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Saproxylic beetles in an isolated pollard willow stand and their association with *Osmoderma barnabita* (Coleoptera: Scarabaeidae)

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ABSTRACT

We studied a population of the hermit beetle (*Osmoderma barnabita*) and co-occurring saproxylic beetles in hollow willows at a small isolated site in southern Moravia (Czech Republic) in 2006 and 2009. The relationship between the presence / absence of the hermit beetle *O. barnabita* and the number of other saproxylic species, as well as its co-occurrence with individual species were investigated. In 2006, the species richness of saproxylic beetles was significantly higher in the trees not occupied by the hermit beetle, whereas it was independent of its presence in 2009. We did not find any saproxylic beetle species positively associated with the presence of *O. barnabita* in the willow cavities; in 2006, two species proved to be associated with hollows uninhabited by *O. barnabita*. The aspects of the observed pattern and methodological bias are discussed.

Keywords: *Osmoderma barnabita*, pollard willow, indicator species, saproxylic beetles, tree hollows

1. INTRODUCTION

Conservation biologists have paid increasing attention to saproxylic beetles (i.e. those associated with dead wood), as they are a vulnerable, highly diverse group for which relatively comprehensive information on taxonomy and ecology is available. They exhibit a wide range of microhabitat preferences, providing valuable information on the quality and continuity of woodland habitats (SCHIEGG 2000, GROVE 2002, DUBOIS *et al*. 2009). One of the most studied saproxylic beetles in Europe is the hermit beetle (*Osmoderma eremita* s. l.) (RANIUS *et al*. 2005).

The hermit beetle depends on the cavities of old deciduous trees (VIGNON 2006, RANIUS *et al*. 2005), where it develops in the wood mould. Due to its low dispersal ability (HEDIN *et al*. 2007), the species is very susceptible to habitat loss and fragmentation. *O. eremita* is considered to be a good indicator of the species richness of saproxylic beetles in tree hollows, on both between-tree and between-stand levels, because its presence in the trees and in the stands is associated with a higher diversity of saproxylic beetles (RANIUS 2002).

Recently, a new taxonomy of the genus *Osmoderma* was established, based on molecular analyses (AUDISIO *et al*. 2007), and the formerly single European species was split into several ones. In agreement with its geographic position, molecular analysis confirmed that our population belonged to *O. barnabita* (G. Antonini, pers. comm.). However, we consider the conclusions of studies on *O. eremita* regarding ecology and conservation to be widely applicable to *O. barnabita*.

In the summers of 2006 and 2009, we studied the population of *O. barnabita* in an isolated willow stand in south-eastern Czech Republic. As a part of the field work, we sampled beetles occurring in tree cavities. In the present study, we assess the validity of the hermit beetle as an indicator of saproxylic beetle diversity on the tree level for the studied assemblage in hollow pollard willows.

2. MATERIALS AND METHODS

2.1. Study site

The study was conducted in a small pollard willow stand near the village of Vojkovice (49°3'N,16°36'E), South Moravia, Czech Republic. The stand consists of ~400 standing pollard willows in an area of 3.8 ha (SEBEK 2009). The willows had been formerly managed by traditional pollarding. This management was discontinued, and the condition of the willows was deteriorating severely (HAUCK 2006). The local authority resumed the management, resulting in the majority of the willows pollarded between 2007 and 2009. The area was also cleared from trees and shrubs overgrowing and shading the pollards. The site is registered as an Important Landscape Element, which ensures some basic protection under Czech legislation. Three saproxylic beetle species protected under Czech legislation had been observed there: *Osmoderma barnabita*, *Lucanus cervus* and *Elater ferrugineus,* (D. Hauck *pers. obs.*).

The study site is rather isolated, with the nearest potential hermit beetle habitat > 700 m away. This nearby habitat is a smaller stand of old pollard willows, mostly destroyed; the presence of *O. barnabita* was not confirmed there. The nearest site inhabited by *O. barnabita* was found 2.5 km away, separated by arable land.

2.2. Beetle sampling

For conservation reasons, we were not allowed to take the wood mould out of the willows. We thus visually searched for *O. barnabita* on the trees and in tree hollows (raking by hand through the upper layer of the wood mould), and we placed pitfall traps in some of the hollows (see e.g. RANIUS / JANSSON 2002). The traps were installed in those tree cavities that were accessible (using a ladder), had an opening large enough to insert the trap and a sufficient amount of would mould to dig in the trap. One trap was installed per tree. The traps were installed in 91 trees in 2006, and in 70 trees in 2009. In 2009, we were limited by the number of accessible trees that had not been part of the study in 2006, thus in 25 trees traps were installed in both sampling seasons. The traps were made of plastic cups with an opening diameter of 7 cm, sunk into the wood mould, with the opening level with the wood mould surface. To avoid mortality of the protected *O. barnabita*, no killing or preserving liquid was used. In 2006, filter paper soaked in red wine was put into the traps as bait and periodically refreshed. In 2009, we decided not to use any bait for two reasons: firstly, in 2006, the proportion of *O. barnabita* individuals caught in the traps was low compared to the number of those captured by active searching. We thus suspected that the bait could repel *O. barnabita*. Secondly, we wanted to avoid potentially high predation of saproxylic beetles by carabid beetles, which were extremely common in the baited traps in 2006. Being aware of potential problems arising from a change of the experimental design between years, we treated the datasets from the two years separately. The effect of bait in the traps was thus ignored as it was indistinguishable from annual variation.

The traps were installed on the 29 June 2006 and on 15 June 2009, and removed on 5 August 2006 and on 14 August 2009 (corresponding to 22 and 30 trap checking dates, respectively). They were checked every two days for the presence of *O. barnabita* individuals. Trees where *O. barnabita* adults or larvae were found were assessed as hosting the beetle. The presence of *O. barnabita*, *Elater ferrugineus* and *Lucanus cervus* specimens was recorded and the specimens released, whereas other trapped beetles were preserved for later identification.

2.3. Analyses

We tested the relationship between the presence / absence of *O. barnabita* and the number of other saproxylic species in the tree cavity with Wilcoxon Rank Sum Test, separately for each year. We also analysed the association of each saproxylic species with *O. barnabita*. Only species found in at least five traps were included in the latter analysis. The extent of co-occurrence of the species was computed from a 2 × 2 contingency table of presence / absence data, using the Yule coefficient: $Q = (ad - bc) / (ad + bc)$, where a is the number of trees in which both species were present, b is the number of trees occupied by *O. barnabita* and not occupied by the other species, c is the number of trees occupied by the given species and not occupied by *O. barnabita*, and d is the number of trees in which both species were absent. The results of the formula range from +1 (both species occur in the same tree cavities) to -1 (the species never occur together in the same tree cavities). The probability of occurrence of the observed relationship was tested with Fisher's exact test.

3. RESULTS

In 70 traps in 2006 and in 63 traps in 2009 at least one beetle species was caught. In 2006, the number of trapped saproxylic species was significantly lower in tree cavities occupied by *O. barnabita*, whereas it was independent of its presence in 2009 (Wilcoxon Rank Sum Test: year 2006 – $W = 634.5$, $n = 70$, $p < 0.001$; year 2009 – $W = 290$, $n = 63$, $p = 0.25$; see also Table 1).

The analysis of co-occurrence showed a significant negative association of *Dorcus parallelipipedus* (Lucanidae) and *Scaphisoma agaricinum*, (Staphylinidae: Scaphidiinae) with *O. barnabita* for the 2006 trapping season. In 2009, none of the analysed relationships was significant (Table 2). Captured saproxylic species are listed in Table 3. Three of them are listed as critically endangered, two species as endangered, three species as near threatened and one species as vulnerable in the Red List of the Czech Republic (FARKAČ et al. 2005).

4. DISCUSSION AND CONCLUSIONS

Our results seem to contradict the concept of the hermit beetle being a good indicator of saproxylic beetle species richness on the tree level (RANIUS 2002). We did not find any species positively associated with the presence of *O. barnabita*. In 2006, the association with *O. barnabita* was negative for most species, although the trend was significant only for *Dorcus parallelipipedus* and *Scaphisoma agaricinum*. In 2009, the presence of other beetle species seemed rather independent of *O. barnabita*. The results can be partly attributed to the low abundance of most species. The analysis of species richness yielded similar results. In 2006, tree cavities occupied by *O. barnabita* hosted less saproxylic species than those uninhabited by the beetle, whereas the numbers were equal in 2009. Our results may give rise to questions about the indication potential of *O. barnabita* on the tree level.

However, it has to be mentioned that our observations largely suffer from bias due to methodological limitations. Firstly, the beetles were collected with pitfall traps. In comparison with other sampling methods (RANIUS / JANSSON 2002, BUSSLER / MÜLLER 2008), the capture efficacy of pitfall traps is known to be limited as only individuals circulating on the wood mould surface are captured. Small or less active species may be highly underrepresented in the samples. Secondly, the pitfall traps were active for the entire activity period of the hermit beetle adults, but not for that of other saproxylic beetles (SCHLAGHAMERSKÝ 2000, BOUGET 2008). Some species that were actually present in the studied tree cavities may have thus remained undetected or underrepresented in our study. Moreover, it is indisputable that the use of the bait could have had an important effect on the results (GREENSLADE / GREENSLADE 1971, JOHNSON *et al*. 2009). Whereas *O. barnabita* could have been repelled by the odour of the wine, other species could have been attracted by it. From this point of view, the results from 2009 are more valid than the results from 2006. Most principally, the low number of individuals captured may have led to errors in the evaluation of the association between species.

Whatever the true reason for our observations might be, it is important to emphasise that these were made on the tree level. Our findings do not devalue the indication potential of the hermit beetle on the between-stand level (RANIUS 2002). Our study site hosts *O. barnabita* and other endangered saproxylic species (Table 3), and thus represents an important hot-spot of diversity in the surrounding landscape. As the hermit beetle depends on the continuous availability of hollow trees, its presence should indicate a high habitat quality for many saproxylic beetles (DUBOIS *et al*. 2009). Hollow trees undergo developments that provide suitable microhabitats for saproxylic species with differing requirements. In general, conservation plans for saproxylic beetles should be designed on the stand and landscape level rather than on the tree level. A broader study comparing the species richness of saproxylic beetle assemblages between several willow stands occupied and not occupied by the hermit beetle would probably shed more light on its use as an indicator of high saproxylic species diversity in willow stands and on the potential limitations of a concept developed on *Osmoderma* populations in old oak trees.

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TABLES

Table 1: Number of saproxylic species in hollows of pollard willows in Vojkovice, Czech Republic, with *O. barnabita* present and absent. Wilcoxon Rank Sum Test, separately for each study year (2006 – W = 634.5, n = 70; 2009 – W = 290, n = 63).

Study year	Presence of *O. barnabita*	Number of trees	Number of species (mean ± sd)	p-value
2006	absent	56	2.7 (± 2.09)	p < 0.001
	present	14	0.7 (± 0.91)	
2009	absent	48	2.1 (± 1.95)	ns
	present	15	2.2 (± 1.01)	

Table 2: The co-occurrence of saproxylic beetles with *O. barnabita* in hollows of pollard willows in Vojkovice, Czech Republic. Species found in at least five traps were included in the analysis. Trees – number of trees (= cavities) occupied by a species; OB trees – number of trees occupied by a given species with *O. barnabita* present (in parentheses, percentage of Trees); Relationship – association between the occurrence of the given species and *O. barnabita* evaluated by the Yule coefficient (*Q*), ranging from +1 (the species occurred in the same trees) to -1 (the two species did not occur together); p-value – probability value computed by Fisher's exact test (ns = not significant).

2006 – wine-baited traps				
Species	**Trees**	**OB trees**	**Relationship**	**p-value**
Catops watsoni	5	0 (0)	-1.00	ns
Cossonus parallelepipedus	5	0 (0)	-1.00	ns
Dorcus parallelipipedus	35	3 (9)	-0.66	p < 0.05
Melanotus villosus	8	1 (13)	-0.30	ns
Neatus picipes	13	1 (8)	-0.56	ns
Osmoderma barnabita	14	14 (100)	-	-
Prionychus ater	10	2 (20)	0.00	ns
Ptomophagus sp.	8	0 (0)	-1.00	ns
Scaphisoma agaricinum	16	0 (0)	-1.00	p < 0.05
Trox scaber	12	0 (0)	-1.00	ns
Xylophilus testaceus	5	1 (20)	0.00	ns
2009 – non-baited traps				
Species	**Trees**	**OB trees**	**Relationship**	**p-value**
Dendrophilus punctatus	5	2 (40)	0.40	ns
Dorcus parallelipipedus	28	7 (25)	0.06	ns
Elater ferrugineus	8	2 (25)	0.04	ns
Neatus picipes	9	4 (44)	0.52	ns
Osmoderma barnabita	15	15 (100)	-	-
Prionychus ater	23	7 (30)	0.27	ns
Scaphisoma agaricinum	10	2 (20)	-0.13	ns
Uloma culinaris	13	3 (23)	-0.03	ns

Table 3: List of saproxylic beetle species captured in hollows of pollard willows in Vojkovice, Czech Republic. Red List – red list categories follow Farkač *et al.* (2005) CR = critically endangered, EN = endangered, NT = near threatened, VU = vulnerable; 2006 and 2009 – number of traps in which the species was found and, in parentheses, its abundance (* Species analysed for its co-occurrence with *Osmoderma barnabita* in cavities at least for one year).

Species	Red List	2006	2009
Acrotrichis sp.		1 (2)	-
Allecula morio		-	2 (2)
Ampedus elegantulus	EN	-	2 (2)
Ampedus spp.		2 (2)	-
Anisotoma castanea		2 (2)	-
Aromia moschata	NT	-	1 (1)
Atomaria analis		1 (1)	-
Catops chrysomeloides		1 (1)	-
Catops nigrita		2 (3)	-
*Catops watsoni**		5 (6)	-
Cerylon histeroides		1 (1)	2 (3)
*Cossonus parallelepipedus**		5 (54)	4 (4)
Cryptophagus dentatus		1 (1)	-
*Dendrophilus punctatus**		4 (10)	5 (5)
Diaperis boleti		-	1 (1)
*Dorcus parallelipipedus**		35 (197)	28 (57)
*Elater ferrugineus**	CR	4 (7)	8 (12)
Epuraea sp.		1 (1)	-
Glischrochilus quadripunctatus		3 (12)	1 (1)
Korynetes ruficornis		-	2 (2)
Leptura quadrifasciata		-	1 (1)
Lucanus cervus	EN	-	1 (1)
Lygistopterus sanguineus		-	2 (4)
*Melanotus villosus**		8 (10)	-
Mycetaea subterranea		4 (7)	4 (4)
Mycetophagus quadripustulatus		1 (1)	2 (2)
*Neatus picipes**	NT	13 (15)	9 (11)
Ootypus globosus		1 (1)	-
Osmoderma barnabita	CR	14 (55)	15 (52)
Paromalus flavicornis		1 (2)	-
Paromalus parallelopipedus		3 (15)	-
Pleurophorus caesus	NT	1 (1)	-
Priobium carpini		1 (1)	-
Prionus coriarius		3 (4)	-
*Prionychus ater**		10 (21)	23 (41)
Protaetia lugubris		3 (3)	2 (3)
Ptilinus fuscus		1 (1)	-
Ptilinus pectinicornis		2 (2)	-
Rhizophagus cribratus	VU	1 (1)	-
Scaphidium quadrimaculatum		1 (1)	-
*Scaphisoma agaricinum**		16 (88)	10 (34)
Serica brunnea		2 (2)	4 (8)
Stereocorynes truncorum		1 (1)	2 (4)
*Trox scaber**		12 (45)	4 (4)
*Uloma culinaris**		4 (6)	13 (15)
*Xylophilus testaceus**	CR	5 (21)	1 (1)