dead wood, (ii) secondary xylophagous, dependant on decayed dead wood (including beetles which feed on mouldy dead wood), (iii) xylomycetophagous, associated with corticolous macrofungi, (iv) predators, which prey on other saproxylic Invertebrates.

Sampling protocol

Saproxylic beetles were sampled monthly using alcohol baited, 1m²-window pan traps from April to August 2001, i.e. the second year after the windstorm, at the culmination of richness and abundance of saproxylic insects (Wermelinger et al., 2002). To maintain a minimal inter-trap distance, we placed 2 traps in large gaps but only 1 trap in small, mid-size gaps, controls and open stands.

Habitat variables

We studied the effect of the following environmental variables on saproxylic beetles: (i) habitat type (gap, closed-canopy control, seedling-sapling), (ii) gap size, obtained by the digitalisation of gap borders using a GPS, (iii) gap isolation, in the landscape mapped using aerial photographs and a GIS, and considered as 4 variables (distance to the closest felling, felling area at 3 spatial scales: 200 m (12 ha), 500 m (78 ha), 1000 m (314 ha)); (iv) micro-environment (*Quercus*, *Populus* or *Tilia* density within a 2m-radius around traps).

Data Analysis

We compared the cumulative species richness between habitat classes using sample-based rarefaction interpolations (Magurran, 1988).

Linear mixed-models (nested spatial variables as random effects: block, plot and site), were used to test the effect of environmental variables upon the (ln+1) transformed richness or abundance per trap of all saproxylic beetles, ecological groups and species (> 40 individuals). Differences among means were investigated by Tukey post hoc tests. Four series of models analysed the effect of: (i) habitat type, (ii) gap size (3 classes), (iii) landscape (4 variables), (iv) micro-environment (3 variables).

Pairwise ANOSIM tests based on the Bray-Curtis dissimilarity were used to check for differences in assemblage composition amongst predefined groups with 10,000 spatially-constrained permutations (Clarke, 1993). The IndVal (Indicator Value) procedure was carried out to find indicator species characterizing groups of samples (Dufrêne, Legendre, 1997), defined by a UPGMA classification of the Bray-Curtis similarity matrix.

Results

1. Differentiation of saproxylic fauna in gaps and closed-canopy forest controls

Saproxylic beetles were as abundant in gaps as in closed-canopy controls (fig. 1). ANOSIM test showed that gaps differed significantly in assemblage composition from closed forest ($R=0.73$, $p<0.001$).

Pioneer xylophagous beetles. The number of pioneer xylophagous individuals, and scolytids in particular, was not significantly greater in gaps than in controls (fig. 1). However, among bark beetles, *Ernoporicus fagi* (F., 1798) was characteristic of closed-canopy controls, and *Platypus cylindrus* (F., 1792), *Trypophloeus asperatus* (GYLLENHAL, 1813) and *Xyleborus. saxeseni* (RATZEBURG, 1837) were typical of gaps. Excluding the scolytids, the abundance of pioneer xylophagous taxa increased significantly - four times as many in gaps compared to closed forest (fig. 1). The increase was not significant for Lymexylidae, but strong for Buprestidae and Cerambycidae (Tab. 1). Several cerambycids (*Leptura aurulenta* F., 1792, *Xylotrechus rusticus* (L., 1758), *X. antilope* (SCHÖNHERR, 1817)) and some buprestids (*Agrilus viridis* L., 1758, *A. sulcicollis* LACORDAIRE, 1835, *Chrysobothris affinis* (F., 1794)) were typical of gaps.

Secondary xylophagous and zoophagous beetles. The abundance of secondary xylophagous or zoophagous beetles was equivalent in gaps and closed-forest controls (fig. 1). Among secondary xylophagous, the decline of several shade-preferent beetles (Anobiidae (*Hemicoelus rufipes* (THUNBERG, 1781)), Eucnemidae (*Microrhagus lepidus* (ROSENHAUER, 1847), *M. pygmaeus* (F., 1792), *Melasis buprestoides* (L., 1761), *Hylis foveicollis* (THOMSON, 1874)), Melandryidae) was compensated for by the increase in Lucanidae or in floricolous species, such as Melyridae and Mordellidae (*Variimorda villosa* (SCHRANK, 1781)) (Tab. 1 and fig. 2). Among predators, some taxa were negatively (Rhizophaginae, Salpinginae), positively (Silvanidae (*Uleiota planata* (L., 1761), *Silvanus unidentatus* (OLIVIER, 1790), *S. bidentatus* (F., 1792)), Laemophloeidae (*Cryptolestes* sp.), Scaphidiinae (*Scaphisoma* sp.) and Cerylonidae) or not affected (Colydiidae, Cleridae, Trogossitidae, Tenebrionidae).

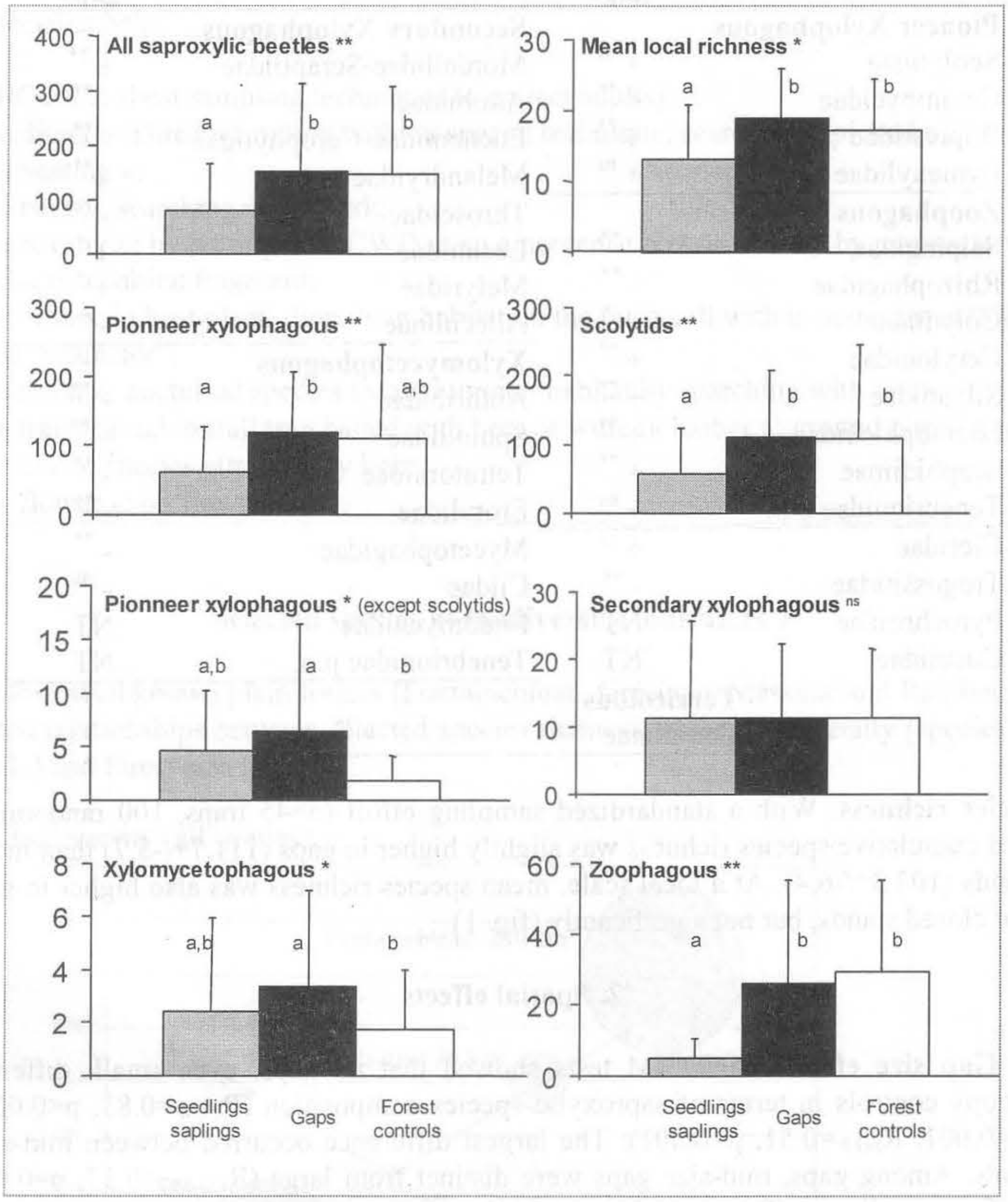

Figure 1. Abundance and richness of saproxylic beetles, and abundance of ecological groups.

For about 34,000 individuals in 184 species combined in gaps, forest controls and seedling-sapling stands, mixed-model ANOVA tested the difference in mean abundance per trap (** $p<0.01$, * $0.01<p<0.05$, ns=non significant ; letters indicate significant differences between means after a post-hoc Tukey test, $p=0.01$).

Xylomycetophagous beetles. Xylomycetophagous beetles increased significantly in abundance in gaps compared to controls (fig. 1). Anthribidae and Sphindidae (*Sphindus dubius* (GYLLENHAL, 1808)) were favoured in gaps, whereas Erotylidae, Mycetophagidae, Tetratomidae were negatively affected. Ciidae were not affected in abundance (tab. 1).

Table 1. Difference in mean abundance per trap of saproxylic families between closed forest and gap. Mixed-model ANOVA tests on mean abundance per trap (** $p<0.01$, * $0.01<p<0.05$, ns $p>0.05$; NT = not tested, in case of low abundance).

	From forest to gaps		From forest to gaps
Pioneer Xylophagous		**Secondary Xylophagous**	
Scolytinae	$+^{ns}$	Mordellidae-Scraptiidae	$+^{**}$
Cerambycidae	$+^{**}$	Anobiidae	$-^{**}$
Buprestidae	$+^{**}$	Eucnemidae-Cerophytidae	$-^{**}$
Lymexylidae	$+^{ns}$	Melandryidae	$-^{**}$
Zoophagous		Throscidae	$-^{ns}$
Salpingidae	$-^{**}$	Lucanidae	$+^{*}$
Rhizophagidae	$-^{**}$	Melyridae	$+^{*}$
Colydiidae	$+^{*}$	Alleculinae	$-^{ns}$
Cerylonidae	$+^{**}$	**Xylomycetophagous**	
Silvanidae	$+^{**}$	Anthribidae	$+^{**}$
Laemophloeidae	$+^{**}$	Sphindidae	$+^{**}$
Scaphidiinae	$+^{**}$	Tetratomidae	$-^{**}$
Tenebrionidae p.p.	$+^{ns}$	Erotylidae	$-^{**}$
Cleridae	$+^{ns}$	Mycetophagidae	$-^{**}$
Trogossitidae	$-^{ns}$	Ciidae	$-^{ns}$
Pyrochroidae	NT	Endomychidae	NT
Cucujidae	NT	Tenebrionidae p.p.	NT
Terricolous			
Cetoniinae	$+^{**}$		

Species richness. With a standardized sampling effort (n=45 traps, 100 randomisations), the rarefied cumulative species richness was slightly higher in gaps (111.7+/-5.7) than in adjacent closed stands (103.3+/-6.4). At a local scale, mean species richness was also higher in gaps than in adjacent closed stands, but not significantly (fig. 1).

2. Spatial effects

2.1. Gap size effects. ANOSIM tests showed that all gaps, even small, differed from closed-canopy controls in terms of saproxylic species composition ($R_{LG\text{-}F}=0.83$, $p<0.001$, $R_{MG\text{-}F}=0.86$, $p<0.001$, $R_{SG\text{-}F}=0.51$, $p<0.001$). The largest difference occurred between mid-size gaps and controls. Among gaps, mid-size gaps were distinct from large ($R_{LG\text{-}MG}=0.37$, $p=0.021$) and especially from small gaps ($R_{SG\text{-}MG}=0.39$, $p<0.001$).

The abundance of pioneer xylophagous beetles increased with gap size, but not significantly (fig. 3). The abundance of secondary xylophagous, zoophagous and xylomycetophagous beetles did not differ in gap size classes.

From the IndVal results (Fig. 2), 7 species were indicators of mid-size gaps, 3 of large gaps, 8 of mid-size and large gaps and no species of small gaps. The standardised cumulative species richness (n=36 traps, 100 randomisations) peaked in mid-size gaps (108.5+/-5.2) and was 20% higher than in small gaps (90.7+/-3.8), and 14% greater than in large gaps (96.5+/-4.3). However, differences in mean local richness between size classes were not significant ($F_{3,21}=2.3$, $p=0.10$).

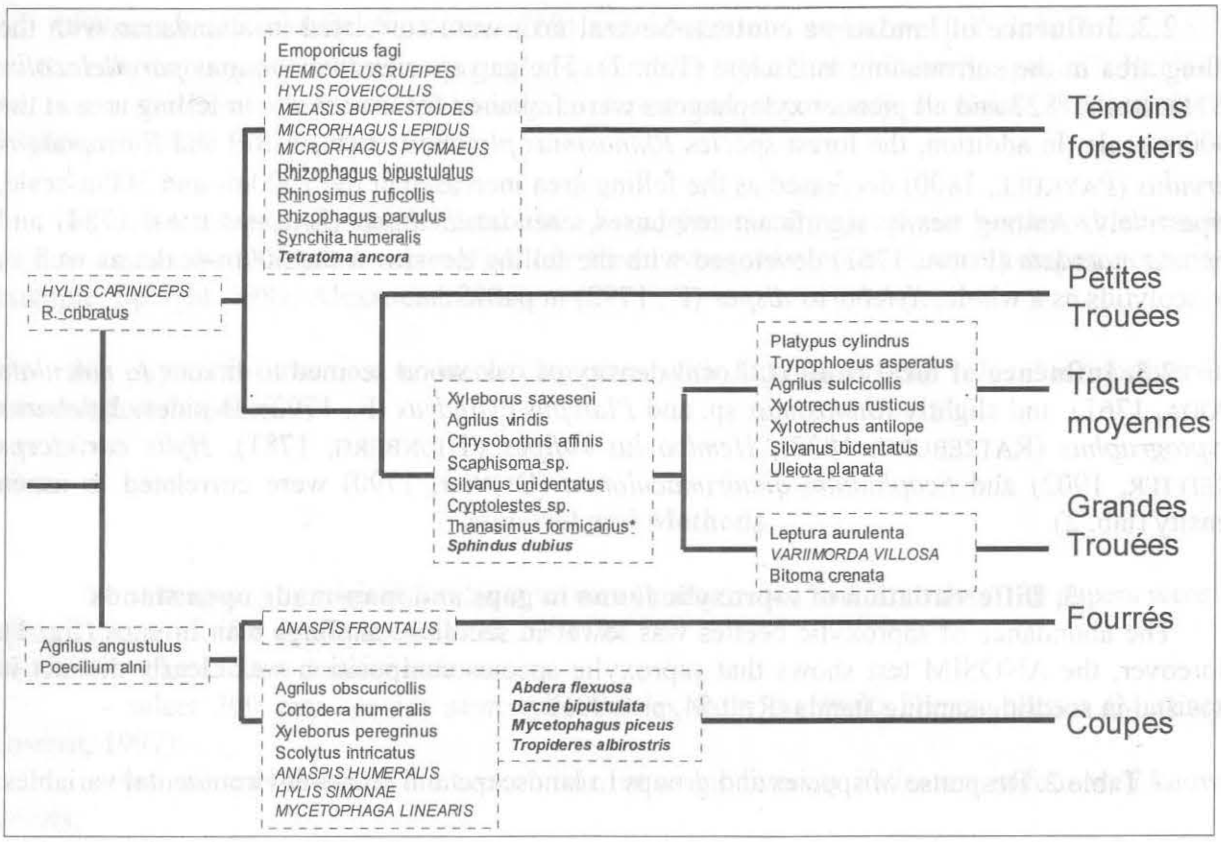

Figure 2. Characteristic species detected by the IndVal method (Dufrêne, Legendre 1997).

The process was based upon a hierarchical habitat typology from an ascendant classification (UPGMA) on Bray-Curtis dissimilarities. Only species with more than 10 individuals, with significant (10,000 iterations, $p<0.01$) and >30% Indicator Value are mentioned. When the Indicator Value of a species is significant at different levels, the species appear only at the level of its maximum Indicator Value. Groups appear in this way: pioneer xylophagous, *SECONDARY XYLOPHAGOUS*, zoophagous, ***xylomycetophagous.***

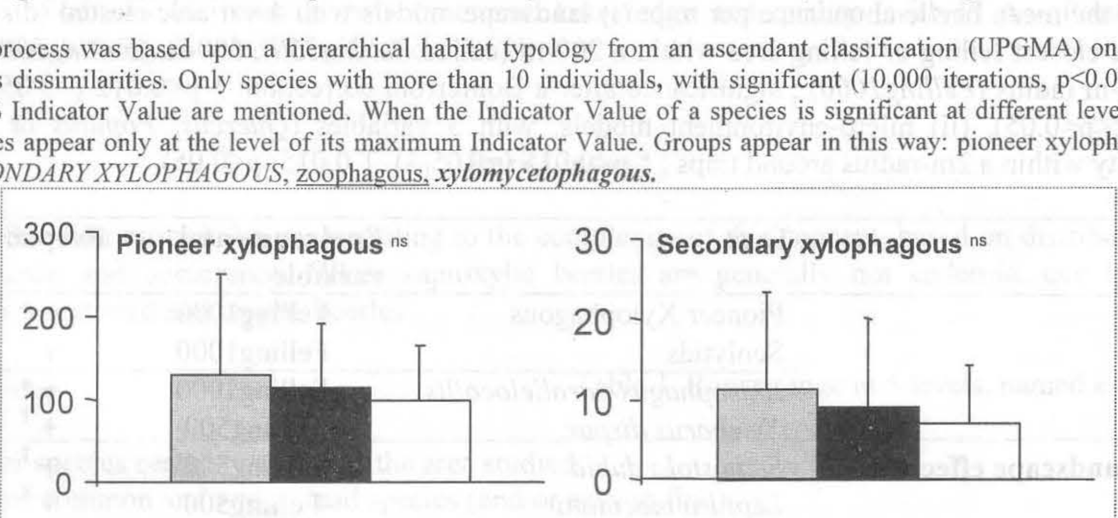

Figure 3. Abundance of saproxylic ecological groups in gap size classes.

Mixed-model ANOVA of mean abundance per trap (+/- SD) in small (area<0.3ha), mid-size (0.3<area<1ha) and large gaps (area > 1ha), (* $0.01<p<0.05$, ns=non significant); letters indicate significant differences between means after a post-hoc Tukey test ($p<0.01$). Values in forest controls are mentioned as a reference.

2.2. Influence of landscape context. Several taxa were correlated in abundance with the felling area in the surrounding landscape (Tab. 2). The gap species *Rhizophagus parallelocollis* GYLLENHAL, 1827 and all pioneer xylophagous were favoured by an increase in felling area at the 1000m-scale. In addition, the forest species *Rhinosimus planirostris* (F., 1787) and *Rhizophagus parvulus* (PAYKULL, 1800) decreased as the felling area increased at the 1000m- and 500m-scale, respectively. Among nearly significant responses, *Stenostola dubia* (LAICHARTING, 1784) and *Leptura maculata* (PODA, 1761) developed with the felling density at the 500m-scale, as well as the scolytids as a whole, *Xyleborus dispar* (F., 1792) in particular.

2.3. Influence of local context. Local density of oak wood seemed to favour *L. maculata* (PODA, 1761), and slightly *Rhinosimus* sp. and *Platypus cylindrus* (F., 1792). Besides, *Xyleborus cryptographus* (RATZEBURG, 1837), *Hemicoelus rufipes* (THUNBERG, 1781), *Hylis cariniceps* (REITTER, 1902) and *Scaphidium quadrimaculatum* (OLIVier, 1790) were correlated to aspen density (tab. 2).

3. Differentiation of saproxylic fauna in gaps and man-made open stands

The abundance of saproxylic beetles was lower in seedlings-saplings than in gaps (fig. 1). Moreover, the ANOSIM test shows that saproxylic species composition was clearly distinct in gaps and in seedling-sapling stands (R=0.54, p=0.001).

Table 2. Response of species and groups to landscape and micro-environmental variables.

Two series of ANOVA based on linear mixed models tested the effect of environmental variables upon the mean beetle abundance per trap: (i) landscape models with 4 variables tested (distance to the closest felling or felling area within a 200-m (called *Felling200*), 500-m (*Felling500*) and 1000-m radius (*Felling1000*) ; significance after a Bonferroni correction: * p<0.012 (=0.05/4), ^{T} 0.012<p<0.05), (ii) micro-environment models, with 3 variables (*Quercus*, *Populus* or *Tilia* density within a 2m-radius around traps ; * p<0.015 (=0.05/3), T 0.015<p<0.05).

	Taxa	**Environmental variable**	**Response**
Landscape effects	Pioneer Xylophagous	Felling1000	+ *
	Scolytids	Felling1000	$+^{T}$
	Rhizophagus parallelocollis	Felling1000	+ *
	Xyleborus dispar	Felling500	$+^{T}$
	Stenostola dubia	Felling500	$+^{T}$
	Leptura maculata	Felling500	$+^{T}$
	Cerylon sp.	Felling200	- *
	Rhinosimus planirostris	Felling1000	- *
	Rhizophagus parvulus	Felling500	$-^{T}$
Micro-environmental effects	*Xyleborus cryptographus*	*Populus*	+ *
	Xyleborus germanus	*Tilia*	$+^{T}$
	Platypus cylindrus	*Quercus*	$+^{T}$
	Leptura maculata	*Quercus*	+ *
	Hemicoelus rufipes	*Populus*	$+^{T}$
	Hylis cariniceps	*Populus*	$+^{T}$
	Rhinosimus planirostris	*Quercus*	$+^{T}$
	Scaphidium quadrimaculatum	*Populus*	$+^{T}$

Pioneer xylophagous. More pioneer xylophagous individuals were caught in gaps than in fellings-saplings (fig. 1). The difference was significant for scolytids but not for other pioneer xylophagous beetles. *Xyleborus peregrinus* EGGERS, 1944, *Scolytus intricatus* RATZEBURG, 1837, *Agrilus obscuricollis* KIESENWETTER, 1857, *Cortodera humeralis* (SCHALLER, 1783) were characteristic of seed cuts (Fig. 2).

Secondary xylophagous and xylomycetophagous. The abundance of secondary xylophagous and xylomycetophagous beetles was equivalent in gaps and fellings-saplings (fig. 1). The mycetophagous *Abdera biflexuosa* CURTIS, 1829, *Dacne bipustulata* (THUNBERG, 1781), *Mycetophagus piceus* (F., 1777), *Tropideres albirostris* (HERBST, 1784) were indicator for fellings (fig. 2).

Zoophagous. Fewer saproxylic predator individuals were found in fellings-saplings than in gaps (fig. 1). No zoophagous species was included in typical felling species (fig. 2).

Species richness. The standardized cumulative richness (n=35 traps) was 20% higher in gaps than in fellings-saplings (93.6+/-5.9). At a local scale, mean saproxylic richness was significantly higher in gaps than in man-made open stands (fig. 1).

Discussion

Shortly after the disturbance, we observed strong changes in assemblage composition but only a slight increase in richness in gaps compared with undisturbed stands. Saproxylic communities were also distinct and richer in gaps than in fellings. As already been reported by Werner (2002), the abundance was lower in fellings than in other forest habitats.

Response of early successional xylophagous beetles. As Wermelinger et al. (2002) had already shown in Swiss spruce gaps, bark beetles did not show a significant global response, but rather some contrasting species responses. *E. fagi* (FABRICIUS, 1798), which lives on dead branches in living hornbeam trees, was negatively affected in gaps. Conversely, *P. cylindrus* benefited from oak treefalls (Winter, 1993), *X. cryptographus* (RATZEBURG, 1837) from aspen dead wood and *X. saxeseni* (RATZEBURG, 1837) from diverse deciduous dead trees. In contrast with scolytids, cerambycids and buprestids responded positively in gaps, in agreement with observations made by Otte (1989), Kopf & Funke (1998), Wermelinger et al. (2002) on spruce.

Pioneer xylophagous beetles as a whole, and bark beetles in particular, were more abundant in gaps than in fellings, probably because of a higher volume of fresh dead wood in unlogged gaps. Nonetheless, bark beetles excluded, the other early successional xylophagous insects, such as cerambycids and buprestids, were as abundant in gaps as in fellings, presumably thanks to an equal development of flower mats.

Response of xylomycetophagous beetles. In gaps compared to controls, fungal resources were changed in that (i) fungi were sun exposed and (ii) some fungi developed on fresh dead wood. Gap changes had a positive impact on the xylomycetophagous beetles as a whole, but the effect seems to be species or group-dependent, as fungivorous beetles may prefer sun-dried or shaded fungi (Rukke, Midtgaard, 1998; Sippola et al., 2002). In fellings, xylomycetophagous beetles were as abundant as in gaps. The felling species were probably related to fungi on large seed trees.

Gap size effect. The abundance of pioneer xylophagous did not increase significantly with the accumulation of fresh dead wood in larger openings. The abundance of secondary xylophagous did not decrease with the increasing adversity of micro-climate in large gaps.

The relationship between gap area and gap effect was nonlinear. The highest dissimilarity occurred between mid-size gaps and closed-canopy controls, and not between large gaps and controls, as would be expected if gap effect was positively correlated with area. Small gaps were more similar in species composition to neighbouring matrix than were larger gaps (like deciduous patches studied by Ås, 1999 in a conifer matrix). Moreover, no characteristic species was detected in small gaps, whereas several taxa exhibited preferences for large gaps, and more for mid-size openings.

The highest cumulative richness was measured in mid-size and not in larger gaps. Such a trend is in agreement with the Intermediate Disturbance Hypothesis (IDH; Petraitis et al., 1989), with an analogy between opening size and disturbance intensity, the highest number of species coexisting in mid-size gaps. However, contrary to IDH expectations, assemblage composition in our mid-size gaps was not intermediate between small and large gaps.

From micro-environment … to landscape effects. Saproxylic beetles were sensitive to local parameters (density of oak and aspen at a 12 m² scale). They were also influenced by the openness of the surrounding landscape at larger scales (78 and 314ha). Similarly, in spruce forests, Økland et al. (1996) showed that 13 saproxylic beetle species were sensitive to the presence of cuttings in the surrounding 400ha landscape. These relationships at large scales may be due to a better match between the study scale and the dispersal range. As far as we know, colonizers of fresh dead wood such as bark beetles and their predators (Cronin et al., 2000), and some xylomycetophagous species (Jonsell et al., 1999), associated with an ephemeral substrate, may disperse over kilometres. Conversely, beetles living in stable habitats, such as cavities, only disperse over several decameters (Ranius, Hedin, 2001).

Conclusion: Implications for forest management. Temperate, deciduous managed forests are rarely threatened by insect pests after windthrow (Winter, 1993). Our results confirmed this trend, since bark beetle abundance remained at low levels. Because of their richness and faunistic dissimilarity with other open stands and closed-canopy controls, uncleared gaps enhance the gamma diversity in the forest. Faunistic peculiarity of gaps was mainly found in mid-size and large gaps, which argue for retaining a range of unlogged gap sizes above 0.5ha. To preserve only small uncleared gaps and scattered treefalls would probably not be efficient for saproxylic conservation. Windthrow gaps may act as magnets for the recruitment and breeding of saproxylic species, before acting as sources.

Moreover, the singularity and the richness of saproxylic assemblages in mid-size openings stressed the interest of fellings 0.5-1ha in size, similar to the patch cutting technique. Anyway, the differences in volume and diversity of dead wood between gaps and fellings (where dead wood is only made up of stumps, harvesting residues and dead branches on seed trees) seem to have a significant impact on saproxylic assemblages. Our results underline the interest to retain sun-exposed dead wood, such as woody debris brought by natural disturbances, for saproxylic conservation (Alexander, 1999).

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Biological Value of French Forests Assessed with Saproxylic Beetles: a Way to Conserve this Natural Heritage

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Abstract: Patterns of rarity are used to select saproxylic beetles as ecological descriptors of biological forest value and state of conservation. A list of 300 species as indicators of higher quality French forests - validated by 59 entomologists - is proposed, along with 54 quality sites. The existence of a relationship between the presence of bio-indicators and bio-diversity is highlighted. A typology of the sites is established based on the knowledge we have of their entomological fauna, and on their quality. A few very rare species reveal sites of high biological value, some of which are not necessarily natural. Conservation policy and forest managers have now to use this work.

Key words: Coleoptera, conservation biology, forest.

Introduction and aims

All saproxylic beetle data including mode of life information can be considered as valuable indicators of the biological value of forests. In saproxylic beetle assemblages, the rare species, due to their strict biological requirements, are particularly valuable for biological conservation purposes in forests. They can be:

- Biodiversity indicators; if a rare species occurs at a site, the common ones should also be here.
- Umbrella species; protecting their habitats will bring many other species under protection.
- "Universal"; saproxylic beetles are numerous and cover a broad range of ecological requirements. They are useful for assessing the biological value or function of all forest types and of any sites with trees.

In France, forests cover about 15 million hectares, 27% of the land area (www.ifn.fr). They include a broad range of ecological conditions with three biogeographic zones (Mediterranean, Atlantic and Continental) and from plains to mountains. They are also influenced by different human uses and impacts (logging, reserve, fire, …).

To assess the biological value of French forests using saproxylic beetles, we do not use any official Red List. Very few saproxylic beetles species are protected by the Bern Convention or the Habitats Directive. There are also some limitations to these lists (Brustel, 2001):

- *Cucujus cinnaberinus* (SCOPOLI, 1763) does not occur in France!
- *Lucanus cervus* (L., 1758) and *Cerambyx cerdo* L., 1758 are common in the plains of the south of France. They cannot be considered as good indicators of the biological value of forest. with the same is true of *Rosalia alpina* (L., 1758) in mountain regions.
- *Stephanopachys substriatus* (PAYKULL, 1800) is known in only one Alp valley, along with *S. linearis* (KUGELANN, 1792) (also in Corsica). It is too restricted a distribution to be used for site assessment.

-*Osmoderma eremita* (SCOPOLI, 1763) and *Limoniscus violaceus* (P.W.J. MÜLLER, 1821) are the only two species whose ecological requirements make them “umbrella species”. But there are two restrictions: they are not strictly in forest and occur only in plains (Ranius, 2002; Whitehead, 2003; Brustel et al., 2004).

In such a context, we want to establish a list of French rare saproxylic beetles which can be used to assess the biological value of all our forest types, like other European experiments (for example, Speight, 1989; Alexander, 2004).

We pay more attention to identifying sites with high biological value for biodiversity conservation purposes.

Material and Methods

59 colleagues (to minimise subjective view) participated and more than 130 papers were used in this work (for details see Brustel, 2001) to:

- make and use 2 rarity indexes;
- select 300 rare species saproxylic beetles from the 9600 French beetles (Martinez, Gauvrit, 1997);
- test the usefulness of the taxa on this list as biodiversity indicators in four well known forests;
- select the best French sites using available data;
- obtain site types in two directions: knowledge and quality (with PCA - Principal Component Analysis - and classification: ACH).

Rarity index

Our first rarity index is, according to the complexity of this concept, based on distribution, abundance and occurrence. While saproxylic beetles are generally not endemic, our Index qualifies scattered and cryptic beetles:

Table 1. Rarity range in 5 levels, named « Ip ».

- “/” for species certainly absent in the area studied;
- “1” for common and widespread species (and/or easy to find);
- “2” for not abundant but widespread species, or, localised but sometimes abundant (and/or difficult to find);
- “3” for species which are never abundant and are localised (special capture techniques required);
- “4” for some very rare species, at present known from less than 5 sites or known only in one French department.

Our second index, based on stenotopic aspects, has 3 axes:

- the state of decay, from fresh wood to decayed wood and cavities;
- the trophic level, from xylophagous to oligophagous predators and mycetophagous (which requires other species – xylophagous or fungi – to occur);
- the rarity of Coarse Woody Debris, from branches to large wood volumes (logs, snags …) for example, or from common wood species (oak, beech …) to rare wood types (*Sorbus*, …).

Table 2. Stenotopic index (larva stage), named « If ».

- "0" for non saproxylic species;
- "1" for pioneer borer species and / or non stenotopic;
- "2" for stenotopic species: in large CWD, in non common tree species, in wood decayed by other organisms and / or non specialised predators;
- "3" for very stenotopic species depending on other rare saproxylic species (oligophagous predators or mycetophagous) or on very rare habitat (big tree hollows, rare fungus …).

Other criteria were also used in the end of our selection, such as:

- knowledge of mode of life;
- study facilities;
- specialist available.

French saproxylic beetle reference list to assess forest biological value

The list (see Appendix I)

Our first result is a species list of three hundred rare saproxylic beetles, from thirty families. All the selected species have a minimum rarity score (If + Ip ≥ 3).

For each species, 11 criteria such as way of life, rarity level, identification difficulties or appropriate capture techniques are listed (keys are presented in Table 3).

Table 3. Criteria and key to present each species selected.

- « ENVIRONMENT »: site types where the species can be found:
  - « Plain » or « Pla. »: in plain and hill;
  - « Mountain » or « Mont. »: in mountain;
  - « Floodplain » or « Flo. »: in floodplain, waterside forests and other moist sites;
  - « with trees »: site with trees but no forest environment;
  - « forest »: forest site with forest environment.

- « TREES SPECIES »: tree species for larval development:
  - « varied »: in both broadleaved and coniferous trees;
  - « broadleaved »: on varied broadleaved tree species;
  - « coniferous »: on varied coniferous tree species;
  - « *Genus* »: *Genus* spp. as host plant.

- « HABITAT »: summarise description of wood types and the states of decay where larva can be found, and other particular habitats for saproxylic beetles.

- « BIOLOGY »: trophic position (larva): "xylophilic I" for pioneer wood borers ; "xylophilic II" for secondary borers, saproxylophagous, predators…

- « If. »: see Table 2.

- « Ip. »: see table 1 with "Ipn" for northern sites and "Ips" for southern sites. Border is a line « Lyon /La Rochelle » for plain forests and « Nice / Bordeaux » for mountain sites (Biogeographical specificity is integrated here).

- « ADULT »: adult phenology: month and period.
- « IDENTIF. »: (= « easy to identify »): when *Genus* is certain and if we use only scientific works:
  - « easy »: can be recognised immediately in the field if you have already seen this species;
  - « not easy »: must be studied at home;
  - « difficult »: recognised only after attentive study at home and comparisons or with specialist help.
- « METHODS »: (best sampling techniques to collect adults):
  - « direct »: Direct sampling without special technique; searching; "picked off" *in situ*…
  - « beating »;
  - « bark »: searching under bark;
  - « rearing »: by putting host CWD in an emergence box or directly by rearing larva or pupa in a habitat fragment;
  - « host »: in host plant, directly in habitat, in the pupa cell with in some cases "sieving" and "extractor";
  - « torch »: nocturnal species located in their habitat by searching with torch;
  - « trap »: trunk pitfall trap baited with beer or wine (« barber »: ground pitfall trap);
  - « UV »: species attracted by light;
  - « flower »: on flowers…

Selected species as biodiversity indicators ?

For four well known plain forests (Fontainebleau, Grésigne, Massane and Rambouillet), we investigated relationships between selected species richness, global biodiversity (species richness of all beetle) and forest size (fig. 1).

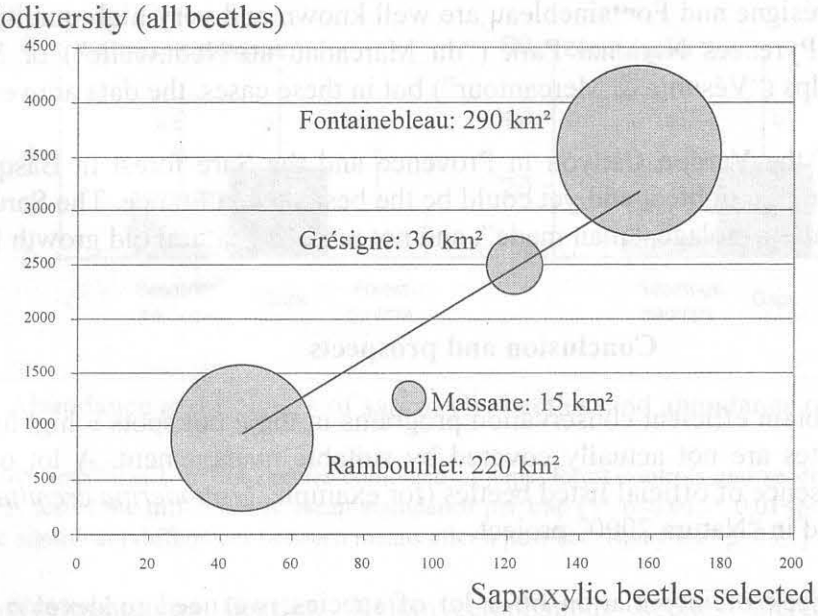

Fig.1. Selected saproxylic beetles species, forest size and other Coleoptera.

A linear relation exists between selected species richness and beetle biodiversity (r = 0,96 significant at 5 %). On the other hand, there is no clear correlation between forest size (size circles) and beetle species richness (saproxylic or not).

Best forest sites highlighted in France and typology

"Hot spots" (Appendix II & III)

We selected 74 suitable sites: 33 deciduous plain forests (Appendix II), 21 sites in mountains (Appendix III) and 20 other type sites:

- coniferous in plains (*Pinus* spp.): St-Guilhem-le-Désert (34), Carlencas (34), Conflent (66), Mont-Lachens (83) ; l'Ospédale (Corse), l'Esterel (06), Fontfroide (11);
- floodplain forests: Maillance (01), Asse and Durance valleys (04, 05, 13, 83, 84), Ibie valley (07), Rhônes floodplain in Camargue (13, 30), Garonne valley (31, 82, 47, 33), Hérault valley (34), Lergue and Buège valleys (34), Adour and Gaves valleys (40, 64, 65), Tech and Têt valleys (66), Argens valley (83) and Rhin floodplain (67, 68);
- bocages: limestone plateau in Aveyron (12), Sarthe (72) and Orne (61).

In relation to the saproxylic fauna, a third of the sites selcted (24) are also included the European list proposed by Speight (1989). 50 sites are highlighted for the first time in this work. Six French sites mentioned in Speight (1989) were not selected due to a lack of data.

Typology

The best sites are well known (a lot of data, recent and confirmed data, all families inventoried) and /or have big biological value (selected beetle richness, very rare species: if = 3, ip = 3 and 4) (Table 4).

For example: Grésigne and Fontainebleau are well known and very high quality sites. The same is true for the Pyrenees National Park ("du Marcadau au Néouvielle") or Mercantour National Park in the Alps ("Vésubie & Mercantour") but in these cases, the data are very old.

Other examples: the Verdon Canyon in Provence and the Sare forest in Basque country have only recently been highlighted, and yet could be the best sites in France. The Sare forest is a very old oak and beech assemblage, "man made", and not really a "natural old growth forest".

Conclusion and prospects

Now we try to obtain efficient conservation programs in the « hot spots » highlighted here. In fact, all the best sites are not actually covered by suitable management. A lot of the sites, despite data on the presence of official listed beetles (for example, *Osmoderma eremita* (SCOPOLI, 1763)), are not included in "Natura 2000" project.

Because of the lack of information on a lot of species, we need to develop a national database on saproxylic beetle biology and distribution. We should also start a national saproxylic beetle monitoring.

Table 4. French forest typology depending on saproxylic beetles fauna (knowledge and biological value).

		Biological value (rares saproxylic beetles)		
		+++	++	+
Knowledge	*good*	forêt de Fontainebleau (77) forêt de Tronçais (03) forêt de Grésigne (81) Vésubie & Mercantour (06, 04) Chartreuse (38) du Marcadau au Néouvielle (64, 65)	causse de Gramat (46) forêt de Marcenat (03) massif du Herrenwald (67) forêts de Rothleible & Harth (68) forêt de Compiègne (60) massif des Landes (64, 40, 33, 32, 47) Vosges (90, 88, 68, 70, 67, 57, 54) Iraty (64) Vallées d'Aspe & d'Ossau (64) Sault est (Gesse, Jau, Madres)(11, 66)	forêt de Chaux (39) forêt de Sénart (91) massif de Bercé (72) forêt d'Orient (10) forêt de Rambouillet (78) forêt de St Germain (78) forêts d'Osthouse & Nordhouse (67) forêt de Châtillon (21) Sault ouest (Belesta …) (09)
	perfectible		*++ (potentially +++)*	*+ (potentially ++)*
		Maurienne,Vanoise et Ronne (73) Mt Blanc au Chablais (73, 74)	massif des Maures (83) forêts de Sare & St Pée (64) gorges du Verdon (83,04) massif de Sainte Baume (13, 83) Massane & Albères or. (66) Queyras (05) Vercors (38, 26) Devoluy, Boscodon aux Ecrins (38, 05) PNR du Haut Jura (25, 39)	forêt de Blois (41) forêt d'Orléans (45) forêt de Loches (37) forêt de Boulogne (41) forêt de Longchamp (21) Caroux & Espinouse (34) bois de Païolive (07) forêts du Luberon (84,04) massifs autour des Monges (04) massifs autour de Lure (04) massif des Cevennes (34,30,48) Mt Lozère ; Margeride (15, 43, 48) Belledonne (38) Aïtone (Corse) Canigou (66) Fanges (11) Carlit & Bragues (09,66) Vivario et Vizzavone (Corse)

In all forests with perfectible knowledge, forest managers can focus inventories on our 300 species. At a comparable knowledge level, our hot spot typology could be different.

We also have some good news:

- We have some new records of saproxylic beetles in the Habitats Directive such as *Rhysodes sulcatus* (F., 1787) (useful in the Pyrenees) and *Phryganophilus ruficollis* (F., 1798) (known only from one very old record in the French Alps - http://europa.eu.int/comm/environment/nature/habitats_annex_1-2_4-5en.pdf);
- Our national «ZNIEFF» ("Natural Zones of Interest for Fauna Flora and Ecology") site selection use our list as criteria in some regions (Midi-Pyrenees, Lorraine and Languedoc-Roussillon at present);
- Fortunately, conservation programs can be more ambitious than existing laws require. For example, in the Gresigne forest where forest managers are very motivated (Brustel, Clary, 2000). It is the key to success. We would like to see the same thing more often!

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Appendix 1.

FAMILY, *Species*	ENVIRONMENT		TREES SPECIES	HABITAT	BIOLOGY	If	Ips	Ipn	ADULT	IDENTIF	METHODS
ALLECULIDAE											
Allecula morio (F.)	Plain	with trees	broadleaved	tree hollow	saproxylophagous	3	2	2	V-IX	not easy	beating, torch, trap
Hymenophorus doublieri Mulsant	Plain	with trees	*Pinus*	decay wood	saproxylophagous	2	2	2	VII-IX ?	not easy	beating, host, UV
Prionychus ater (F.)	Plain	with trees	broadleaved	hollow, decay wood	saproxylophagous	3	2	2	VI-IX	not easy	direct, rearing, UV
Pseudocistela ceramboides (L.)	Plain	with trees	broadleaved	decay wood varied	saproxylophagous	3	2	2	IV-VII	not easy	direct, beating, rearing.
ANTHRIBIDAE											
Anthribus albinus (L.)	Plain	forest	broadleaved	dead branches	xylophilic II	2	2	2	V-IX	easy	beating, direct, rearing
Dissoleucas niveirostris (F.)	Plain	with trees	broadleaved	dead branches	xylophilic II	2	2	2	V-X	not easy	direct, rearing, beating
Enedreutes sepicola (F.)	Plain	forest	broadleaved	dead branches	xylophilic II	2	2	2	V-IX	not easy	direct, rearing, beating
Platyrhinus resinosus (Scop.)	Pla., Mont.	with trees	broadleaved	stump, trunks, branches	xylophilic II	2	2	2	XI-VII	easy	beating, host, rearing
Tropideres albirostris (Herbst)	Plain	forest	broadleaved	dead branches	xylophilic II	2	2	2	I-XII	not easy	rearing, beating, trap
Tropideres dorsalis (Thunberg)	Pla., Mont.	with trees	broadleaved	branches	xylophilic II	2	3	3	V-IX	not easy	beating, rearing
BIPHYLLIDAE											
Biphyllus lunatus (F.)	Plain	forest	broadleaved	fungus, decay wood	mycetophagous	3	2	2	I-XII	easy	host
BOSTRICHIDAE											
Lichenophanes varius (Illiger)	Plain	forest	broadleaved	decay wood	xylophilic II	2	2	2	IV-VIII	easy	rearing, torch, trap
Stephanopachys linearis (Kugelann)	Mountain	forest	coniferous	bark big wood	xylophilic I	1	4	4	V-VIII	difficult	host
Stephanopachys substriatus (Paykull)	Mountain	forest	coniferous	bark big wood	xylophilic I	1	/	4	V-VIII	difficult	host
BOTHRIDERIDAE											
Bothrideres contractus (Fabricius)	Pla., Mont.	with trees	varied	under bark, snags	predator	3	3	3	I-XII ?	not easy	bark
Ogmoderes angusticollis (Brisout)	Plain	with trees	*Quercus*	branches	predator	3	3	/	VI-VII	easy	rearing, beating, UV
Oxylaemus cylindricus (Panzer)	Pla., Mont.	with trees	broadleaved	decay wood	predator ?	3	2	2	X-VII	not easy	host, trap
Oxylaemus variolosus (Dufour)	Pla., Mont.	with trees	broadleaved	decay wood	predator ?	3	3	3	VI	not easy	host, trap

Teredus cylindricus (Olivier)	Plain	with trees	broadleaved	under bark, big wood	predator	3	3	3	I-XII	not easy	bark
BUPRESTIDAE											
Acmaeodera degener (Scopoli)	Plain	with trees	*Quercus*	branches	xylophilic I	1	3	/	V-VII	not easy	flower
Agrilus ater (L.)	Pla., Flo., Mont.	with trees	*Populus, Salix*	bark	xylophilic I	1	2	2	V-VIII	not easy	rearing,host wood
Agrilus curtulus Mulsant et Rey	Plain	with trees	*Quercus*	branches	xylophilic I	1	3	3	V-VII	difficult	beating, rearing
Agrilus grandiceps Kiesenwetter	Plain	with trees	*Quercus*	branches	xylophilic I	1	3	/	VI-VIII	difficult	beating, rearing
Agrilus guerini Lacordaire	Pla., Flo.	with trees	*Salix*	branches	xylophilic I	1	3	3	VI-VII	easy	beating, host
Agrilus massanensis Schaefer	Floodplain	with trees	*Salix incana*	branches	xylophilic I	1	4	/	VI-VII	difficult	beating, host
Anthaxia midas Kiesenwetter	Plain	forest	*Acer*	dead wood	xylophilic I	1	4	/	IV-VII	not easy	flower
Buprestis octoguttata L.	Pla., Mont.	with trees	*Pinus*	big wood	xylophilic I	1	2	2	VI-IX	easy	host
Buprestis rustica L.	Mountain	forest	coniferous	trunks, stump	xylophilic I	1	2	2	VI-IX	not easy	cut host
Chalcophora intermedia (Rey)	Plain	with trees	*Pinus*	big wood	xylophilic II	1	3	/	VI-VIII	not easy	host
Chalcophora mariana (L.)	Plain	with trees	*Pinus*	big wood	xylophilic II	1	2	2	IV-IX	not easy	host
Chrysobothris chrysostigma (L.)	Mountain	forest	coniferous	trunks, branches	xylophilic I	1	/	2	V-IX	easy	cut host
Coroebus undatus (F.)	Plain	with trees	*Quercus*	big wood	xylophilic I	1	2	2	V-VIII	easy	trunk, trap
Dicerca aenea (L.)	Pla., Flo.	with trees	*Populus, Salix*	big wood	xylophilic I	1	2	2	V-VII	not easy	host
Dicerca alni (Ficher de W.)	Floodplain	with trees	*Alnus, Salix*	big wood	xylophilic I	1	2	2	V-VII	not easy	host
Dicerca berolinensis (Herbst)	Plain	forest	*Fagus, Carpinus*	big wood	xylophilic I	2	3	3	V-IX	not easy	trunk, rearing
Eurythyrea austriaca (L.)	Mountain	forest	coniferous	big wood	xylophilic I	1	3	/	VI-VIII	not easy	cut host
Eurythyrea micans (F.)	Floodplain	with trees	*Populus, Salix*	big wood	xylophilic I	1	2	3	VI-VIII	not easy	host
Eurythyrea quercus (Herbst)	Plain	forest	*Quercus, Castanea*	big wood	xylophilic I	2	3	3	VII-IX	not easy	trunk
Kisanthobia ariasi (Robert)	Plain	with trees	*Quercus*	big wood, branches	xylophilic I	1	3	/	IV-VII	easy	beating, rearing
Latipalpis plana (Olivier)	Plain	with trees	*Quercus*	big wood, branches	xylophilic I	1	2	/	IV-VIII	easy	trunk, rearing
Phaenops formaneki Jakobson	Plain	with trees	*Pinus*	branches	xylophilic I	1	3	/	VI-VII	difficult	beating, rearing
Phaenops knotecki Reitter	Mountain	forest	*Abies*	big wood	xylophilic I	1	/	4	VI-VIII	not easy	cut host
Phaenops sumptuosa (Abeille de P.)	Pla., Mont.	with trees	*Pinus*	branches	xylophilic I	1	4	/	VI-VII	not easy	beating, rearing
Scintillatrix dives (Guill.)	Floodplain	with trees	*Salix, …*	big wood	xylophilic I	1	3	3	VI-VIII	difficult	beating,
CERAMBYCIDAE											
Acanthocinus reticulatus (Razoum.)	Mountain	forest	*Abies*	big wood	xylophilic I	1	3	3	VI-IX	not easy	beating, rearing
Acmaeops marginatus (F.)	Mont., Pla.	forest	*Pinus*	branches	xylophilic I	1	3	3	V-VII	not easy	beating, trap
Acmaeops pratensis (Laicharting)	Mountain	forest	coniferous	decay wood	xylophilic I	1	2	2	VI-VIII	not easy	flower
Acmaeops septentrionis (Thomson)	Mountain	forest	coniferous	branches	xylophilic I	1	/	3	VI-VIII	not easy	cut host
Acmaeops smaragdulus (F.)	Mountain	forest	coniferous	big wood	xylophilic I	1	/	4	VI-VIII	not easy	flower

Aegomorphus clavipes (Schrank)	Pla., Mont., Flo.	with trees	broadleaved	wood varied	xylophilic I	1	2	2	V-VIII	easy	host
Aegosoma scabricorne (Scopoli)	Pla., Flo.	with trees	broadleaved	big wood	xylophilic I	1	2	2	VII-VIII	easy	host (torch)
Akimerus schaefferi (Laicharting)	Plain	forest	*Quercus*	roots (big *Quercus*)	xylophilic I	2	3	3	VI-IX	easy	direct, trap
Anaglyptus mysticus (L.)	Pla., Mont.	with trees	broadleaved	wood varied	xylophilic II	1	2	2	V-VII	easy	flower, beating, trap
Anastrangalia reyi (Heyden)	Mountain	forest	coniferous	big wood	xylophilic II	1	3	3	VI-VIII	difficult	flower
Anisorus quercus (Goeze)	Plain	forest	*Quercus*	roots	xylophilic I	1	3	3	IV-VI	not easy	flower, trap,…
Anoplodera rufipes (F.)	Pla., Mont.	with trees	broadleaved	wood varied	xylophilic II	1	2	2	V-VII	not easy	flower, trap
Anoplodera sexguttata (F.)	Pla., Mont.	forest	broadleaved	wood varied	xylophilic II	1	2	2	V-VII	easy	flower
Aredolpona erythroptera (Hagenbach)	Plain	forest	broadleaved	tree hollow	xylophilic II	2	3	3	VI-VII	not easy	direct, trap
Aredolpona fontenayi (Mulsant)	Plain	forest	broadleaved	wood varied	xylophilic II	1	3	/	V-VII	not easy	direct, trap
Aredolpona scutellata (F.)	Pla., Mont.	forest	broadleaved	big wood	xylophilic II	2	2	2	V-IX	not easy	direct, trap
Aredolpona stragulata (Germar)	Pla., Mont.	with trees	*Pinus*	trunks	xylophilic II	1	2	/	VI-VIII	not easy	flower
Aredolpona trisignata (Fairmaire)	Plain	with trees	broadleaved	trunks	xylophilic II	1	3	/	VI-VIII	not easy	flower, trap
Arhopalus syriacus (Reitter)	Plain	with trees	*Pinus*	big wood	xylophilic I	1	3	/	VII-IX	not easy	rearing, UV, host
Callidium aeneum (De Geer)	Mont., Pla.	forest	coniferous	trunks, branches	xylophilic I	1	/	3	V-VII	easy	host, rearing
Callidium coriaceum (Paykull)	Mountain	forest	coniferous	branches, trunks	xylophilic II	2	/	3	VI-VIII	not easy	host
Callimellum abdominalis (Olivier)	Plain	with trees	broadleaved	branches	xylophilic I	1	3	/	V-VIII	not easy	flower, beating, trap
Callimellum angulatum (Schrank)	Plain	with trees	broadleaved	branches	xylophilic I	1	2	2	III-VII	not easy	flower, beating, trap
Cerambyx cerdo L.	Plain	with trees	*Quercus*	big wood	xylophilic I	2	1	3	V-VIII	easy	torch, trap, UV
Cerambyx welensii (Küster)	Plain	with trees	*Quercus*	big wood	xylophilic I	1	2	/	VI-VIII	easy	direct, trap
Chlorophorus glabromaculatus (Goeze)	Plain	with trees	broadleaved	wood varied	xylophilic I	1	2	2	VI-VIII	easy	direct, trap, rearing
Chlorophorus herbstii (Brahm)	Pla., Mont.	with trees	*Tilia*	trunks, branches	xylophilic II	1	4	4	VI-VIII	not easy	host, flower
Clytus tropicus (Panzer)	Plain	with trees	*Quercus*	wood varied	xylophilic I	1	3	3	V-VIII	not easy	direct, trap
Cornumutila quadrivittata (Gebler)	Mountain	forest	coniferous	wounded / big trees ?	xylophilic II	2	/	4	VI-VIII	easy	host
Cyrtoclytus capra (Germar)	Pla., Flo.	with trees	*Alnus*, …	trunks	xylophilic II	1	4	4	V-IX	not easy	flower, rearing
Deroplia genei (Aragona)	Plain	with trees	*Quercus*	branches	xylophilic I	1	3	3	III-IV	not easy	rearing, beating
Drymochares truquii Mulsant	Pla., Flo.	with trees	*Corylus*	snags base, stump	xylophilic II	1	4	/	VI-VIII	easy	Barber, rearing
Ergates faber (L.)	Plain	with trees	coniferous	big wood	xylophilic II	2	2	3	VII-IX	easy	rearing, host, UV, …
Glaphyra marmottani (Brisout)	Pla., Mont.	with trees	*Pinus*	branches	xylophilic I	1	3	/	V-VII	not easy	beating, rearing
Judolia sexmaculata (L.)	Mountain	forest	coniferous	decay wood, stump	xylophilic II	1	3	3	VI-VIII	easy	flower
Lamia textor (L.)	Pla., Flo.	with trees	*Salix*	stump, big wood	xylophilic I	1	3	2	I-XII	easy	direct, host, on ground

Leioderes kollari Redtenbacher	Pla., Mont.	with trees	*Acer, ...*	branches	xylophilic I	1	4	/	V-VI	difficult	beating, rearing
Leiopus punctulatus (Paykull)	Pla., Flo.	forest	*Populus tremula*	trunks, branches	xylophilic I	1	/	4	VI	not easy	host
Leptura aethiops Poda	Plain	forest	broadleaved	wood varied	xylophilic I	1	3	2	V-VII	not easy	direct
Leptura annularis F.	Plain	forest	broadleaved	big wood	xylophilic I	1	/	4	VI-VIII	not easy	direct
Lepturobosca virens (L.)	Mountain	forest	coniferous	big wood	xylophilic II	2	3	2	VI-IX	easy	flower
Mesosa curculionoides (L.)	Pla., Mont., Flo.	with trees	broadleaved	wood varied	xylophilic II	1	2	2	IV-IX	easy	host
Monochamus sartor (F.)	Mountain	forest	coniferous	big wood	xylophilic I	1	/	3	VII-IX	not easy	cut host
Morinus asper (Sulzer)	Pla., Mont., Flo.	with trees	varied	big wood	xylophilic I	1	2	2	IV-IX	easy	host
Necydalis major L.	Pla., Mont., Flo.	with trees	broadleaved	decay wood wood	xylophilic II	2	3	3	VI-VII	not easy	trap, host
Necydalis ulmi Chevrolat	Plain	with trees	broadleaved	decay wood wood	xylophilic II	2	3	3	VI-VII	not easy	trap, host
Nothorhina muricata (Dalman)	Mont., Pla.	with trees	*Pinus*	bark / big trees	xylophilic I	1	3	3	VI-VII	easy	trunks (torch)
Oplosia cinerea (Mulsant)	Mont., Pla.	forest	*Tilia, ...*	branches on the ground	xylophilic II	2	3	3	V-VII	not easy	rearing, beating
Oxymirus cursor (L.)	Mountain	with trees	coniferous	big wood	xylophilic II	2	2	2	IV-VIII	easy	host
Oxypleurus nodieri Mulsant	Pla., Mont.	with trees	*Pinus*	branches, decay wood	xylophilic II	2	3	/	IX-V	easy	torch, beating, rearing
Pachyta lamed (L.)	Mountain	forest	*Picea*	roots	xylophilic I	2	/	4	VI-VIII	not easy	flying, flower
Pedostrangalia revestita (L.)	Pla., Flo.	with trees	broadleaved	decay wood	xylophilic II	1	3	3	V-VI	not easy	flower, trap
Poecilium pusillum (F.)	Plain	forest	*Quercus*	trunks, branches	xylophilic I	1	2	2	III-V	not easy	host
Pogonocherus caroli Mulsant	Pla., Mont.	with trees	*Pinus*	branches	xylophilic I	1	3	3	IX-V	not easy	beating, rearing
Prinobius myardi Mulsant	Plain	with trees	broadleaved	big wood	xylophilic I	2	4	/	VII-VIII	easy	direct, torch, UV.
Prionus coriarius (L.)	Plain	forest	broadleaved	stump	xylophilic II	2	2	2	VI-IX	easy	direct, torch, UV.
Pseudosphegestes cinereus (Cast. et Gor.)	Plain	with trees	*Quercus*	branches	xylophilic I	1	3	3	VI-VIII	easy	beating, rearing, trap
Purpuricenus globulicollis Mulsant	Plain	with trees	*Quercus?*	branches ?	xylophilic I ?	1	3	/	VI-VIII	not easy	trap
Purpuricenus kaehleri (L.) (var. *ruber*)	Plain	with trees	*Quercus*	trunks, branches	xylophilic I	1	2	3	VI-VII	easy	trap, direct
Rhagium mordax (DeGeer)	Pla., Mont.	forest	broadleaved	big wood	xylophilic I	1	2	2	IX-VII	easy	host
Rhagium sycophanta (Schrank)	Plain	forest	*Quercus*	big wood	xylophilic I	1	2	1	X-VII	easy	direct, host, trap
Rhamnusium bicolor (Schrank)	Plain	with trees	broadleaved	tree hollow	xylophilic II	2	3	3	V-VI	easy	host
Ropalopus femoratus (L.)	Plain	with trees	broadleaved	branches	xylophilic I	1	3	3	V-VII	not easy	direct, trap
Ropalopus insubricus (Germar)	Pla., Mont., Flo.	with trees	*Acer*	wood alive	xylophilic I	1	3	/	VI-VIII	not easy	trap, direct
Ropalopus ungaricus (Herbst)	Mont., Pla.	with trees	*Acer*	branches, trunks	xylophilic I	1	/	4	VI-VIII	difficult	host
Ropalopus varini (Bedel)	Plain	with trees	*Quercus*	branches	xylophilic I	1	3	3	V-VII	not easy	direct, trap

Rosalia alpina (L.)	Pla., Mont., Flo.	with trees	*Fagus, ...*	big wood	xylophilic I	1	2	3	VI-VIII	easy	host, trap
Saperda octopunctata (Scopoli)	Pla., Mont., Flo.	with trees	*Tilia*	trunks, branches	xylophilic I	1	2	2	VI-IX	not easy	host
Saperda perforata (Pallas)	Pla., Flo.	with trees	*Populus tremula*	big wood	xylophilic I	1	3	3	V-VIII	easy	host, (trap)
Saperda punctata (L.)	Pla., Mont., Flo.	with trees	*Ulmus*	trunks, branches	xylophilic I	1	2	2	VI-IX	not easy	host
Saperda similis (Laicharting)	Floodplain	with trees	*Salix*	branches	xylophilic I	1	3	3	V-VII	not easy	host, UV
Saphanus piceus (Laicharting)	Pla., Flo.	with trees	*Corylus, Alnus, ...*	trunk base, stump	xylophilic II	2	3	/	VI-VIII	easy	Barber, rearing
Semanotus undatus (L.)	Mountain	forest	coniferous	branches, trunks	xylophilic I	1	/	3	IV-VII	easy	host
Stenocorus meridianus (L.)	Pla., Mont., Flo.	with trees	broadleaved	stump, roots	xylophilic II	2	3	2	V-VII	easy	direct, trap
Strangalia attenuata (L.)	Pla., Flo.	with trees	broadleaved	wood varied	xylophilic II	1	3	3	VI-IX	not easy	flower
Tetropium fuscum (F.)	Mont., Pla.	forest	coniferous	trunks	xylophilic I	1	3	3	V-VIII	difficult	host
Tetropium gabrieli Weise	Mountain	forest	*Larix, ...*	trunks	xylophilic I	1	3	3	V-VIII	difficult	host
Tragosoma depsarium (L.)	Mountain	with trees	coniferous	big decay wood	xylophilic II	2	4	4	VII-VIII	easy	torch, bark, UV
Trichoferus holosericeus (Rossi)	Plain	with trees	broadleaved	trunks	xylophilic I	1	3	3	VI-VIII	not easy	torch, trap, beating
Trichoferus pallidus (Olivier)	Plain	with trees	*Quercus*	trunks	xylophilic I	1	2	2	VII-VIII	easy	direct, trap
Xylotrechus antilope (Schönherr)	Plain	with trees	*Quercus*	branches	xylophilic I	1	2	2	V-VIII	easy	direct, trap
CEROPHYTIDAE											
Cerophytum elateroides Latreille	Plain	forest	broadleaved	big dead wood	saproxylophagous ?	3	3	3	IV-VI	easy	host
CETONIIDAE											
Cetonischema aeruginosa Drury	Pla., Flo.	with trees	broadleaved	hollow	saproxylophagous	2	2	2	V-X	easy	rearing, trap
Eupotosia mirifica Mulsant	Plain	with trees	broadleaved	hollow	saproxylophagous	2	4	/	V-VIII	easy	trap
Gnorimus variabilis L.	Plain	with trees	broadleaved	big decay wood, hollow	saproxylophagous	2	2	2	VI-VII	easy	rearing, trap, flower
Liocola lugubris Herbst	Plain	with trees	broadleaved	hollow	saproxylophagous	2	3	2	V-VIII	easy	trap
Osmoderma eremita Scopoli	Pla., Flo.	with trees	broadleaved	gdes hollow	saproxylophagous	3	3	3	VII-VIII	easy	rearing, trap
Potosia fieberi Kraatz	Plain	with trees	broadleaved	hollow	saproxylophagous	2	3	2	V-VIII	not easy	rearing, trap, flower
Trichius sexualis Bedel	Plain	with trees	broadleaved	stump	saproxylophagous	2	/	3	V-VII	difficult	flower
CLERIDAE											
Allonyx quadrimaculatus (Schaller)	Plain	with trees	*Pinus,* broadleaved	trunks, branches	predator	2	3	3	IV-VII	easy	beating, rearing
Dermestoides sanguinicollis (F.)	Plain	forest	*Quercus*	big wood	predator	3	4	4	V-VIII	easy	trunk, traps
Opilo abeillei Korge	Plain	with trees	broadleaved	branches	predator	2	4	/	VI-VIII	difficult	beating, rearing

Opilo mollis L.	Pla., Mont., Flo.	with trees	broadleaved	wood decay varied	predator	2	2	2	I-XII	not easy	bark, host, trap…
Opilo pallidus (Olivier)	Plain	with trees	broadleaved	branches	predator	2	2	3	VI-VIII	not easy	beating, rearing, trap
Thanasimus femoralis (Zetterstedt)	Pla., Mont.	with trees	*Pinus*	wood varied	predator	2	2	2	IV-VII	not easy	cut host
Tillus elongatus L.	Plain	with trees	broadleaved	wood decay varied	predator	2	2	2	VI-VII	easy	trunk, rearing
COLYDIIDAE											
Aulonium ruficorne Olivier	Plain	with trees	*Pinus*	under bark	predator	2	2	3	I-XII ?	not easy	bark, rearing
Aulonium trisulcum (Fourcroy)	Plain	with trees	broadleaved, …	under bark	predator	2	3	2	I-XII ?	not easy	bark, rearing, trap
Colobicus marginatus Latreille	Plain	with trees	broadleaved	under bark	predator	2	2	3	III-X	not easy	bark, beating
Pycnomerus terebrans (Olivier)	Plain	with trees	broadleaved, …	decay wood with *Lasius*	saproxylophagous ?	3	3	3	IX-VIII	not easy	host, trap
Rhopalocerus rondanii (Villa)	Plain	with trees	broadleaved	base hollow with *Lasius*	saproxylophagous ?	3	/	4	I-XII ?	not easy	host
Xylolaemus fasciculosus Gyllenhal	Pla., Mont.	with trees	broadleaved	under bark, decay wood	predator ?	3	4	/	I-XII ?	not easy	bark
ELATERIDAE											
Ampedus aethiops (Lacordaire)	Mountain	forest	varied	big decay wood	predator	3	2	2	I-XII	not easy	host, bark, direct
Ampedus balteatus (L.)	Mont., Pla.	forest	varied	decay wood	predator	3	3	2	I-XII	easy	host, bark, batt.
Ampedus brunnicornis Germ.	Plain	forest	*Quercus*, …	hollow with red decay	predator	3	3	3	IX-VIII	difficult	host
Ampedus cardinalis (Schiödte)	Plain	forest	*Quercus*, *Castanea*	hollow with red decay	predator	3	3	3	IX-VIII	difficult	host
Ampedus cinnabarinus (Eschscholtz)	Plain	with trees	varied	big decay wood	predator	3	2	2	IX-VIII	difficult	host
Ampedus elegantulus Schonherr	Pla., Mont., Flo.	with trees	varied	moist decay wood	predator ?	3	3	3	IX-VIII	easy	host
Ampedus elongatulus (F.)	Pla., Mont., Flo.	with trees	varied	decay wood	predator	3	2	2	VIII-V	easy	host, trap
Ampedus erythrogonus (Müller)	Mont., Pla.	forest	varied	decay wood	predator	3	3	3	I-XII	not easy	host, bark, batt.
Ampedus melanurus (Muls. et Guill.)	Mont., Pla.	forest	varied	decay wood	predator	3	3	3	I-XII	difficult	host, bark
Ampedus nigerrimus Lacordaire	Plain	forest	varied	red decay	predator	2	2	2	IX-VIII	difficult	host, trap
Ampedus nigrinus (Herbst)	Mont., Pla.	forest	coniferous	decay wood	predator	3	3	3	I-XII	difficult	host, bark
Ampedus nigroflavus (Goeze)	Pla., Flo.	with trees	broadleaved	white decay	predator ?	3	3	3	IX-VII	not easy	host, trap
Ampedus pomonae (Stephens)	Pla., Flo.	with trees	broadleaved	big decay wood	predator ?	3	3	3	IX-VI ?	not easy	host
Ampedus pomorum (Herbst)	Pla., Mont., Flo.	with trees	broadleaved	decay wood	predator ?	2	2	2	IX-VIII	easy	host, trap
Ampedus praeustus (F.)	Plain	with trees	varied	red decay	predator	3	3	3	IX-VIII	difficult	host, trap

Ampedus quadrisignatus (Gyllenhal)	Plain	forest	broadleaved	big decay wood	predator	3	4	4	IX-VIII	easy	host
Ampedus ruficeps (Muls. et Guill.)	Plain	forest	broadleaved	decay under bark, hollow	predator ?	3	3	3	IV-VIII	not easy	host, trap
Ampedus rufipennis (Stephens)	Pla., Mont.	with trees	broadleaved	big decay wood	predator	3	2	2	IX-VIII	not easy	host, trap
Ampedus sanguinolentus (Schrank)	Pla., Flo.	forest	broadleaved	decay wood	predator ?	3	2	2	IX-VIII	not easy	beating, host
Ampedus sinuatus (Germar)	Plain	forest	broadleaved	decay wood	predator ?	3	/	4	IX-VIII	easy	beating flower
Athous mutilatus (Rosenhauer)	Plain	forest	broadleaved	decay wood and hollow	predator ?	3	4	4	V-VII	not easy	host
Brachygonus bouyoni Chassain	Plain	forest	*Quercus*	hight hollow	predator	3	3	3	IX-VIII	difficult	host, trap, UV
Brachygonus dubius (Platia et Cate)	Plain	forest	*Quercus*	hight hollow	predator	3	3	3	IX-VIII	difficult	host, trap
Brachygonus megerlei (Lacord.)	Plain	with trees	broadleaved	hollow	predator	3	2	2	IX-VIII	difficult	host, trap
Cardiophorus anticus Erichson	Pla., Flo.	with trees	broadleaved	decay wood	saproxylophagous ?	3	2	/	V-VI	difficult	beating
Cardiophorus gramineus (Scopoli)	Plain	with trees	broadleaved	base hollow	polyphagous ?	3	2	2	IX-VI	not easy	host, beating
Denticollis borealis (Paykull)	Mountain	forest	coniferous	decay wood	saproxylophagous ?	2 ?	/	4	VII	not easy	UV ?
Denticollis rubens (Piller et Mitterp.)	Mont., Pla.	with trees	varied	decay wood	saproxylophagous	2	2	2	V-VII	not easy	beating, rearing
Ectamenogonus montandoni Buysson	Plain	with trees	*Quercus*	hollow	predator	3	4	/	VII	not easy	beating, trap
Elater ferrugineus L.	Plain	with trees	broadleaved	hollow	predator	3	2	3	VI-VIII	easy	rearing, trap
Harminius undulatus (De Geer)	Mountain	forest	coniferous	big wood	predator ?	3	3	3	V-VII	not easy	trunks, bark
Hypoganus inunctus (Lac.)	Pla., Mont., Flo.	with trees	varied	decay wood, hollow	predator ?	3	3	3	I-XII ?	not easy	host, bark
Ischnodes sanguinicollis (Panzer)	Pla., Flo.	with trees	broadleaved	mould, base hollow	polyphagous ?	3	3	3	IX-VII	not easy	host, flower
Lacon fasciatus (L.)	Mountain	with trees	coniferous	big decay wood	predator ?	3	3	3	I-XII	easy	host, bark
Lacon lepidopterus (Panzer)	Mont., Pla.	with trees	varied	big decay wood	predator ?	3	4	4	I-XII	easy	host, bark
Lacon querceus (Herbst)	Plain	forest	*Quercus, Fagus*	red decay	predator ?	3	3	3	IX-VIII	easy	host, torch, trap
Limoniscus violaceus (Müller)	Plain	forest	*Quercus, Fagus*	base hollow	polyphagous ?	3	4	4	IX-VI	not easy	host, beating
Megapenthes lugens (Redtenbacher)	Plain	with trees	broadleaved	hollow, white decay	predator	3	3	3	IX-VII	not easy	host, beating
Orithales serraticornis (Paykull)	Plain	with trees	broadleaved	decay stump ?	saproxylophagous ?	3	/	4	IV-VI	not easy	bark, beating, …
Podeonius acuticornis (Germar)	Plain	forest	broadleaved	hollow, red decay	predator ?	3	4	4	IX-VII	not easy	host, beating
Porthmidius austriacus (Schrank)	Plain	forest	*Fagus*	?	predator ?	3	4	4	V-VI	not easy	beating

Procraerus tibialis (Lacordaire)	Plain	with trees	broadleaved	hollow, white decay	predator	3	3	3	IX-VIII	not easy	host, beating, trap
Selatosomus bipustulatus (L.)	Plain	with trees	broadleaved	bark, moss / stump	predator	2	3	3	IX-VIII	easy	direct, trap, beating
Selatosomus nigricornis (Panzer)	Pla., Flo.	with trees	broadleaved	?	?	2	3	2	V-VII	difficult	flying., beating, fauchage
Stenagostus rhombeus (Ol.)	Pla., Mont., Flo.	with trees	varied	big decay wood	predator	2	2	2	VI-VIII	not easy	torch, trap, UV, …
Stenagostus rufus (De Geer)	Pla., Mont.	with trees	coniferous	big decay wood	predator	3	2	2	VI-VIII	not easy	host, bark
EROTYLIDAE											
Triplax aenea (Schaller)	Pla., Mont.	forest	broadleaved	fungus, decay wood	mycetophagous	3	3	3	I-XII	easy	host
Triplax lacordairei Crotch	Plain	forest	broadleaved	fungus, decay wood	mycetophagous	3	3	3	I-XII	difficult	host
Triplax melanocephala Lacordaire	Plain	forest	broadleaved	*Pleurotus* spp.	mycetophagous	3	2	2	I-XII	not easy	host
Triplax scutellaris Charp.	Pla., Mont.	forest	broadleaved	*Pleurotus* spp.	mycetophagous	3	2	2	I-XII	not easy	host
EUCNEMIDAE											
Dirhagus emyi Rouget	Plain	with trees	broadleaved	dead wood	xylophilic II	2	3	3	V-VIII ?	difficult	beating
Dirhagus lepidus (Rosenh.)	Plain	with trees	broadleaved	dead wood	xylophilic II	2	3	3	V-VIII ?	difficult	beating
Dirhagus pygmaeus (F.)	Plain	with trees	broadleaved	dead wood	xylophilic II	2	2	2	V-VIII ?	difficult	beating, trap
Dromeolus barnabita (Villa.)	Plain	with trees	broadleaved	dead wood	xylophilic II	2	2	2	V-VIII ?	not easy	beating, trap
Epiphanis cornutus Esch.	Mountain	forest	coniferous	decay wood ?	xylophilic II	2	4	4	VI-VIII?	difficult	beating, bark
Eucnemis capucina Ahrens	Plain	with trees	broadleaved	big decay wood	xylophilic II	2	3	3	V-VIII ?	not easy	host, beating, trap
Hylis cariniceps (Reitter)	Plain	forest	broadleaved	decay wood	xylophilic II	2	3	3	V-VIII ?	difficult	beating, trap, rearing
Hylis foveicollis (Thoms.)	Pla., Mont., Flo.	forest	varied	decay wood	xylophilic II	2	3	3	VI-VII	difficult	beating, rearing
Hylis olexai (Palm.)	Pla., Mont., Flo.	forest	varied	decay wood	xylophilic II	2	2	2	VI-VIII ?	difficult	beating, trap, rearing
Hylis procerulus (Mannh.)	Plain	forest	varied	snags	xylophilic II	2	4	4	V-VIII ?	difficult	beating, rearing
Hylis simonae (Olexa)	Plain	forest	broadleaved	decay wood	xylophilic II	2	3	3	V-VIII ?	difficult	beating, rearing
Isorhipis marmottani Bonv.	Plain	forest	*Carpinus, Fagus* ...	snags	xylophilic II	2	3	3	VI-VII	not easy	beating, trap
Isorhipis melasoides Lap.	Pla., Mont.	forest	broadleaved	snags	xylophilic II	2	2	2	VI-VII	not easy	trunk, trap, beating
Isorhipis nigriceps (Mannerheim)	Pla., Mont.	forest	*Fagus*	snags	xylophilic I	2	4	/	IV-VII	difficult	trunk, rearing
Nematodes filum (F.)	Pla., Mont.	forest	*Fagus*	big snags	xylophilic II	2	4	/	VII	not easy	trunk, beating
Rhacopus pyrenaeus (Bonv.)	Plain	forest	broadleaved	dead wood	xylophilic II ?	2	4	4	V-VIII ?	difficult	beating
Rhacopus sahlbergi (Mannh.)	Plain	with trees	varied	decay wood	xylophilic II	2	3	3	V-VIII ?	not easy	beating
Xylophilus corticalis (Paykull)	Mountain	forest	varied	decay wood	xylophilic II	2	3	3	VI-VIII	difficult	beating, bark

HISTERIDAE											
Abraeus granulum Erichson	Pla., Mont.	forest	*Fagus*	big decay wood	predator	3	3	2	III-X	not easy	sieving + Berlèze
Aeletes atomarius (Aubé)	Plain	forest	broadleaved	decay wood with ants	predator	3	3	3	V-IX	not easy	sieving + Berlèze
Eubrachium pusillum (Rossi)	Plain	forest	*Quercus suber*	mould under bark	predator	2	3	3	II-IX	not easy	under bark, sieving
Merohister ariasi (Marseul)	Plain	with trees	*Quercus suber*, ...	moist hollow	predator	3	4	/	I-XII	not easy	direct in host
Plegaderus caesus (Herbst)	Plain	forest	varied	decay under bark	predator	2	2	2	III-IX	not easy	under bark, sieving
Plegaderus discisus Erichson	Plain	forest	*Pinus*	mould under bark	predator	2	2	/	III-IX	not easy	under bark, sieving
Plegaderus dissectus Erichson	Pla., Mont.	forest	varied	mould under bark	predator	2	2	2	I-XII	not easy	under bark, sieving
Plegaderus vulneratus (Panzer)	Pla., Mont.	forest	coniferous	mould under bark	predator	2	2	2	III-X	not easy	under bark, sieving
LISSOMIDAE											
Drapetes cinctus (Panzer)	Plain	with trees	broadleaved	decay wood	saproxylophagous	2	3	3	IV-IX	easy	direct, trap
LUCANIDAE											
Aesalus scarabaeoides Panz.	Pla., Flo.	forest	broadleaved	big decay moist wood	saproxylophagous	3	3	3	IX-VIII	easy	host
Ceruchus chrysomelinus (Hochenwarth)	Mountain	forest	coniferous, …	big decay wood	saproxylophagous	2	4	4	VIII-VI	easy	host
Lucanus cervus L.	Pla., Flo.	with trees	broadleaved	stump	saproxylophagous	2	1	2	VI-VIII	easy	direct, trap
Lucanus tetraodon provincialis Colas	Pla., Flo.	with trees	broadleaved	stump	saproxylophagous	2	4	/	VI-VIII	not easy	direct flying
Platycerus caprea (DeGeer)	Pla., Mont.	with trees	broadleaved	big decay wood	saproxylophagous	2	2	2	IX-VI	not easy	direct, host
Platycerus caraboides L.	Pla., Mont.	with trees	broadleaved	decay wood	saproxylophagous	2	2	2	IX-VI	not easy	direct (flying), host,…
Sinodendron cylindricum (L.)	Pla., Mont.	forest	broadleaved	big decay wood	xylophilic II	2	2	2	IX-VIII	easy	direct, host
LYCIDAE											
Benibotarus alternatus (Fairmaire)	Mountain	forest	coniferous	big decay wood	predator	3	3	/	IV-VI	difficult	host
Dictyoptera aurora (Herbst)	Mont., Pla.	forest	coniferous	big decay wood	predator	3	2	2	III-VI	not easy	host
Lopherus rubens (Gyllenhal)	Mountain	forest	coniferous	big decay wood	predator	3	3	3	V-VII	not easy	host
Platycis cosnardi (Chevrolat)	Plain	with trees	broadleaved	decay wood	predator ?	3	/	3	V-VI	not easy	direct
Platycis minutus (F.)	Pla, Mont.	with trees	varied	decay wood	predator ?	3	2	2	VIII-IX	not easy	host
Pyropterus nigroruber (Degeer)	Mountain	forest	coniferous	big decay wood	predator	3	3	3	V-VII	not easy	host
MELANDRYIDAE											
Abdera flexuosa (Paykull)	Pla., Mont.	with trees	broadleaved	fungus	mycetophagous	3	3	3	VIII-VI	not easy	host, rearing

									?		
Dircaea australis Fairmaire	Plain	forest	broadleaved	decay wood	saproxylophagous	2	3	3	V-VIII ?	difficult	beating, host
Eustrophus dermestoides (F.)	Plain	with trees	broadleaved	big decay wood	mycetophagous	3	3	3	I-XII ?	not easy	host
Hypulus bifasciatus (F.)	Mountain	forest	varied ?	big decay wood	saproxylophagous	3	/	4	I-XII ?	not easy	host
Hypulus quercinus (Quensel)	Pla., Mont.	forest	broadleaved	big decay wood	saproxylophagous	3	3	3	I-XII ?	not easy	host
Melandrya barbata (F.)	Plain	forest	broadleaved	decay wood	saproxylophagous	3	3	3	IV-VI	not easy	on trunk, direct
Melandrya caraboides (L.)	Pla., Flo.	forest	broadleaved	big wood	xylophilic II	2	2	2	IV-VII	not easy	on trunk, direct
Melandrya dubia (Schaller)	Plain	forest	broadleaved	small snags	xylophilic II	2	/	3	IV-VI	not easy	beating
Mycetoma suturale (Panzer)	Mountain	forest	varied	*Lasiochlaena* spp.	mycetophagous	3	3	3	VIII-VI	not easy	host : in fungus
Orchesia fasciata (Illiger)	Plain	forest	varied	fungus	mycetophagous	3	3	3	I-XII ?	not easy	host, rearing
Orchesia luteipalpis Mulsant et Guill.	Plain	forest	varied	fungus	mycetophagous	3	3	3	I-XII ?	not easy	host, rearing
Orchesia micans (Panzer)	Pla., Mont.	with trees	varied	fungus	mycetophagous	3	2	2	I-XII ?	not easy	host, rearing
Orchesia minor Walker	Pla., Mont.	forest	varied	dead branches, fungus	mycetophagous	3	2	2	I-XII ?	not easy	host, rearing
Phloeotrya vaudoueri Mulsant	Pla., Mont.	with trees	broadleaved	wood varied	xylophilic II	1	2	3	VII-IX	not easy	torch, trap, rearing
Phryganophilus ruficollis (F.)	Mountain	forest	varied	big decay wood	saproxylophagous	3	4	4	?	easy	host
Xylita laevigata (Hellenius)	Mountain	forest	coniferous	under bark, decay wood	xylophilic II ?	2	3	3	V-VII ?	not easy	bark
Xylita livida (C.R.Sahlberg)	Mountain	forest	coniferous	under bark, decay wood	xylophilic II ?	2	3	3	V-VII ?	not easy	bark
Zilora sericea (Sturm)	Mont., Pla.	forest	coniferous	bark decay wood	xylophilic II	2	3	3	IX-VII	not easy	host
MYCETOPHAGIDAE											
Mycetophagus ater (Reitter)	Plain	forest	*Carpinus*, ...	small snags	mycetophagous	3	/	3	I-XII ?	not easy	beating
Mycetophagus decempunctatus F.	Plain	forest	broadleaved	fungus	mycetophagous	3	3	3	I-XII ?	difficult	host
Mycetophagus fulvicollis F.	Pla., Flo.	forest	broadleaved	under bark decay wood	mycetophagous	3	2	2	I-XII ?	not easy	host
Mycetophagus piceus (F.)	Plain	forest	*Quercus*	red decay wood	mycetophagous	3	2	2	I-XII ?	difficult	host
Mycetophagus populi F.	Plain	forest	broadleaved	hollow, decay wood	mycetophagous	3	4	4	I-XII ?	not easy	host
Pseudotriphyllus suturalis (F.)	Plain	forest	broadleaved	fungus	mycetophagous	3	3	3	IV-X	not easy	host
Triphyllus bicolor (F.)	Plain	forest	broadleaved	fungus	mycetophagous	3	2	2	VIII-VI ?	not easy	host
OEDEMERIDAE											
Anogcodes ferruginea (Schrank)	Floodplain	with trees	broadleaved ?	decay wood ?	saproxylophagous	2	4	4	VI-VII ?	not easy	flower ?
Calopus serraticornis (L.)	Mountain (+ Pla.)	forest	coniferous	stump	xylophilic II	2	3	3	IX-VII	easy	host, bark, UV
Ischnomera caerulea (L.)	Pla., Mont.	with trees ?	broadleaved	hollow, decay wood	saproxylophagous	2	2	2	VIII-VI	difficult	flower, beating, host

Ischnomera cinerascens (Pandellé)	Pla., Mont.	with trees	broadleaved	decay wood	saproxylophagous	2	3	2	V-VI	difficult	flower, beating
Ischnomera cyanea (F.)	Pla., Mont.	with trees ?	broadleaved ?	decay wood	saproxylophagous	2	2	2	VIII-VI	difficult	beating
Ischnomera sanguinicollis (F.)	Pla., Mont.	with trees	broadleaved, …	decay wood	saproxylophagous	2	2	2	VIII-VI	not easy	flower, beating, host
Xanthochroa gracilis (Schmidt)	Pla., Mont.	with trees ?	varied	big decay wood	saproxylophagous	2	3	3	VI-IX	not easy	trap, UV
PLATYPODIDAE											
Platypus oxyurus Dufour	Mountain	forest	*Abies*	big wood	xylophilic I	1	3	/	I-XII ?	not easy	bark, host
PROSTOMIDAE											
Prostomis mandibularis F.	Pla., Mont.	forest	varied	big decay wood	polyphagous ?	3	3	3	IX-VI	easy	host, bark
PYROCHROIDAE											
Agnathus decoratus Germar	Floodplain	with trees	*Alnus*	decay wood ?	predator ?	3	3	3	II-VI	not easy	host ?
PYTHIDAE											
Pytho depressus (L.)	Mont., Pla.	forest	coniferous	under bark, decay wood	predator	3	3	3	VII-IX	easy	bark
RHYSODIDAE											
Rhysodes sulcatus (F.)	Mountain	forest	varied	big decay wood	saproxylophagous	3	4	4	I-XII	easy	host, bark
SILVANIDAE											
Dendrophagus crenatus (Paykull)	Mountain	forest	*Pinus*	under bark, decay wood	saprophagous ?	2	4	4	I-XII ?	not easy	bark
TENEBRIONIDAE											
Bius thoracicus (F.)	Mountain	forest	coniferous, …	under bark, decay wood	saproxylophagous	3	4	4	V-IX ?	not easy	bark
Bolitophagus interruptus Illiger	Mountain	forest	*Abies, Fagus*	fungus	mycetophagous	3	4	4	VII-VI	not easy	host (in fungus)
Bolitophagus reticulatus (L.)	Pla., Mont., Flo.	with trees	broadleaved	fungus	mycetophagous	3	2	2	I-XII	easy	host, rearing
Clamoris crenata (Mulsant)	Plain	forest	*Pinus*	under bark, fungus	polyphagous ?	2	2	3	I-XII	easy	bark
Corticeus bicoloroides Roubal	Plain	with trees	broadleaved	decay wood	polyphagous ?	3	4	4	I-XII	difficult	sieving, direct
Corticeus fasciatus F.	Plain	with trees	broadleaved	under bark, decay wood	polyphagous ?	2	3	3	I-XII ?	difficult	host
Corticeus longulus Gyllenhal	Mont., Pla.	forest	*Pinus*	under bark, dead wood	polyphagous ?	2	4	4	I-XII ?	difficult	bark, traps
Corticeus rufulus (Rosenhauer)	Plain	forest	broadleaved	under bark, hollow	predator ?	3	/	4	I-XII ?	difficult	host
Eledonoprius armatus (Panzer)	Pla., Flo.	forest	broadleaved	fungus, hollow	mycetophagous	3	3	3	X-I	not easy	host
Menephilus cylindricus (Herbst)	Pla., Mont.	forest	*Pinus*	bark, big decay wood	saproxylophagous	3	2	/	I-XII	easy	host
Neatus picipes (Herbst)	Plain	forest	broadleaved	under bark, hollow	saproxylophagous	3	4	/	I-XII ?	not easy	torch, direct
Neomida haemorrhoidalis (F.)	Pla., Mont., Flo.	with trees	broadleaved	*Fomes fomentarius*	mycetophagous	3	3	3	VIII-VII	easy	host

Platydema dejeani Laporte	Plain	forest	broadleaved	under bark, fungus	mycetophagous	3	4	/	I-XII ?	easy	host, rearing
Platydema europea Lap.	Plain	with trees	*Pinus*	fungus, under bark	mycetophagous	3	2	2	I-XII ?	not easy	host
Platydema violaceum F.	Pla., Mont.	with trees	broadleaved	under bark, big wood	mycetophagous	3	2	2	I-XII	easy	bark, torch…
Tenebrio opacus Duftschmid	Plain	forest	broadleaved	hollow	saprophagous ?	3	3	3	I-XII	difficult	torch, direct
TETRATOMIDAE											
Tetratoma ancora F.	Pla., Mont.	forest	broadleaved	under bark snags	mycetophagous	3	3	3	I-XII ?	not easy	host
Tetratoma baudueri Perris	Plain	with trees	broadleaved	bark, decay wood, hollow ?	mycetophagous	3	4	/	I-XII ?	not easy	host
Tetratoma desmaresti Latreille	Plain	forest	broadleaved	under bark, decay wood	mycetophagous	3	4	4	I-XII ?	not easy	host
Tetratoma fungorum F.	Pla., Mont., Flo.	with trees	varied	under bark, fungus	mycetophagous	3	2	2	VIII -V ?	easy	host
TROGOSSITIDAE											
Calitys scabra (Thunberg)	Mountain	forest	*Pinus*	big decay wood	mycetophagous	3	4	/	I-XII	easy	host
Grynocharis oblonga (L.)	Pla., Mont.	with trees	varied	big decay wood	mycetophagous	3	3	3	I-XII	not easy	bark, hollow
Ostoma ferruginea (L.)	Mountain	forest	coniferous	big decay wood	mycetophagous	3	3	3	I-XII	easy	bark
Peltis grossum (L.)	Mountain	forest	varied	under bark, decay wood	mycetophagous	3	4	4	I-XII	easy	bark
Temnochila caerulea (Olivier)	Plain	with trees	coniferous	wood varied	predator	2	2	2	IV-IX	easy	direct, rearing
Thymalus limbatus (F.)	Pla., Mont., Flo.	forest	varied	fungus, under bark	mycetophagous	3	2	2	I-XII ?	easy	bark, rearing, …

Appendix 2.

Forest sites / Taxa	Rarity index (Ips)	massif des Maures (83)	massif de Sainte Baume (13, 83)	forêts du Luberon (84,04)	bois de Paiolive (07)	massifs autour des Monges (04)	massifs autour de Lure (04)	gorges du Verdon (83,04)	Massane & Albères or. (66)	Caroux & Espinouse (34)	massif des Cevennes (34,30,48)	causse de Gramat (46)	forêt de Grésigne (81)	forêts de Sare & St Pée (64)	massif des Landes (64, 40, 33, 47)	Rarity index (Ipn)	massif de Bercé (72)	forêt de Loches (37)	forêt de Boulogne (41)	forêt de Blois (41)	forêt d'Orléans (45)	forêt de St Germain (78)	forêt de Rambouillet (78)	forêt de Sénart (91)	forêt de Fontainebleau (77)	forêt de Compiègne (60)	forêt d'Orient (10)	forêt de Longchamp (21)	forêt de Châtillon (21)	forêt de Tronçais (03)	forêt de Marcenat (03)	forêt de Chaux (39)	massif du Herrenwald (67)	forêts d'Osthouse & Nordhouse (67)	forêts de Rothleible & Harth (68)
Bioclimatical types																																			
Mediterranean		X	X	X	X	X	X	X	X	X	X	X	X																						
Continental										X	X											X	X	X	X	X	X	X	X	X	X	X	X	X	X
Atlantic												X	X	X	X		X	X	X	X	X	X	X	X	X	X									
ALLECULIDAE																																			
Allecula morio (F.)	2	X	X		X		X	X	X			X	X	X	X	2	X	X							X	X				X	X				
Pseudocistela ceramboides (L.)	2		X					X	X				X	X	X	2					X	X			X	X							?	?	X
BOTHRIDERIDAE																																			
Teredus cylindricus (Olivier)	3	X							X					X	X	3				X		X			X	X	?			?	?		?	?	
BUPRESTIDAE																																			
Anthaxia midas Kiesenwetter	4		X					X	X	X						/																			
Coroebus undatus (F.)	2	X	X	X	X	?	X	X	X			X	X			2	?	X		X	X	?		X	X	X				X	X		X	?	X
Dicerca berolinensis (Herbst)	3		?			X		X	X	?	X		X		X	3									X	X				X	?			?	X
Eurythyrea quercus (Herbst)	3	X	?				X	X	X	X	X	X	X	X	X	3									X					X				?	
Kisanthobia ariasi (Robert)	3	X	X	X	X		?	X		?	X					/																			
Latipalpis plana (Olivier)	2	X	?	X	X			?		X	X					/																			
CERAMBYCIDAE																																			
Akimerus schaefferi (Laicharting)	3										X		X			3		X	X	X	X									?	X				
Anisorus quercus (Goeze)	3	X	X	X		X	X	X								3																			X
Aredolpona erythroptera (Hagenbach)	3	X	X	X	?	X	X	X	X		X	X	X	X	X	3		X			?					X									
Aredolpona fontenayi (Mulsant)	3	X	X	X	X	?	X	X	X	X	X			X		/																			
Aredolpona scutellata (F.)	2	X	X	?	X	X	X	X	X	X	X	X	X	X		2		X	X	X	X		X	X	X	X				X	X				X
Callimellum abdominalis (Olivier)	3	X	X	X	?	X		X	X	X			X	X		/																			
Callimellum angulatum (Schrank)	2	X	X	X	?	X	X	X	X			X	X	X		2									X							X			
Cerambyx cerdo L.	1	X	X	X	X	X	X	X	X	?	X	X	X	X	X	3		X	X	X	X	X	X		X			?	?	X	X	?			X
Cerambyx welensii (Küster)	2	X	X	X	X	X	?	X	X	X	X	X	X	X	X	/																			
Chlorophorus glabromaculatus (Goeze)	2	X	X	X	X	X	X	X	X		X	X	X	X		2	?	X	?	X	?				X		X	?		X		X			

Clytus tropicus (Panzer)	3		?	X	X	X	X	X			X		X			3			X	X	X	X	X		X	X	?			X	X	X	X		X
Deroplia genei (Aragona)	3	X	X	X	X		X		X				X			3		X												?					
Leptura aethiops Poda	3							?			X					2	?	?	?	?				X	X	X	X	X	X		X	X	X		X
Leptura annularis F.	/															4												X	?				?	?	?
Necydalis ulmi Chevrolat	3	X	X	X	X	X	X	X	X	?		X	X	X		3		X				X			X		?	?	?	?	?				
Prinobius myardi Mulsant	4	X					?									/																			
Prionus coriarius (L.)	2	X	X	?			?		X	X	X	X	X	X	X	2		X		X	X	X	X	X	X	X	X			X	X	X	X		X
Pseudosphegestes cinereus (Cast.et G.)	3	X	X	X	X	X	X	X	X	X		X	X	X		3		X	X			X			X					?					X
Purpuricenus globulicollis Mulsant	2	X	X	X	?	X	X	X		X	X	X	X			/																			
Rhagium sycophanta (Schrank)	2	X	X	X	X	X	X	X	X			X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ropalopus femoratus (L.)	3	X	X	X	?	X	X	X	X			X	X	X	X	3		X		X	X	X	X	X	X		X			X	X	X	X		X
Ropalopus varini (Bedel)	3		X	X	X	X	X	X	X		X	X	X	X		3		X				X		X	X	X									X
Trichoferus holosericeus	3	X		X	X	?	?	?	X		X	X		X		3					X							?	?	?	?				
Trichoferus pallidus (Olivier)	2		X	?	X			X	X	X	X	X	X	X	X	2		X	X	X	?	X		X	X	X				X	X				X
Xylotrechus antilope (Schönherr)	2	X	X	X	X			X	?	X	X	X	X	X		2		X	X	X	X		X	X	X		X	X		X	X	X	X		X
CEROPHYTIDAE																																			
Cerophytum elateroides Latreille	3		?				?				?		X			3						X			X	X	?	?	?	X	?		?	X	?
CETONIIDAE																																			
Cetonischema aeruginosa Drury	2				X	X	X					X	X	?	X	2	X	X	X	X	X				X			?		X	X	X	X		X
Eupotosia mirifica Mulsant	4				X					?	X					/																			
Gnorimus variabilis L.	2	X	X	?	X		X	X	X	X	X	X	X	X	X	2			X	X					!					X	?		X	?	
Liocola lugubris Herbst	3								?			X	X	X	X	2	X	X	X	X	X				X	X				X	?	X	X		X
Osmoderma eremita Scopoli	3	X	X	?		?	X	X	X		X	?		X	X	3	X								X	X	?			X	?		X		
Potosia fieberi Kraatz	3	X			X	X	X	X	X		X	X	X		?	2	X	X		X		X			X	X	X			X	X	X	X		X
CLERIDAE																																			
Dermestoides sanguinicollis (F.)	4		?										X			4									X					?	?				
Tillus elongatus L.	2		X					X	X			X	X	X	X	2									X		X	?	?	X			X	X	X
COLYDIIDAE																																			
Pycnomerus terebrans Olivier	3								X			X	X	X	X	3	?	X		?	?				X	X							?	?	?
ELATERIDAE																																			
Ampedus brunnicornis Germar	3							X				?				3			X	X		X	X		X	X				X					
Ampedus cardinalis (Schiödte)	3	X	X	?					X			X	X	X		3						X			X	X				X					
Ampedus nigerrimus Lacordaire	2							X	X			X	X	X	X	2		X			X		X		X	X	X	?	?	X	X	X	X		
Ampedus praeustus (F.)	3	X	X	X		X			X	?	X		X	X	X	3					X		X		X	X									
Ampedus quadrisignatus (Gyllenhal)	4								X							4																			?
Ampedus ruficeps (Muls. & Guill.)	3		?					?	?			?	X	X	X	3									X					?	?				
Ampedus rufipennis (Stephens)	2	X	?	?		X	?	X	X	?	?	?	X	X		2	?	X	?	?	X	X			X	X				X	?		X		X
Ampedus sinuatus (Germar)	/															4													X				X	?	X
Athous mutilatus (Rosenhauer)	4		X													4												?	?	?	?		?	?	?
Brachygonus bouyoni Chassain	3				X	X		X			?	X	X			3																			
Brachygonus dubius (Platia & Cate)	3							X								3			X						X	X				X					
Brachygonus megerlei (Lacord.)	2	X	X	X	X		?	X	X		X	X	X	X	X	2	?	?	X	?	X	X			X	X				X	X		X		X
Ectamenogonus montandoni Buysson	4								X		X	X				/																			
Elater ferrugineus L.	2	X	X	X	X	X	X	X	X	X		X	X	X	X	3	X	X	?	X					X		?			X	X		?		X
Lacon querceus (Herbst)	3								X			X	X	X	X	3	X	X							X	X				X	?				

Limoniscus violaceus (Müller)	4		X									X	X			4		X	X						X	X				X					
Podeonius acuticornis (Germar)	4											X	X			4									X					X					
Porthmidius austriacus (Schrank)	4					?	?									4										X			X						
Selatosomus bipustulatus (L.)	3		X			X		X	X			X	X	X	X	3					X	X	X	X	X	X	X	X	?	X	X	X	?	?	X
EUCNEMIDAE																																			
Dirhagus emyi Rouget	3	?		X	?		X	?				X	X			3									X			?	X	?	X		?	?	
Dirhagus pygmaeus (F.)	2		X									X	X	X	X	2		X			X	X	X		X	X		?	X	?	X	X		X	X
Dromeolus barnabita (Villa.)	2	X										X	X			2		X							X				X			X	X	X	X
Eucnemis capucina Ahrens	3		X	X					X	?		X	X		X	3	?	X				X	X	X	X	X		?	?	?	?		?	?	X
Hylis cariniceps (Reitter)	3				?		X					X	X	X	X	3									X								X		
Hylis simonae (Olexa)	3			X		?							X	X	X	3							X							X					
Isorhipis marmottani Bonv.	3												X			3									X	X				X	?		?		
Isorhipis melasoides Lap.	2					?			X				X	X		2		X		X			X	X	X	X				X	?		X		
Rhacopus pyrenaeus (Bonv.)	4												X			4						X			X										
LISSOMIDAE																																			
Drapetes cinctus (Panzer)	3	X										X	X		X	3	?	?					X		X					X			X		X
LUCANIDAE																																			
Aesalus scarabaeoides Panz.	3								X				X	X		3									X					X		X	X		X
Lucanus cervus L.	1	X	X	X	X	X	X	X	X	?	?	X	X	X	X	2	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
MELANDRYIDAE																																			
Melandrya barbata (F.)	3													X		3		?	?	?	X		X		X										
Melandrya caraboides (L.)	2	?							X	X		X	X	X	X	2	?					X	X		X	X	X			?	?		X	X	
Phloeotrya vaudoueri Mulsant	2	?	?						X			X	X	X		3									X								X		
MYCETOPHAGIDAE																																			
Mycetophagus ater (Reitter)	/															3										X							?	X	X
Mycetophagus populi F.	4												X			4	?					X			X	X							?		
OEDEMERIDAE																																			
Ischnomera caerulea (L.)	2	X	X		X			X	X		X	X	X	X	X	2					X				X								?	X	
Ischnomera cyanea (F.)	2	X	X	X		X	X	X	X		X	X	X			2									X								?	?	?
TENEBRIONIDAE																																			
Corticeus bicoloroides Roubal	4								?					X	X	4									X	X									
Platydema violaceum F.	2	X	X			X			X	X		X	X		X	2	?	X			X		X	X	X	X	X	X	?	X		X	X	X	?
Tenebrio opacus Duftschmid	3	X	?	X							X	X			X	3									X					X					
TOTALLY																																			
X		40	40	30	27	26	27	40	48	16	29	48	62	46	36		9	31	15	20	23	24	20	14	62	39	13	7	8	39	21	18	26	9	31
?		3	10	7	7	7	9	5	4	9	4	4	0	1	1		11	4	5	5	4	1	0	0	0	0	6	12	11	13	17	1	15	14	7

Appendix 3.

FAMILIES	Sites Taxa	*Rarity index (Ips)*	Vivario et Vizzavone (Corse)	Aïtone (Corse)	Iraty (64)	Vallées d'Aspe & d'Ossau (64)	Marcadau au Néouvielle (64, 65)	Sault ouest (*Belesta* ...) (09)	*Sault est (Gesse, Jau, Madres)*(11, 66)	Carlit & Bragues (09,66)	Fanges (11)	Canigou (66)	*Rarity index (Ipn)*	Mt Lozère ; Margeride (15, 43, 48)	Vésubie & Mercantour (06, 04)	Devoluy, Boscodon aux Ecrins (38, 05)	Queyras (05)	Vercors (38, 26)	Chartreuse (38)	Belledonne (38)	Maurienne, Vanoise et Ronne (73)	Mt Blanc au Chablais (73, 74)	PNR du Haut Jura (25, 39)	Vosges (90, 88, 68, 70, 67, 57, 54)
BOSTRICHIDAE	*Stephanopachys linearis* (Kugelann)	4	X										4			X	X							
BOSTRICHIDAE	*Stephanopachys substriatus* (Payk.)	/											4				X							
BUPRESTIDAE	*Buprestis rustica* L.	2	X		X	X	X		X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	
BUPRESTIDAE	*Chrysobothris chrysostigma* (L.)	/											2		X		X	X	X		X	X		
BUPRESTIDAE	*Eurythyrea austriaca* (L.)	3	X	X	X	?			X		X		/											
BUPRESTIDAE	*Phaenops knotecki* Reitter	/											4		X									
CERAMBYCIDAE	*Acanthocinus reticulatus* (Razoum.)	3			X	X	X		X	X	X		3	?	X		X		X				X	X
CERAMBYCIDAE	*Acmaeops marginatus* (F.)	3					X		X	X		X	3		X		X							?
CERAMBYCIDAE	*Acmaeops pratensis* (Laicharting)	2				X	X		X	X	X	X	2	X	X		X				X	X		
CERAMBYCIDAE	*Acmaeops septentrionis* (Thomson)	3											3		X		X	X	X				X	
CERAMBYCIDAE	*Acmaeops smaragdulus* (F.)	/											4							X	?	X		
CERAMBYCIDAE	*Anastrangalia reyi* (Heyden)	3				X			X	X		X	3				X		?		?			
CERAMBYCIDAE	*Callidium aeneum* (De Geer)	/											3	?	X		X	X	X	X	X	X	X	X
CERAMBYCIDAE	*Callidium coriaceum* (Paykull)	/											3		X		X	X	X		X	X	X	
CERAMBYCIDAE	*Cornumutila quadrivittata* (Gebler)	/											4				X							
CERAMBYCIDAE	*Judolia sexmaculata* (L.)	3							X	X			3				X				X	X		
CERAMBYCIDAE	*Lepturobosca virens* (L.)	3			X		X			X			2					X	X	X	X	X	X	
CERAMBYCIDAE	*Monochamus sartor* (F.)	/											3		X			X	X		?	X	X	
CERAMBYCIDAE	*Nothorhina muricata* (Dalman)	3					?			X			3		?	?								
CERAMBYCIDAE	*Oplosia cinerea* (Mulsant)	3					X	?	X		?		3		X			X	X	?	?	?	X	X
CERAMBYCIDAE	*Oxymirus cursor* (L.)	2			X	X	X	X	X			X	2		X	X	X	X	X		X	X	X	X
CERAMBYCIDAE	*Pachyta lamed* (L.)	/											4		X				X		X	X		
CERAMBYCIDAE	*Ropalopus ungaricus* (Herbst)	/											4					X	X			?	X	X
CERAMBYCIDAE	*Rosalia alpina* (L.)	2	X	X	X	X	X	X	X		?		3	?	X	X	?	X	X	?	?	X	X	
CERAMBYCIDAE	*Semanotus undatus* (L.)	/											3		X	X		X	X		?	X	X	

CERAMBYCIDAE	*Tetropium fuscum* (F.)	3											3		X				X				X	X
CERAMBYCIDAE	*Tetropium gabrieli* Weise	3											3	X	X	X	X						?	
CERAMBYCIDAE	*Tragosoma depsarium* (L.)	4					X			?			4		X	?	?				?	X		
ELATERIDAE	*Ampedus aethiops* (Lacordaire)	2			?	X	X		X	X			2		X	X	X	X	X	X	X	X	X	X
ELATERIDAE	*Ampedus balteatus* (L.)	3			?		X		X	X			2			X				X	X			X
ELATERIDAE	*Ampedus erythrogonus* (Müller)	3											3	?	X	X		X	X	X	X		X	X
ELATERIDAE	*Ampedus melanurus* (Muls.et Guill.)	3			X	X	X		X		X		3	?	X	X			X					X
ELATERIDAE	*Ampedus nigrinus* (Herbst)	3			X		X		X				3	?	?	X	X	X	X	X	X		?	X
ELATERIDAE	*Denticollis borealis* (Paykull)	/											4					X						
ELATERIDAE	*Denticollis rubens* (Piller & Mitt.)	2			X	X	X	X	X				2	?	X			X	X				X	X
ELATERIDAE	*Harminius undulatus* (De Geer)	3			X	X	X		X	X			3	?	X				X			X	?	?
ELATERIDAE	*Lacon fasciatus* (L.)	3					X						3		X	X	X	X	X		X	X		
ELATERIDAE	*Lacon lepidopterus* (Panzer)	4				X	X						4		X							X		
EUCNEMIDAE	*Epiphanis cornutus* Eschscholtz	4							X				4		X	X	X		X					
EUCNEMIDAE	*Xylophilus corticalis* (Paykull)	3	X		X	X	X		X				3			X			X		?			
LUCANIDAE	*Ceruchus chrysomelinus* (Hochen.)	4							X			?	4	?	X				X	?	?	?	?	X
LYCIDAE	*Benibotarus alternatus* (Fairmaire)	3			X		X	X	X	X	X	X	/											
LYCIDAE	*Dictyoptera aurora* (Herbst)	2			X	X	X		X	X		X	2		X	X	X	X	X			X		X
LYCIDAE	*Lopherus rubens* (Gyllenhal)	3	X			X	?	X			X		3		X				X	X				X
LYCIDAE	*Pyropterus nigroruber* (Degeer)	3						X	X		X		3		X				X	X		X	X	X
MELANDRYIDAE	*Xylita laevigata* (Hellenius)	3			X	X	X						3		X	?	?		X			X	X	X
MELANDRYIDAE	*Xylita livida* (C.R.Sahlberg)	3											3		X	X								X
MELANDRYIDAE	*Zilora sericea* (Sturm)	3				X			X			X	3		X									X
MELANDRYIDAE	*Mycetoma suturale* (Panzer)	3			X	X	X						3											
OEDEMERIDAE	*Calopus serraticornis* (L.)	3				X	X			X		X	3		X						?	?		X
PLATYPODIDAE	*Platypus oxyurus* Dufour	3		X	X	X		X	X		X		/											
PYTHIDAE	*Pytho depressus* (L.)	3					X	?	X	X			3		X	?	X					X		
RHYSODIDAE	*Rhysodes sulcatus* (F.)	4			X	X	?		X		X		3	X							X			
SILVANIDAE	*Dendrophagus crenatus* (Paykull)	4					X			X			4								?	?	?	?
TENEBRIONIDAE	*Bius thoracicus* (F.)	4					X						4								X	X		
TENEBRIONIDAE	*Bolitophagus interruptus* Illiger	4			X	X							4								X	?		
TROGOSITIDAE	*Calitys scabra* (Thunberg)	4					X						/											
TROGOSITIDAE	*Ostoma ferruginea* (L.)	3			X	X	X						3		X			X	X		X	?		X
TROGOSITIDAE	*Peltis grossum* (L.)	4	X		X	X			X				4						X			?		
TOTALLY	X ?		7 0	3 0	20 2	23 1	28 3	7 2	27 0	16 1	10 2	9 1		4 9	36 2	16 4	21 3	20 0	31 1	10 3	18 11	23 8	18 5	21 3

Saproxylic Beetles on Snags and Logs of Oak

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FRANC N., 2005. SAPROXYLIC BEETLES ON SNAGS AND LOGS OF OAK (*abstract*). Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 50.

Abstract: For conservation of forest biodiversity, dead wood in the form of snags or cut high stumps is often left or created when forests are harvested. In Scandinavia, such dead wood usually comes from conifers. In this study, I examined the occurrence of saproxylic beetles trapped at snags and logs of European oaks (*Quercus robur* and *Quercus petraea*) in deciduous and mixed forest of high conservation value. Species richness was significantly higher in traps placed on logs than in those on snags and the community composition of beetles was strikingly different on snags and logs. Many red-listed beetles were recorded, but even though no differences in species richness could be detected between substrates, there are differences in the actual species utilising the different substrates. These results suggest that logs of dead oaks are valuable and that both snags and logs of oak should be retained and created in forestry such that both types of substrate are available over long periods.

Key words: saproxylic, Coleoptera, logs, snags, oak (*Quercus robur* /*Quercus petraea*).

Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles
Rīga / Latvia, 07th-11th July, 2004: 51-67.

The Stag Beetle *Lucanus cervus* (L.) (Coleoptera: Lucanidae) in the County of Suffolk (England): Distribution and Monitoring

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HAWES C.J., 2005. THE STAG BEETLE *LUCANUS CERVUS* (L.) (COLEOPTERA: LUCANIDAE) IN THE COUNTY OF SUFFOLK (ENGLAND): DISTRIBUTION AND MONITORING. Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 51-67.

Abstract: In Suffolk the stag beetle is at the northernmost limit of its principal distribution in the UK. The geographical distribution of the stag beetle in Suffolk is described and a hypothesis presented to explain its restriction to the south east of the county. Stag beetle distribution prediction is discussed, and the likely effects of climatic warming on the insect's geographical range suggested. Data from belt transect surveys of stag beetle road casualties are presented to illustrate a reliable method that can be used to monitor the insect's abundance and population trends. An account of the beetle's sex ratio, sex ratio changes and road casualty sex ratio is provided.

Key words: belt transects, road casualties, population trends, sex ratio, biodiversity action plan.

Nomenclature

A number of vernacular names have been given to *Lucanus cervus* (LINNAEUS, 1758), including Hornbug and Stag Beetle. In this paper only the popular name Stag Beetle is used as an alternative to *L. cervus*.

Introduction

There is considerable anecdotal evidence of declines in local stag beetle abundance in Britain, even in stronghold areas (Percy et al., 2000). Conversely, certain survey results suggest that the species is as abundant as ever and may even have increased its distribution in some localities (Bowdrey, 1997). There is some evidence that the geographical range of the species has decreased in Suffolk (Hawes, 1998), whereas an extension in the beetle's range has been postulated for the county of Sussex (Pratt, 2001).

It is clear from these various reports that a reliable method for measuring stag beetle abundance is required, so that changes in populations can be objectively documented. Such data is essential if the UK Biodiversity Action Plan targets are to be met.

Distribution of *L. cervus* in the UK

In the UK, the stag beetle is on the north-western edge of its European range and is mostly confined to the warmer, drier, south east of England. It is a recognised thermophilous species (Whitehead, 1993). Its distribution is contained almost exactly by the 16.5°C mean July isotherm and is restricted so that the majority of key sites for the insect fall within the 5°C mean isotherm for January (Met.Office; Hawes, in prep. a). The principal regions for the insect are London and the Thames Valley, north Essex, south Suffolk, north Kent and areas along the south coast (Napier, 1999; Percy et al., 2000) (Fig. 1).

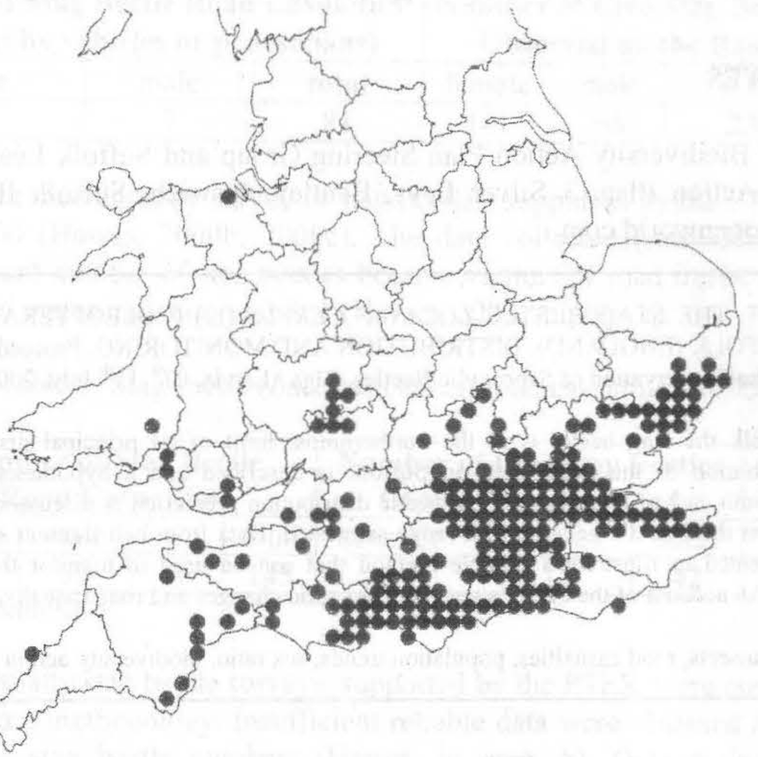

Figure 1. Distribution of the stag beetle (*Lucanus cervus*) in the UK.
PTES 1998 & 2002 survey data. Resolution 10km square (Source: PTES).

The county of Suffolk

Landscape. Part of East Anglia, Suffolk (Vice-counties 25 and 26) (Fig. 2) is a large county covering some 380,000 ha, bounded by Norfolk (V-c 27 and 28), Cambridgeshire (29), Essex (19) and 80 km of North Sea coastline in the east. It is a rural region of scattered villages and wide areas of arable farmland, which rises to no more than 128m in the south-west, falling gradually across central Suffolk to the coast, and the most easterly point of the UK at Lowestoft Ness. The principal landscape features are its estuaries and river valleys (Killeen, 1992; Mendel, Piotrowski, 1986).

Climate. The climate of Suffolk is 'more continental than most parts of the UK, and both diurnal and seasonal ranges of temperature are more extreme. The frequency of warm summer days and the maximum temperatures attained are generally well above those of more westerly counties, and Suffolk enjoys above average daily total hours of sunshine' (Mendel, Piotrowski, 1986). The county has little rainfall, less than 635 mm per annum over much of the area (the average rainfall for Ipswich (1900-2000) is 604.25 mm per annum). The coastal belt is particularly dry.

Geology and soils. A comprehensive description of the county's geology and soils has been given by Killeen (1992), and Martin (in: Dymond, Martin, 1999). Suffolk comprises several distinct regions and landscapes, which are largely the product of different soils. These soils are mostly derived from glacial drift, which masks the solid geology (Martin, in: Dymond, Martin, 1999), chalk forming the dominant underlying rock in western and central Suffolk, and crag in the east. Heavy boulder clay covers most of central Suffolk, giving way on either side to large areas of lighter sandy soils. To the west these overlie the chalk, while in the extreme north-west they dip beneath the peat of the Fen basin. In the east a large complex of well-drained sand and gravel soils cover the crags, except to the south on the Felixstowe and Shotley peninsulas, where the covering is wind-blown loess known as cover loam (Martin, in: Martin, Dymond, 1999).

Figure 2. Geographical position of Suffolk in the UK (Source: SBRC).

Distribution of *L. cervus* in Suffolk

In Suffolk *L. cervus* is at the northernmost limit of its principal distribution in the UK, and is largely confined to the south and east of the county in an area between the rivers Deben and

Stour. There are significant colonies in Ipswich and Woodbridge, which are hotspots for the beetle, as well as Hadleigh and Nayland, and at a number of sites across the Shotley and Felixstowe peninsulas (Hawes, 1998) (Fig. 3. and Fig. 4). The pattern of distribution for the stag beetle in Suffolk illustrated by Hawes (1998) has been confirmed by the national stag beetle surveys undertaken in 1998 and 2002 (Percy et al., 2000; Smith, 2003).

Suffolk stag beetle records

Records for sightings of stag beetles in Suffolk have come from a wide variety of sources. They are scattered thinly in the literature, in newspaper cuttings and among entomological collections. Records have also been provided by the Field Studies Council (Flatford) and members of the Suffolk Naturalists' Society (SNS). The vast majority of records, however, have come from the general public during the stag beetle survey of Suffolk (Hawes, 1998), with further records being added by the general public during the national surveys of 1998 and 2002 (Percy et al., 2000; Smith, 2003).

Pre-1900 records for *L. cervus* in Suffolk are sparse. The first recorded sighting of the beetle appears to be that made by Curtis (1834), but no precise location is given. Some ten Suffolk locations for the insect are recorded in Morley's "Coleoptera of Suffolk" (Morley, 1899), including Ipswich, Belstead, Sproughton and Stratford St Mary, all of which have thriving stag beetle populations today.

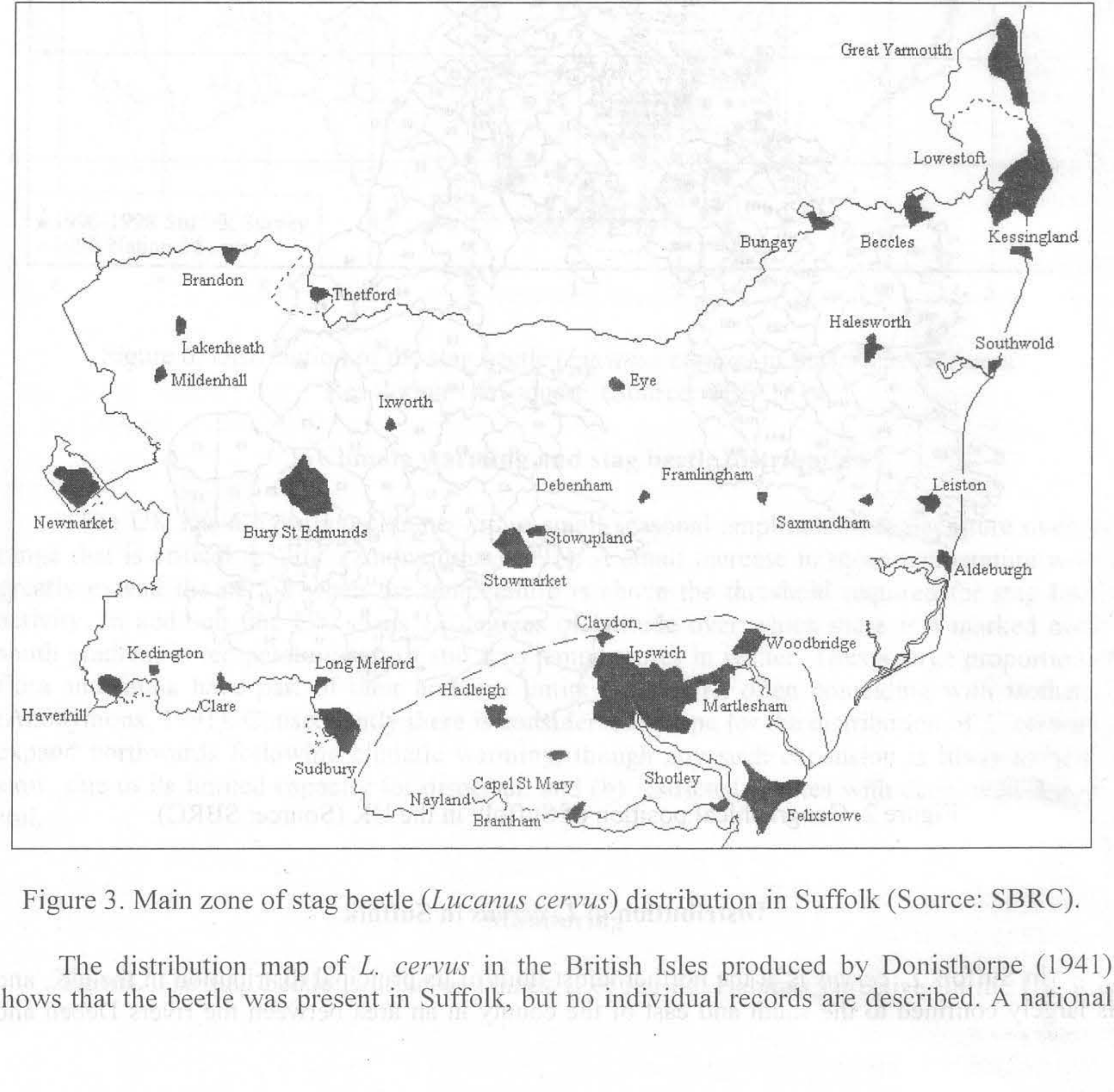

Figure 3. Main zone of stag beetle (*Lucanus cervus*) distribution in Suffolk (Source: SBRC).

The distribution map of *L. cervus* in the British Isles produced by Donisthorpe (1941) shows that the beetle was present in Suffolk, but no individual records are described. A national survey of stag beetles made by Hall (1964) shows only two records for Suffolk, Woodbridge and Woolverstone, both of which are current hotspots for this insect. Clark (1966) brought together some 400 stag beetle records to illustrate the insect's distribution in Britain, but only nine localities were listed for Suffolk. Data collected from the first stag beetle survey of Suffolk (1990-97) showed that the insect was much more widespread in the county than previously described, with records coming from 61 parishes (Hawes, 1998). Additional records have been obtained from the national stag beetle surveys of 1998 and 2002, organised by the People's Trust for Endangered Species (PTES), bringing the total of reported localities (towns and parishes) for the insect in Suffolk to 89 (Table 1).

Table 1. Cumulative Number of towns and parishes in Suffolk with records of stag beetles (*Lucanus cervus*).

Historical records	Pre 1900	11
Historical records	1900-1989	28
Suffolk Survey (Colin Hawes)	1990-1997	61
National Surveys (PTES)	1998 & 2002	89

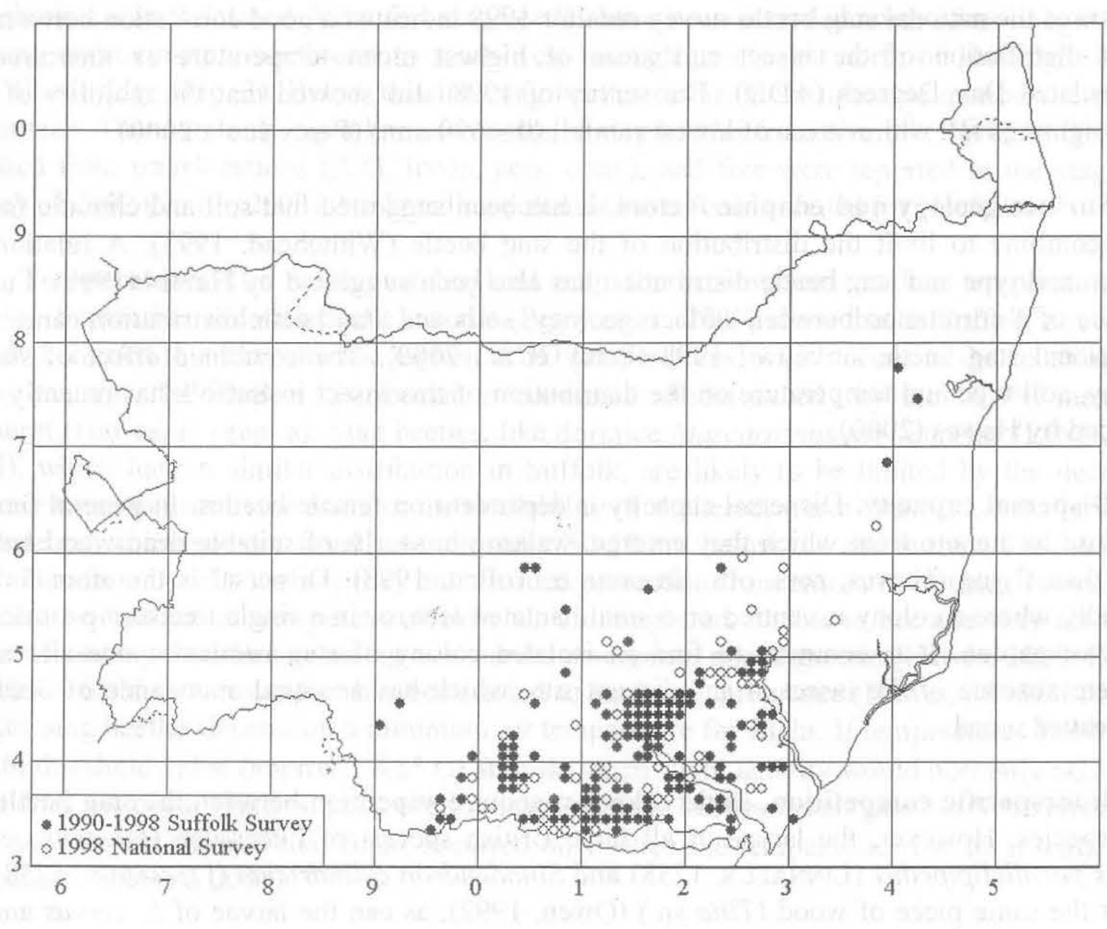

Figure 4. Distribution of the stag beetle (*Lucanus cervus*) in Suffolk. SBRC 1990-1998 survey data. Resolution 1km square (Source: SBRC).

Factors determining distribution

The requirements of a species at every stage of its life cycle will ultimately determine its geographical distribution. Factors affecting the distribution of the stag beetle are likely to be numerous. Dead-wood habitat is known to be essential. The beetle relies on decaying broadleaved wood for oviposition and larval development (Bowdrey, 1997; Hawes, 1998; Hyman (revised Parsons), 1992; Tullett, 1998). Factors which seem to restrict stag beetle distribution, other than the availability of suitable decaying wood, are climate (especially air temperature and annual rainfall), surface geology and soil type (Hawes, 1998; 2000; Napier, 1999; Percy et al., 2000; Pratt, 2001; Tullett, 1998). Dispersal capacity, interspecific competition, predation and other hazards may also influence the insect's distribution (Hawes, 1998, 2000; Tullett, 1998; Percy et al., 2000).

Habitat. The choice of underground sites for ovipositing may be influenced by such factors as the timber's degree of decay, its moisture content and the presence of specific saproxylic fungi (Bowdrey, 1999), but it appears not to be limited to particular species of broadleaved wood. Stag beetle larvae have been found in a wide variety of timbers ranging from indigenous oak (*Quercus* sp.) (Bowdrey, 1997; Hawes, 1998; Percy et al., 2000; Smith, 2002) to non-native Mahonia (*Mahonia* sp.) (Hawes, pers. obs., 2004).

Climate. A possible association between stag beetle distribution and areas that experience mean summer temperatures above a certain threshold value was suggested by Hawes (1998). Analysis of the national stag beetle survey data for 1998 indicated a good correlation between the current distribution of the insect and areas of highest mean temperature as measured by Accumulated Day Degrees (ADD). The survey of 1998 also showed that the majority of stag beetle sightings fall within areas of lowest rainfall (0 – 690 mm) (Percy et al., 2000).

Surface geology and edaphic factors. It has been suggested that soil and climatic factors might combine to limit the distribution of the stag beetle (Whitehead, 1993). A relationship between soil type and stag beetle distribution has also been suggested by Hawes (1998). Further evidence of a correlation between surface geology, soils and stag beetle distribution came from the national stag beetle survey of 1998 (Percy et al., 2000). The combined effect of surface geology, soil type and temperature on the distribution of this insect in Suffolk has recently been described by Hawes (2000).

Dispersal capacity. Dispersal capacity is dependent on female beetles. In general females stay close to the site from which they emerge, walking in search of suitable dead wood habitat, rather than flying (Hawes, pers. obs., in prep. a; Tullett, 1998). Dispersal is therefore limited, especially where a colony is centred on a small isolated area, or in a single tree stump situated in a park or garden. It is common to find an isolated colony of stag beetles at one site and a complete absence of the insect at an adjacent site, which has an equal abundance of decaying broadleaved wood.

Interspecific competition. Little is known about competition between the stag beetle and other species. However, the larvae of all three British species of Lucanidae (*Lucanus cervus, Dorcus parallelipipedus* (LINNAEUS, 1758) and *Sinodendron cylindricum* (LINNAEUS, 1758) can inhabit the same piece of wood (*Tilia* sp.) (Owen, 1992), as can the larvae of *L. cervus* and the long-horn beetle *Prionus coriarius* (LINNAEUS, 1758), which have been found together in decaying sycamore (*Acer pseudoplatanus* LINNAEUS, 1758) (Hawes, pers. obs., 2004). An association of *L. cervus, D. parallelipipedus* and *P. coriarius* has also been reported (Sprecher, 2003). Rose chafer (*Cetonia aurata* (LINNAEUS, 1758)) and stag beetle larvae have also been found inhabiting the same piece of decaying wood (Harvey, Gange, 2003).

Predation and other hazards. The magpie *Pica pica* (LINNAEUS, 1758) is well documented as a major predator of stag beetles (e.g. Verdcourt, 1988; Baker, 1990; Bowdrey, 1997; Hawes, 1998; Percy et al., 2000; Smith, 2003). Other predators include hedgehog *Erinaceus europaeus* LINNAEUS, 1758 and fox *Vulpes vulpes* (LINNAEUS, 1758) (Hawes, 1998; Klausnitzer, 1995; Percy et al., 2000), woodpecker spp. and badger *Meles meles* (LINNAEUS, 1758) (Hawes, 1998; Klausnitzer, 1995), and thrush (*Turdus philomelos* BREHM, 1831) (Hawes, 1998).

In addition, many stag beetles become the unwitting victims of road traffic (Bowdrey, 1997; Hawes, 1998; Percy et al., 2000). The number of stag beetle road casualties reported by Bowdrey (1997) and Hawes (1998; SNS Newsletters 47, 53, 54, 55, 56, 57; Hawes, in prep. b) suggest that road traffic is a significant cause of death. Low fecundity (Harvey, Gange, 2003) and high mortality, due mainly to magpies and road traffic, limit the number of stag beetles available to breed and disperse.

A hypothesis for stag beetle distribution in Suffolk

The geographical distribution of *L. cervus* in Suffolk appears to be determined by a combination of temperature, annual rainfall, surface geology and soil type (Hawes, 2000). The distribution is well defined. Very few stag beetles have been recorded north of an imaginary line running approximately north-east to south-west through points just north of Hadleigh, Ipswich and Woodbridge (Fig. 3). Below this line stag beetles occur in considerable numbers, especially in Ipswich. There are only eight known records of stag beetles from Norfolk. Three of these have resulted from translocations (A.G. Irwin, pers. com.), and five were reported in the stag beetle survey of 2002 (Smith, 2003). No breeding colonies have been recorded for Norfolk.

Temperature. The south-east England map for accumulated median temperature from April to September and stag beetle records (Percy et al., 2000) show that in Suffolk *L. cervus* is largely confined to areas with the highest ADD temperatures, which occur in the south and east of the county. The beetle's distribution is contained almost exactly by the 16.5°C mean July isotherm (Hawes, in prep. a). Stag beetles, like dormice *Muscardinus avellanarius* (LINNAEUS, 1758), which have a similar distribution in Suffolk, are likely to be limited by the decreasing summer temperatures to the north or the availability of sheltered, warm sites. *L. cervus* larvae and pre-emergence imagos are usually found some 30-50 cm below the soil surface (Tochtermann, 1987; Hawes, pers. obs.) where they are afforded protection from extremes of temperature. There will also be a minimum temperature below which imagos are unable to become very active. Air temperature may therefore be acting as a cue for emergence above ground (Hawes, 2000; Percy et al., 2000). Cold or wet weather has been noted to set back emergence (Hawes, 1998). Like most insects, stag beetles depend on a minimum air temperature for flight. If temperatures fall below a certain threshold value (approx. 16.5° C) at dusk, when flight activity would normally take place, flight does not occur (Hawes, pers. obs.; in prep. a). Stag beetles investigated in Switzerland over a ten year period showed that flight occurred only when the temperature rose to at least +16°C (Sprecher-Uebersax, 2001).

Cities and towns are generally warmer than rural areas with the same latitude, especially in winter. The mean 4°C January isotherm illustrates the difference, deviating round large built up areas, such as London and Southampton (stag beetle hotspots), which are thus contained by the 5°C mean January isotherm (Met. Office). The milder conditions created in cities, and towns like Ipswich in Suffolk, may be important in determining stag beetle distribution and account for the large populations which have been recorded in urban environments.

Rainfall. The distribution of *L. cervus* falls within areas which have the lowest rainfall in

Suffolk.

Soils. Examination of stag beetle distribution data overlaid on maps of surface geology, soils and rivers of Suffolk shows that the insect's strongholds occur predominantly on deep, well-drained, loamy soils overlying sands and gravels (Fig. 5), and on the loamy soils of river corridors (Fig. 6). Areas of clay and chalk seem to be avoided (Hawes, 1998, 1999, 2000; Napier, 1999). Soil plays an important role in the life of the beetle.

- burrowing is common throughout the breeding season, adults of both sexes spending a considerable time below ground (Harvey, Gange, 2003).
- eggs are usually laid 30-50 cm below ground level (Tochtermann, 1992), the female burrowing down through the soil to reach a suitable ovipositing site adjacent to decaying wood (Harvey, Gange, 2003) .
- larval life is spent in decaying wood, but movement occurs back and forth between wood and soil over the period of development, which lasts up to six years (Harvey, Gange, 2003).
- larvae move into the soil to pupate, where they use soil particles and secretions to build a large, underground pupal cocoon (Harvey Gange, 2003; Hawes, 2000; Horion, 1958; Palm, 1950).
- adult beetles emerge from their cocoons in late summer, but stay quiescent underground up to 45 cm below the soil surface over winter (Harvey Gange, 2003).
- the beetles emerge above ground by digging an almost vertical tunnel to the surface (Klausnitzer, 1995), when temperatures rise in late May to early June.

Burrowing, cocoon building, adult subterranean quiescence and emergence above ground could all be affected by soil type, the physical properties of different soils enhancing or limiting the beetle's ability to inhabit particular areas (Hawes, 2000). Heavy clay soils are likely to be unsuitable for stag beetles, becoming either too sticky and/or waterlogged in wet weather, or too dried and hard in the summer, conditions which would restrict burrowing, emergence and mobility of the larvae when moving back and forth between their feeding substrate and the soil, as well as when taking to the soil to pupate. Thin soils over chalk do not provide the depth that seems to be required for ovipositing, whilst heathland soils, found in the 'Sandlings' region of the Suffolk coastal belt to the north of the River Deben, are perhaps too light and dry to provide the moisture requirements of the insect. Stag beetle larvae are noted to have a higher moisture requirement than their closest British relatives (Klausnitzer, 1995).

Deep, loamy, well-drained soils seem to provide the best edaphic conditions for stag beetles. Good drainage is vital. Many larvae and underground quiescent adults are likely to drown in waterlogged ground, as happened during a period of above average, prolonged, excessive rainfall in Suffolk from October 2000 to well into March 2001 (Hawes, 2002). Excess rain is likely to have more impact on quiescent females than males, as females are reported to lie deeper in the soil than males (Tochtermann, 1992). There is a strong correlation between stag beetle distribution and areas that have soils with low moisture content (high moisture deficit, as measured by the moisture required to grow winter wheat). Loamy soils are usually well aerated and provide a plentiful supply of oxygen for subterranean insect respiration, but at the same time retain sufficient moisture for larval development, whilst their crumb structure allows both adult and larval stages to burrow with little difficulty (Hawes, 2000). Light, well-drained loamy and sandy soils, like those found to the south and east of Suffolk, warm up more quickly in spring and summer than clay soils, benefiting both developing larvae and adults ready to emerge.

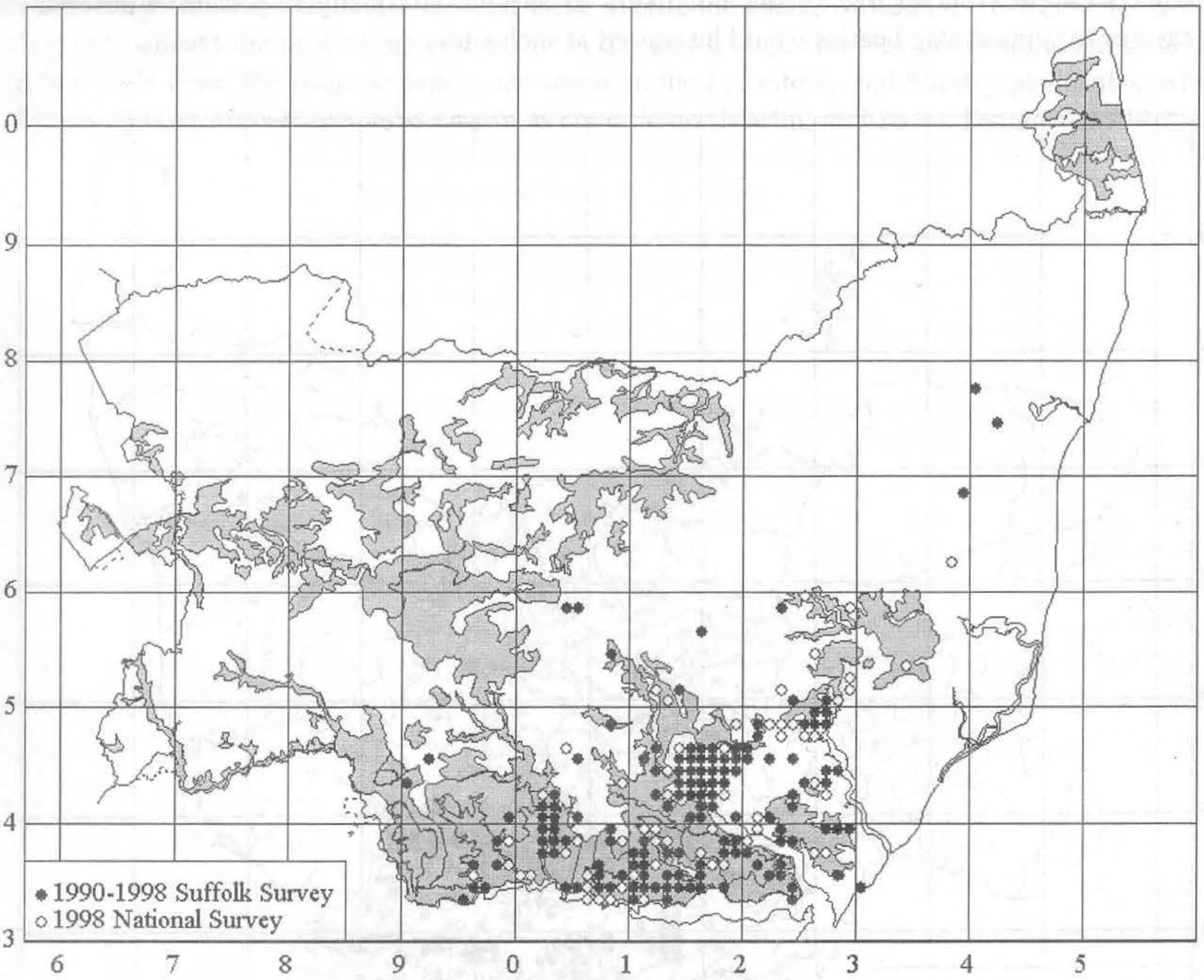

Figure 5. Distribution of the stag beetle (*Lucanus cervus*) in Suffolk, with light, well-drained soils. Resolution 1km square. (Source: SBRC).

The majority of records collected in the stag beetle survey of Suffolk (Hawes, 1998) came from urban, suburban and village gardens, and adjacent streets. Gardens, both in urban and rural areas provide important suitable habitat for the species. Over 70% of records obtained in each of the national stag beetle surveys (1998 and 2002) came from private gardens (Percy et al., 2000; Smith, 2003). Britain is a land of gardeners, and many gardens have deep, improved soils with good drainage, prepared for growing vegetables, flowers, shrubs and trees. Such soils provide ideal conditions for the beetle, and perhaps occasionally allow stag beetle colonisation in areas where the original soil type would have been unsuitable for the species.

Stag beetle occupancy prediction

Combined climatic and soil requirements, which seem to limit the distribution of stag beetles, may be important in predicting where this species could survive (Hawes, 2000; Napier, 1999) and might be present, even where there are no current records for the insect. In Suffolk, stag beetle occupancy predictions have been tested in the field. Twenty sites were chosen, each with suitable climate and soil type for stag beetles but no known records of the species, and volunteers were asked to look out for the insects (Hawes, 1999a). Stag beetles have so far been reported at two of these locations, Claydon and Wickham Market (Hawes, 2000b). The ability to predict areas where stag beetles are not likely to survive is equally important. Conservation measures to support stag beetles would be wasted at such sites.

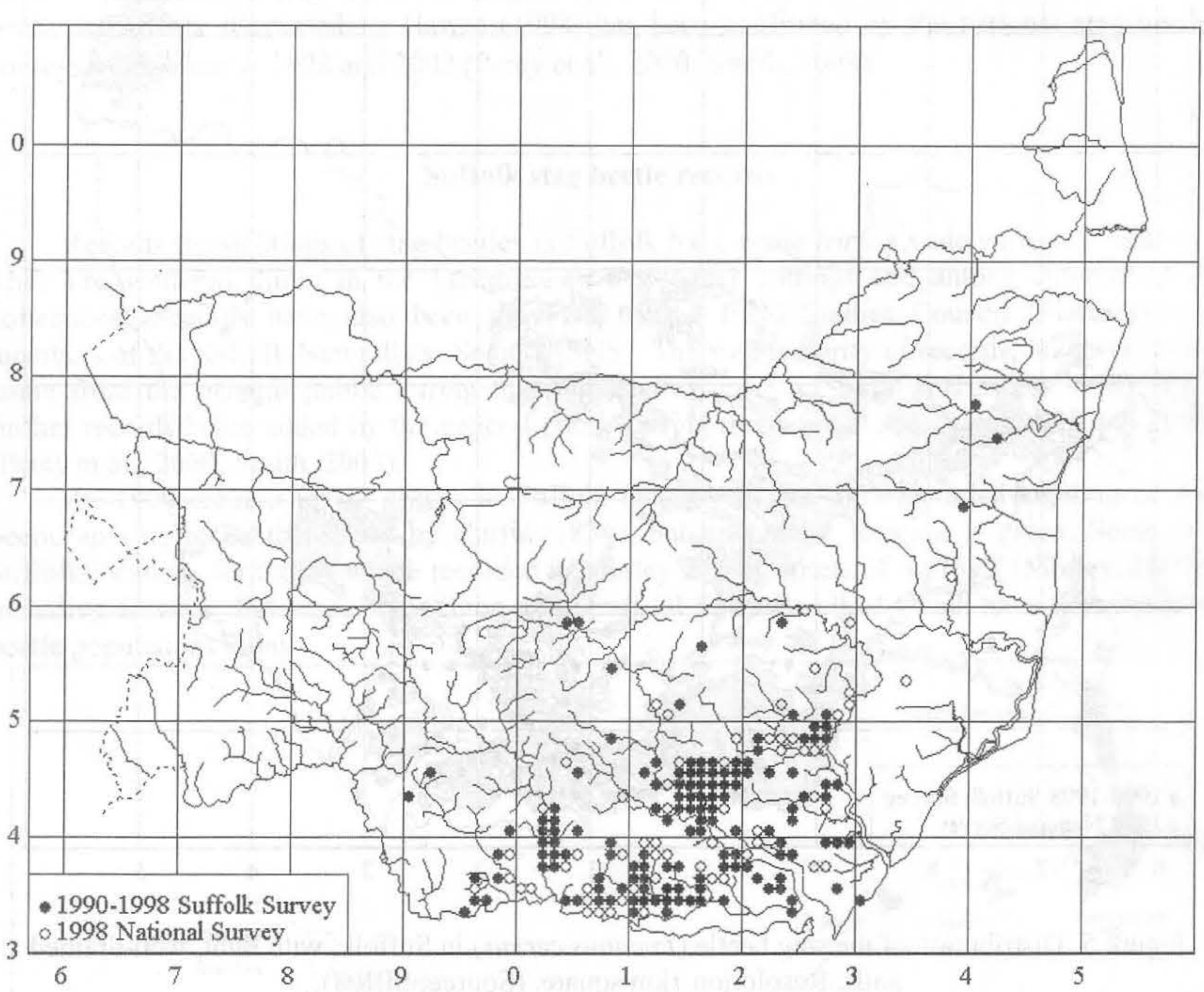

Figure 6. Distribution of the stag beetle (*Lucanus cervus*) in Suffolk, with rivers. Resolution 1km square. (Source: SBRC).

Climate warming and stag beetle distribution

'The UK has a maritime climate with a small seasonal amplitude in temperature over the range that is critical for life' (Anonymous, 1991). A small increase in mean temperature would greatly extend the period when the temperature is above the threshold required for stag beetle activity. In addition, the UK spans 11 degrees of latitude over which there is a marked north-south gradient in temperature and of sub zero temperatures in winter. Thus a large proportion of flora and fauna have part of their northern limits in the UK, often coinciding with isotherms (Anonymous, 1991). Consequently there is considerable scope for the distribution of *L. cervus* to expand northwards following climatic warming, though any such expansion is likely to be (a) slow, due to its limited capacity for dispersal, and (b) restricted to sites with deep, well-drained soil.

Monitoring

Status. The stag beetle is listed on Annex II of the EC Habitats Directive. In the UK it is classed as Nationally Scarce (Notable B) and is listed on Schedule 5 of the Wildlife and Countryside Act, making it illegal to trade in the species. It is a Priority Species in the UK Biodiversity Action Plan (UK BAP). Management of the UK BAP is led by the PTES.

UK Biodiversity Action Plan targets. The current targets (reviewed and revised 2001) are:

1. to maintain the population size at all key sites;
2. to maintain the current geographical range.

To achieve these aims, stag beetle populations need to be monitored. This requires regular, targeted surveys to be undertaken at:

1. key stag beetle strongholds/sites;
2. sites with stag beetle populations at the edge of the insect's geographical range.

Further distribution research is also required to ensure that areas with possible stag beetle populations are not excluded, for example:

1. sites from which there are no recent stag beetle records, but where records of the insect have been made in the past.
2. sites with singleton records of the beetle (especially in rural locations where the human population is sparse), which may hold breeding colonies.

Stag beetle abundance and population trends are currently being investigated using trapping methods and road casualty surveys. Garden surveys have also undergone trials.

Trapping. Live specimens of stag beetles have been captured using baited traps of two types:

1. window flight-interception;
2. pitfall.

Annual capture data, as yet unpublished, are being collated as part of postgraduate research at Royal Holloway London University.

Road casualty surveys. Every year numerous stag beetles are crushed on roads. Observations of stag beetle road casualties have proved useful in helping to determine presence or absence of *L. cervus* at a locality. Records of stag beetle road-traffic victims found along some of the roads in the village of Bentley, Suffolk are illustrated in Table 2 (Hawes, 1998). The records and the dead beetles were collected during regular daily walks along the same route over a period of nine years. This data, along with that assembled by Bowdrey (1997), suggested road traffic as a significant cause of stag beetle mortality (Hawes, 1998). Additionally, the 1989-1997 data indicated that female beetles were more likely to become victims of road traffic than males. The large number of stag beetle corpses counted on roads and the road casualty difference between the sexes suggested that annual road casualty surveys might be a useful tool for monitoring stag beetle population trends (Hawes, 2000a).

Table 2. Stag beetle (*Lucanus cervus* road casualties in Bentley, Suffolk (1989-1997).

Number of Stag Beetle Road Casualties (crushed by vehicles or pedestrians)			Number of Live Stag Beetles Observed on the Road		
female	male	**total**	female	male	**total**
74	7	**81**	141	98	**239**

A successful pilot road casualty survey of stag beetles, supported by the PTES, was carried out in Suffolk in 2000 (Hawes, 2000b; 2000c). The data collected (summarised in Table 3) showed that a significant number of stag beetles became victims of road traffic and that female casualties outnumbered males in a ratio of 3.3: 1 (Hawes, 2003, in prep. b).

Table 3. Stag beetle (*Lucanus cervus*) road casualties. Suffolk Survey 2000.

Number of Surveyors	Number of Stag Beetle Road Casualties				Number of Live Stag Beetles Observed on the Road			Total Number of Beetles
	female	male	?	**total**	female	male	**total**	
10	99	30	16	**145**	27	15	**42**	**187**

? = beetle's sex unidentifiable.

National road casualty stag beetle surveys, supported by the PTES, were conducted in 2001 and 2003 using the same methodology. Insufficient reliable data were obtained in 2001 to draw any conclusions about stag beetle numbers (Hawes, in prep. b). Data collected during the successful survey of 2003 (summarised in Table 4) supported the findings of the earlier survey in 2000, the female to male road death ratio being 2.4 : 1. The combined results for the 2000 and 2003 surveys, which are presented in Table 5, gave a mean value for the ratio of female to male beetles killed on the road of 2.9 : 1 (Hawes, in prep. b). Results obtained from the road casualty survey of stag beetles carried out in 2004 (not available at the time of the 3rd Pan-European Saproxylic Beetle Conference) were substantially similar to those collected in 2000 and 2003 and gave a female to male road death ratio of 3.4 : 1 (Hawes, in prep. b). The mean value for the ratio of female to male stag beetle road deaths for all three surveys (2000, 2003 & 2004) is 3 : 1.

Table 4. Stag beetle (*Lucanus cervus*) road casualties. National Survey 2003.

Number of Surveyors	Number of Stag Beetle Road Casualties				Number of Live Stag Beetles Observed on the Road			Total Number of Beetles
	female	male	?	**total**	female	male	**total**	
15	55	23	11	**89**	23	20	**43**	**132**

? = beetle's sex unidentifiable.

Table 5. Stag beetle (*Lucanus cervus*) road casualties. Combined Suffolk and National Surveys (2000 and 2003).

Number of Surveyors	Number of Stag Beetle Road Casualties				Number of Live Stag Beetles Observed on the Road			Total Number of Beetles
	female	male	?	**total**	female	male	**total**	
25	154	53	27	**234**	50	35	**85**	**319**

? = beetle's sex unidentifiable

Further annual road casualty surveys of stag beetles are planned.

Road casualty survey conclusions

- Local and national annual road casualty surveys of stag beetles have in most cases been successful.
- The surveys have been shown to provide a useful means of monitoring stag beetles.
- If carried out at regular intervals, say annually, such surveys could be used to give an indication of trends in stag beetle abundance.
- An annual index of stag beetle abundance can be calculated(Hawes, in prep. b).
- The sex ratio of stag beetle road casualties can be determined (Hawes, in prep .b).
- The transect method used for surveying stag beetle road casualties has proved reliable both at local and national levels.
- The surveys were easily repeatable, could be carried out quickly and required no special equipment.
- No special training was required, except to ensure that surveyors were able to recognise male and female stag beetles.
- The surveys have been carried out along roads of all types, as well as tracks, footpaths and pavements (Hawes, 2004).
- A guidance for surveyors booklet 'The Stag Beetle Road-Kill Survey' containing survey instructions (designed and revised by Hawes; produced by the PTES), issued to all surveyors, proved effective and easy to use (Hawes, 2004).

Data collected from transect walks at dusk (21.30 – 22.00 hrs) in June at some Suffolk locations, when stag beetle activity is at its peak, have also been used to calculate an index of abundance for the insect (Hawes, in prep. a).

Sex ratio

Since it is only the females that lay eggs, the ratio of females to males in a population (sex ratio) is a matter of significance. Most dioecious organisms produce roughly equal numbers of male and female offspring and evolution maintains a stable ratio of 1 : 1. Biased sex ratios do occur in nature and can be found among the Coleoptera, e.g in Coccinellidae (Majerus, 1994), but evidence suggests that stag beetles have an unbiased sex ratio. Of the total number of sightings where sex was distinguished (1,270 individuals) in the stag beetle survey of north-east Essex, 52% were of males and 48% of females (Bowdrey, 1997). An analysis made by Hawes of the number of stag beetle sightings noted in the two national surveys of 1998 and 2002, where sex was recorded, showed a total of 8,334 (54.3% males : 45.7% females) and 3,189 (51.9% males : 48.1% females) respectively. The average male to female sex ratio for all three surveys is 1.1 : 1 (Hawes, in prep. b).

Sex ratio changes

Hall (1961) and Clark (1964) suggested that male stag beetles become active about a week before the females. These observations are supported by the records received during the survey of stag beetles in Suffolk (Hawes, 1998) and those from the national surveys (Percy et al, 2000; Smith, 2002). Harvey & Gange (2003) also reported that the first emergent beetles were male, with the females emerging a week or so later.

As the stag beetle 'season' progresses, females become more abundant than males, the latter dying and declining in number after mating. Tochtermann (1992) recorded the ratio of female to male beetles as 1 : 3 or 4 at the start of the activity phase, 1 : 1.5 after three weeks and 1 : 0.5 to 0.7 for the final week of activity. The 1996 survey of stag beetles in north-east Essex revealed that males dominated in June (63.6% : 36.4%) and females in July (57.5% : 42.5%) and in August (76.6% : 23.4%) (Bowdrey, 1997). An analysis of the national survey stag beetle records for 1998 and 2002, made by Hawes, showed a similar pattern of change in the sex ratio over the period of adult beetle activity, males outnumbering females during May and June (1998. 61.3% : 38.7%; 2002. 64.2% : 35.8%), females dominating in July and August (1998. 61.7% : 38.3%; 2002. 65.2% : 34.8%) (Hawes, in prep. b).

Sex ratio of stag beetle road casualties

Although stag beetles produce roughly equal numbers of male and female offspring, female stag beetle road casualties, on average, outnumber those of males by approximately 3 : 1. A possible explanation for this difference lies in the locomotory behaviour of the two sexes. Though both sexes can fly, males have a greater propensity to be on the wing than females (Drake. 1994; Hawes, pers. obs., in prep.a; Hyman (revised Parsons), 1992; Mamonov, 1991; Radnai, 1995). Females spend most of their active time on the ground searching for suitable habitat in which to lay their eggs, whereas males spend more time in the air seeking out females with which to mate (Hawes, pers. obs.; in prep.a). As a result female beetles are more likely to be found crawling on footways and highways than males, where they are vulnerable to passing pedestrian and vehicular traffic (Hawes, 2002, 2003). It is possible, too, that crawling females find roads attractive due to the heat retained by the highway's surface (Bowdrey, 1997; Hawes, in prep. a), as can be the case with other fauna (Slater, 1994).

The shift in sex ratio from male to female dominance as the stag beetle season progresses affects road casualty numbers for both sexes from week to week over the period of adult activity (Hawes, in prep.b).

Other factors may also be involved in determining the sex ratio of stag beetle road casualties including stag beetle longevity and attempted necrophilia. In captivity, female beetles have been shown to live an average of thirteen days longer than males (Rockstein, Miguel, 1972). If the same longevity is characteristic of beetles in the wild, the chance of females becoming victims of pedestrian or vehicular traffic is greatly increased. There are numerous reports of male stag beetles attracted to female road casualties (e.g. Bowdrey, 1997; Clemens, 1982; Langton, 1967). In most cases, the female had been crushed, possibly causing the release of sex pheromones (Bowdrey, 1997). Males have also occasionally been observed attempting to mate with female corpses on roads (Bowdrey, 1997; Clemens, 1982). Live females on roads can also attract males, sometimes in twos or threes (Hawes, pers. obs., in prep. a, in prep. b). Males lured to roads often become road casualties themselves (Hawes, in prep. b).

The large number of stag beetles killed by pedestrian and vehicular traffic is likely to have a significant local impact on colonies of *L. cervus*, not least because of the loss of potential offspring from gravid female casualties.

Humans, it seems, are a major cause of stag beetle mortality. Twice as many beetle deaths were documented in the national survey of 1998 as directly or indirectly caused by humans than by their main predator, the magpie (*Pica pica*) (Percy et al., 2000).

Summary – Key Points

- Stag beetles are largely restricted to the south and east of Suffolk.
- There is a strong correlation between stag beetle distribution, high ADD temperatures and low rainfall.
- Stag beetle distribution is contained almost exactly by the 16.5°C July and 5°C January isotherms.
- Stag beetles are largely restricted to soils which:
    - are well-drained
    - are deep and loamy or sandy
    - do not become waterlogged
    - warm up quickly in spring and summer
    - provide the physical properties that enable beetles and larvae below the surface to move easily from place to place.
- There appears to be a correlation between stag beetle distribution, deep well-drained soils and glaciofluvial or aeolian drift geology.
- There appears to be a close association between the distribution of the stag beetle and the river corridors of Suffolk.
- Stag beetles are absent from the boulder clay and chalk.
- Gardens often provide ideal habitat for stag beetles, especially when the soil has been 'improved'.
- A combination of high ADD temperatures, low rainfall and well-drained soil seems to provide the best conditions for stag beetles.
- Predictions of probable stag beetle occupancy can be based on temperature and soil map data.
- Road casualty transect surveys of stag beetles:
    - can be carried out in daylight
    - are easily repeatable
    - can be used to indicate the presence or absence of stag beetles at a locality
    - provide data which can be used to calculate an annual index of stag beetle abundance
    - provide data which can give an indication of trends in stag beetle abundance
    - provide stag beetle sex ratio data.

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Diversity of "Saproxylic" Beetles in the Past, as Represented in the Catalogue of the World Fossil Coleoptera at www.zin.ru/animalia/coleoptera/eng/paleosys.htm

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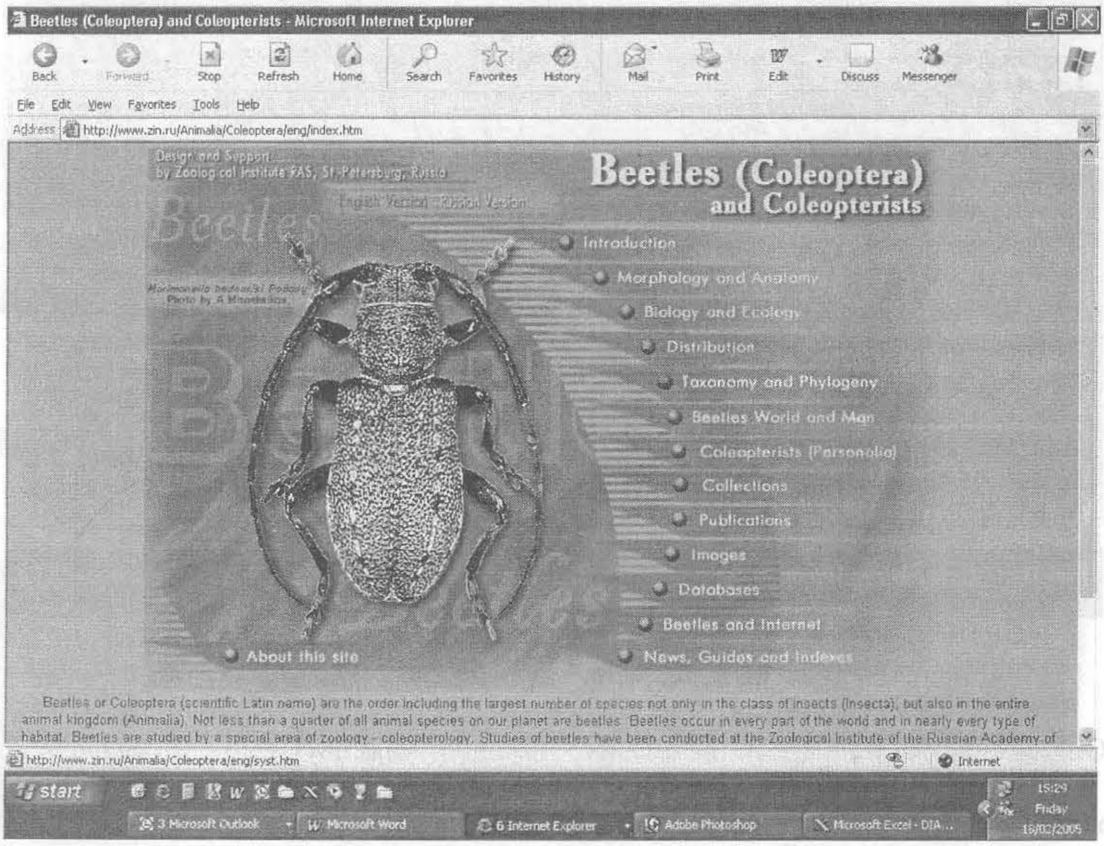
KIREJTSHUK A.G., 2005. DIVERSITY OF "SAPROXYLIC" BEETLES IN THE PAST, AS REPRESENTED IN THE CATALOGUE OF THE WORLD FOSSIL COLEOPTERA AT www.zin.ru/animalia/coleoptera/eng/paleosys.htm Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 68-78.

Abstract: This paper shows that understanding of the phylogeny of the Coleoptera is scarcely possible without taking the evolutionary past into consideration. For now, most fossils recovered remain undescribed. Although a lot of data has already been published, coleopterists working with the systematics and phylogenetic reconstructions of the order rarely use these data. The catalogue of fossil Coleoptera represented on the WEB-site of the Zoological Institute of the Russian Academy of Sciences gives some important information to compensate this gap in knowledge. The list of depository sites of known fossil beetles, along with their stratigraphic attribution, detailed bibliography and a table summarizing data on fossil records supplement the lists of fossil taxa.

Key words: Coleoptera, Fossil records, catalogue, stratigraphic attribution, bibliography, Internet

Beetles with some association with wood represent a considerable proportion of the recent coleopterous diversity. Most coleopterous groups have greater or lesser connections with decaying trees. Even water beetles such as Gyrinidae in some cases use the trunks of old trees for pupation (Kirejtshuk, 2001), and many others use them for shelter. According to the previous symposium [on "saproxylic" beetles] in the fauna of Great Britain, true "saproxylic" beetles compose 6% of the order (Alexander, 2002) and in the Latvian fauna about 10% (Telnov, 2003). At the same time we can assume that, in tropical rainforest communities, this proportion will be considerably greater. It is thought that the first Coleoptera were associated with subcortical space of trees and other interstices (crevices) on trees containing fungi and decomposing microorganisms (Ponomarenko, 1969; Crowson, 1981 etc.). Evolution of beetles associated with subcortical space was discussed at the previous symposium (Kirejtshuk, 2003). It was pointed out that during the whole history of the order, trees provided localities for the survival of archaic forms on the one hand, and an environment for substantial transformations of young groups with a great evolutionary potential, on the other. Despite the absence of fossils connecting the Permian and Mesozoic xylophilous forms (Ponomarenko, 2003), it would be reasonable to admit that dead and damaged trees have been used by beetles during the whole period of their evolutionary history. Although it would be important to mention Ponomarenko's note (Ponomarenko, 2003) that the absence of xylophagous forms coincided chronologically with the gap in coal deposition (Retallack et al., 1996).

At the 2nd and 3rd symposia on "saproxylic" beetles (London in 2002, and Riga in 2004), discussions on the term "saproxylic" sometimes occurred. If we use this term in a strict meaning, it should designate only the forms inhabiting trees or in parts of trees which are subject to decay. Usually some participants of the mentioned symposia referred to the publication by F. Silvestri in 1913, who proposed term "saproxylophiles" for forms coming to the decomposed wood from soil ("sapros" meaning decay in Greek). This word was transformed into "saproxylique" and used similarly by R. Dajoz (1966, etc.). Such an interpretation of the term is quite correct in the semantic sense. Later R. Dajoz (2000, etc.) somewhat increased the meaning of this term by adding to such forms species associated with dry wood. Nevertheless, his concept remains comparable with the initial one. Some recent workers changed the meaning of this word still more in a new combination "saproxylic complex", including all the components, which could visit dead trees and their parts (except for foliage and inflorescences). If the "saproxylic complex" is to be regarded as a strict term, the "saproxylic species" can give the wrong impression. Excepting some specialized species, very frequently the forms which are more or less characteristic of dead decaying tree parts, can also live in damaged, but still living trees with sap exuding and being fermented by yeast and microbes. On the other hand, it is difficult to apply this term to predaceous forms, which regularly visit such habits, but have no obligatory association with them. In different presentations of both the mentioned symposia, some authors considered among "saproxylic" taxa even species that are certainly associated with soil fungi.

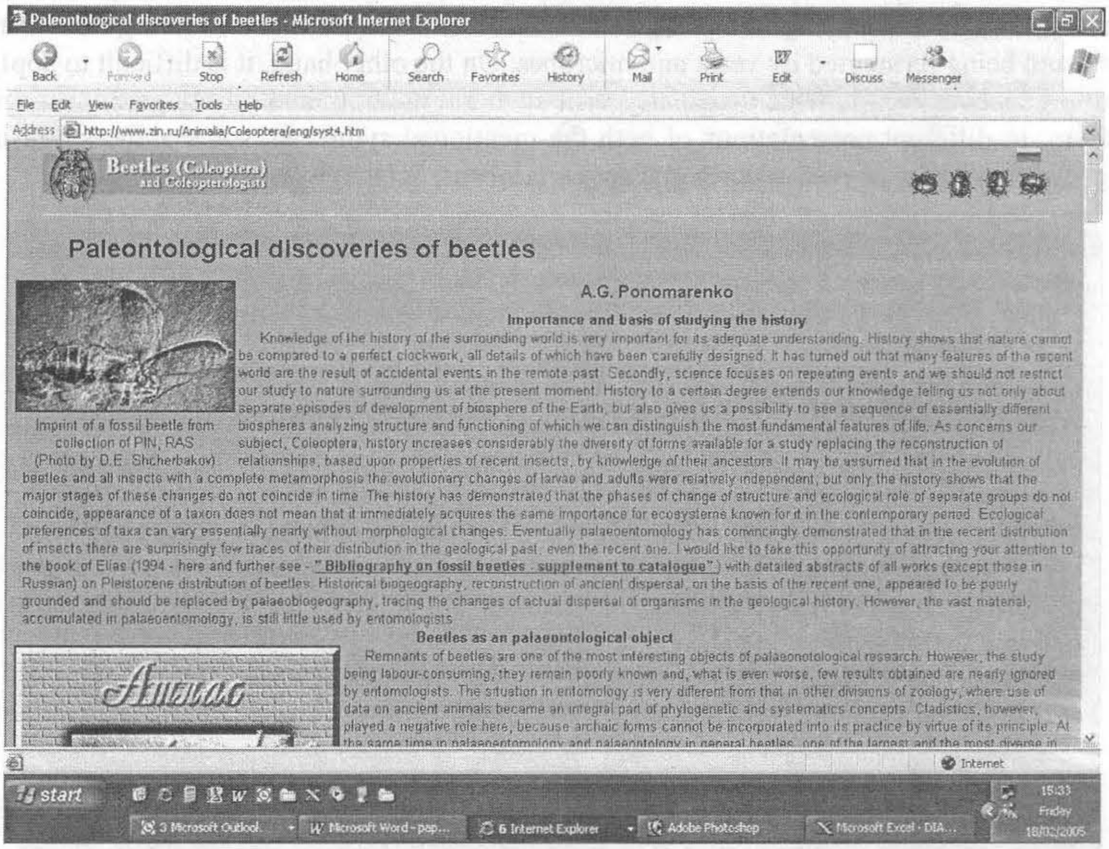


Beetles or Coleoptera (scientific Latin name) are the order including the largest number of species not only in the class of insects (Insecta), but also in the entire animal kingdom (Animalia). Not less than a quarter of all animal species on our planet are beetles. Beetles occur in every part of the world and in nearly every type of habitat. Beetles are studied by a special area of zoology - coleopterology. Studies of beetles have been conducted at the Zoological Institute of the Russian Academy of

Figure 1. Page with index of divisions of the site.

Thus, this term seems to have become rather devalued and unclear. Perhaps, it would be advisable in many cases to use the nomenclature developed in the beginning and middle of the last century, and still recognized among many entomologists and specialists in forestry (including R. Dajoz in the publications discussed; Mamaev, 1977, etc.), which is composed of 3 semantic roots: first indicating the substrate of inhabitation, second the substrate of feeding, and finally the suffix "phage" or "biont". Not infrequently, regular visitors to decaying wood could be called "xylomycetophages" or "xylomycetobiontes", meaning that they live in wood and feed on fungal components in this substrate. Consistently the term "saproxylomycetophages" or "saproxylomycetobiontes" are applied to forms which would have been referred to by F. Silvestri as "saproxylophiles". "Saproxylic" can be applied to assemblages of insects in certain habits, but it would be better to indicate individual species using a more concrete term.

It seems to be appropriate to draw the attention of specialists on xylobiotic (xylobious) beetles to the resources of data that is quite important to explain ecological processes, their origin and changes in time. I have in view the historical aspect of consideration of interactions between insects and wood substrate. In some sense this report is a continuation and illustration for the presentation at the 2nd symposium in London (Kirejtshuk, 2003). This material has already been posted on the website "Beetles (Coleoptera) and coleopterists" (Fig. 1. - http://www.zin.ru/Animalia/Coleoptera/eng/index.htm) and has potential for future improvement.



Paleontological discoveries of beetles

A.G. Ponomarenko

Imprint of a fossil beetle from collection of PIN, RAS (Photo by D.E. Shcherbakov)

Importance and basis of studying the history

Knowledge of the history of the surrounding world is very important for its adequate understanding. History shows that nature cannot be compared to a perfect clockwork, all details of which have been carefully designed. It has turned out that many features of the recent world are the result of accidental events in the remote past. Secondly, science focuses on repeating events and we should not restrict our study to nature surrounding us at the present moment. History to a certain degree extends our knowledge telling us not only about separate episodes of development of biosphere of the Earth, but also gives us a possibility to see a sequence of essentially different biospheres analyzing structure and functioning of which we can distinguish the most fundamental features of life. As concerns our subject, Coleoptera, history increases considerably the diversity of forms available for a study replacing the reconstruction of relationships, based upon properties of recent insects, by knowledge of their ancestors. It may be assumed that in the evolution of beetles and all insects with a complete metamorphosis the evolutionary changes of larvae and adults were relatively independent, but only the history shows that the major stages of these changes do not coincide in time. The history has demonstrated that the phases of change of structure and ecological role of separate groups do not coincide, appearance of a taxon does not mean that it immediately acquires the same importance for ecosystems known for it in the contemporary period. Ecological preferences of taxa can vary essentially nearly without morphological changes. Eventually palaeoentomology has convincingly demonstrated that in the recent distribution of insects there are surprisingly few traces of their distribution in the geological past, even the recent one. I would like to take this opportunity of attracting your attention to the book of Elias (1994 - here and further see - **" Bibliography on fossil beetles . supplement to catalogue"**) with detailed abstracts of all works (except those in Russian) on Pleistocene distribution of beetles. Historical biogeography, reconstruction of ancient dispersal, on the basis of the recent one, appeared to be poorly grounded and should be replaced by palaeobiogeography, tracing the changes of actual dispersal of organisms in the geological history. However, the vast material, accumulated in palaeoentomology, is still little used by entomologists.

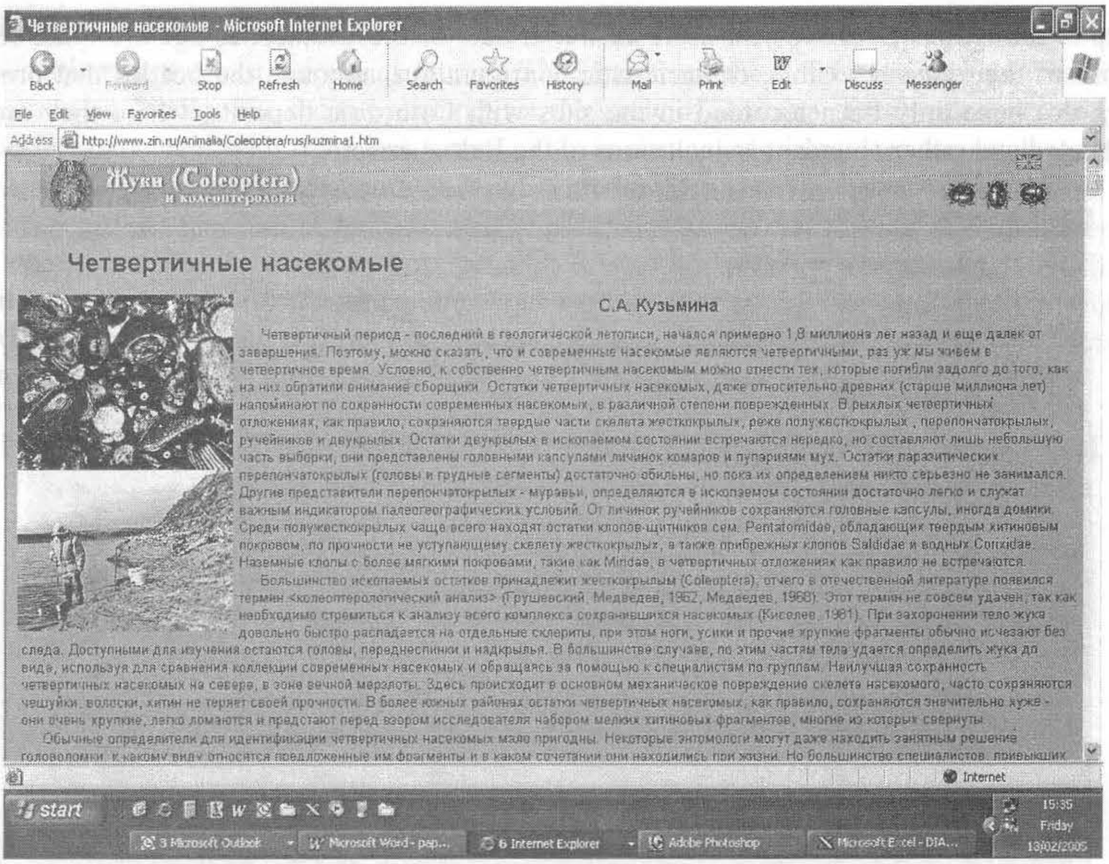
Beetles as an palaeontological object

Remnants of beetles are one of the most interesting objects of palaeonotological research. However, the study being labour-consuming, they remain poorly known and, what is even worse, few results obtained are nearly ignored by entomologists. The situation in entomology is very different from that in other divisions of zoology, where use of data on ancient animals became an integral part of phylogenetic and systematics concepts. Cladistics, however, played a negative role here, because archaic forms cannot be incorporated into its practice by virtue of its principle. At the same time in palaeentomology and palaeontology in general beetles, one of the largest and the most diverse in

Figure 2. Page with a review on historical development of the order.

On this site two years ago in the division "Taxonomy and phylogeny" we began to develop pages with palaeontological information and databases. There are presented some various pages. One page is devoted to a large paper by A.G. Ponomarenko containing a review of the fossil records and the historical development of the order up to the Pleistocene, with some methodological comments by the author (Fig. 2. - http://www.zin.ru/Animalia/Coleoptera/eng/syst4.htm).

Others include a paper by S.A. Kuzmina and a paper by E.V. Zinoviev on the Quaternary beetles, with a large list of references (Fig. 3. - http://www.zin.ru/Animalia/Coleoptera/rus/kuzmina1.htm - I am obliged to refer to some pages from the Russian version of the site, which at present is much more complete than the English one, because of different rates of preparation of these two versions). Besides, the most important pages are devoted to the catalogue of the fossil records of Coleoptera (Fig. 4. - http://www.zin.ru/Animalia/Coleoptera/eng/paleosys.htm) known from publications, and also data recovered and defined by the authors of this catalogue. The catalogue consists of 4 parts with a list of recorded taxa (Fig. 5. - http://www.zin.ru/Animalia/Coleoptera/eng/paleosy0.htm).



Четвертичные насекомые

С.А. Кузьмина

Четвертичный период - последний в геологической летописи, начался примерно 1,8 миллиона лет назад и еще далек от завершения. Поэтому, можно сказать, что и современные насекомые являются четвертичными, раз уж мы живем в четвертичное время. Условно, к собственно четвертичным насекомым можно отнести тех, которые погибли задолго до того, как на них обратили внимание сборщики. Остатки четвертичных насекомых, даже относительно древних (старше миллиона лет) напоминают по сохранности современных насекомых, в различной степени поврежденных. В рыхлых четвертичных отложениях, как правило, сохраняются твердые части скелета жесткокрылых, реже полужесткокрылых , перепончатокрылых, ручейников и двукрылых. Остатки двукрылых в ископаемом состоянии встречаются нередко, но составляют лишь небольшую часть выборки, они представлены головными капсулами личинок комаров и пупариями мух. Остатки паразитических перепончатокрылых (головы и грудные сегменты) достаточно обильны, но пока их определением никто серьезно не занимался. Другие представители перепончатокрылых - муравьи, определяются в ископаемом состоянии достаточно легко и служат важным индикатором палеогеографических условий. От личинок ручейников сохраняются головные капсулы, иногда домики. Среди полужесткокрылых чаще всего находят остатки клопов-щитников сем. Pentatomidae, обладающих твердым хитиновым покровом, по прочности не уступающему скелету жесткокрылых, а также прибрежных клопов Saldidae и водных Corixidae. Наземные клопы с более мягкими покровами, такие как Mindae, в четвертичных отложениях как правило не встречаются.

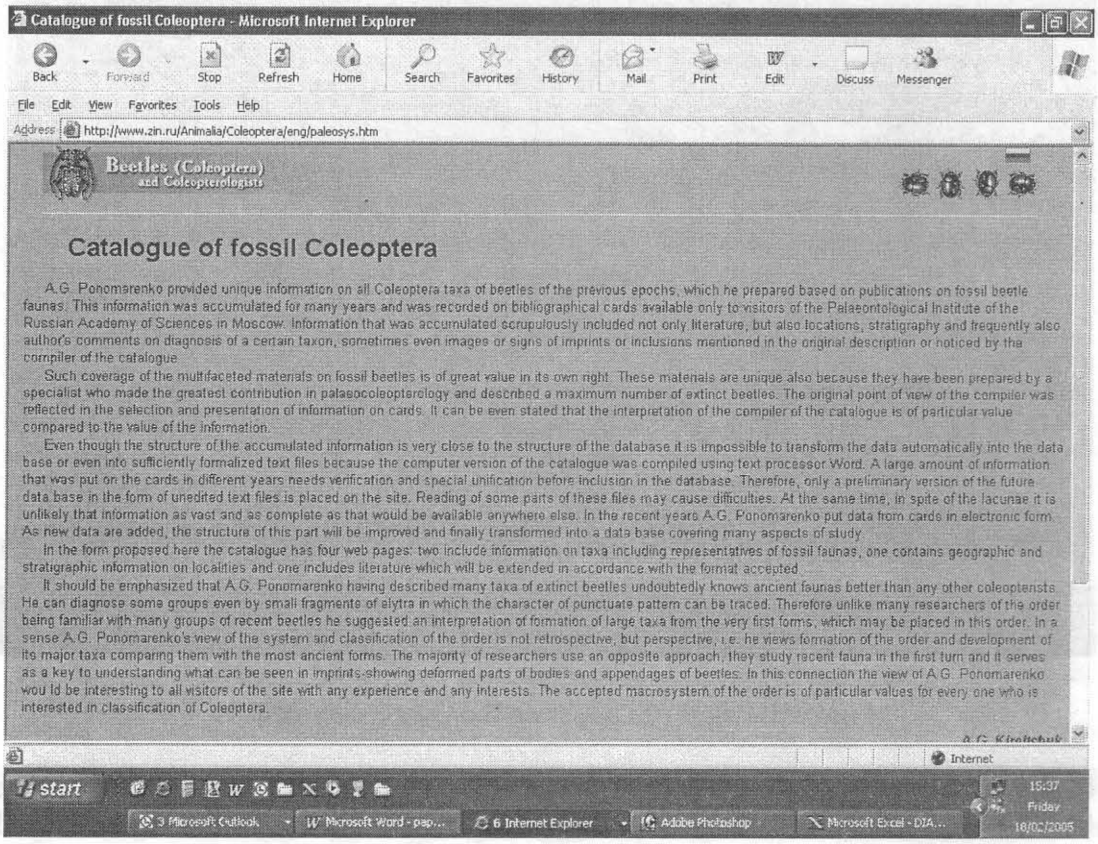
Большинство ископаемых остатков принадлежит жесткокрылым (Coleoptera), отчего в отечественной литературе появился термин <колеоптерологический анализ> (Грушевский, Медведев, 1962, Медведев, 1968). Этот термин не совсем удачен, так как необходимо стремиться к анализу всего комплекса сохранившихся насекомых (Киселев, 1981). При захоронении тело жука довольно быстро распадается на отдельные склериты, при этом ноги, усики и прочие хрупкие фрагменты обычно исчезают без следа. Доступными для изучения остаются головы, переднеспинки и надкрылья. В большинстве случаев, по этим частям тела удается определить жука до вида, используя для сравнения коллекции современных насекомых и обращаясь за помощью к специалистам по группам. Наилучшая сохранность четвертичных насекомых на севере, в зоне вечной мерзлоты. Здесь происходит в основном механическое повреждение скелета насекомого, часто сохраняются чешуйки, волоски, хитин не теряет своей прочности. В более южных районах остатки четвертичных насекомых, как правило, сохраняются значительно хуже - они очень хрупкие, легко ломаются и предстают перед взором исследователя набором мелких хитиновых фрагментов, многие из которых свернуты.

Обычные определители для идентификации четвертичных насекомых мало пригодны. Некоторые энтомологи могут даже находить занятным решение головоломки, к какому виду относятся предложенные им фрагменты и в каком сочетании они находились при жизни. Но большинство специалистов, привыкших

Figure 3. Page with paper on the Quaternary insects.

Each taxon in this list is supplied with stratigraphic attribution and localities, where the earliest and latest records of a given taxon have been found. In case where any taxon is known from only one finding, it is provided with an indication to only one age and one locality. In cases where a taxon is known in the recent fauna, it is indicated by the capital letter "R" (Fig. 6. - http://www.zin.ru/Animalia/Coleoptera/eng/paleosy2.htm). The main synonyms for the taxa above the generic level and all synonyms of generic and species taxa are mentioned in all cases. The catalogue also includes all known ichnotaxa, i.e. names proposed for remnants of living activity of ancient beetles. In order to reach an easy estimation of the position of any generic taxon included in the catalogue, it contains not only the names of all family taxa, but also the names of subfamily taxa and in some cases tribe and even subtribe taxa used by specialists in each large group. As a special supplement to the list of taxa, a register is provided with all known sites of deposition (Fig. 7. - http://www.zin.ru/Animalia/Coleoptera/eng/paleoloc.htm), where fossil beetles have been collected. Moreover, the catalogue also contains references to the publications (Fig. 8. - http://www.zin.ru/Animalia/Coleoptera/eng/paleolit.htm) with description of the fossil taxa, and the publications that consider problems of phylogeny and historical development.

Particular pages summarize the data of the catalogue showing the distribution of all coleopterous families through time (Fig. 9. - http://www.zin.ru/Animalia/Coleoptera/rus/tabla.htm). Reliable records are shown in dark grey color, but light grey and blue colors mean that some doubtful data on any group are known, but some of them should be additionally checked and others should be ignored. Unfortunately some data published in connection with consideration of phylogeny of some groups have not been provided with any real evidence, and are based on only some interpretations of morphological characters or some theoretical speculations of the writers concerned. At the same time some ichnotaxa present quite reliable indications of the existence of some groups of organisms. For example, the remnants of scolytid holes in tree trunks of the Cretaceous age are quite reliable because of their clearly visible, characteristic configuration, although the beetles that produced such holes have only been recorded in the sites with Cainozoic deposits, where they are well represented and rather abundant as inclusions of the Baltic amber.



Catalogue of fossil Coleoptera

A.G. Ponomarenko provided unique information on all Coleoptera taxa of beetles of the previous epochs, which he prepared based on publications on fossil beetle faunas. This information was accumulated for many years and was recorded on bibliographical cards available only to visitors of the Palaeontological Institute of the Russian Academy of Sciences in Moscow. Information that was accumulated scrupulously included not only literature, but also locations, stratigraphy and frequently also author's comments on diagnosis of a certain taxon, sometimes even images or signs of imprints or inclusions mentioned in the original description or noticed by the compiler of the catalogue.

Such coverage of the multifaceted materials on fossil beetles is of great value in its own right. These materials are unique also because they have been prepared by a specialist who made the greatest contribution in palaeocoleopterology and described a maximum number of extinct beetles. The original point of view of the compiler was reflected in the selection and presentation of information on cards. It can be even stated that the interpretation of the compiler of the catalogue is of particular value compared to the value of the information.

Even though the structure of the accumulated information is very close to the structure of the database it is impossible to transform the data automatically into the data base or even into sufficiently formalized text files because the computer version of the catalogue was compiled using text processor Word. A large amount of information that was put on the cards in different years needs verification and special unification before inclusion in the database. Therefore, only a preliminary version of the future data base in the form of unedited text files is placed on the site. Reading of some parts of these files may cause difficulties. At the same time, in spite of the lacunae it is unlikely that information as vast and as complete as that would be available anywhere else. In the recent years A.G. Ponomarenko put data from cards in electronic form. As new data are added, the structure of this part will be improved and finally transformed into a data base covering many aspects of study.

In the form proposed here the catalogue has four web pages: two include information on taxa including representatives of fossil faunas, one contains geographic and stratigraphic information on localities and one includes literature which will be extended in accordance with the format accepted.

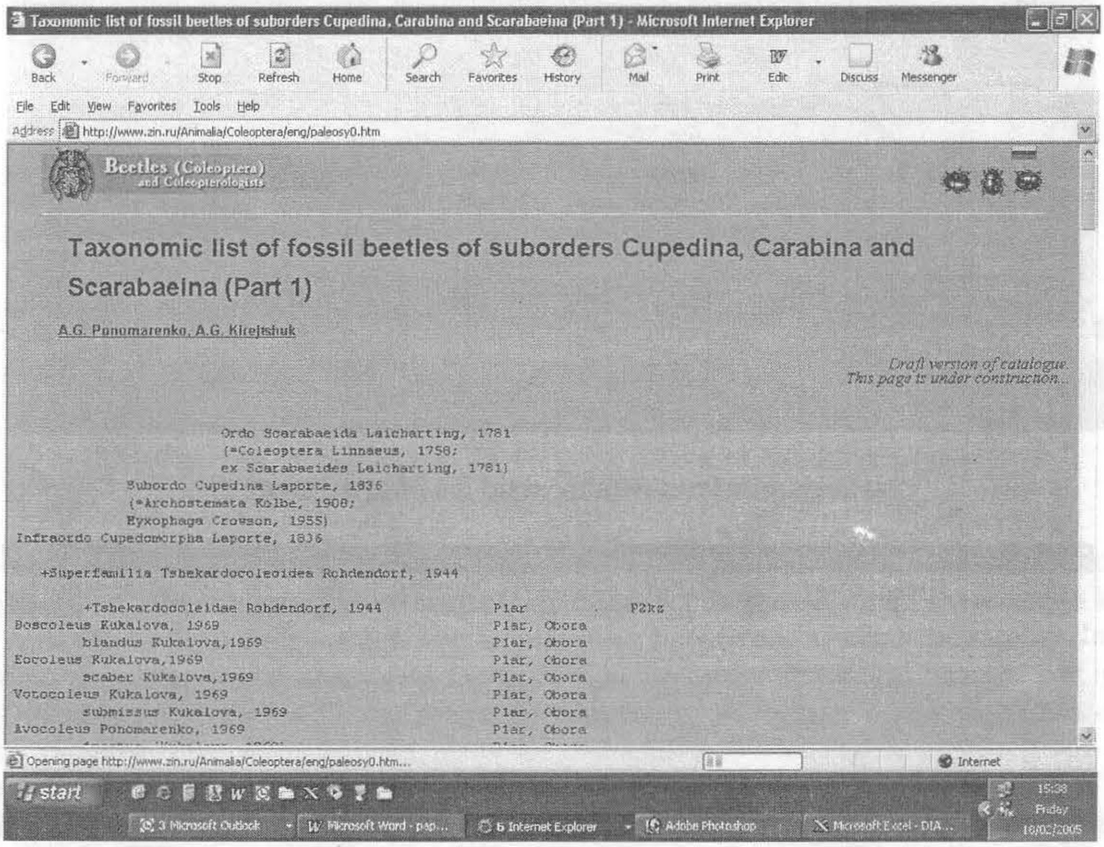
It should be emphasized that A.G. Ponomarenko having described many taxa of extinct beetles undoubtedly knows ancient faunas better than any other coleopterists. He can diagnose some groups even by small fragments of elytra in which the character of punctuate pattern can be traced. Therefore unlike many researchers of the order being familiar with many groups of recent beetles he suggested an interpretation of formation of large taxa from the very first forms, which may be placed in this order. In a sense A.G. Ponomarenko's view of the system and classification of the order is not retrospective, but perspective, i.e. he views formation of the order and development of its major taxa comparing them with the most ancient forms. The majority of researchers use an opposite approach, they study recent fauna in the first turn and it serves as a key to understanding what can be seen in imprints showing deformed parts of bodies and appendages of beetles. In this connection the view of A.G. Ponomarenko wou ld be interesting to all visitors of the site with any experience and any interests. The accepted macrosystem of the order is of particular values for every one who is interested in classification of Coleoptera.

A.G. Kireitchuk

Figure 4. Page with introduction to the catalogue.

Thus, it is a quite delicate matter to interpret the known fossil records correctly. The general opinion of many biologists dealing with research on recent specimens, that fossil records are full of gaps, needs many specifications. On the other hand, most records already obtained in different collections remain unpublished or were published with wrong interpretations and, therefore, need to be revised. In order to reach an adequate level of interpretation, firstly the conditions of deposition of insects, and any possible transformations which may have happened while the remains were in their sites of deposition, have to be taken into account. Main types of assemblages of deposited remains of organisms accessible for study came from sedimentary deposits in water basins and inclusions in fossil resin. Animals and other organisms can be also preserved in peat, volcanic ash, asphalt morasses and under other conditions, though the quantity of such fossils is small and their state of preservation generally poor. Besides, the composition of taxa preserved in carbonates and amber with the same age can scarcely coincide; the occurrence of insect fossils in sediment that also yields insect-bearing resin is extremely rare (Martínez-Declòs et al., 2004, etc.). The available assemblages of fossil insects depend not only on a certain faunal composition of the place where they were formed at a certain time, but also on the deposition environment and diagenic history.

The places of insect deposition, which can be found in carbonate rocks, often represent the former bottoms of ancient water basins (fresh water basins and marine lagoons) that accumulated flood animals. Most remains in such sites belong to aquatic and actively flying insects. Wingless insects and species living mostly in soil or on the ground, especially in arid areas, are much less likely to be preserved there. Xylobiotic beetles occur in these sites in lower proportions than their representation in the past terrestrial faunas. The data from these sites are the main source of information on fossils. The second resource for the study of coleopterous fossils contains mostly the species associated with trees and forests. This is particularly important for small xylobiotic beetles, which very quickly became covered with liquid resin. However, larger insects were contacting the resin only with a part of their sclerites and, therefore, in some or many cases they were able to escape. As a result, this resource is also not properly representative. Although, careful analysis of data from both resources, as well as after taking into consideration probable interconnections between different organisms at the considered period, we can obtain a comparatively confident impression of the xylobiotic fauna of a certain geological period.



Taxonomic list of fossil beetles of suborders Cupedina, Carabina and Scarabaeina (Part 1)

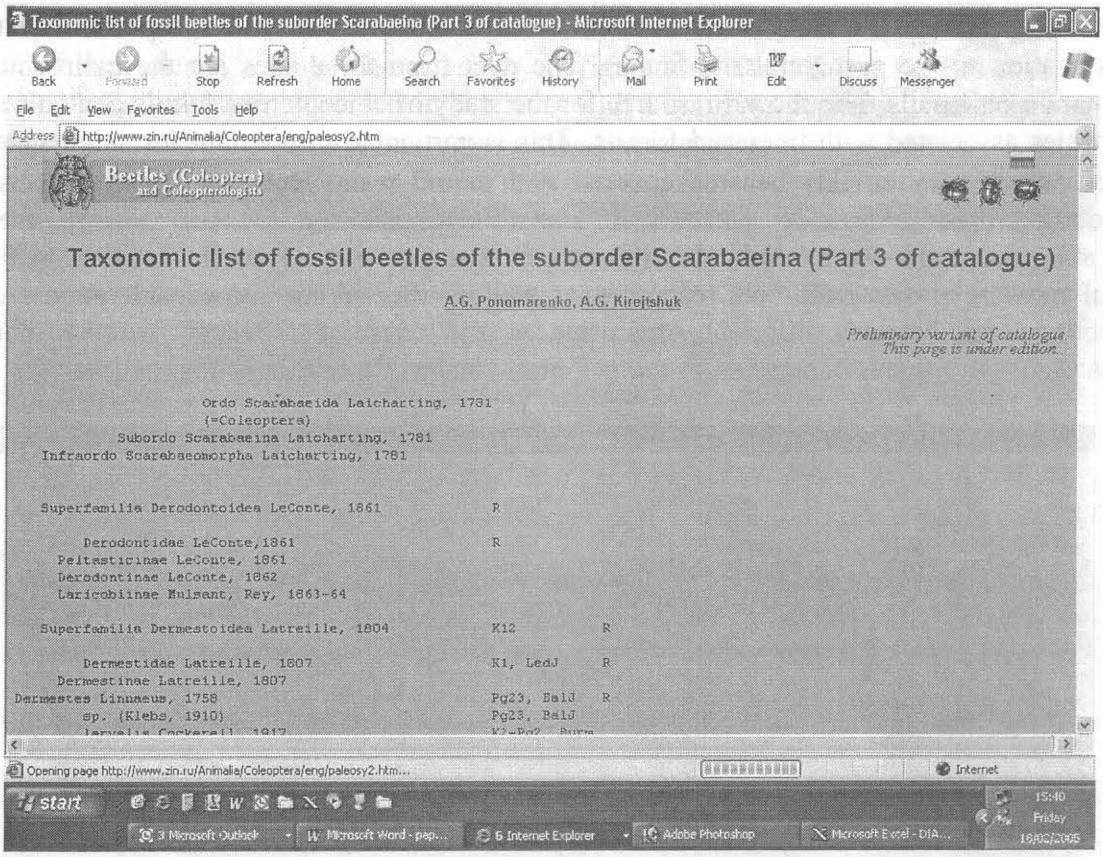
A.G. Ponomarenko, A.G. Kirejtshuk

Draft version of catalogue.
This page is under construction...

```
                Ordo Scarabaeida Laicharting, 1781
                (*Coleoptera Linnaeus, 1758;
                ex Scarabaeides Laicharting, 1781)
        Subordo Cupedina Laporte, 1836
        (*Archostemata Kolbe, 1908;
        Eyxophaga Crowson, 1955)
Infraordo Cupedomorpha Laporte, 1836

   +Superfamilia Tshekardocoleoidea Rohdendorf, 1944

      +Tshekardocoleidae Rohdendorf, 1944             Plar           P2kz
Boscoleus Kukalova, 1969                              Plar, Obora
      blandus Kukalova,1969                           Plar, Obora
Eocoleus Kukalova,1969                                Plar, Obora
      scaber Kukalova,1969                            Plar, Obora
Votocoleus Kukalova, 1969                             Plar, Obora
      submissus Kukalova, 1969                        Plar, Obora
Avocoleus Ponomarenko, 1969                           Plar, Obora
```

Figure 5. Page with the first list of fossil taxa.

In addition to the catalogue on the website, the pages of the atlas of fossil beetles started to develop as well. This atlas is planned in accordance with the general system of the order. It has the usual systematic hierarchy from the general scheme of superfamilies, leading to the pages with family composition of each superfamily (Fig. 10. - http://www.zin.ru/Animalia/Coleoptera/eng/fossils.htm) and further to the pages for every particular family with main characteristics of the known fossil records on these families. On each page devoted to a particular family, one picture or pictures of some impressive specimens of it are provided. (Fig. 11. - http://www.zin.ru/Animalia/Coleoptera/rus/coptcl_f.htm). Here is shown one specimen of Coptoclavidae, the extinct group of water beetles with faceted eyes divided horizontally, like those of recent Gyrinidae, and also with prehensile anterior legs and with swimming or running intermediate and posterior legs.



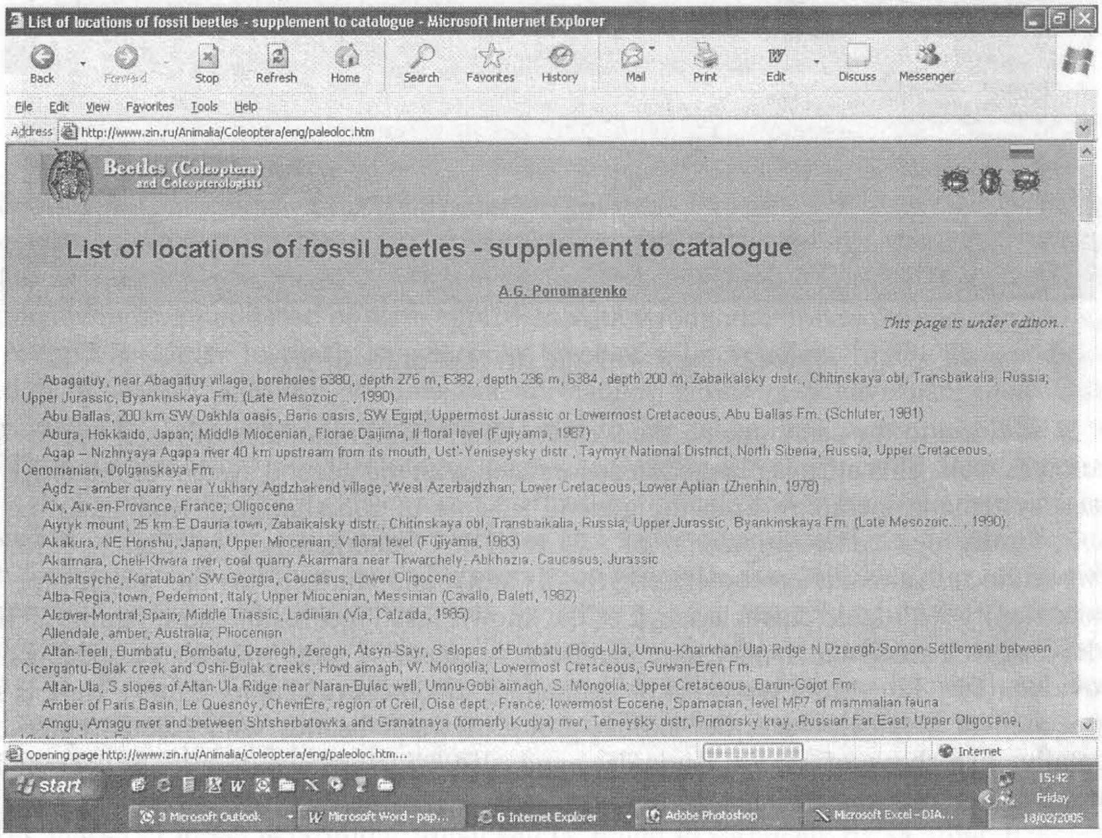
Taxonomic list of fossil beetles of the suborder Scarabaeina (Part 3 of catalogue)

A.G. Ponomarenko, A.G. Kirejtshuk

Preliminary variant of catalogue.
This page is under edition.

```
                    Ordo Scarabaeida Laicharting, 1781
                    (=Coleoptera)
          Subordo Scarabaeina Laicharting, 1781
 Infraordo Scarabaeomorpha Laicharting, 1781


 Superfamilia Derodontoidea LeConte, 1861            R

      Derodontidae LeConte,1861                      R
   Peltasticinae LeConte, 1861
   Derodontinae LeConte, 1862
   Laricobiinae Mulsant, Rey, 1863-64

 Superfamilia Dermestoidea Latreille, 1804           K12          R

      Dermestidae Latreille, 1807                    K1, LedJ     R
   Dermestinae Latreille, 1807
Dermestes Linnaeus, 1758                             Pg23, BalJ   R
      sp. (Klebs, 1910)                              Pg23, BalJ
```

Figure 6. Page with the third list of fossil taxa.



List of locations of fossil beetles - supplement to catalogue

A.G. Ponomarenko

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Abagaituy, near Abagaituy village, boreholes 6380, depth 276 m, 6382, depth 236 m, 6384, depth 200 m, Zabaikalsky distr., Chitinskaya obl, Transbaikalia, Russia; Upper Jurassic, Byankinskaya Fm. (Late Mesozoic…, 1990)

Abu Ballas, 200 km SW Dakhla oasis, Baris oasis, SW Egipt; Uppermost Jurassic or Lowermost Cretaceous, Abu Ballas Fm. (Schluter, 1981)

Abura, Hokkaido, Japan; Middle Miocenian, Florae Daijima, II floral level (Fujiyama, 1987)

Agap – Nizhnyaya Agapa river 40 km upstream from its mouth, Ust'-Yeniseysky distr., Taymyr National District, North Siberia, Russia; Upper Cretaceous, Cenomanian, Dolganskaya Fm.

Agdz – amber quarry near Yukhary Agdzhakend village, West Azerbajdzhan; Lower Cretaceous, Lower Aptian (Zherihin, 1978)

Aix, Aix-en-Provance, France; Oligocene

Aiyryk mount, 25 km E Dauria town, Zabaikalsky distr., Chitinskaya obl, Transbaikalia, Russia; Upper Jurassic, Byankinskaya Fm. (Late Mesozoic…, 1990)

Akakura, NE Honshu, Japan; Upper Miocenian, V floral level (Fujiyama, 1983)

Akarmara, Cheli-Khvara river, coal quarry Akarmara near Tkwarchely, Abkhazia, Caucasus; Jurassic

Akhaltsyche, Karatuban' SW Georgia, Caucasus; Lower Oligocene

Alba-Regia, town, Pedemont, Italy; Upper Miocenian, Messinian (Cavallo, Balett, 1982)

Alcover-Montral,Spain; Middle Triassic, Ladinian (Via, Calzada, 1985)

Allendale, amber, Australia; Pliocenian

Altan-Teeli, Bumbatu, Bombatu, Dzeregh, Zeregh, Atsyn-Sayr, S slopes of Bumbatu (Bogd-Ula, Umnu-Khairkhan Ula) Ridge N Dzeregh-Somon Settlement between Cicergantu-Bulak creek and Oshi-Bulak creeks, Hovd aimagh, W. Mongolia; Lowermost Cretaceous, Gurwan-Eren Fm.

Altan-Ula, S slopes of Altan-Ula Ridge near Naran-Bulac well, Umnu-Gobi aimagh, S. Mongolia; Upper Cretaceous, Barun-Gojot Fm.

Amber of Paris Basin, Le Quesnoy, ChevrIEre, region of Creil, Oise dept., France; lowermost Eocene, Sparnacian, level MP7 of mammalian fauna

Amgu, Amagu river and between Shtsherbatowka and Granatnaya (formerly Kudya) river, Terneysky distr, Primorsky kray, Russian Far East; Upper Oligocene,

Figure 7. Page with the list of the known sites with deposited insects.

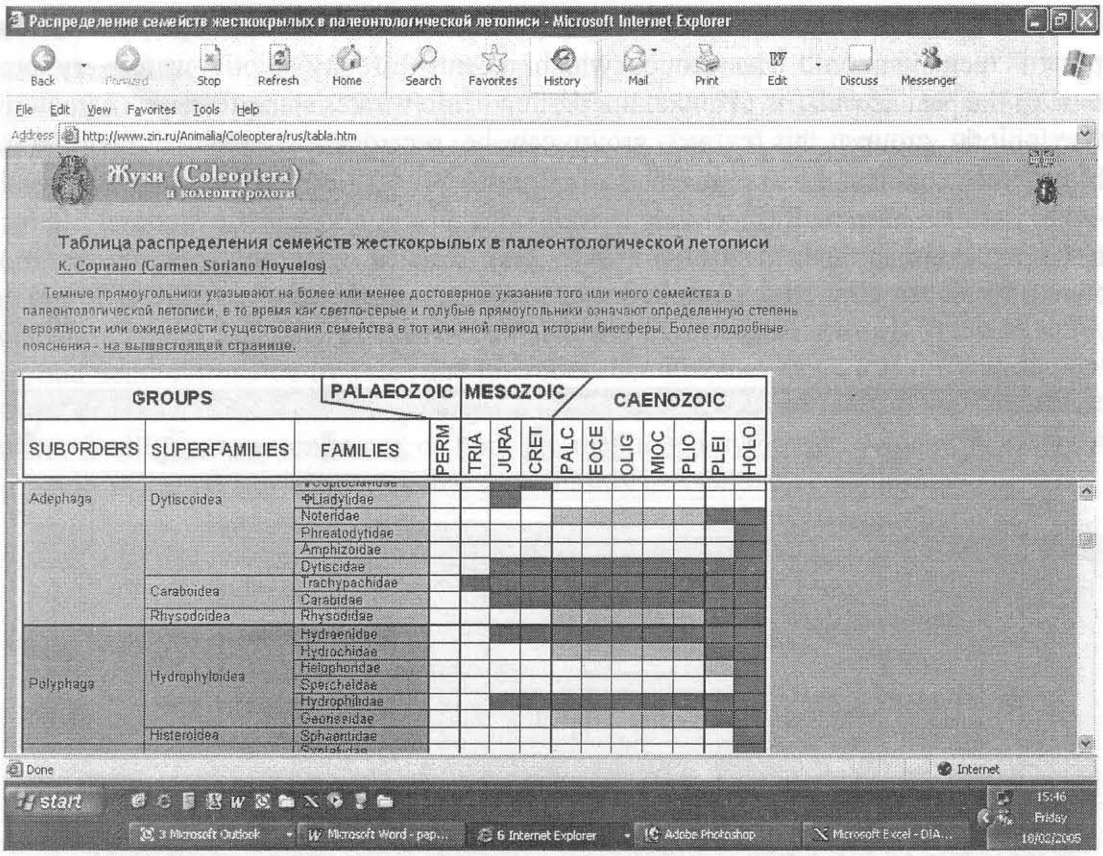

Таблица распределения семейств жесткокрылых в палеонтологической летописи

К. Сориано (Carmen Soriano Hoyuelos)

Темные прямоугольники указывают на более или менее достоверное указание того или иного семейства в палеонтологической летописи, в то время как светло-серые и голубые прямоугольники означают определенную степень вероятности или ожидаемости существования семейства в тот или иной период истории биосферы. Более подробные пояснения - на вышестоящей странице.

GROUPS			PALAEOZOIC	MESOZOIC			CAENOZOIC						
SUBORDERS	SUPERFAMILIES	FAMILIES	PERM	TRIA	JURA	CRET	PALC	EOCE	OLIG	MIOC	PLIO	PLEI	HOLO
Adephaga	Dytiscoidea	†Liadytidae			▨								
		Noteridae					░	░	░	░	░	▨	▨
		Phreatodytidae											▨
		Amphizoidae											▨
		Dytiscidae			▨	▨	▨	▨	▨	▨	▨	▨	▨
	Caraboidea	Trachypachidae		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
		Carabidae			▨	▨	▨	▨	▨	▨	▨	▨	▨
	Rhysodoidea	Rhysodidae					░	░	░	░	░	▨	▨
Polyphaga	Hydrophyloidea	Hydraenidae			▨	▨	▨	▨	▨	▨	▨	▨	▨
		Hydrochidae					░	░	░	░	░	▨	▨
		Helophoridae										░	▨
		Spercheidae											▨
		Hydrophilidae			▨	▨	▨	▨	▨	▨	▨	▨	▨
		Georissidae					░	░	░	░	░	▨	▨
	Histeroidea	Sphaeritidae											▨

Figure 8. The table of distribution of coleopterous families in time.

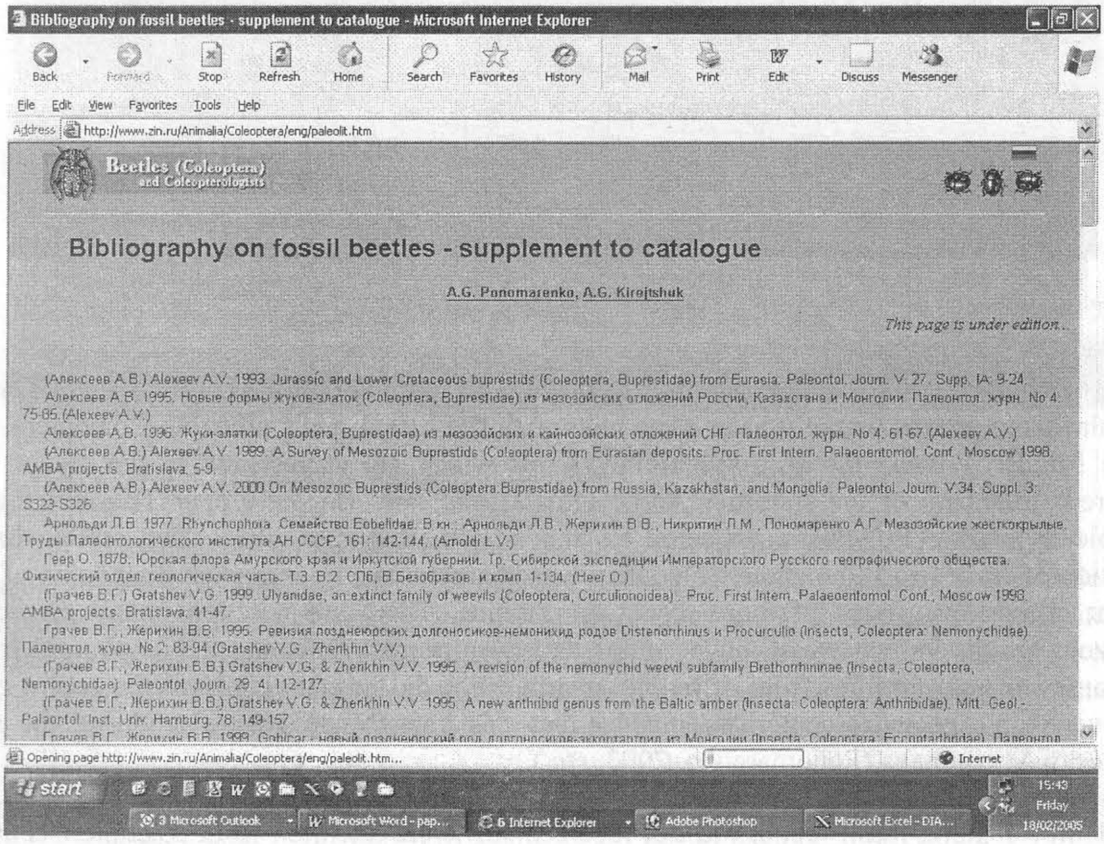

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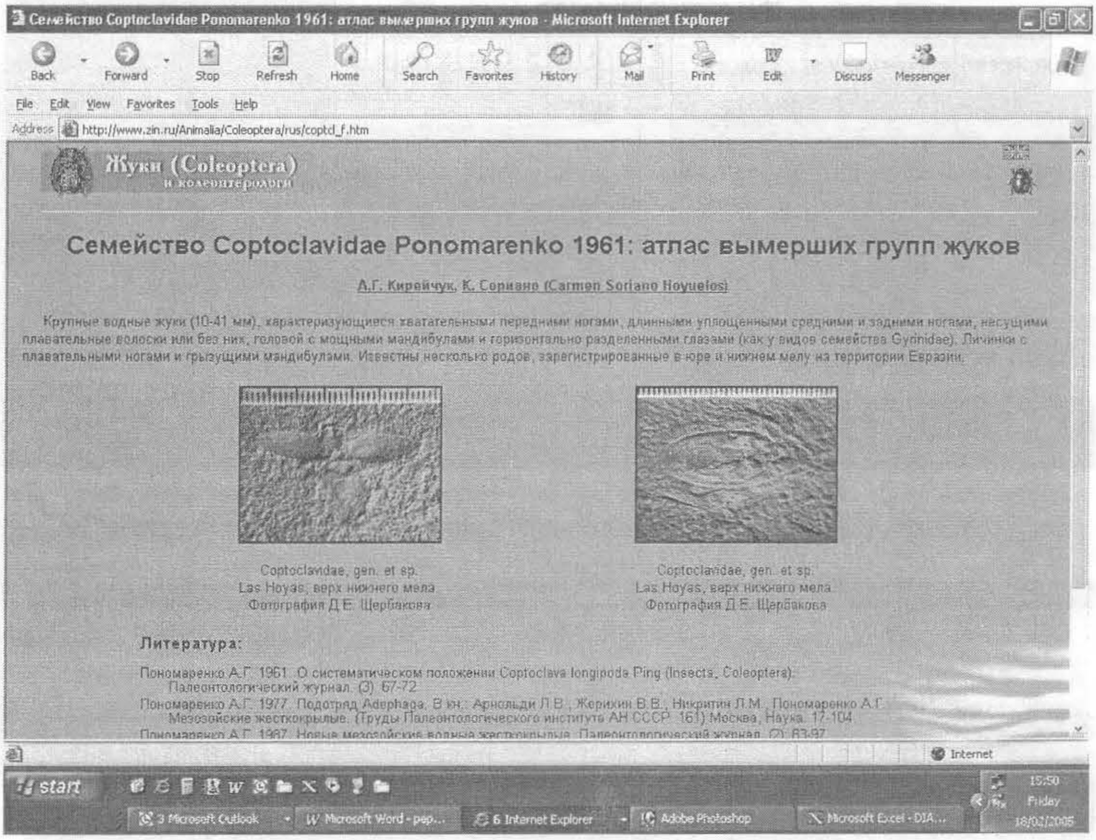
Figure 9. Page with bibliography on extinct beetles.

There is no other way to define if a group of extinct beetles was xylobiotic, except the principle of "actualization". The groups which recently are xylobiotic were very probably xylobiotic in the past as well, or, if any extinct group demonstrates some features characteristic of recent xylobiotic groups, this extinct group can be regarded as xylobiotic with a certain probability. Such conclusions were reached after the study of the earliest coleopterous fossils, and many other Permian beetles. Respectively, conclusions on a non-xylobiotic mode of life for some extinct Upper Permian and Mesozoic groups was reached after analyses of the structural characters of their remains, which can be interpreted as an evidence of a mode of life in or near water.



Семейство Coptoclavidae Ponomarenko 1961: атлас вымерших групп жуков

А.Г. Кирейчук, К. Сориано (Carmen Soriano Hoyuelos)

Крупные водные жуки (10-41 мм), характеризующиеся хватательными передними ногами, длинными уплощенными средними и задними ногами, несущими плавательные волоски или без них, головой с мощными мандибулами и горизонтально разделенными глазами (как у видов семейства Gyrinidae). Личинки с плавательными ногами и грызущими мандибулами. Известны несколько родов, зарегистрированные в юре и нижнем мелу на территории Евразии.

Coptoclavidae, gen. et sp.
Las Hoyas, верх нижнего мела
Фотография Д.Е. Щербакова

Coptoclavidae, gen. et sp.
Las Hoyas, верх нижнего мела
Фотография Д.Е. Щербакова

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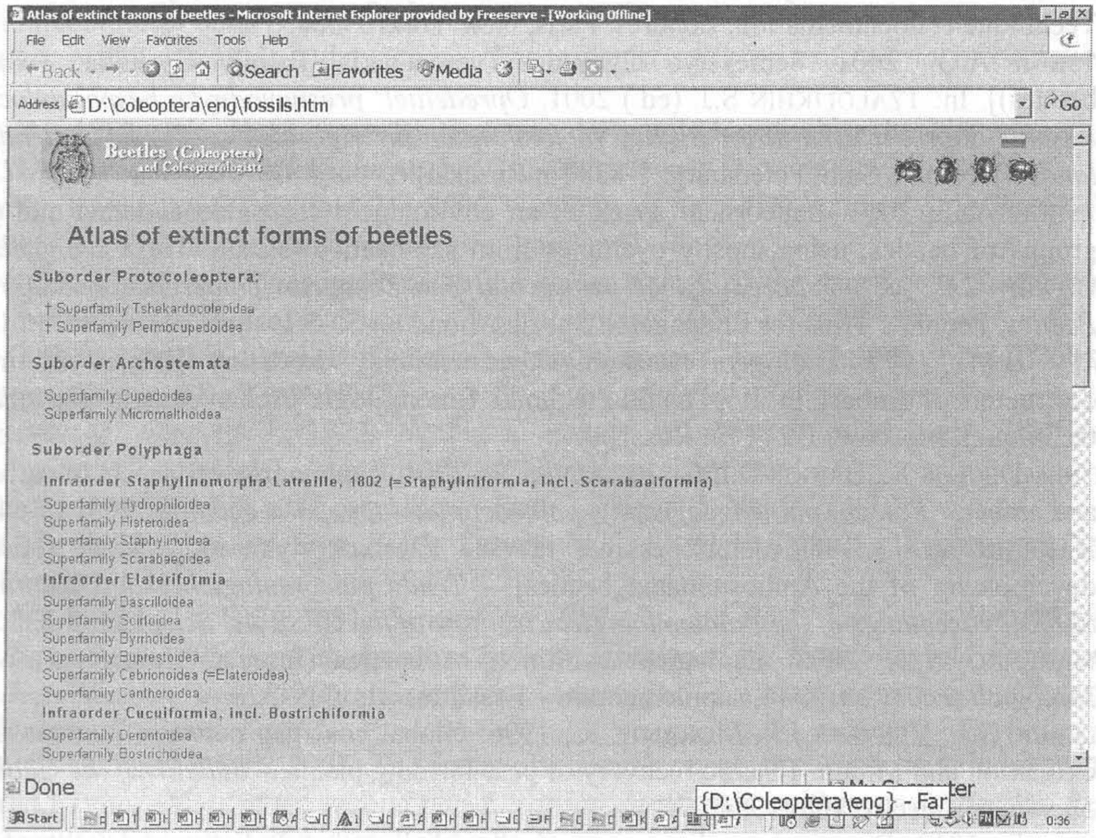
Figure 10. Page on family Coptoclavidae.

The catalogue and table of distribution of all coleopterous families through time show that the Palaeozoic groups scarcely have clear links with the Meso- and Cainozoic Coleoptera. Only in the Middle Triassic the first xylobiotic groups which are represented in the recent fauna appeared (members of the suborder Archostemata) and later (in the Upper Triassic) the first possible xylobiotic Polyphaga appeared in depositions of known sites. They show that the evolution of Meso- and Cainozoic Coleoptera was characterized by a gradual dislodging of more ancient groups by groups of more recent appearance. There are not very many palaeorelict Mesozoic groups known which have completely disappeared. Only the Schizophoroid lineage and some separate families from different superfamilies did not survive until the recent epoch. However, some palaeocoleopterists consider that this lineage could have produced the recent families of Myxophaga (Ponomarenko, 2003, etc.).

Unfortunately, fossil record has not received sufficient attention from coleopterists and, as was mentioned before, most material still waits in different collections to be studied and published. Therefore, a lot of work is needed in order to reach any adequate presentation of the data already available in the collections, in scientific publications, and on the pages of the website

"Beetles (Coleoptera) and coleopterists". Every contribution to this important field of knowledge would be welcomed. Nevertheless, some tendencies can be traced even at the current level of knowledge of ancient xylobiotic beetles. The xylophilous Archostemata, rather numerous in the Mesozoic era, are represented by only a few relicts in recent ecosystems. The number of Elateridae and some other groups of Elateriformia (like Ptilodactylidae, Eucinetidae and probably related families) seems to have decreased towards the end of the Cretaceous and particularly in the Cainozoic era, while their proportion were significantly diminished due to the intensive diversification of different Cucujiformia. However, Peltidae and some other Cucujiform groups (e.g., Mordellidae) were rather common in the past, like the mentioned elateriforms, but also became quite rare recently. In contrast to the groups mentioned, the xylobiontic Buprestidae and Scarabaeoidea appeared in the Middle or Upper Jurassic, became rather abundant through the Cretaceous, and thus produced certain changes in the taxonomic composition of saproxylic and other xylophilous communities. The same is true of the superfamily Cucujoidea, which appeared in fossil records only in the Cretaceous (except for Parandrexidae recorded from the Middle Jurassic).



Atlas of extinct forms of beetles

Suborder Protocoleoptera:

† Superfamily Tshekardocoleoidea
† Superfamily Permocupedoidea

Suborder Archostemata

Superfamily Cupedoidea
Superfamily Micromalthoidea

Suborder Polyphaga

Infraorder Staphylinomorpha Latreille, 1802 (=Staphyliniformia, incl. Scarabaeiformia)
Superfamily Hydrophiloidea
Superfamily Histeroidea
Superfamily Staphyinoidea
Superfamily Scarabaeoidea
Infraorder Elateriformia
Superfamily Dascilloidea
Superfamily Scirtoidea
Superfamily Byrrhoidea
Superfamily Buprestoidea
Superfamily Cebrionoidea (=Elateroidea)
Superfamily Cantheroidea
Infraorder Cuculformia, incl. Bostrichiformia
Superfamily Derontoidea
Superfamily Bostrichoidea

Figure 11. First page of the Atlas of extinct forms of beetles.

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It is the pleasant duty of the author to express his sincere recognition of the people who contributed data for the discussed palaeontological pages on the site "Beetles (Coleoptera) and coleopterists", and firstly to express acknowledgement of the authors of these pages (A.G. Ponomarenko, V.V. Zherikhin, C. Soriano, S.A. Kuzmina, E.V. Zinoiev and others) and the photographers (D.E. Shcherbakov, I.M. Verdu, P.V. Korsunovich and others). The general development of the site was supported by the Russian Foundation for Basic Research (grant Nr 02-07-90105) and the development of the palaeontological partition of this site was additionally supported by the grant of the Presidium of the Russian Academy of Sciences according to the programme "Origin and evolution of biosphere". The author's particular thanks go to all members of the Editorial Board of the site and particularly to A.L. Lobanov (ZIN, St.-Petersburg) and D. Telnov (The Entomological Society of Latvia, Rīga). The author recognizes the assistance of M.V.L. Barclay (The Natural History Museum in London) in correcting the English.

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Osmoderma eremita (SCOPOLI, 1763) (Coleoptera: Scarabaeidae: Cetoniinae) in Europe: a Short Summary of a Pan-European Project

THOMAS RANIUS *, LUÍS OSCAR AGUADO, KJELL ANTONSSON, PAOLO AUDISIO, ALBERTO BALLERIO, GIUSEPPE M. CARPANETO, KAREL CHOBOT, BRANIMIR GJURAŠIN, ODDVAR HANSSEN, HANS HUIJBREGTS, FERENC LAKATOS, OLE MARTIN, ZAHARIA NECULISEANU, NIKOLAI B. NIKITSKY, WOLFGANG PAILL, ALJA PIRNAT, VOLODYMYR RIZUN, ADRIAN RUICĂNESCU, JAN STEGNER, ILMAR SÜDA, PRZEMYSŁAW SZWAŁKO, VYTAUTAS TAMUTIS, DMITRY TELNOV, VADIM TSINKEVICH, VEERLE VERSTEIRT, VINCENT VIGNON, MATTHIAS VÖGELI, PETER ZACH

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RANIUS T., AGUADO L.O., ANTONSSON K., AUDISIO P., BALLERIO A., CARPANETO G.M., CHOBOT K., GJURAŠIN B., HANSSEN O., HUIJBREGTS H., LAKATOS F., MARTIN O., NECULISEANU Z., NIKITSKY N.B., PAILL W., PIRNAT A., RIZUN V., RUICĂNESCU A., STEGNER J., SÜDA I., SZWAŁKO P., TAMUTIS V., TELNOV D., TSINKEVICH V., VERSTEIRT V., VIGNON V., VÖGELI M., ZACH P., 2005. *OSMODERMA EREMITA* (SCOPOLI, 1763) (COLEOPTERA: SCARABAEIDAE: CETONIINAE) IN EUROPE: A SHORT SUMMARY OF A PAN-EUROPEAN PROJECT. Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 79-82.

Abstract: We are 28 co-authors representing 25 European countries, who have collected data on a threatened beetle associated with tree hollows, *Osmoderma eremita* (SCOPOLI, 1763) (Coleoptera: Scarabaeidae). This project has arisen from our own initiative, based on the belief that entomology and nature conservation would do better with stronger co-operation between professional and amateur entomologists from all European countries. Totally, we found records from 2,141 localities in 34 countries. *O. eremita* seems to have decreased in all countries. Relatively high densities of *O. eremita* localities occur in Central Europe (northern Italy, Austria, Czech Republic, Poland and Eastern Germany), some parts of Northern Europe (south-eastern Sweden, Latvia) and France. In some regions in north-western Europe, the species has become extinct or occurs only in some single localities. *O. eremita* is useful as an indicator and umbrella species for the preservation of the entire invertebrate community associated with hollow trees in Europe.

Key words: saproxylic, cavity, bioindicator, Scarabaeoidea.

Introduction

In Europe today, ancient trees are scarce and, therefore, many species dependent on this habitat seem to be confined to small remnants with no possibility for dispersal between local populations (e.g. Harding, Rose, 1986; Speight 1989). In ancient trees, there are often hollows with wood mould in the trunks. Wood mould is loose wood colonised by fungi, often with remains from bird nests and insects. Trunk hollows with wood mould harbour a specialised fauna mainly consisting of beetles, flies, mites, pseudoscorpions and ants. Many invertebrate species associated with hollow trees are threatened (Ehnström, Waldén, 1986; Warren, Key, 1991). One beetle species associated with hollow trees, *Osmoderma eremita* (SCOPOLI, 1763) (Coleoptera: Scarabaeidae), has been studied more thoroughly in ecological research than any other invertebrate species associated with this habitat (see e.g. Ranius, 2002a, for a review). Here we give a short summary of a pan-European project aimed at compiling data on this species. The results will be presented in detail in a paper in press in *Animal Biodiversity and Conservation* (Ranius et al., 2005).

Results and Discussion

We have compiled data on the occurrence of *O. eremita* from museums and private collections, literature and field inventories, and found records of *O. eremita* from 2,141 localities in Europe (Fig. 1). At many of these localities, *O. eremita* has probably already become extinct; at only 918 of the localities, we know that the beetle has been found since 1990. On the other hand, there are probably many unknown localities that have not yet been discovered. All over Europe it seems that the majority of the localities with *O. eremita* are small and isolated. For that reason we should expect many local extinctions in the future, even though the hollow trees that are left will be protected. In some countries (for instance, Denmark), all localities are small, and there, the risk for regional extinction is considerable. In other countries (for instance France, Sweden, Latvia and Austria) there are also a few larger localities, where *O. eremita* may survive in the long term, if the sites are properly managed.

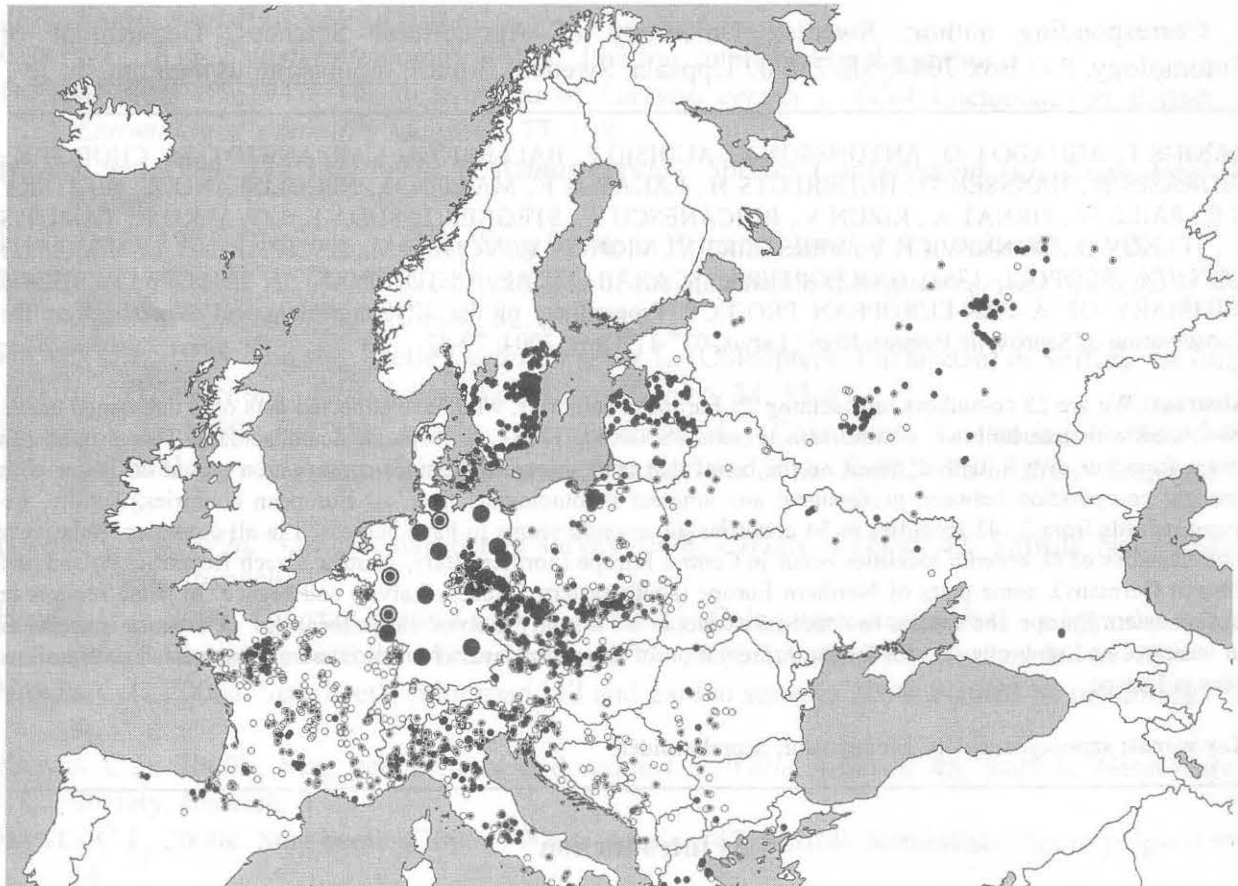

Fig. 1. Distribution of *Osmoderma eremita* s.l. (SCOPOLI, 1763) in Europe.

Open circle = last record before 1950, circle with filled centre = last record 1950-1989, filled circle = last record in 1990 or later. Larger circles represent records in German federal states where we do not have data for individual localities.

O. eremita still occurs in almost all European countries, however, it is absent from the boreal region, the British Isles and the main part of the Iberian peninsula. *O. eremita* seems to have decreased in all European countries. Relatively high densities of localities occur in Central Europe (northern Italy, Austria, Eastern Germany, Czech Republic and Poland), some parts of

Northern Europe (south-eastern Sweden, Latvia) and France. Perhaps there are also many localities in the Balkans, but the search effort has been very low there during the last few decades. In some regions in northwestern Europe, the species has become extinct or may occur on some single localities (Norway, Danish mainland, The Netherlands, Belgium, north-eastern France). Bearing in mind the severe loss of old trees in Europe, it is perhaps surprising that *O. eremita* has not become extinct in larger regions. However, the species can survive in small relict populations over decades, and even if it is doomed to extinction, it will take time before the species totally disappears from a region (Ranius, 2000).

O. eremita mainly occurs in habitats that have been used by man for a long time, however, there are also *O. eremita* localities in forests. Many of the man-made habitats are destroyed due to changes in agriculture. For instance, in Sweden, pasture woodlands suffer from forest regrowth due to cessation of management, while the abandonment of pollarding of oaks in France has restricted the supply of new, suitable trees for *O. eremita*. The beetle can obviously also survive in urban areas; however, in many cases there are problems with conflicts with public safety.

Our compilation of data supports the view that *O. eremita* is useful as a biodiversity indicator and umbrella species because it is widespread in Europe, and everywhere confined to hollow trees, which are a threatened habitat. There are a few observations of the beetle from stumps, but there is no indication that *O. eremita* populations can survive at localities with no tree hollows present. Moreover, the presence of *O. eremita* indicates high species richness with many threatened invertebrate species associated with old trees (Ranius, 2002b). The preservation of *O. eremita* is related to three tasks that are of general importance for nature conservation in Europe today: (1) to preserve those small remnants of natural forest that still exist, (2) to preserve and restore habitats connected with old agricultural landscapes and (3) to preserve those small pieces of nature that still exist in urban areas. Thus, if we take the measures needed to protect *O. eremita*, it will also help to solve many other current problems in nature conservation in Europe.

Acknowledgements

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Polyporus pseudobetulinus (PILÁT) THORN, KOTIR. & NIEMELÄ – a Rare Polypore Fungus (Basidiomycetes, Aphyllophorales) in Finland, and its Beetles

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SCHIGEL D.S., 2005. *POLYPORUS PSEUDOBETULINUS* (PILÁT) THORN, KOTIR. & NIEMELÄ - A RARE POLYPORE FUNGUS (BASIDIOMYCETES, APHYLLOPHORALES) IN FINLAND, AND ITS BEETLES. Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 83-84.

Abstract: *Polyporus pseudobetulinus* (PILÁT) THORN, KOTIR. & NIEMELÄ is a rare polypore fungus in northern Europe. The mycetophagous beetles (8 species) associated with *P. pseudobetulinus* have been studied in Pisavaara Strict Nature Reserve in Perä-Pohjanmaa province of Finland.

Key words: *Polyporus, pseudobetulinus,* polypore, saproxylic, Coleoptera, beetles.

Results and discussion

An increasing interest in forest conservation and red-listed saproxylic species is linked with polypores — a valuable tool for evaluating forest biodiversity. The Pisavaara Strict Nature Reserve in Perä-Pohjola province of Finland is famous for its high species diversity. The solitary forest-covered hill accumulates atmospheric water and feeds numerous brooks running down the slopes. The combination of high humidity and old-growth forest makes a favourable habitat for a number of polypore species, in particular *Polyporus pseudobetulinus* (PILÁT) THORN, KOTIR. & NIEMELÄ. Standing, dead, giant aspen trees (*Populus tremula* LINNAEUS) harbour specific saproxylic organisms, both fungi and insects. The fruiting bodies of *Polyporus pseudobetulinus*, a fungus specialist of old aspen, were collected at different decomposition stages.

Of the 8 beetles species found, the species *Atheta picipes* (THOMSON, 1856) (Staphylinidae), *Orthoperus rogeri* KRAATZ, 1874 (Corylophidae), *Corticarina lambiana* (SHARP, 1910) (Latridiidae) and *Cerylon ferrugineum* STEPHENS, 1830 (Cerylonidae) are attracted by moist and anamorphic-fungi-covered sporocarps, while *Cis comptus* GYLLENHAL, 1827 (Ciidae) shows no preference to the decomposition stage. *Cis boleti* (SCOPOLI, 1763), *Cis bidentatus* (OLIVIER, 1790) and *Sulcacis affinis* (GYLLENHAL, 1827) (Ciidae) were found on dry, dead fruiting bodies. All the Ciidae species found, except *Cis boleti* (SCOPOLI, 1763), use *Polyporus pseudobetulinus* as larval food source.

The rarity of this fungal substrate makes it unlikely that a specialised beetle fauna will have developed, and as expected, a set of fairly common beetle species was obtained from *Polyporus pseudobetulinus*.

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Parasitology and Tropical Medicine) identified parts of the beetle material. The Finnish Forest and Park Service supported the fieldwork. Dr. Tuomo Niemelä (University of Helsinki) revised the manuscript. I appreciate this assistance and the support of the study in a form of research grant from the Ministry of Environment, Finland (YM131/5512/2002).

Saproxylic Beetles of a Hardwood Floodplain Forest Canopy

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SCHLAGHAMERSKÝ J., 2005. SAPROXYLIC BEETLES OF A HARDWOOD FLOODPLAIN FOREST CANOPY. Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 85-92.

Abstract: The results of a pilot project on the saproxylic beetle fauna of the canopy and trunk layers of a Central European hardwood floodplain forest are presented. Beetles were trapped in 2002 and 2003 by means of flight interception traps installed on a monitoring tower; data thus reflect flight activity in the outer tree crowns at 25 m and between trunks at 12 m above ground level. Most individuals and species were trapped in May and particularly in June. Of a total catch of 1190 beetle specimens, 340 specimens belonged to 92 species classified as obligatory, facultative or potential saproxylics. If the mass catch of a coccinellid species during a single month of trap operation is excluded, saproxylic species made up for 58 % and 73 % of individuals in the canopy and trunk layer respectively. The species composition of both layers differed substantially. Several species considered rare and threatened were collected, some in high numbers. Attention is drawn to potential implications of this for the conservation status of species considered rare due to their hidden life in the tree canopy.

Key words: saproxylic, Coleoptera, floodplain forest, canopy, flight interception traps.

Introduction

Only in connection with biodiversity research in the tropics we have realised how little we know about the fauna of forest canopies in the temperate zone. Although differences between the fauna of the canopy and of lower strata are surely much smaller than in the tropics, factors such as insolation or humidity produce an environment different from that near to the ground level most often considered in field studies. This should also affect the composition of the saproxylic beetle community. Although the mobility between the individual layers seems rather high, some species that are generally considered rare and potentially threatened might actually be canopy dwellers (and therefore scarcely recorded by conventional methods). Also species belonging to other groups of insects show specific preference for the various forest strata (e.g. Raabe et al., 1996). On the other hand, one could assume some similarities of the temperate canopy fauna with the fauna of lower strata in forest edges or hedges. However, comparisons available for the same types of woody species show considerable differences between the insect faunas of these habitats (e.g. Ambsdorf, 1996). Two methods have been used most frequently to sample the fauna of tree crowns and the upper trunk zone: canopy fogging (using an arthropod-specific pesticide, usually natural pyrethrum of low persistence but high knock-down effect) and flight interception traps (mostly some modification of traditional window traps). Attracting beetles using light can also be very efficient but the results can not be linked to a specific vegetation layer of the stand. Bußler et al. (2004) compared the efficiency of flight interception traps and canopy fogging, both applied in four forest stands with warm climate in Bavaria (Germany). Each method was applied on 20 oaks in each of the stands. The flight interception traps were exposed in the inner tree crows from March to October; canopy fogging was applied at a single date in July. Comparing species numbers yielded by one month of trap exposure with the single fogging of one tree crown, no significant difference was found (while the number of trapped specimens exceeded that collected by fogging). However, when the entire trapping period was compared with the single fogging, the traps yielded six times higher numbers of individuals and three times higher numbers of species.

The efficiency of the methods differed for the individual beetle families. Families with species leading a hidden life for most of their life cycle were better represented in the traps while fogging was more efficient for jewel beetles (Buprestidae). The first finding shows that the opinion of Floren & Schmidl (2003) on the more objective character of the fogging method is to be questioned. The latter finding might have been a consequence of placing the flight interception traps in the inner tree crowns, as jewel beetles are mostly active in the insolated outer parts.

The present data are the outcome of a pilot study on the composition of the saproxylic beetle community of the canopy and trunk layers of a Central European floodplain forest. They are based on the catch of flight interception traps, thus reflecting the flight activity of the species recorded. As only one monitoring tower was available for trap installation on the study site the information obtained is mainly a qualitative one. Using a tower for trap installation meant that the traps were installed in the free space between the trunks and, in the case of the canopy layer, in the outer sphere of the tree crowns. The study was a follow-up on research on saproxylic beetles of Central European floodplain forests conducted by the author in 1996-1998 in floodplain forests on the lower reaches of the Dyje and Morava rivers in South Moravia, Czech Republic (Schlaghamerský, 2000). More detailed information on the study site and the wider area are found in this work. As most other studies on saproxylic invertebrates this preceding research had focused on the ground layer and a zone of standing trunks reaching to about 2 m above ground level. The comparison of data presented by different authors, for instance the numbers of saproxylic or xylobiotic species and all computations based on these numbers, is hampered by the fact that definitions of saproxylic species differ and so does the understanding of the ecology of individual species. The definition of saproxylic beetles as adopted for the purpose of this study is given in the above-cited monograph.

Material and Methods

In 2002 and 2003 beetles were collected in the canopy and trunk layers of a hardwood floodplain forest (in the terminology established in continental Europe, i.e. dominated by deciduous trees with hard wood as oak and ash). The site (48° 48′ N, 16° 46′ E) is an almost 130 year old stand (6.9 ha) situated at 161 m a.s.l. near the town of Lednice in South Moravia (south-eastern part of the Czech Republic) in the historical floodplain of the river Dyje (Thaya in German). The site had been flooded rather regularly, mostly in early spring, but flooding ceased in 1972 due to river regulation. It has been a research plot under the UNESCO MaB programme since 1968 and in fact under scientific observation and special management since the 1950s. The stand is dominated by pedunculate oak (*Quercus robur* – 50 %) and narrow-leaved ash (*Fraxinus angustifolia* – 35 %), followed by *Tilia cordata* (10 %) and interspersed *Populus nigra*, *Ulmus laevis*, and *Acer campestre*. Some extraction of dead wood has taken place but generally dead wood has been allowed to accumulate. This also includes substantial dead wood present in the canopy layer, presumably due to a die-back of many trees affected by water stress after the ceasing of natural inundation. The adjacent forest area is of a similar character but the stands are commercially managed and mostly younger, including small clear-cut areas.

The beetles were collected by means of flight interception traps (two panels of clear, transparent plastic fixed in perpendicular position to each other, thus forming a cross-like structure, covered on the top by a roof and suspended above a funnel with a wide opening connected to a container with preservative). These traps were installed on a monitoring tower present on site at a height of 12 m (tree trunk layer) and 25 m (upper canopy layer) above ground level (positioned some distance from the structures of the tower). In 2003 the same traps were also installed at 1 m above the forest floor to provide a comparable data set for this layer (from which extensive data are also available from previous research on site). However, data for the latter traps are not presented here. In 2002 the set of traps used included one large trap (upper diameter of funnel and effective width of plastic panels 30 cm; height of plastic panels 50 cm) and one smaller one (upper diameter of funnel and thus effective width of plastic panels 18 cm, panel height 33 cm) at 25 m above ground level and two traps of the latter, smaller type at 12 m above ground. In 2004 two large traps (upper diameter of funnel and effective width of plastic panel 24 cm; panel height 50 cm) were installed at 25 m above ground, while the larger and one of the small traps used also in 2002 were hung up at 12 m above ground level. Thus the total area of plastic panels exposed was roughly similar between the different heights and years with exception of the panel area exposed in the trunk layer in 2002, which was about half of that used in the other layer-year combinations. However, no information is available on the correlation of trap efficiency with trap size for this type of trap, and efficiency can probably not be directly derived from the sum of panel area. The traps were operated from the 5th of May to the 2nd of October 2002 and from the 5th of May to the 11th of October 2003, being usually checked and emptied monthly (bi-weekly in the first half of 2002, but un-checked for almost two months during July and August 2002). Furthermore, particularly in 2002 there were trapping intervals for which the catch of one of the traps was lost or in which the trap was out of operation (e.g. knocked down by a falling branch): the small trap in the canopy layer from June 15 to June 29, 2002; one small trap in the trunk layer from August 21 to October 2, 2002; one of the traps in the canopy layer from Sept. 6 to Oct. 11, 2003. The trapping design was far from being optimal, but as said above this was just a pilot study and particularly the first year was also used to test the design of the traps and the way they were installed.

Results

In total 1190 specimens of Coleoptera were trapped. Of those 43 were rove beetles (Staphylinidae), which were not identified. 997 specimens were trapped in the canopy layer, of those 200 (20 %) belonged to saproxylic species. However, when we exclude the 653 ladybirds (*Oenopia conglobata* (LINNAEUS, 1758), Coccinellidae) present in one single autumn catch (Sept. 6 to Oct. 11, 2003), the proportion of saproxylic beetles was 58 %. In the trunk layer 193 specimens were trapped, 140 of which belonged to saproxylic species (73 %). In total, 92 species were classified as potential, facultative or obligatory saproxylics (Table 1). In the canopy layer 66 such species were recorded, in the trunk layer 49. Only 22 of these species were recorded in both layers, the similarity of the assemblage thus being low (Sörensen's quotient of similarity = 0.49; Jaccard's index = 0.31). 33 saproxylic species had not been reported from the site before (underlined in Table 1), 21 of which were recorded exclusively in the canopy layer in this study. Species numbers were highest in June 2002 in both layers (Fig. 1).

In 2003, the number of species trapped in May and June were similar in both layers. Species numbers encountered for the rest of the trapping season were substantially lower. Abundance (flight activity) was again highest in June 2002 and very low in the subsequent months (Fig. 2).

In 2003, numbers of trapped individuals were generally lower than in 2002; highest numbers were caught in May and June. In both years higher numbers of individuals (and in 2002 also of species) were trapped in the trunk layer than in the canopy in May.

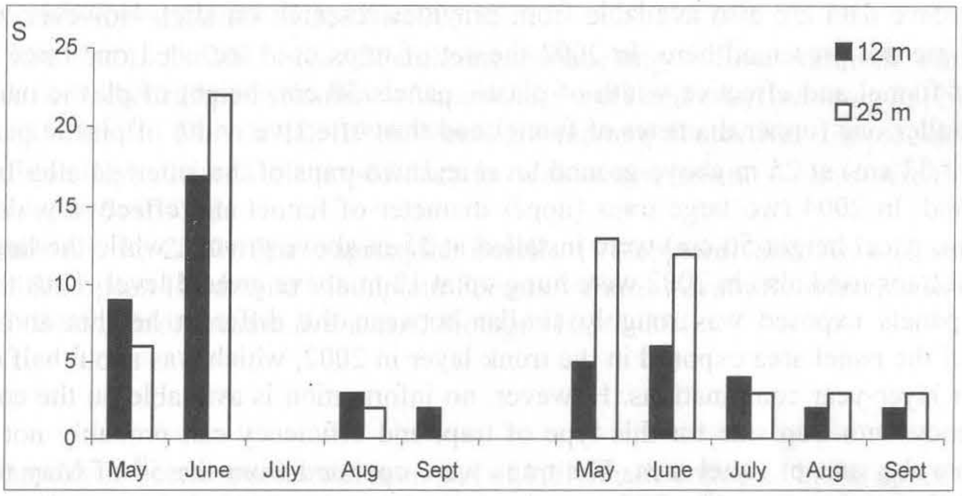

Figure 1. Monthly numbers of saproxylic beetle species trapped per layer (trunk layer at 12 m and upper canopy at 25 m above ground) in the trapping seasons 2002 and 2003; numbers for August 2002 include July catch.

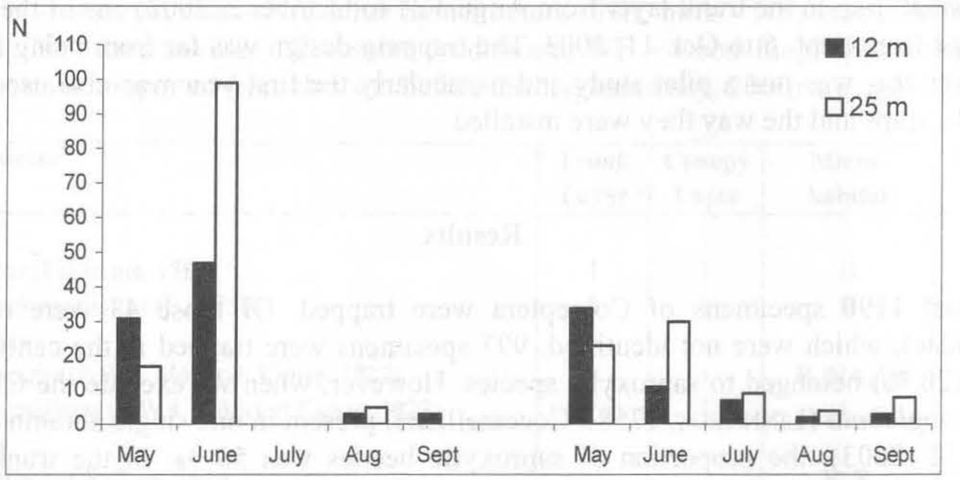

Figure 2. Monthly numbers of saproxylic beetle individuals trapped per layer (trunk layer at 12 m and upper canopy at 25 m above ground) in the trapping seasons 2002 and 2003; numbers for August 2002 include July catch.

Discussion

Saproxylic species make up for a high percentage of the total beetle fauna in the trunk layer as well as (although less so) in the canopy. Communities of the trunk and canopy layers seem to differ substantially (but the low and differing trapping intensity might have caused some bias). Despite the fact that 321 saproxylic species (286 when Staphylinidae are excluded) were already known from the site (Schlaghamerský, 2000) many species new for the site were recorded (11 % excluding rove beetles from the calculation). Although the occurrence of some of these species is not really surprising, as they have been recorded in the wider area, this result still shows that the site inventory is incomplete despite the long and intensive entomological research conducted here. Flight interception traps installed high up in the forest stand can thus contribute substantially to site-specific species inventories. However, flight interception traps do not capture all groups with the same efficiency (which is true for other methods as well). This is indicated by the present data and has also been reported by other authors (see Introduction). Thus for instance soldier beetles (Cantharidae) seemed under-represented in the catch. Probably this applies to all beetle families of slow flight or with small, light bodies as their representatives tend to land on the plastic panels and to take of again instead of hitting them hard and falling into the collection container. Flight interception traps with an additional upper funnel and collection container as used by Bußler et al. (2004) may be more effective because species belonging to these groups often avoid obstacles by flying upwards. More important than just the number of additional species obtained in the present study is the fact that this assemblage included a number of species considered rare and threatened. Some were trapped in rather high numbers in the canopy, for instance *Trichoferus pallidus* (OLIVIER, 1790) (Cerambycidae), *Opilo pallidus* (OLIVIER, 1795) (Cleridae), and *Dromaeolus barnabita* (VILLA et VILLA, 1838) (Eucnemidae), typically species already known to develop in thin branches in the tree crowns. The latter is a good example of a species that can pass without notice for decades of collecting in an area as long as no attention is paid to its true habitat in the tree crowns (see Floren & Schmidl, 2003). Also the mass occurrence of the non-saproxylic coccinellid *Oenopia conglobata* (LINNAEUS, 1758) is in line with these findings. This species is thought to live in tree crowns, mainly of poplar and elm, and hibernating in aggregations under bark (BIELAWSKI, 1959). However, a previous long-term study on the beetle fauna of the site in question yielded only a single specimen (DROZD, 1997).

The high proportion of rare species in the catch can be interpreted in two different ways: either the upper stand strata are particularly important for the conservation of such species or the assumed scarcity of many species (usually going along with a high conservation status) is a consequence of not looking for them in the right place (i.e. a methodological artefact). The truth lies probably in the middle. The need of re-assessing red lists based on new data from forest canopies has also been pinpointed by Floren & Schmidl (1999).

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Table 1. Saproxylic beetle species and numbers of individuals collected in the upper canopy and trunk layers of a hardwood floodplain forest in South Moravia (Czech Republic) by means of flight interception traps (2 traps per layer) in 2002 and 2003.

Assigned saproxylic status and preferred micro-habitat (based on literature) are given: 1 - obligatory, 2 – facultative, 3 – potential; B – in and under bark, D – decaying matter, L – litter layer / soil, N – nests (of ants – NA, other hymenoptera - NH, birds - NB, mammals – NM), R – rotten wood, TC – tree cavities, W – solid dead wood, WF – wood fungi (particularly fruiting bodies). Species not reported from this site before (Schlaghamerský, 2000) are underlined.

Family / Species	Trunk Layer	Canopy Layer	Micro-habitat	Saproxylic status
Carabidae				
Dromius agilis (Fabricius, 1787)	1	1	B	2
Dromius quadrimaculatus (L., 1758)	1	2	B	2
Scydmaenidae				
Scydmaenus rufus (P.W.J. Müller et Kunze, 1822)	1	1	R, NA, D	2
Stenichnus scutellaris (P.W.J. Müller et Kunze, 1822)		1	L	3
Pselaphidae				
Bibloporus minutus Raffray, 1914		1	B, R	1
Euplectus punctatus (?) (Mulsant, 1861)		1	B, R	1
Trogidae				
Trox scaber (L., 1767)		1	NB	3
Scarabaeidae				
Valgus hemipterus (L., 1758)		3	W	1
Liocola lugubris (Herbst, 1786)		3	R	1
Buprestidae				
Anthaxia podolica Mannerheim, 1837		3	B	1
Chrysobothris affinis (F., 1794)		1	B	1
Agrilus sulcicollis Lacordaire, 1835		1	W	2
Elateridae				
Stenagostus rhombeus (Olivier, 1790)		4	R	1
Calambus bipustulatus (L., 1767)	1		R	1
Ampedus megerlei (Lacordaire, 1835)	1	1	R	1
Ampedus pomorum (?) (Herbst, 1784)	1	4	R	1
Ampedus sinuatus Germar, 1844	1		R	1
Melanotus villosus (Fourcroy, 1785)	1		R	1
Throscidae				
Trixagus brevicollis (Bonvouloir, 1859)	1	1	W	1
Lissomidae				
Drapetes mordelloides (Horst, 1789)		2	W	1

Eucnemidae				
Dromaeolus barnabita (A. et G.B. Villa, 1838)		15	R	1
Hylis olexai (Palm, 1955)	1		R	1
Microrhagus lepidus Rosenhauer, 1847	1		R	1
Lycidae				
Lygistopterus sanguineus (L., 1758)		2	R	1
Dermestidae				
Trogoderma versicolor (Creutzer, 1799)		1	TC, N	2
Globicornis marginata (Paykull, 1798)	2	2	TC, N	2
Bostrichidae				
Xylopertha retusa (Olivier, 1790)		2	W	1
Anobiidae				
Priobium carpini (Herbst, 1793)	1		W	1
Oligomerus brunneus (Olivier, 1790)		3	W, R	1
Dorcatoma chrysomelina Sturm, 1837	1		W	1
Dorcatoma serra Panzer, 1796	2		WF, R	1
Ptinidae				
Ptinus sexpunctatus Panzer, 1795		1	TC, NH	2
Trogossitidae				
Nemozoma elongatum (L., 1761)	6	1	B	1
Cleridae				
Korynetes caeruleus (De Geer, 1775)	1		W, R	1
Opilo pallidus (Olivier, 1795)		4	B, W, R	1
Dasytidae				
Dasytes plumbeus (O.F. Müller, 1776)		2	R	1
Malachiidae				
Axinotarsus marginalis (Laporte de Castelnau, 1840)		1	W	1
Malachius bipustulatus (L., 1758)	1		B, R, NH	1
Nitidulidae				
Epuraea sp. Erichson, 1843		1		3
Carpophilus hemipterus (?) (L., 1758)		1	D	3
Laemophloeidae (Cucujidae)				
Lathropus sepicola (P.W.J. Müller, 1821)		1	B	1
Silvanidae				
Silvanus unidentatus (F., 1792)	1	4	B	1
Cryptophagidae				
Atomaria affinis C.R. Sahlberg, 1834		2		3
Cerylonidae				
Cerylon ferrugineum Stephens, 1830	6	1	R, B, WF	1
Cerylon histeroides (F., 1792)		1	R, B, WF	1
Endomychidae				
Symbiotes gibberosus (Lucas, 1849)	2	2	R, B, TC, NA	1
Corylophidae				
Clypastrea (= *Sacium*) *brunnea* (Brisout de Barneville, 1863)		1	B	1
Sericoderus lateralis (Gyllenhall, 1827)	2		D	3
Corticariidae				
Latridius hirtus Gyllenhall, 1827	2		WF, B	1
Enicmus atriceps Hansen, 1962	2		WF	1
Enicmus histrio Joy et Tomlin, 1910	2		R, L, D	2
Enicmus rugosus (Herbst, 1793)	7	2	R, B, WF	1
Corticaria abietorum Motschulsky, 1867		1	B, WF, L	2
Corticaria serrata (Paykull, 1798)	1	4	NB, WF, D	2
Cortinicara gibbosa (Herbst, 1793)	3	10	B, D, L	3
Corticarina fuscula (Gyllenhall, 1827)		1	B, NAM, E	3
Melanophthalma taurica (Mannerheim, 1844)	16	6	B?	3
Zopheridae: Colydiinae				

Synchita humeralis (F., 1792)	1		B	1
Bitoma crenata (F., 1775)		1	B, (WF)	1
Mycetophagidae				
Litargus connexus (Fourcroy, 1785)	3	3	B, WF	1
Ciidae				
Orthocis alni (Gyllenhall, 1813)		1	WF, B, R	1
Melandryidae				
Conopalpus testaceus (Olivier, 1790)	1		R	1
Mordellidae				
Tomoxia bucephala (Costa, 1854)		3	R	1
Mordella brachyura Mulsant, 1856	1	8	R	1
Oedemeridae				
Chrysanthia viridissima (L., 1758)		1	R	1
Aderidae				
Aderus populneus (Creutzer, 1796)	1		R, B, TC	1
Euglenes pygmaeus (De Geer, 1774)	1		R, B	1
Scraptiidae				
Anaspis frontalis (L., 1758)	6	7	R	1
Anaspis flava (L., 1758)		1	W	1
Salpingidae				
Lissodema cursor (Gyllenhall, 1813)		3	B, R, W	1
Lissodema denticolle (Gyllenhall, 1813)	1		B, R	1
Salpingus planirostris (F., 1787)	11	8	B	1
Tenebrionidae				
Tribolium madens (Charpentier, 1872)		2	R, B, D	2
Tenebrio molitor L., 1758		1	R, B	2
Cerambycidae				
Trichoferus pallidus (Olivier, 1790)		2	B	1
Cerambyx scopoli (Füessli, 1775)		1	B, W	1
Clytus arietis (L., 1758)		2	B, W	1
Stenocorus meridianus (L., 1758)	1		B, W	1
Grammoptera ruficornis (F., 1781)	1		B, W	1
Mesosa curculionides (L., 1761)	1		B, W	1
Anthribidae				
Phaeochrotes cinctus (Paykull, 1800)	1	4	B	1
Curculionidae				
Dryopthorus corticalis (Paykull, 1792)		1	R	1
Rhyncolus punctatulus (Boheman, 1838)	1		R	1
Magdalis cerasi (L., 1758)		2	B, W	1
Scolytidae				
Hylesinus crenatus (F., 1787)	2	4	B	1
Hylesinus oleiperda (F., 1792)	30	38	B	1
Leperisinus fraxini (Panzer, 1799)		1	B	1
Scolytus intricatus (Ratzeburg, 1837)		1	B, W	1
Scolytus multistriatus (Marsham, 1802)	3		B	1
Xyleborus dryographus (Ratzeburg, 1837)	1		B, W	1
Xyleborus monographus (F., 1792)	2	2	B, W	1
Xyleborus saxeseni (Ratzeburg, 1837)	2		B, W	1

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Ceruchus chrysomelinus (HOCHENWARTH, 1785) (Lucanidae) in Latvia: Distribution and Ecology

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TELNOV D., 2005. *CERUCHUS CHRYSOMELINUS* (HOCHENWARTH, 1785) (LUCANIDAE) IN LATVIA: DISTRIBUTION AND ECOLOGY. Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 93-96.

Abstract: Some ecological and faunal information on *Ceruchus chrysomelinus* (HOCHENWARTH) (Coleoptera: Lucanidae) in Latvia is presented.

Key words: *Ceruchus chrysomelinus*, Latvia, distribution, ecology.

The Genus *Ceruchus* was described in 1819 by McLeay. Systematically, the genus belongs to the tribe Ceruchini LECONTE, 1862 of the subfamily Lucaninae LATREILLE, 1806.

The genus has a holarctic distribution, with some species also known also from the borders with the Oriental zoogeographical region. There are 16 recent species and subspecies (Table 1). A single fossil species is also known (Table 1).

Table 1. Alphabetic index of recent and fossil members of the genus *Ceruchus* McLeay, 1819.

Nr.	Species	Distribution
1.	*atavus* FAIRMAIRE, 1891	North-western India (Jammu & Kashmir), North-eastern Pakistan
2.	*chrysomelinus* (HOCHENWARTH, 1785)	Europe (from eastern Spain to Ural Mts., from southern Scandinavia to northern Italy, Croatia & Bulgaria), western and probably eastern Siberia
3.	*deuvei* BOUCHER, KRÁL, 1997	Southern China (Sichuan)
4.	*fuchsii* WICKHAM, 1911	Miocene of Colorado (USA)
5.	*katerinae* KRÁL, 1995	Southern China (Sichuan)
6.	*lignarius lignarius* LEWIS, 1883	Japan (Hokkaido, northern Honshu), eastern Russia (Sakhalin & South Kurile Isls)
7.	*lignarius monticola* NAKANE, 1978	Japan (central Honshu)
8.	*lignarius nodai* FUJITA, 1987	Japan (Kyushu, Shikoku)
9.	*minor* TANIKADO, OKUDA, 1994	Central China (Shaanxi)
10.	*niger* BOUCHER, KRÁL, 1997	Southern China (Yunnan)
11.	*piceus* (WEBER, 1801)	North-eastern USA (to Nebraska), eastern Canada (Ontario, Quebec)
12.	*punctatus* LECONTE, 1869	Western USA (California, Oregon Washington, Idaho), western Canada (British Columbia)
13.	*reginae* BOUCHER, KRÁL, 1997	Southern China (Yunnan)
14.	*sinensis* NAGEL, 1933	Southern China (Sichuan, Yunnan), northern Myanmar
15.	*striatus* LECONTE, 1859	Western USA (California, Oregon, Washington), western Canada (British Columbia)

The species *Ceruchus chrysomelinus* (HOCHENWARTH, 1785) were described from "Prussia". The known species name synonyms are:

= *piceus* (BONSDORFF, 1785)
= *silesiacus* (MERGELE, DEJEAN, 1837)
= *sylvicola* (MULSANT, 1842)
= *tarandus* (PANZER, 1789)
= *tenebrioides* (LATREILLE, 1807)
= *tenebroides* (FABRICIUS, 1787)

In Latvia, the body length of males is 12-18 mm (up to 22 mm including mandibles), females are smaller, 11-16 mm (up to 18 mm including mandibles). Mature larvae up to 37 mm. In males, there are two size classes: f. minor –mandibles as long as head; f. major – male mandibles considerably longer than head.

Species Distribution

Ceruchus chrysomelinus (HOCHENWARTH, 1785) is known from the main part of the Baltic and Fennoscandian region, namely from Latvia, Estonia, Lithuania, southern Sweden, extreme South of Finland, and also from southern Karelia and the St. Petersburg area of Russia as well as from Byelorussia. Horotype: Euro-Siberian.

Species Ecology in Latvia

This saproxylo-mycetopahgous species inhabit moist to average moist ancient to middle-aged dark / shaded mixed or deciduous woods on mostly non-sandy soils. Forest biotopes types inhabited by *C. chrysomelinus* are (codes according the Palaearctic biotope codes); Western taiga (boreal forests) – code 9010, Medio-European oak or oak-hornbeam forests – code 41.2, Tilio-Acerion forests of slopes, screes, ravines and glens – code 9180, Riparian and moist mixed forests – code 91F0, Alluvial forests with *Alnus glutinosa* (alnion incanae, Alno-Padion, Salicion albae) – code 91E0, Other alder woods – code 41C, Boreal aspen woods – code 41D5. According to references (Palm, 1959) this species is characteristic of dark, ancient relictual forests.

Larvae occur in rotten wood ("red & brown-red rot") of fallen trunks and branches with relatively high wood moisture. Eggs are laid in partly hard parts of the same wood pieces of whitish-brown or whitish-red colour, with dense polypore mycelia. Shade and substrate moisture are strongly interconnected, and this combination is necessary to reach the particular stage of wood rot preferred by *C. chrysomelinus*. Exposed populations (for example, as tested on newly felled areas in the Gulbene district, E Latvia) strongly decreased (over 2-3 years), because of active drying of the wood substrate and soil. After 3-5 years, populations in exposed conditions are lost.

Larvae develop in rotten wood of fallen trunks and stumps of various trees: 60% - *Picea abies*, 10% - *Betula* spp., 10% - *Quercus robur*, 10% - *Alnus incana* / *A. glutinosa*, less than 5% each *Pinus sylvestris*, *Populus tremula*, *Tilia cordata*. According to the literature, this species also is recorded from *Abies* spp. and *Fagus* spp. (Franciscolo, 1997) which are not native to Latvia and do not occur in natural habitats. In southern (except for mountainous) parts of the distribution area development in deciduous trees is more common, than in northern parts.

The period of adult activity is from May (when average daily temperatures exceed +10 C degrees) until the end of September; larvae can be found during the whole year. In one trunk (of course, depending on the dimensions of the tree) several hundred larvae can be counted. Trunks inhabited by larvae are commonly in a particular stage of rot: they are relatively hard outside and mainly extremely rotten (soft) and moist inside and on the side adjoining the soil. The colour of the wood is (except for in *Populus tremula*) generally a deep red-brown. According to Palm (1959), such a type of rot can only be formed in shaded conditions with very high moisture. Larvae live on the border between soft and hard wood, or inside hard wood. They may be found together with larvae and adults of some another beetles, such as Lucanidae *Sinodendron cylindricum* (LINNAEUS, 1758) in deciduous wood or *Platycerus caraboides* (LINNAEUS, 1758) in coniferous wood, birch or alder. Pupation occurs at the end of the summer and in autumn (August-September). The pupation chamber is ~20 mm long and 10 mm broad; a simple "cocoon" is occasionally build by mature larvae from frass and wood dust. Adults emerge from the pupae after ~one month and remain in the pupal chamber until the spring. Adults are active during daylight hours, in the same microhabitat, and are generally observed on or near to the pieces of wood where they developed. There is no set flight time, but the main period of adult activity and copulation is from the end of June until the middle of July. On numerous occasions during this time period I have been able to observe males and females excavating together the partly hard wood of fallen trunks, and females laying eggs in tunnels made by both beetles together. The eggs are covered by the females with a glue-like substance. The average time needed to prepare a ~2 cm long tunnel inside partly hard wood was ~2 hours (on spruce wood). Both adults and larvae are to be found in winter in diapause inside the wood.

In Latvia, the development cycle of this species is 2-3 years, depending on geographical location: in north-eastern parts of the country (Vidzeme province) with a comparatively longer and colder winter period, the development of larvae of this species takes in average on 4-5 months longer time than in western populations (Kurzeme province).

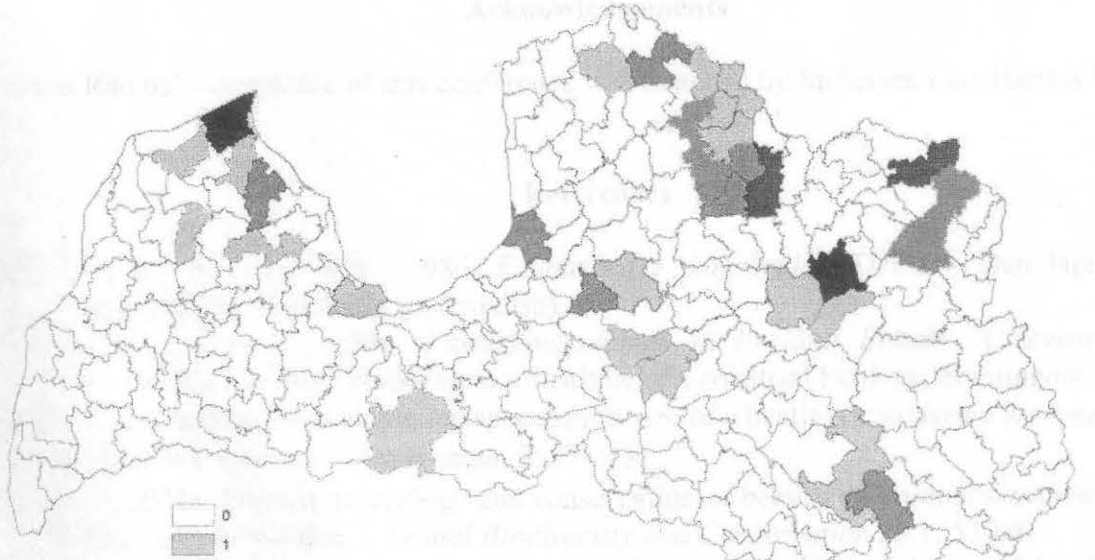

Figure 1. Recent distribution of *Ceruchus chrysomelinus* (HOCHENWARTH) by state forestries of Latvia.

Digits 0-4 indicate density of populations on 1 square km (darker colour means higher density; zero means no known populations).

Species Protection in Latvia

Ceruchus chrysomelinus is strongly protected by laws in Latvia. According to the Regulations of Latvian Cabinet of Ministers Nr. 45 from 30th of January, 2001, a microreserves should be established to protect each known population outside from existing nature protection areas. This helps to easely and relativelyt fast establishing the microreserves in valuable forests. Actually, one microreserve is established specially for *C. chrysomelinus* in Latvia in Jelgava district, Zaļenieki parish.

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The Belgian (Saproxylic) Elateroidea Fauna in Danger? A Study in Deciduous Forests in Southern Belgium

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Abstract: To gain better knowledge on the current distribution of flagship species, indicators of microhabitats and successional processes in natural and non-intensely managed oak and beech forests in Belgium, 'Xylobios' was begun. 22 Sites were sampled monthly with 4 different techniques for 2 years. The Elateroidea fauna was examined by identification of specimens of Elateridae, Eucnemidae and Throscidae. In total about 25.000 individuals (54 species) were sampled. Most individuals belonged to more common species, whilst specialised species were rare, this is an indication that due to intensive forestry (and habitat destruction) these species are endangered or have become extinct.

Key words: oak, beech, Elateroidea, saproxylic species, diversity.

Introduction

Forestry is an important economic resource in many European countries, leading sometimes to monotonous highly managed single species woodlands. Intense use of forests in the past has lead to a high percentage of small, isolated forest patches (Hannah et al., 1995). Belgium has experienced historical deforestation since the Roman period; especially the northern part (Flanders) suffered from severe woodland destruction (Tack et al., 1993; Tack, Hermy, 1998). In total, about 25% of Belgium is registered as forested area. Forests cover 10% of the total surface (13500 ha) in Flanders, most are broadleaved (60%) with young pine plantations (20%) and some mixed forests, all mostly used for recreation and with practically no economic value. About 32% of Wallonia is covered with woodland (55000 ha), about 50% broadleaved and 50% pine forests. The latter are heavily exploited and cleared. Both in Flanders as in Wallonia, dead wood was removed until recent times for sanitary and social reasons. Without knowing, these actions greatly reduced overall biodiversity and lead to the decrease or extinction of several vulnerable and specialised saproxylic species (Schiegg, 2001; Speight, 1989; Hyman, 1992). Nowadays potentially valuable areas are protected and forest reserves with low or even non-existent forest management regimes are established, where dead wood is allowed to accumulate. In Flanders reserves were created in the early nineties; the goal is to achieve at least 10 ha of old, decaying trees and to have 4% of the total wood mass as dead wood in each reserve. In Wallonia however most state forest are heavily managed and the total of dead wood on the ground is about $3.3 m^3$/ha. Dead wood is still removed (also by locals, for use as fire- wood) and forests are cleared.

To study the endangered saproxylic fauna and improve knowledge of the saproxylic fauna in deciduous forests in Belgium, a 4 year study began in 2001; Xylobios. In this contribution, attention is paid to 3 families of the superfamily Elateroidea: Elateridae, Eucnemidae and Throscidae. Little is known of the distribution and diversity of Throscidae and Eucnemidae in Belgium. On the Elateridae, however, old data are available offering the possibility to compare our data with these old records. Whilst the ecology of Elateridae and Eucnemidae is known, there is much doubt about that of most throscid species (see Lawrence et al., 1995; Johnson, 1999). The importance of these families on the forest functioning has long been ignored, this study aims improve our knowledge on their distribution (and role) in our deciduous forests.

Material and methods

In total 22 forests (Table 1) were sampled in 4 different ecoregions (the Brussels region, Ardennes, Hautes Ardennes and Gaume; figure 1). Eleven sites with a high dead wood stock were chosen (rich sites) and compared with 11 (poor) control sites, in a radius of at least 1 km and with comparable soil and vegetational characteristics.

Figure 1. Situation of the 22 sample plots in Belgium.

The first year (2002) all sites contained 8 hanging window traps, 3 (stump) emergence traps and 1 malaise trap (Fayt 2004, in press). The sampling design is shown in figure 2. In sites rich in dead wood, 8 additional trunk window traps were installed. The second year (2003) the sampling campaign was conducted according to the same sampling design, however another malaise trap and one (or 2) black window traps were added. Black window traps with chemical pheromones were placed 300 metres outside 4 sites to test if additional (saproxylic) species were caught, hereby testing if the applied campaign was successful. All containers were filled with a saturated saline solution, except for the containers of the malaise traps, filled with a 50% monopropylene glycol solution. The traps were emptied monthly from March to October.

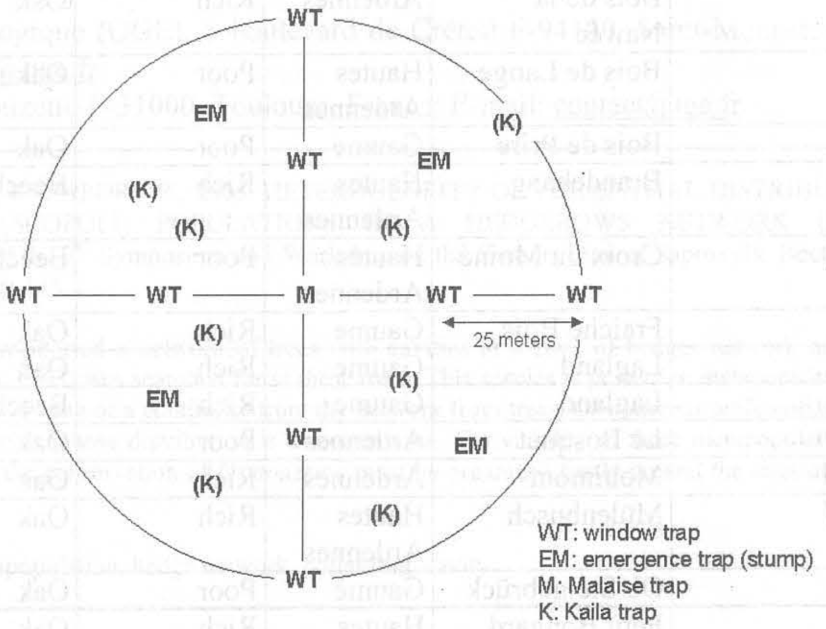

Figure 2: Sampling design used in Xylobios.

Results

Results presented are from the sampling campaign of 2003 (except for the Elateridae where data from 2002 is incorporated).

Only 4 Throscidae species are recorded. Probably a fifth species is present in our data but this will have to be verified. In total 3321 individuals were sampled (Table 2). Some of these species are new to the Belgian fauna or were only known from limited records and areas. About 69% of all individuals (2299 specimens) were found in malaise traps, window and kaila traps counted for respectively 20% and 7% of all adults (678 and 245 specimens. *Throscus dermestoides* (LINNÉ, 1758) and *T. carinifrons* (BONVOULOIR, 1859) (respectively in 21 and 22 sites) were most abundant, with a total number of 1607 individuals. The former species was not found in the FS site (Brussels region) were it was apparently replaced by *T. brevicollis* (BONVOULOIR, 1859), exclusively found in this site (3 specimens). *T. leseigneuri* (MUONA, 2002) on the other hand was found in 12 (mostly “poor) sites (104 individuals). However there was little or no difference between sites rich in dead wood and poor sites.

In total 10 Eucnemidae species were sampled (474 individuals) (Table 3). *Hypocoelus olexai* (PALM, 1955) was the most abundant species, occurring 21 times in 21 sites, whilst *Eucnemis capucina* (AHRENS, 1812) was recorded only from one site (1 specimen). The highest species richness was sampled in the Ardennes and Haute Ardennes, but on average most sites contained 4 species. Kaila traps yielded about 40% of all individuals (192 adults), whilst malaise and window traps counted for respectively 31 (149 specimens) and 25% (122 specimens) of the total number of individuals.

Table 1. List of all sites with their ecoregion, the indication of dead wood amount and the dominant tree species.

Abbreviation	Site	Region	Rich / poor	Dominant tree species
BN	Bois de la Nawée	Ardennes	Rich	Oak
BL	Bois de Lange	Hautes Ardennes	Poor	Oak
PR	Bois de Prire	Gaume	Poor	Oak
BR	Brandehaag	Hautes Ardennes	Rich	Beech
MO	Croix du Moiné	Hautes Ardennes	Poor	Beech
FB	Fraiche Bois	Gaume	Rich	Oak
CL	Lagland	Gaume	Rich	Oak
HL	Lagland	Gaume	Rich	Beech
LB	Le Bosquet	Ardennes	Poor	Oak
MH	Mohimont	Ardennes	Rich	Oak
MU	Mülenbusch	Hautes Ardennes	Rich	Oak
ST	Ob Steinebrück	Gaume	Poor	Oak
PB	Petit Bongard	Hautes Ardennes	Rich	Oak
PO	Porfays	Hautes Ardennes	Poor	Beech
RA	Ravenstein III-3	Brussels	Poor	Beech
FS	RN de Groenendaal	Brussels	Rich	Beech
R1	Roubrouck 1	Hautes Ardennes	Poor	Oak
R2	Roubrouck 2	Hautes Ardennes	Poor	Beech
RU	Rurbusch	Hautes Ardennes	Rich	Beech
TR	Trimetrichet	Gaume	Poor	Beech
VS	Vallée de la Soristène	Hautes Ardennes	Rich	Beech
VR	Virée du Rot	Ardennes	Poor	Oak

The first year (2002) a total of 7949 adult click beetles (belonging to 37 species, Table 4) were sampled. There is little difference between sites rich and poor in dead wood, even in number of saproxylic species (resp. 14 and 13 species). The sampling in the former sites yielded 34 species (4558 individuals) whilst in the latter 27 species and 3382 individuals were sampled. About 72% of the individuals (5755 specimens) were from window traps, whilst about 20% (1561) came from kaila traps and about 8% from malaise traps, the amount of species found in emergence traps was negligible. The same pattern is seen in the second year, 5143 individuals (31 species) in the rich sites and 3779 individuals (23 species) in the poor site (Table 4). Most species were caught with the window (55% of the total, 4879 individuals), the malaise (29% or 2562 specimens) and kaila traps (13% or 1045 individuals). The difference between sampled saproxylic species is however more pronounced; 12 saproxylic species were found in the 11 rich sites whilst 7 species were captured in the poor (replicate) sites. Not surprisingly, *Athous* *subfuscus* (MÜLLER, 1764) was the most abundant species (in total 8468 individuals), this species is in expansion in many European countries (JEUNIAUX, 1996). Other abundant species included *Athous haemorrhoidalis* (FABRICIUS, 1801) and *A. vittatus* (FABRICIUS, 1792), *Agriotes pallidulus* (ILLIGER, 1807) and *Dalopius marginatus* (LINNÉ, 1758); all common in forested sites. Saproxylic species are found in very low numbers (1 to 5 individuals) because of their cryptic ecology. Among these are 3 *Ampedus* species (*A. cardinalis* (SCHIÖDTE, 1865), *A. nigrinus* (HERBST, 1784) and *A. sanguineus* (LINNÉ, 1758)) and *Stenagostus villosus* (GEOFFROY, 1785). All data was compared with the distribution maps made by Jeuniaux (1996) to form an idea about the current status of click beetles in the southern part of Belgium (Table 5). Although most rare and threatened species show a small decline, some species that were presumed extinct or nearly extinct were rediscovered. The population level of most abundant species is stagnant or increasing. Assumptions on distribution are difficult to make, because of the small (13) number of 10km squares. On the other hand, these data are already an indication of the actual distribution of the species.

Table 2. Total number of individuals of Throscidae.

Code site	*Throscus brevicollis*	*Throscus carinifrons*	*Throscus dermestiodes*	*Throscus leseigneuri*
BL		27	12	
BN		57	9	
BR		11	34	
CL		8	91	
FB		91	28	
FS	3	2		
HL		17	26	
LB		55	2	
MH		65	209	18
MO		6	3	3
MU		32	1024	4
PB		37	11	9
PO		9	9	6
PR		310	17	15
R1		332	19	1
R2		137	1	
RA		5	8	1
RU		1	3	
ST		165	4	1
TR		106	5	39
VR		54	4	3
VS		80	88	4
Total	**3**	**1607**	**1607**	**104**

Trap efficiency for Elateroidea was preliminary studied; pooled and detailed (saproxylic) data show highest efficiency for window traps (more than 50% of all individuals and almost 27% of all species). Malaise and kaila traps yielded respectively 27% and 16% of all individuals, 20% and 23% of the total species number, the results of the other traps are negligible. Window traps show again the highest trap efficiency, for all Elateroidea as well as for saproxylic species.

Table 3. Total number of individuals of Eucnemidae.

Code site	*Dirhagus lepidus*	*Dirhagus pygmaeus*	*Dromeolus barnabata*	*Epiphanis cornutus*	*Eucnemis capucina*	*Hypocoelus cariniceps*	*Hypocoelus foveicollis*	*Hypocoelus olexai*	*Hypocoelus porcerulus*	*Melasis buprestoides*
BL	1					2				
BN				2			4	11		
BR							9	14		7
CL	4						1	5		1
FB	10	1	3			2	10	1		1
FS	2	1						45		1
HL	6						2	20		4
LB						2		1		1
MH	3			1		8		9		9
MO						2				
MU					1	4		13		3
PB	1					28		8		1
PO	1					13		5		1
PR	7	1		1		1	11	8		
R1	1					3	8	4		
R2	2					2	7	3		
RA	2						8	3		1
RU							11	38	1	2
ST	5	1		1			1	2	1	
TR	2					5	5	6		
VR	2						4	1		1
VS						1	12	13		4
Total	**49**	**4**	**3**	**5**	**1**	**73**	**93**	**210**	**2**	**37**

Discussion

About 97 Elateridae species are known from Belgium with 49 species present in forested areas (Jeuniaux, 1996). In total 27 of the click beetles sampled in our study are restricted to or commonly found in forested areas. It is wrong to assume that these species only inhabit forest sites, single trees can be sufficient if they are old enough to support a viable population. Other factors influencing their presence or absence, such as tree age and site history are more important habitat determinants for Elateridae than forest site type. In case of saproxylic beetles the species richness is only weakly associated with stand structure characteristics at stand level, and is strongly correlated with the amount of dead and decaying wood (Similä et al., 2002; Martikainen et al., 2000, Økland et al., 1996; Schiegg, 2000). Preliminary results of the Elateridae fauna (raw data) show that the mean number of species and individuals was higher overall in sites with a higher amount of dead wood. A slow decrease of specialised saproxylic species is ongoing in our forests whilst more common woodland species tend to show an increasing pattern. Species attached to hollow oaks (such as *Elater ferrugineus* (LINNAEUS, 1758)) were, contrary to expectations, not found in our oak woodlands. The absence of these specialised species could indicate a habitat devaluation or destruction. Preservation of its fauna can only be realised when long term management has allowed pre-existence of the habitat (Ranius, 2002).

Table 5: Current status of Elateridae compared with data from 1996.

Species	**1996**	**2002-2003**
Agriotes acuminatus	locally abundant	locally abundant
Agriotes aterrimus	abundant	abundant
Agriotes gallicus	rare	endangered
Agriotes obscurus	abundant	rare
Agriotes pallidulus	abundant	rare
Agriotes pilosellus	locally abundant	abundant
Agriotes ustulatus	rare	endangered
Ampedus balteatus	rare	scarce
Ampedus cardinalis	extinct	endangered
Ampedus elongatulus	scarce	scarce
Ampedus nigrinus	endangered	endangered
Ampedus pomorum	abundant	abundant
Ampedus sanguineus	locally abundant	scarce
Anostirus castaneus	locally rare	rare
Anostirus purpureus	locally abundant	rare
Athous bicolor	locally abundant	rare
Athous haemorrhoidalis	abundant	abundant
Athous subfuscus	abundant	abundant
Athous vittatus	abundant	abundant
Cidnopus parvulus	scarce	scarce
Ctenicera heyeri	endangered	scarce
Ctenicera pectinicornis	locally rare	scarce
Ctenicera sjaelendicus	locally rare	scarce
Dalopius marginatus	abundant	abundant
Denticollis linearis	abundant	abundant
Denticollis rubens	scarce	endangered
Haplotarsus angustulus	scarce	endangered
Haplotarsus incanus	locally abundant	rare
Hypnoides riparius	rare	scarce
Hypoganus cinctus	rare	rare
Limonius aeneoniger	locally abundant	rare
Melanotus castanipes	rare	abundant
Melanotus rufipes	abundant	locally abundant
Prosternon tessellatum	locally abundant	rare
Pseudathous hirtus	locally abundant	locally abundant
Selatosomus aeneus	rare	scarce
Selatosomus bipustulatus	rare	rare
Selatosomus nigricornis	endangered	rare
Sericus brunneus	rare	scarce
Stenagostus villosus	rare	scarce

Careful attention has to be paid to sampling design of an ecological study on tree-insect communities (Stork et al. 2001). Catches only reflect part of the insect community present in a site and depend on the techniques used and sampling artefacts, which can distort the global picture. Moreover the sampling methods used during the study have a strong effect on the output, different aspects play a role to catch different species. The species specificity of the traps make it impossible to compare catches of different species but for a single species the probability of being caught is likely to be comparable in structurally similar forest stands (Martikainen et all., 1999). A window trap without any pheromones is a good indication of the flight activity of beetles. Trunk window traps on the other hand (Kaila, 1993) are attached to old, decaying or dead trees and therefore influenced by this substrate that has a baiting effect (Kaila et al., 1994; Økland, Hågvar, 1994). This technique however is more efficient in catching rare and threatened saproxylic species than a window trap (Martikainen, 2000). At first sight our results do not support this, they show a higher number of saproxylic species caught in window traps, but the number of window traps was higher than the number of trunk window traps. If we look only at those sites with both trap techniques the same results are yielded; species richness is higher in window traps but most individuals are in trunk window traps. The probability of finding a species is therefore higher using window traps while the probability of finding numerous examples of one species is higher in trunk window traps. Furthermore unique samples of species can be based more on chance than on the presence of a viable population.

Conclusions

Although it is difficult to make assumptions about the specific situation of the Elateroidea fauna of Belgium, some suggestion towards conservation and restoration management should be made. Most specialised species, with high habitat requirements, are abundant in suitable habitats (eg. Renvall, 1995) but are in general more sensitive to extensive habitat loss. They have become isolated (single old trees) and are probably on the verge of extinction. More detailed studies focused on the distribution and abundance of Elateroidea species in Belgium will have to be conducted before profound conservation and restoration measurements can be made. However, it is clear that the habitat of these species need to be protected. We suggest that measures to augment old decaying trees or rot holes and the creation of greater levels of dead wood stock will have to be stimulated.

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Table 4. Total number of individuals of Elateridae of year 2002 and 2003.

	BL	BN	BR	CL	FB	FS	HL	LB	MH	MO	MU	PB	PO	PR	R1	R2	RA	RU	ST	TR	VR	VS	Total
2002																							
Agriotes acuminatus	16	5	2		9	16			1	3	42	2	2	2	1		6		16				**123**
Agriotes aterrimus				20		1	47				48		1		1	7				10		22	**125**
Agriotes gallicus				2																			**2**
Agriotes obscurus				1																			**1**
Agriotes pallidulus	2	102		1		5		3	20	16	27	12	5	4	3	2		4	9	8	20	1	**215**
Agriotes pilosellus	9	3	1	3	1	5	6	1	53		33	29	9		44	11	3			2	9	25	**211**
Agriotes ustulatus	1																						**1**
Ampedus balteatus		2						1			1	2			3		1						**10**
Ampedus elongatulus		1							1						1								**3**
Ampedus nigrinus			1						2		5	4			3							1	**15**
Ampedus pomorum	4	12	8	1	2	8	9	3	31	8	58	58	11	1	16	7	11	15	1	1	1	28	**264**
Ampedus sanguineus							1										1			1			**2**
Anostirus castaneus		3	1			2	1				1	3					1				1		**12**
Anostirus purpureus						3		1			1			1			3				1		**9**
Athous bicolor																					1		**0**
Athous haemorrhoidalis	88	17			17	88	1	7	2	1	108			10	129	17	91		9	1	7		**585**
Athous subfuscus	203	163	399	53	16	104	116	47	192	368	119	618	402	18	390	200	195	224	12	39	48	209	**3839**
Athous vittatus	161	67		6	1	71		7	19		83	24	8	49	1		5	5	7		19	2	**514**
Cidnops parvulus									1														**1**
Ctenicera heyeri															1			2					**3**
Ctenicera pectinicornis																		2				2	**2**
Ctenicera sjaelendicus											2	1										2	**3**
Dalopius marginatus	31	51	10	17	9	2	24	23	37	7	26	42	13	2	87	39	11	2	9	16	22	33	**442**
Denticollis linearis	2	11	4	17	5	13	6	3	10	2	7	21	1	1	8	5	1	3		1	2	22	**120**
Denticollis rubens		1	2																1	1			**4**
Haplotarsus angustulus					1							3			1							4	**5**
Haplotarsus incanus										1		2			3			2				6	**8**
Hypnoides riparius																		1				2	**1**
Hypoganus cinctus				1	1	1	5		2			1		1	8					1	1	1	**20**
Limonius aeneoniger												3											**3**

Melanotus castanipes	17	30	78	3	4		10	6	29	29	37	86	36		63	24	7	76		1	10	52	**535**
Melanotus rufipes		1		2		139	1			3	1	13					8			1			**168**
Prosternon tessallatum					1																		**1**
Pseudathous hirtus			1		2	5			2		3	6	1	5			1	1	7	1		1	**34**
Selatosomus bipustulatus		1			1		2		1					2						3			**7**
Sericus brunneus							1		2				1										**4**
Stenagostus villosus						3					1						2						**6**
2003																							
Agriotes acuminatus	1	5	1		7	3					35			3			24		15				**94**
Agriotes aterrimus				34		2	39				36					3				20		12	**114**
Agriotes obscurus		1		1																			**2**
Agriotes pallidulus	1	361	2	33	1	61		81	15	32	37	18	6	22	1	1	62		6	11	33	1	**740**
Agriotes pilosellus	6	1	2	6		7	3	2	46		18	30	12	4	25	9	5		1	1	9	21	**177**
Ampedus balteatus		1						1		2					1	1	3						**9**
Ampedus cardinalis							1																**1**
Ampedus elongatulus		1					1		1								1						**4**
Ampedus nigrinus			4				1		2		1	3	1		1								**13**
Ampedus pomorum	3	7	23	2	5	6	3	1	24	4	23	38	14	2	12	3	9	16		2	1	14	**195**
Anostirus castaneus			1			1	1	2				1			1		2	2					**11**
Anostirus purpureus						2					1						4		1				**8**
Athous bicolor								1															**1**
Athous haemorrhoidalis	50	6		1	46	42		5	2	1	87	3		2	176	35	198		18	1	13	3	**672**
Athous subfuscus	80	177	468	68	43	147	121	84	125	412	109	626	214	35	456	232	209	218	11	40	86	372	**3835**
Athous vittatus	50	92	2	10	4	138		4	15		54	38	5	72	2	2	24	3	18	1	33	6	**533**
Ctenicera heyeri			1																				**1**
Ctenicera pectinicornis						6						1						5				4	**12**
Ctenicera sjaelendicus					1																		**1**
Dalopius marginatus	34	38	12	45	21	6	30	58	35	11	18	68	19	13	165	62	13	8	8	22	45	60	**664**
Denticollis linearis	1	10	15	26	15	41	8	18	16	8	11	23	8	10	4	5	3	7	15	9	21	17	**244**
Denticollis rubens			1																				**1**
Haplotarsus angustulus												1			1								**2**
Haplotarsus incanus																		5			4	14	**5**
Hypoganus cinctus	1				3	4	4		1						1								**14**
Melanotus castanipes	12	46	67					6	55	23	36	66	29		25	18	19	74		2	13	34	**476**

Melanotus rufipes				2		95	7	2						1			14			3			**121**
Pseudathous hirtus			1			3			4		4	6		7			3		2	1	1	3	**30**
Selatosomus aeneus																						1	**0**
Selatosomus bipustulatus				1	1				2														**4**
Selatosomus nigricornis					2																		**2**
Stenagostus villosus	1										1												**2**

Heterogeneity of the Spatial Distribution of *Osmoderma eremita* (SCOPOLI, 1763) Populations in a Hedgerow Network (France, Normandy)

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Abstract: We exhaustively inventoried a network of trees with cavities in a zone of hedges network of 2100 ha. *Osmoderma eremita* (SCOPOLI, 1763) was searched for in these trees. This species is present in metapopulations more or less insulated between them in spite of a continuity from the network from trees. *Osmoderma* preferentially lives in large cavities of two trees species whose distribution is discontinuous. The viability of these metapopulations is not certain. In the hedge network, the conservation of *Osmoderma* must be organized firstly around the sites occupied by this species.

Key words: *Osmoderma*, metapopulation, hedge network, pollarding, cavity

Introduction

Studies were carried out to take into account *Osmoderma eremita* (SCOPOLI, 1763), concerning the realisation of the A28 motorway project and the projects of land consolidation (impact assessment studies). These studies were undertaken on behalf of the company ALIS, concessionary of the A28 motorway and the General Council of the Orne department (Normandy), contractor of the land consolidation.

These studies made it possible to detail the structure of the original habitat constituting a habitat of *Osmoderma*: a hedgerow network and orchards of apple trees. The hedgerows network consisted of a set of plots of meadows or cultures enclosed by hedges. It is an original feature of the landscape, which is characteristic of certain Atlantic climates.

Osmoderma eremita is protected by French law and figures in Annex II of the 'Habitats' Directive 92/43/EEC as a priority species. In addition to that it figures in the Red Data List.

Recall of some elements of biology of *Osmoderma eremita*

Osmoderma eremita lives in cavities of old deciduous trees (Tauzin, 1994a & b; Luce, 1995). The adult stage accounts for approximately 5% of the individual lifespan, which is 2 to 3 years. Almost all the activity of individuals in the larval or adult state takes place in the wood mould of the cavity of a tree. A cavity sheltering the species gathers a population (Ranius, 2000). Approximately 15% of the adults emerging in a given cavity disperse (Ranius, Hedin, 2001). The dispersal ability is limited to about 200 metres. Thus, a stand of trees located less than 250 metres from one another gathers a metapopulation (Ranius, 2000; Hedin, 2003; Ranius et al., in press).

Methods of inventory

Deciduous tree species likely to present cavities were localised with the GPS. These trees are generally pollarded trees. The pollarding favours the formation of cavities favourable to *Osmoderma* at younger ages than in not cut trees (Vignon, Orabi, 2003). These trees are taken into account starting from a diameter of 20 cm (measured at 1.3 m from the ground). Large unpollarded trees develop cavities more slowly. We took them into account by fixing a minimum diameter threshold of 50 cm. Apple trees or pear trees of orchards, which frequently develop cavities, were localised. We systematically examined accessible cavities to check for the presence of *Osmoderma*.

Cartography

The objective of the cartography was to present the density of hollow trees on the landscape. This density is expressed by the number of existing trees with cavities in a circle of 300 metres radius. This radius is slightly higher than the maximum distance known for the dispersal of the species. The cartography of the different levels of density calculated in the radius of 300 metres makes it possible to define the nucleus of dense habitats on a metapopulation scale (Vignon et al., in press).

17880 trees were inventoried on 2100 ha including 10290 hollow trees, that means a density of 8,5 trees/ha including approximately 5 trees with cavities/ha.

The nucleus of the densest habitats comprises a density of about 10 trees with cavities/ha on approximately 200 ha. This value is close to the densities of hollow trees of the sub-natural forests (Vallauri et al., 2002). This zone had not been subjected to fragmentation by land consolidation and cattle rearing still exist.

Presence of *Osmoderma*

Nineteen species of trees were inventoried in the study area. 56 trees presenting evidence of *Osmoderma* were found in 6 different deciduous species. Four pollarded deciduous species: Common Oak (*Quercus robur*), Common Ash (*Fraxinus excelsior*), Alder (*Alnus glutinosa*), Black Poplar (*Populus nigra*) and two fruit trees of orchards: apple (*Malus spp.*) and pear (*Pyrus spp.*). On the other hand many existing cavities in Maple (*Acer sp.*) and Hornbeam (*Carpinus betulus*) were not occupied by *Osmoderma* (figure 1).

Two of the trees species are selected by *Osmoderma*: orchard apples and oaks. The occurrence of *Osmoderma* in these trees is respectively three to five times higher than the occurrence of these selected tree species among the trees of the study area. The tree species more rarely exploited are poplars, alders and pears (the latter are rare in the study area).

Occupancy rate of the trees with cavities

The construction of the A28 motorway required tree felling. A systematic examination of the populations of *Osmoderma* was performed in the trees that had been felled, to preserve these populations as required by French law (Vignon et al., 2004). This study made it possible to evaluate the occupancy rate of the cavities by *Osmoderma*.

The trees were examined on the same criteria of development as those which were inventoried in the study area. Thus, 655 trees were examined. Among those, 213 did not have a cavity and 140 had a cavity with at least 10 litres of wood mould. This value of 10 litres of wood mould was retained because this is the smallest volume sheltering *Osmoderma* in the study area. Among the 655 trees examined, 7 trees presented evidence or larvae of *Osmoderma*, so 1% of the trees or 5% of the trees with cavities containing at least 10 litres of wood mould.

	Percentage of each species among all the trees	**Percentage of trees harbouring Osmoderma**	
Quercus robur (pollarded oak)	**9,4 %**	**46 %**	**Selected tree species**
Malus spp. (apple of orchard)	**10,6 %**	**34 %**	
Fraxinus excelsior (pollarded ash)	**28,5 %**	**14 %**	
Populus nigra (pollarded poplar)	**3,8 %**	**2 %**	
Alnus glutinosa (pollarded alder)	**1,4 %**	**2 %**	
Pyrus spp. (pear of orchard)	**0,02 %**	**2 %**	
Acer sp. (pollarded maple)	**22 %**	**0 %**	
Carpinus betulus (pollarded hornbeam)	**11,5 %**	**0 %**	

Fig. 1: Species of trees harbouring Osmoderma in the study area

With a rate of 1% of trees occupied by *Osmoderma*, the 17880 trees inventoried in the study area potentially shelter 180 populations of *Osmoderma*. In the field, we found 56 trees presenting evidence of this species, representing nearly a third of expected current or previous populations.

In the study area, the occupancy rate is small compared to the values from 20% to 75% observed in Sweden (Ranius, 2000). The occupancy rate per tree is positively correlated with the number of hollow trees per stand (Ranius, 2000). In the hedgerow network, the occupancy rates should be measured on the basis of the nucleus of favourable habitats. This concept is difficult to delimit in the field. Moreover, the cavities occupied in Sweden by *Osmoderma* are larger than those of our hedgerow network. In the study area, large cavities of more than 50 litres are rare (3% of the examined trees). These large cavities were observed in 19 trees of which 3 sheltered larvae of *Osmoderma* (ratio of about 15%).

Population size

The size of the populations was evaluated in the cavities which were completely examined among the 655 trees examined. The number of larvae was not looked at in the large cavities in which evidence was immediately found. This was the case for two trees: an oak and an ash containing approximately 100 litres of wood mould each. A complete examination of the wood mould was made when no evidence was visible on the surface. Thus, in 4 relatively small cavities with 10 to 50 litres of wood mould (an apple tree and 3 ashes), the larvae discovered were very few (3 to 9 larvae). The larvae in the ashes were all at the last larval stage. That suggests that these cavities were occupied by larvae resulting from only one laying. In another ash, a cavity with 25 litres of wood mould contained evidence (deposit of larvae and an elytron of an adult) without any living larva. The occupation of these cavities, in particular of certain pollarded ashes, is perhaps discontinuous in time.

The large cavities are occupied by larvae at various larval stages. An important population of *Osmoderma* was discovered in an old dead standing apple tree that we had found in October 2003 outside the proposed route of the motorway. On the 15th of July 2004, we found the trunk of this tree moved a hundred metres and deposited horizontally in an accumulation of trunks. The tree had been cut down and piled up with 12 other apple trees that had died, in February 2004. The cavity contained approximately 100 litres of wood mould including 5 adults of *Elater ferrugineus* (LINNAEUS, 1758) (a predator of *Osmoderma*), 60 larvae of *Osmoderma* of all stages and 22 adults of *Osmoderma,* 5 males and 17 females. More than the half of the females were in the bottom of the cavity. Some of the males, which spend more time on the surface of the wood mould, had probably left the cavity while the tree was falling on the ground. It is noteworthy that the adults came from cocoons which were formed in October, i.e. before the felling, the displacement and the deposit in a horizontal position of this tree. Emergence, which takes place between March and June, was carried out once all these cocoons had been disorientated. This cavity sheltered an important population, probably established for several decades.

Distribution of *Osmoderma* populations

Although the hedgerows network is continuous in space, the populations of *Osmoderma* are clustered (figure 2). The distribution of populations which are known (potentially a third) suggests a distribution structured in more or less isolated metapopulations.

In spite of the relative continuity of the hedgerow network, there can be breaks in the habitat to which *Osmoderma* is sensitive. These ruptures are determined in particular by the rarity of large cavities and their discontinuous distribution. At the end of the year 1970s, elms (*Ulmus*) were eliminated by Dutch elm disease. These trees of large size developed important cavities. According to local landowners, they accounted for approximately 40% to 70% of the trees. The loss of the elms caused breaks in the continuity of habitats in the sites where they dominated. Actually, the highest density of trees with cavities are mostly in oak hedgerows. The elms have been replaced by Ashes that are less than 30 years old today. A study of the history of the last 50 years of the hedgerow networks is necessary (on the scale of each hedge) for better understanding the current spatial organization of the populations of *Osmoderma.* The hedgerows network is about 200 years old. Before this landscape, the history of orchards of apple trees is important to understand the continuity of trees with cavities.

A follow-up of the populations by capture-recapture is in progress to better understand the size of the populations and to obtain data relating to the dispersal of the adults in this habitat.

Part of the populations is in the dense habitats. The present distribution of the species is not determined by the current space organization of the hedgerows network. The cavities which shelter populations since tens of years could be colonized in a dense context of network of hollow trees even if these trees are insulated today.

Lastly, the distribution joins that of the two tree species selected by *Osmoderma*: apple trees and oaks. There are thus metapopulations in zones dominated by the oaks and metapopulations in orchards of apple trees.

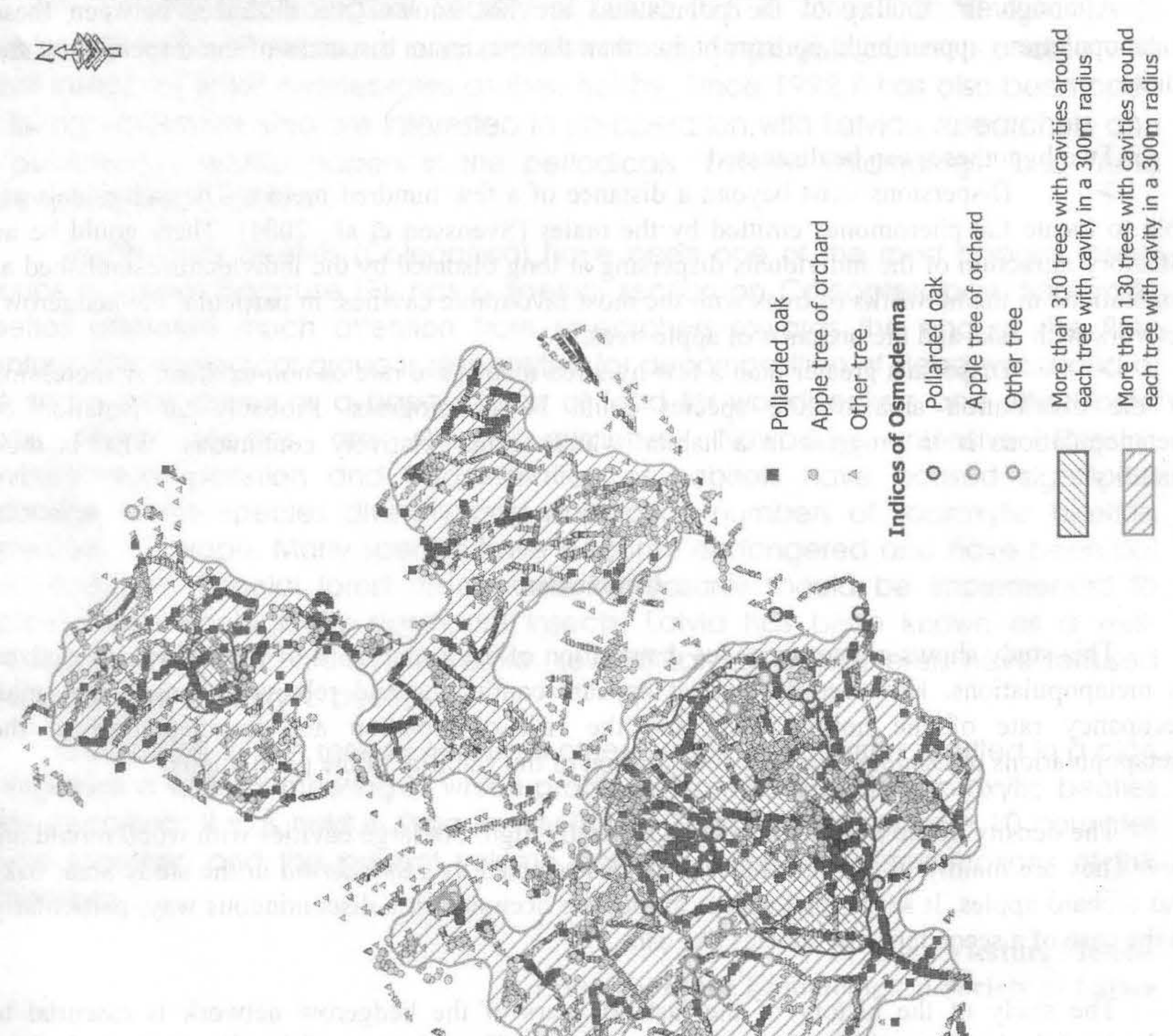

Figure 2. Localisation of the *Osmoderma* populations in the area.

Although the totality of the populations are not known, the distances between these metapopulations appear high, perhaps higher than the maximum distances of the dispersion of the adults.

Two hypotheses can be discussed.

- Dispersions exist beyond a distance of a few hundred meters. The individuals are able to locate the pheromones emitted by the males (Svensson et al., 2004). There could be an olfactory attraction of the individuals dispersing at long distance by the individuals established as populations in the networks of trees with the most favourable cavities, in particular the hedgerows network with oaks and the orchards of apple trees.
- Dispersals greater than a few hundred metres are rare or non-existent. A regression of the distribution area of the species could be in progress. Probably an isolation of metapopulations is in progress in a habitat which seems relatively continuous. What is their viability?

Conclusion

This study shows a heterogeneous distribution of the populations of *Osmoderma* organized as metapopulations. However the habitat appears continuous and relatively dense. The small occupancy rate of the hollow trees and the risk of isolation and fragmentation of the metapopulations of *Osmoderma* raise the question of the viability of the populations.

The density of the trees with cavities is locally high, but large cavities with wood mould are rare. They are mainly in trees of the two species selected by *Osmoderma* in the study area: oaks and orchard apples. It seems that small cavities are occupied in a discontinuous way, particularly in the case of a secondary tree species like ash.

The study of the history of the last 50 years of the hedgerow network is essential to understand the breaks in the habitats in space and time. Thus, the loss of the elms at the end of the 1970s constitutes one of the major losses of habitat. The distance of dispersal of *Osmoderma* is a key piece of data to evaluate the viability of the metapopulations. Data gathered in Sweden (Ranius, 2000; Hedin, 2003) suggest that the factor of risk of extinction of the populations is quite real in these habitats of hedgerow networks. The situation is serious because the hedgerows network of this study area is the densest that we could inventory (8,5 trees/ha). Indeed, in the Sarthe and in the Orne department, we inventoried exhaustively 5 areas adding up 32750 ha and including 126500 trees, we could find an average of 3,8 trees/ha (these trees were inventoried on the criteria of the selection of this study). Moreover, part of the habitat inventoried in the Sarthe department has been selected among the largest and densest (maximum density 4,8 trees/ha). This selection was made after a complete overview of the Sarthe department (Vignon, Orabi, 2003).

This observation shows the importance of locating metapopulations of *Osmoderma* in the structured habitats in networks. This information is essential to organize the conservation of the species, around the occupied sites, in the hedgerow networks which are increasingly fragmented.

The hedgerow networks and traditional orchards regressed to less than 70% in forty years (Pointereau, 2002). There is an urgency to preserve the zones of hedgerow networks still dense and the ecological networks which connect them. The dense hedgerow networks are the only ones which have the capacity to preserve the most remarkable elements of the natural inheritance of these sites which have often been described as "ordinary nature".

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Baseline Data for the Coleoptera of Mt Ainos National Park, Kefallinia, Greece

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Abstract: Ninety five species of Coleoptera and a variety of other invertebrates define the taxocoenosis of Greek *Abieta* on Mt Ainos, Kefallinia. They include a range of pre-Holocene relicts, many of which survived the Pleistocene Period *in situ*, confirming long-term assemblage stability thereby highlighting crucial issues of bioresource conservation. At least five species of Coleoptera are regarded as endemic to Kefallinia, with others new to the archipelago and Greece.

Key words: Ionian Islands, Kefallinia, Coleoptera, relicts, new records.

Introduction

With a coastline of some 180 kms and a land area of 781 km^2 Kefallinia is the largest of the seven principal Ionian Islands or Greek Heptanisoi spread over three degrees of longitude off the west coast of the Peloponnese, Greece. The population density of Kefallinia is modest; approximately 47 people/km^2. The islands are karstic and Mt Ainos at 1628m, the Monte Nero of the Venetians, composed of Upper Cretaceous limestones, is the highest mountain in the archipelago (Drandaki, Foundou, 1997).

The climate is mediterranean but with wet winters; in the mountains summer weather is subject to major small-scale instability. Kerkyra, or Corfu, another island in the group, is one of the wettest places in Greece, receiving up to 4m of rain in a wet year. According to Phitos and Damboldt (1985), the meteorological station at Argostoli, Kefallinia (geographic coordinates: 38^o 10' north, 20^o 30' east), received an average of 215 rain days per year in a 25 year period up to 1970. Annual precipitation on Mt Ainos exceeds 2m and at the summit *ca* 2.5m has been recorded (Dr L. Tiniakos, in litt.). From ca 1300m altitude, arboreal foliose lichens *Lobaria* cf. *pulmonaria* (L.) Hoffm., are conspicuous, and bearded lichens *Evernia divaricata* (L.) ACH. become more noticeable from ca 1400m altitude. In summer the montane crest is often bathed in saturated orographic cloud.

Mt Ainos is a linear feature, and its topography is accurately mapped by Phitos and Damboldt (1985). It is draped by montane climatic climax *Abieta* (Palaearctic habitat: 42.1) composed of Grecian Fir *Abies cephalonica* LOUDON. The overall altitudinal range of *Abies* on Mt Ainos is *ca* 650m - 1628m, the trees generally descending to lower levels on the colder northern and eastern slopes. They reach their lowest levels on the Argostoli to Sami road, and fill gorges above Vlahata and Moussatis (ca 800m); they persisted *in situ* throughout the Pleistocene Period, when in very broad terms, the mean annual air temperature may have fallen from its current 18.5^{o}C (Phitos, Damboldt, 1985) at Argostoli (close to sea-level) to ca 14.5^{o}C (Dr L. Tiniakos, in litt.), thus favouring the development of *Abieta*. It is construed that elements of the beetle fauna, especially those that 'fingerprint' *Abieta* are Neogene relicts and that at least a significant proportion of the entire taxocoensis also survived the Pleistocene *in situ* greatly extending the heritage value of the National Park. When ambient summer temperatures of 22°C are experienced in the lowlands, the temperature at the summit of Mt Ainos may only reach 10°C (Whitehead, pers. obs.) under orographic cloud. In the long term, Mediterranean montane *Abieta* are at risk from climatic warming, however caused.

Mt Ainos descends steeply to the coast on the western side where it loses 1000m of altitude over a distance of only 2km; the summit is only 4km from the sea. On the eastern side fertile valleys between Mt Ainos and Mt Atros (895m) are filled with Pleistocene colluvial sediments forming well-marked gentler slopes. The unyielding topography of Mt Ainos has, as a matter of considerable good fortune, protected its *Abieta* from exploitation by, amongst others, Normans, Franks, Turks, and Venetians. *Abies cephalonica* is believed to have survived on the more accessible mountains of the adjacent island of Zakynthos only until later prehistoric time (Whitehead, 1997).

This study is based on rapid transect surveys of Mt Ainos from its northern approaches at 1100m to the summit during two days in mid-May 1996. Here, above and to the south of Aghios Eleftherios, the forest is sparse and fragmented, converted by anthropogenic land-use impacts into montane plateaux 'culture-savannah' of scattered firs and junipers *Juniperus phoenicea* L. The fringes of the forest especially are marked by small spinneys of hawthorn *Crataegus monogyna* JACQ., ssp. *monogyna* providing nectar and other resources for a wide range of invertebrates, both from the *Abieta* and from the 'culture-savannah,' although it is clear that much of the invertebrate fauna of the *Abieta* is delineated exclusively by its boundaries.

The herb layer in the closed canopy forest is typically impoverished and may be limited to mosses with *Cymbalaria microcalyx* (BOISS.) Wettst., frequent on damp shaded rocks, *Cyclamen hederifolium* AITON (syn. *C. neapolitanum* TEN.), and the orchids *Orchis pauciflora* TEN. and *Ophrys lutea* CAV. ssp. *minor* (TOD.) O. & E. DAYESCH. *Cardamine graeca* L. and *Lamium garganicum* L. ssp. *striatum* (SM.) Hayek are especially characteristic of small canopy gaps in the *Abieta*. *Saxifraga chrysoplenifolia* BOISS. (from >1200m altitude) is a montane element in the flora of Kefallinia (Phitos, Damboldt, 1985), as is *Aubrietia deltoidea* (L.) DC. (from >1400m altitude). The herb layer has a characteristic beetle fauna dominated by *Stenus subaeneus* ERICHSON. Above 1550m altitude the forest is often fragmented by naturally created insolated clearings and glades littered with desiccated fungoid fallen trees, a situation well illustrated in Jeník (1979). The arboreal entomofauna of these trees is especially rich in conformation with an evidently general rule (Whitehead, 2004a). The terrestrial invertebrates of these and other clearings may be dominated by somewhat eurytopic xerothermic species.

Although Coleoptera from Mt Ainos are scattered in collections throughout Europe, it is believed that this synthesis of original data is the only overview presently available, of what is, without question, one of Europe's most significant natural assets. The list of beetles given below for the Mt Ainos *Abieta* (Palaearctic habitat: 42.1) in all its forms follows that given by Whitehead (2004b); any minor changes here result from recent overviews. It should be appreciated that these species represent only a fraction of the beetle fauna, the prime objective being to provide baseline data for southern European *Abieta* and their ongoing investigation. Tezcan (1997) listed buprestids from *Abies* in Turkey. Little-known and undescribed species still await formal study.

Species List

Coleoptera	**altitude range**
Carabidae	
Carabus (*Tomocarabus*) *convexus* (F., 1775) ssp. *dilatatus* DEJEAN, 1826 At decaying *Abies*.	1110m-1560m
Leistus (*Pogonophorus*) *magnicollis* MOTSCHULSKY, 1865 Scarce Neogene or Quaternary relict new to archipelago, rocky clearings.	1460m
Leistus (*Pogonophorus*) *spinibarbis* (F., 1775) ssp. *rufipes* CHAUDOIR, 1843 Frequent, loose bark and under rocks.	1130m-1450m
Nebria (*Nebria*) *brevicollis* (F., 1792) Summit clearing only.	1625m
Nebria (*Nebria*) *heydenii* DEJEAN, 1830 Rare Neogene or Quaternary relict endemic to Kefallinia, amongst mosses in shaded weakly developed herb layer.	1400m
Calathus (*Neocalathus*) *cinctus* MOTSCHULSKY, 1850 Clearings; eurytopic xerophile widespread in archipelago (Whitehead, 1997).	1430m
Zabrus (*Pelor*) *incrassatus* (AHRENS, 1814) Summit clearing with lygaeid bug *Lygaeosoma sardae sardae* SPINOLA, 1837; South-east Europe to Turkey.	1625m
Cymindis (*Cymindis*) *lineata* (QUENSEL, 1806) Insolated extensive rocky clearing. Eastern Europe, Turkey to Asia.	1130m
Histeridae	
Margarinotus (*Stenister*) *graecus* (BRULLÉ, 1832) Insolated clearing, two under rock amongst nesting ants *Messor wasmanni* (KRAUSSE, 1910)..	1150m
Cholevidae	
Anemadus pellitus REITTER, 1885 ?Scarce, two only. On *Abies* foliage and *Crataegus* flowers.	1100m-1450m
Anemadus whiteheadi GIACHINO, VAILATI 2001 Frequently found, up to 30 together, amongst fallen degrading *Abies*. Pleistocene (or earlier) relict (Giachino, Vailati 2001), endemic to Kefallinia, taxonomically near *A. arcadius* REITTER, 1885, dominantly of Arkadhia, Greece.	1100m-1525m
Staphylinidae	
Eusphalerum aetolicum (KRAATZ, 1858) One at *Crataegus* flowers, probably endemic to Greece (Zanetti, in litt., 17.iii.1998).	1220m
Tachyporus caucasicus KOLENATI, 1846 Nectaring on *Crataegus* flowers.	1130m
Oxypoda formosa KRAATZ, 1856 Nectaring on *Crataegus* flowers.	1100m
Scaphisoma agaricinum (L., 1758) On fallen fungoid *Abies*.	1130m-1250m
Stenus subaeneus ERICHSON, 1840 Dominant element in terrestrial beetle fauna; thin sediments over rock, in moss.	1460m-1520m
Quedius (*Quedius*) *laevicollis* (BRULLÉ, 1832) (syn. *Q. tristis* (GRAVENHORST, 1802)) Notable large predator in mosses and herbage.	1400m-1530m
Quedius (*Raphirus*) *nemoralis* BAUDI, 1874 Localised species in herb and moss layer.	1520m-1580m
Xantholinus rufipennis ERICHSON, 1839 ?Scarce, amongst decaying *Abies* wood.	1470m
Glaphyridae	
Pygopleurus diffusus (PETROVITZ, 1957) Abundant; *in cop.* in flowers of *Papaver apulum* TEN. (syn. *P. argemone* auctt. non L.). East Mediterranean species.	1100m
Aphodiidae	
Aphodius (*Nimbus*) *affinis* PANZER, 1823 Fragments under bark moribund *Abies*. Mediterranean, N. Africa.	1110m
Buprestidae	
Eurythyrea austriaca (L., 1767) Breeding in wind-shattered *Abies* on which monophagous, Central and southern Europe.	1550m
Dicerca (*Argante*) *herbstii* (KIESENWETTER, 1857) Endemic to Greece; monophagous on *Abies cephalonica* LOUDON.	1450m-1550m

Anthaxia (Melanthaxia) nigrojubata incognita BÍLÝ, 1974 1430m
On fallen *Abies* on which monophagous. Central, southern and eastern Europe, Anatolia.

Elateridae

Lacon punctatus (HERBST, 1779) 1400m
On *Abies*, presumably host tree. High altitude record; rarely over 1600m (G. Platia, in litt.).

Nothodes parvulus (PANZER, 1799) 1100m
On *Crataegus* flowers in 'culture-savannah.' Euro-Siberian species of cleared or open woodland.

Ampedus ochropterus GERMAR, 1844 1580m
Neogene *Urwaldrelikt* of Turkey and the Caucasus, with westerly extension on Kefallinia, where also found on 2.v. 1987 by the late F. Battoni (G. Platia in litt.). Rare, fungoid *Abies*.

Ampedus praeustus (F., 1792) 1580m
Fungoid heartwood of *Abies*, relict. Euro-Siberian species.

Melanotus tenebrosus (ERICHSON, 1841) 1125m
Under rock, 'culture-savannah.' Xerothermic in south-central Europe, Mediterranean-Caucasus.

Melanotus villosus (GEOFFROY in FOURCROY, 1785) 1580m
?Scarce, single male, atypical, in fungoid heartwood *Abies*. This specimen has been examined by Dr G. Platia and both he and I feel that this is the correct name for it. All diagnoses for this and the sympatric *M. castanipes* (PAYKULL) seen by PFW to date appear fraught with difficulty and PFW has not yet found absolutely conclusive diagnoses for all specimens.

Cardiophorus discicollis (HERBST, 1806) 1120m-1400m
Mostly nectaring on *Crataegus* flowers, also on *Abies*. South-east Europe, Turkey.

Cardiophorus parvulus PLATIA, GUDENZI, 2000 1520m
One on *Abies* foliage, new to archipelago as western outpost of Greek and Turkish range (Platia, Gudenzi, 2000).

Cardiophorus ruficruris (BRULLÉ, 1832) 1120m
Scarce, on *Crataegus* flowers. South-east Europe, Turkey, Cyprus.

Dicronychus cinereus (HERBST, 1784) 1120m-1220m
Mostly nectaring on *Crataegus* flowers, also on *Abies* foliage.

Drilidae

Malacogaster sp. 1130m
Two on *Crataegus* flowers.

Cantharidae

Metacantharis keizeri WITTMER, 1969 1150m
Possibly diagnostic of southern *Abieta*; possibly endemic to Kefallinia as Neogene isolate. In small numbers mostly on *Abies* foliage.

Rhagonycha lignosa (MÜLLER, 1764) 1130m-1300m
In small numbers on *Abies* foliage.

Rhagonycha viduata (KÜSTER, 1854) 1100m
Nectaring on *Crataegus* flowers.

Dermestidae

Attagenus unicolor (BRAHM, 1791) 1100m-1120m
Frequently nectaring on *Crataegus* flowers; occasionally on *Abies* foliage and certainly part of the subcortical *Abies* taxocoensis.

Anthrenus (Florilinus) museorum (L., 1761) 1120m
Nectaring on *Crataegus* flowers.

Anobiidae

Stagetus pilula (AUBÉ, 1861) 1110m
One example nectaring on *Crataegus* flowers. South Central Europe, France to Greece, Syria.

Cleroidea

Trogossitidae

Cymba procera (KRAATZ, 1858) 1120m-1580m
Cymba procera was described from Greece (KRAATZ, 1858) under the name *Peltis procera*. Although often regarded as stenotopic on *Abies*, Kraatz described it from Aleppo Pine *Pinus halepensis* Miller. Neogene relict of Greece, southern Turkey and apparently also Cyprus.

Temnoscheila caerulea (OLIVIER, 1790) 1120m-1250m
Locally numerous on *Abies*, occasionally sometimes with *Cymba procera*.

Cleridae

Thanasimus formicarius (L., 1758) 1540m
Fragments under bark of *Abies*.

Dasytidae

Aplocnemus sp. 1130m-1230m

Female examples from around the low fringes of the forest are not presently identifiable.

Aplocnemus (*Diplambe*) sp. 1220m

Nectaring on *Crataegus* flowers.

Mauroania hispana (KIESENWETTER, 1859) 1230m-1590m

New to Greece (confirmed by Dr K. Majer), previously only known from Spain (Majer, 1997). On *Abies* as a predatory element in the subcortical taxocoenosis.

Danacaea sp. 1120m

Two females on *Crataegus* flowers may represent an undescribed species.

Malachiidae

Attalus dalmatinus ERICHSON, 1840 1100m

Frequent and in cop. on *Crataegus* flowers. South-eastern Europe to Near East.

Hypebaeus flavicollis (ERICHSON, 1840) 1100m-1130m

Small numbers nectaring on *Crataegus* flowers.

Laemophloeidae

Cryptolestes cf. *fracticornis* (MOTSCHULSKY, 1845) 1250m

Examples representing this group from under *Abies* bark warrant critical study, possibly in relation to a taxonomic review.

Endomychidae

Cholovocera formicaria MOTSCHULSKY, 1983 1150m

14 under rock amongst *Messor wasmanni* (KRAUSSE, 1910). Myrmecophile of Switzerland, Italy, Greece, Spain and Malta.

Cryptophagidae

Cryptophagus fasciatus KRAATZ, 1852 1130m

One example nectaring on *Crataegus* flowers.

Coccinellidae

Aphidecta obliterata (L., 1758) 1580m

Oedemeridae

Ischnomera caerulea (L., 1758) 1120m

One example nectaring on *Crataegus* flowers. West Palaearctic species - Europe to Iran.

Tenebrionidae

Prionychus ater (F., 1775) 1100m-1580m

Abies confirmed as host tree, especially in soft fungoid wood.

Gonodera luperus (HERBST, 1783) 1115m

One example nectaring on *Crataegus* flowers.

Isomira antennata (PANZER, 1798) 1250m

On *Abies* foliage; often lowland species of phrygana.

Podonta nigrita (F., 1794) 1130m

Omophlus (*Paromophlus*) *curtus* KÜSTER, 1850 1100m

Mass emergence with scores around *Crataegus*. *Omophlus* disperse on thermals and emergence probably originated largely from lower levels.

Dailognatha quadricollis BRULLÉ, 1832. 1350m

Apparently rare in hot clearings; confirms presence on Kefallinia (Oertzen, 1866).

Idastrandiella graecus (KRAATZ, 1877) 1580m

Apparently rare. Fragments under bark of moribund *Abies*; new to archipelago. Kühnelt (1965) cites no modern records for Greece, where the distribution was mapped Scupola (1984).

Dendarus caelatus BRULLÉ, 1832 1110m-1250m

Frequent forest detritivore, amongst fallen *Abies*.

Dendarus plicatulus BRULLÉ, 1832 ssp. *jonicus* KOCH, 1944 1130m-1500m

Colpotus pectoralis MULSANT, REY, 1853 1100m-1525m

Occurs widely; not cited for Ionian Islands by Kühnelt (1965).

Opatrum verrucosum GERMAR, 1817 1130m-1430m

Occurs widely in clearings.

Menephilus cylindricus (HERBST, 1784) 1100m

In *Abies*. Neogene *Urwaldrelikt* new to Ionian Islands; modern Greek record. Apparently scarce.

Neatus subaequalis REITTER 1920 (sensu Schawaller, Grimm, 1995) 1580m

Confirms Kefallinia as apparently only Greek location (Kühnelt, 1965).

Diaperis boleti (L., 1756) 1580m

Fungoid *Abies* wood. Apparently rare in Greece with a scattering of old records.

Raiboscelis azureus BRULLÉ, 1832 1100m

Scarce in insolated large clearings, culture-steppe; mostly lowland in the archipelago.

Helops rossii GERMAR, 1817 1580m

Fragments in *Abies* wood; modern record for Kefallinia. Likely to be a Neogene relict (Whitehead, 1997).

Odocnemus badius REDTENBACHER, 1849 (syn. *Odocnemus asphaltinus* KÜSTER, 1850) 1500m
?Rare, new to Kefallinia; modern record for Greece.

Cerambycidae

Ergates faber (L., 1767) 1200m-1495m
Last instar larvae and dead beetles in *Abies*.
Callimus angulatus (SCHRANK, 1789) (syn. *Calimellum angulatum* (SCHRANK, 1789)) 1150m
Frequently on *Crataegus* flowers.
Molorchus minor (L. 1758) 1130m-1200m
Breeding on *Abies*. Rather more boreal species; probably Pleistocene relict.
Hylotrupes bajulus (L., 1758) 1400m-1440m
Breeding on *Abies*.
Grammoptera ustulata (SCHALLER, 1783) 1120m
Apparently rare; more or less boreal; Pleistocene relict. One nectaring on *Crataegus*.
Morinus asper (SULZER, 1776) 1130m
M. asper is held to be the species with the elytral spot pubescence more or less vestigial. *Abies* confirmed as host tree.

Chrysomelidae

Orsodacne lineola (PANZER, 1795) 1120m
On *Crataegus* flowers.
Smaragdina salicina (SCOPOLI, 1763) (syn. *S. cyanea* (F.)) 1130m
On *Abies* foliage; usual host plants woody Rosaceae and Fabaceae.

Bruchidae

Bruchidius holosericeus (GYLLENHAL, 1833) 1110m
Clearings at forest edge.

Apionidae

Apion (*Hemitrichapion*) *reflexum* (GYLLENHAL, 1833) 1110m
Crataegus flowers.
Apion (*Oryxolaemus*) *scabiosus* (WEISE, 1889) 1530m
Abies foliage. Mediterranean species.

Curculionidae

Otiorhynchus (*Thalycrynchus*) *cephalonicus* PIC, 1902 1110m
Two nectaring on *Crataegus* flowers. Endemic to Kefallinia.
Otiorhynchus (*Misenatus*) *lugens* (GERMAR, 1817) 1250m
Otiorhynchus (*Podonebistus*) *prolongatus* STIERLIN, 1861 1130m
Fragments under *Abies* bark.
Phyllobius (*Plagius*) *insulanus* SCHILSKY, 1911 1100m
Endemic to archipelago. Nectaring on *Quercus coccifera* L. and *Crataegus* flowers.
Parascythopus apollinis (MILLER, 1862) 1130m-1450m
On *Abies*, much scarcer above 1425m. Endemic to Greece; Heijerman, Magnano (2000) suggest that it is exclusively insular.Uniformly dark and striped morphs in proportions of 1:40 respectively.
Polydrusus (*Eustolus*) *armipes* BRULLÉ, 1832 1100m
A few on *Quercus coccifera* L. and *Crataegus* flowers.
Polydrusus (*Eudipnus*) *jucundus* MILLER, 1862 1110m
Endemic to Kefallinia. Four on *Crataegus* flowers.
Minyops carinatus (L, 1767) 1150m
Dead under *Abies* bark.
Rhyncolus (*Rhyncolus*) *elongatus* GYLLENHAL, 1827 1120m-1520m
Widespread locally on moribund *Abies*.
Rhyncolus (*Rhyncolus*) *strangulatus* PERRIS, 1852 1540m
One example on moribund standing *Abies*.
Anthonomus kirschi DESBROCHERS DES LOGES, 1868 1120m
Rhychaenus hirtellus MILLER, 1862 1100m
One example on *Quercus coccifera* L. (Whitehead, 1999).

Other invertebrate groups

Dolistenus savii FANZAGO, 1874 (Diplopoda: Andrognathidae) 1495m
Two amongst organic litter under actively decaying *Abies* bark 40 cms above ground, 15.v.1996. Usually subterranean, scattered around the eastern Mediterranean, det. Professor H. Enghoff.
Aradus pictus BAERENSPRUNG, 1859 (Hemiptera: Aradidae) 1250m-1430m

Confirmed breeding on *Abies* in Greece, 15.v.1996.

Ornatoraphidia flavilabris (COSTA, 1855) (Neuroptera: Raphidiidae) 1160m
On *Abies* foliage 15.v.1996, det. Dr H. Aspöck. South-east Central Europe to Greece.

Dactylolabis sp. (Diptera: Tipulidae) 1250m
Undescribed species (*vide* Dr H. de Jong), 15.v.1996.

Beierochelifer peloponnesiacus peloponnesiacus (BEIER, 1929) (Pseudoscorpiones: Cheliferidae) 1120m
Under loose bark *Abies*, 17.v.1996, det. Dr M. Judson. Possibly new to Kefallinia. Gardini (2000) regards this as a possibly central to eastern Mediterranean faunal element.

Nemesia meridionalis (COSTA, 1835) (Araneae: Nemesiidae) 1260m
Mygalomorph of Spain, France, Italy, here new to Greece, 15.v.1996, det. Dr A. Decae. The genus *Nemesia* was unrecorded in Greece prior to Decae (1995).

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Mediterranean invertebrate studies frequently involve dealing with poorly understood species. The assistance of the following people has greatly enhanced knowledge of the invertebrates of Kefallinia: Dr H. Aspöck (Linz), Dr Svatopluk Bílý (Prague), Dr Alessandro Ciceroni (Rome), Dr M. L. Cox (London), Dr A. Decae (Rotterdam), Professor H. Enghoff (Copenhagen), Dr Julio Ferrer (Stockholm), Dr H. de Jong (Amsterdam); Dr Mark Judson (Paris), Dr Barbara Knoflach (Innsbruck), Dr Luigi Magnano (Poggibonsi), Dr Karel Majer (Brno), Professor D. Phitos (Patras), Dr Giuseppe Platia (Gatteo), Dr Gianfranco Sama (Cesena), Dr Vladimir Švihla (Prague), Dr L. Tiniakos (Patras), Professor Augusto Vigna Taglianti (Rome), Dr Tomas Yelamos (Barcelona), Dr Adriano Zanetti (Verona), Dr Lothar Zerche (Berlin).

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The Shadier Side of Epping Forest: Saproxylic Coleoptera Research

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WILDE I., 2005. THE SHADIER SIDE OF EPPING FOREST: SAPROXYLIC COLEOPTERA RESEARCH. Proceedings of the 3rd Symposium and Workshop on the Conservation of Saproxylic Beetles, Rīga / Latvia, 07th-11th July, 2004: 124-125.

Abstract: A 5-year research project was initiated in 2003 in Epping Forest cSAC to investigate the effect of shade on the Coleoptera species of veteran oak (*Quercus* robur) pollards and to inform the future management of the trees. Initial results show a difference in Coleoptera assemblage in shaded and unshaded conditions.

Key words: saproxylic Coleoptera, Epping Forest, UK.

Introduction

Epping Forest is London's largest public open space, stretching over 12 miles into Essex. It is primarily a wood-pasture landscape and contains over 50,000 veteran Oak (*Quercus robur*), Hornbeam (*Carpinus betulus*) and Beech (*Fagus sylvatica*) pollarded trees.

The Forest is still grazed by English Longhorn cattle in certain areas, but in much of the Forest the grazing has ceased and the pollards have become heavily shaded by young trees and Holly (*Ilex aquifolium*).

In 2003, a research project was initiated to determine any differences between the Coleoptera species found in open sunny trees and those found in shady trees, and also to investigate the effects of removing infill.

Methods

50 veteran *Quercus robur* trees showing cavities with red rot were selected from within the Forest:

* 20 surrounded by infill at Bury Wood (10 control, 10 trees to have infill removed)
* 20 surrounded by infill at Lords Bushes (10 control, 10 trees to have infill removed)
* 10 in open conditions at Barn Hoppitt (for comparison)

Coleoptera were trapped from May to September 2003 using cross-vaned flight interception traps and pitfall traps where possible. The species are currently being identified and the results are being collated.

Initial Results

Initial results show a difference in Coleoptera species found in shaded and unshaded areas, with species such as *Ampedus cardinalis* (SCHIÖDTE, 1865) and *Stenagostus rhombeus* (OLIVIER, 1790) only found in the open conditions, but full results are not yet available.

Further Work

During the winter of 2004, 50% of the infilled trees will have the infill removed as part of veteran tree management (haloing). The trees will be re-surveyed for Coleoptera after 5 years (2008) when a full analysis of the results will be made.

This project is being undertaken by Imogen Wilde & Jeremy Dagley of the Corporation of London.

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THE ENTOMOLOGICAL SOCIETY OF LATVIA

The Entomological Society of Latvia (LEB in official abbreviation) has united entomologists, arachnologists and other invertebratologists from Latvia and the World since 1951. LEB is a discussion club for scientists, applied biologists and wildlife managers. It publishes scientific journals, principally "Latvijas Entomologs", and distributes knowledge to a wider audience through mass media.

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The Entomological Society of Latvia (LEB in official abbreviation) was founded in 1951. It unites not only professional entomologists but also people who have insects or other invertebrates as their hobby. Since 1992 it has also been open to foreign members who are interested in co-operation with Latvian researchers and in publishing scientific papers in the periodicals "Latvijas Entomologs" and "Acta coleopterologica latvica".

Traditionally beetles (Coleoptera) have been one of the most popular insect groups in Latvia, because LES has a special section on Coleopterology. Saproxylic beetles attracted much attention from researchers towards the end of the 20th century. This ecological group is responsible for decomposition of dead wood and at the same time serves as a basic source of food for woodpeckers and other forest birds. Many species are visually attractive. Nowadays intensive forestry, environmental pollution and fragmentation of habitats have caused significant reduction in the species diversity and population numbers of saproxylic beetles, especially in Europe. Many species have become endangered and have been put onto Red Lists. Special forest management measures should be implemented to protect these ecologically significant insects. Latvia has been known as a well-forested country for centuries. Therefore, several Latvian coleopterists have focused their studies on saproxylic beetles.

Co-operation with researchers from other European countries resulted in a plan to organise a special meeting in which problems connected with saproxylic beetles were discussed. It was held in Rīga in July 2004. Coleopterologists from 10 countries came together, and the present volume contains papers on presentations of this symposium.

Dr. Biol. Viesturs Melecis
President of the Entomological Society of Latvia

Forests produce an enormous biomass every year, feeding myriads of leaf and needle eating animals. At the same time, the presence of dead wood provides food for much more numerous armies of fungi, algae, insects, mites, snails, millipedes and many other living creatures ecologically connected with them, thus maintaining ecosystems with high biological diversity and stability. The loss of dead wood causes a significant loss of biodiversity. This is global problem.

The saproxylic beetles are the most diverse and well-known inhabitants of dead wood, of differing moisture levels and state of decomposition and of various tree species. Beetles are commonly used to identify biologically valuable forest habitats. These beetles also indicate definite stages in the wood decomposition succession, and their life is not possible without interaction with wood decomposing fungi. Saproxylic beetles also create ecological niches for ants, wasps, spiders, parasitic invertebrates and many others, and provide a long lasting food supply for birds. This is the intrinsic value of saproxylic beetles.

The investigation of saproxylic beetles is complicated, but highly important for maintaining biodiversity in forests and other places with trees.

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