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Deadwood-Dwelling Beetles (Coleoptera: Eucnemidae) in a Beech Reserve: A Case Study from the Czech Republic

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Abstract: The saproxylic beetles (deadwood-dependent) belong to frequently studied groups of forest insects. Eucnemidae is a rare and poorly studied saproxylic family with a hidden life strictly related to deadwood. We studied the family Eucnemidae in a beech reserve, using 59 window traps placed on standing deadwood (snags) and lying logs. A total of 348 specimens in eight species were recorded in two seasons. The identified species included one critically endangered species (CR): *Hylis cariniceps*; five endangered species (EN): *H. olexai*, *H. foveicollis*, *Isorhipis melasoides*, *Eucnemis capucina*, and *Microrhagus lepidus*; one new species found in Bohemia (a region of the Czech Republic): *Clypeorhagus clypeatus*; and one common species: *Melasis buprestoides*. Most species preferred lying logs, but *E. capucina* and *M. buprestoides* preferred snags. Species richness (q = 0) was higher on lying logs than on snags, and similarly, Shannon diversity (q = 1) was significantly higher on lying logs compared to snags. The species *C. clypeorghagus*, *H. foveicollis*, *H. cariniceps*, and *M. lepides* preferred moist lying logs, while *M. buprestoides* and *E. capucina* preferred drier snags with cavities. The results suggest that in beech forests, lying logs serve as a fundamental habitat for the existence of Eucnemids. This could be due to the more stable microclimatic conditions inside the lying deadwood. From this perspective, our study may help better understand the biology of hidden and understudied rare saproxylic Eucnemids.

Keywords: conservation; forest biodiversity; coleoptera; deadwood moisture; melasidae; deadwood microclimate

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1. Introduction

In recent decades, an increasing interest has been in a more detailed understanding of invertebrate life in forests [1]. The focus of research ranges from broad multitaxon studies, e.g., [2,3], to more detailed investigations of orders, families, and individual genera and taxa, e.g., [4–6]. One of the most studied groups of organisms in forests is saproxylic beetles [7]. Saproxylic beetle species are associated with deadwood, as defined by Speight [8]. During some part of their life cycle, saproxylic invertebrates depend upon the dead or dying wood of moribund or dead trees (standing or fallen), upon wood-inhabiting fungi, or the presence of other obligate saproxylic. Increased volumes and variable deadwood microhabitats are crucial for this group's high richness in forests [9,10]. Targeted removal of deadwood from forests results in a dramatic decline in beetle biodiversity [11], as saproxylic species contribute substantially to forest species richness [5].

The Eucnemidae (Eschscholtz, 1829), also called Melasidae (Leach, 1817), are rare beetles inhabiting deadwood. According to the *Catalogue of Palaearctic Coleoptera*, the valid name of this family is Eucnemidae [12]. Eucnemids are strongly associated with forest environments and are considered a vital indicator group for forest conservation [13,14]. Many species of Eucnemids are listed as primeval forest relicts [15]. The Eucnemids in Europe and the European Union consist of 31 and 29 species, respectively [16]. Currently, in Central Europe, 23 species of the family Eucnemidae have been recorded [12]. In the

Czech Republic, 22 species are documented [17]. The 2017 Red List itemizes 19 species, and 95% of them are categorized as threatened species (18 species: 9 in CR, 7 in EN, and 2 in VU) [14]. The following 18 species are included: *Dirrhagofarsus attenuatus* (Mäklin, 1845), *Farsus dubius* (Piller et Mitterpacher, 1783), *Hylis cariniceps* (Reitter, 1902), *Hylis procerulus* (Mannerheim, 1823), *Hylis simonae* (Olexa, 1970), *Microrhagus emyi* (Rouget, 1856), *Microrhagus pyrenaeus* (Bonvouloir, 1872), *Rhacopus sahlbergi* (Mannerheim, 1823), *Xylophilus corticalis* (Paykull, 1800), endangered (EN) species *Eucnemis capucina* (Ahrens, 1812), *Hylis foveicollis* (C. G. Thomson, 1874), *Hylis olexai* (Palm, 1955), *Isorhipis marmottani* (Bonvouloir, 1871), *Isorhipis melasoides* (Laporte, 1835), *Microrhagus lepidus* (Rosenhauer, 1847), *Xylophilus testaceus* (Herbst, 1806), vulnerable (VU) species *Dromaeolus barnabita* (A. Villa et J. B. Villa. 1838), and *Microrhagus pygmaeus* (Fabricius, 1792). Three species were recorded in the Czech Republic for the first time after the valid Red List [18] was published [19–21], but these species are also extremely rare: *Clypeorhagus clypeatus* (Hampe, 1850), *Nematodes filum* (Fabricius, 1801), and *Otho sphondyloides* (Germar, 1818). The only relatively common species of Eucnemids is *Melasis buprestoides* (Linnaeus, 1761). Eucnemids are primarily linked to lowlands up to hilly areas, and their life is mainly associated with deciduous tree species [13]. In beech forests and beech-dominated stands of Europe, up to 15 Eucnemids species have been recorded [22]. Although the bionomics of the Eucnemids is poorly studied, recent advancements in knowledge include insights into the diurnal activity of *E. capucina* [23] and the description of the life requirements of several species in protected lowland oak forest sites [13]. In the species database of the Czech Nature Conservation Agency [24], only 2347 individuals of the family Eucnemidae have been recorded in over fifty years. However, it is likely that many records, including published ones, may not have been incorporated into this database. This family represents an important yet rare group of saproxylic species, and understanding this taxonomic group is crucial for formulating effective conservation strategies. The identification of suitable attributes for the targeted support of Eucnemids in beech forests can be applied in forestry management practices. The aim of the study was to investigate the rare and understudied obligately saproxylic family Eucnemidae in a beech reserve established circa 70 years ago. The research focused on the differences between two types of deadwood, i.e., snags (standing) and lying logs (lying deadwood). Study subjects include: (i) What type of deadwood provides a more important habitat for Eucnemids in terms of species richness and abundance? (ii) What variables of deadwood affected the Eucnemids?

2. Materials and Methods

2.1. Study Site

The National Nature Reserve (NNR) Voděradské bučiny (49°58′ N, 14°48′ E) is located at an altitude ranging from 345 to 501 m [25]. The parent rock is granodiorite, and the prevailing soil type is Cambisols, characterized by a low humus content. The mean annual temperature is 7.8 °C, with an annual precipitation of 623 mm. During the period from April to September, the mean temperature is 14.0 °C, and the precipitation is 415 mm. The vegetation period, defined by a mean temperature above 10 °C, spans over 158 days. The NNR Voděradské bučiny was established in 1955 on a total area of 658 ha to protect old-growth beech stands with a semi-natural stand structure (mainly associations *Luzulo-Fagetum* and *Asperulo-Fagetum*) and scattered geomorphological peri-glacial phenomena. Presently, over 65% of the area is classified as unmanaged beech stands and semi-managed, close-to-nature areas, with potential for transitioning to a non-intervention zone. The NNR Voděradské bučiny currently covers an area of 677 ha. The long-term objective of nature protection is the spontaneous development of most forest stands without direct human interventions [26]. This approach aligns with the focus on biodiversity research, e.g., [6,27].

The old beech stands that currently form the majority of the nature reserve were formerly managed beech stands. The main regeneration method in the past was a shelterwood system, which retained 42 seed trees per hectare. After 1838, a three-phase shelterwood felling approach was implemented, with silver fir being preferentially harvested during the first phase. The whole parent stand was removed within 12–15 years. Subsequently, release felling was followed by secondary felling, and after the next four or five years, the process was finished by final cutting [28]. This very short regeneration period resulted in almost pure and even-aged beech stands [29]. From 1810 to 1850, almost 500 ha of the area (i.e., 76% of Voděradské bučiny) was felled and regenerated. The current beech stands are over 180 years old.

2.2. Deadwood Variables

Eucnemids are strictly related to deadwood microhabitats [13,14]. For this reason, the study focused on the main components of old-growth beech forests and reserves, concentrating on snags and lying logs (minimum diameter of 5 cm) [30]. The deadwood types were analyzed within permanent research plots established in 2000 and 2005 [31]. Due to the irregular distribution of deadwood types, traps were attached to logs or snags within the research plot, i.e., in the same stand with identical structural conditions. Thus, it was possible to assess the influence of the deadwood types studied. The minimum distance between traps was 25 m. Deadwood was selected for trapping where there were no significant pieces of deadwood within the minimum distance (25 m). Several variables were measured for the studied deadwood types (Table 1). Moisture levels were assessed using a point-resistance moisture meter, and measurements were conducted on the same day for all the studied deadwood units (September 2023). This procedure avoids the influence of wet weather on the obtained moisture content of deadwood. The diameter was measured at breast height for snags and mid-length for lying logs using a diameter caliper. The height of the snags was measured with an altimeter, and the length of the logs was measured using a tape measure. The volume of lying logs was calculated using the Huber formula (V), considering the log's length (L) and cross-sectional area at the mid-point (gmid): $V = L \times gmid$. For snags, the formula was based on Brunet and Isacsson [32]: $V = \pi \times d2 \times h/6$ (V = volume, d = DBH, and h = snag height in meters). The formula results in a volume corresponding to 2/3 of a cylinder of a given height and diameter. The canopy openness (canopy) was determined using spherical photographs taken with a fisheye lens above each trap. The analysis was performed using the Gap Light Analyzer software v2.0 [33]. The software converts the open sky to vegetation cover ratio into percentages for each trap site. The number of cavities (birds, base cavity, and dendrotelms) was counted on snags and logs, according to Winter and Möller [34]. Fungi were quantified based on the presence of fruiting bodies, mainly *Fomes fomentarius* and fungal groups (>5 cm in diameter). The proportion of bark loss and bryophytes was recorded as the percentage of the surveyed deadwood surface of the assessed microhabitat, ranging from 0% to 100%. Classification of deadwood into decay classes, according to [35], included the following: Class 1, freshly dead (1–2 years); 2, initiated decomposition (loose bark, tough sapwood); 3, advanced decomposition (soft sapwood and partly tough hardwood); and 4/5, extremely decomposed and moldered. The relationships between the characteristics of deadwood are shown in Figure 1.

Table 1. Values of the variables recorded in deadwood: mean (min–max). Differences were evaluated using one-way ANOVA. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; n.s. = non-significant.

Treatment	Units	Log	Snag	
moisture	%	23.2 (13–59)	14.1 (12–21)	***
diameter	cm	43.9 (9–110)	55.3 (21–131	n.s.
length	m	12 (4–21)	11.1 (3.6–22.2)	n.s.
volume	m^3	2.7 (0.03–12.7)	3.3 (0.6–9.1)	n.s.
canopy	%	8.3 (4.3–21.7)	11.4 (4.7–42.5)	*
cavity	pcs	0.1 (0–3)	0.9 (0–7)	*
fungi	pcs	3.2 (0–20)	5.3 (0–78)	n.s.
bark loss	%	54.3 (0–100)	42.5 (5–100)	n.s.
decay class	class	1st:15; 2nd:6; 3rd:5; 4th:3	1st:9; 2nd:14; 3rd:7	
bryophytes	%	10.9 (0–75)	0.2 (0–5)	**

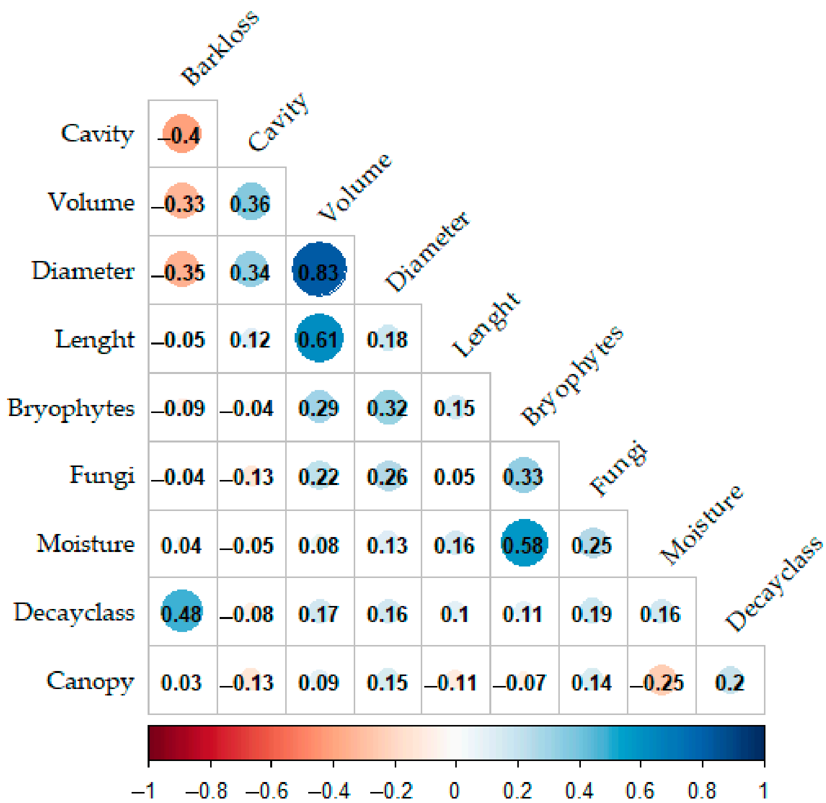

Figure 1. Spearman correlogram showing the relationship between deadwood characteristics (R package Corrplot; Wei and Simko [36]).

2.3. Beetle Sampling and Determination

Data collection was conducted from April to September in both 2022 and 2023. For both years, traps were set for different types of deadwood, consisting of 30 snags (2022) and 29 lying logs (2023). A total of 59 traps were used for the study. Window traps were used to capture beetles for the study objectives. This type of trap is suitable for recording saproxylic beetles [37,38] and thus is the most used type for beetles in many recent entomological studies, e.g., [2,5,6]. Window traps (unbaited) with a preservative solution of propylene glycol, water (1:1.5), and a drop of detergent to remove the surface tension of the solution were used to collect beetles. The catch was retrieved from the traps every two to three weeks. The trap consisted of a roof, a Plexiglass barrier, a funnel, and a collection container. The trap roof was made of a 45 cm diameter plastic bowl. Under the roof, two perpendicular Plexiglass panels created a barrier measuring 40 cm in width and 50 cm in height. Traps on the snags were hung using wire at a height of 1.3 m (southern direction, one trap per snag, Figure 2A). For recording beetles on lying logs, traps were placed directly against the log, with a catch basin on small (5 cm) pegs to prevent the capture of non-target groups (e.g., epigeic beetles) (Figure 2B). To determine the Eucnemids, all specimens (excluding *M. buprestoides*) from this family were first mounted on entomological tags (Figure 2C). Specimens were identified by the specialist Oto Nakládal, following the identification key, e.g., [39] and relying on his extensive experience and expertise in the family Eucnemidae, e.g., [20,23]. The conservation status of the Czech Republic and Germany (Deutschland) (CZ, DE) was also considered [18,40].

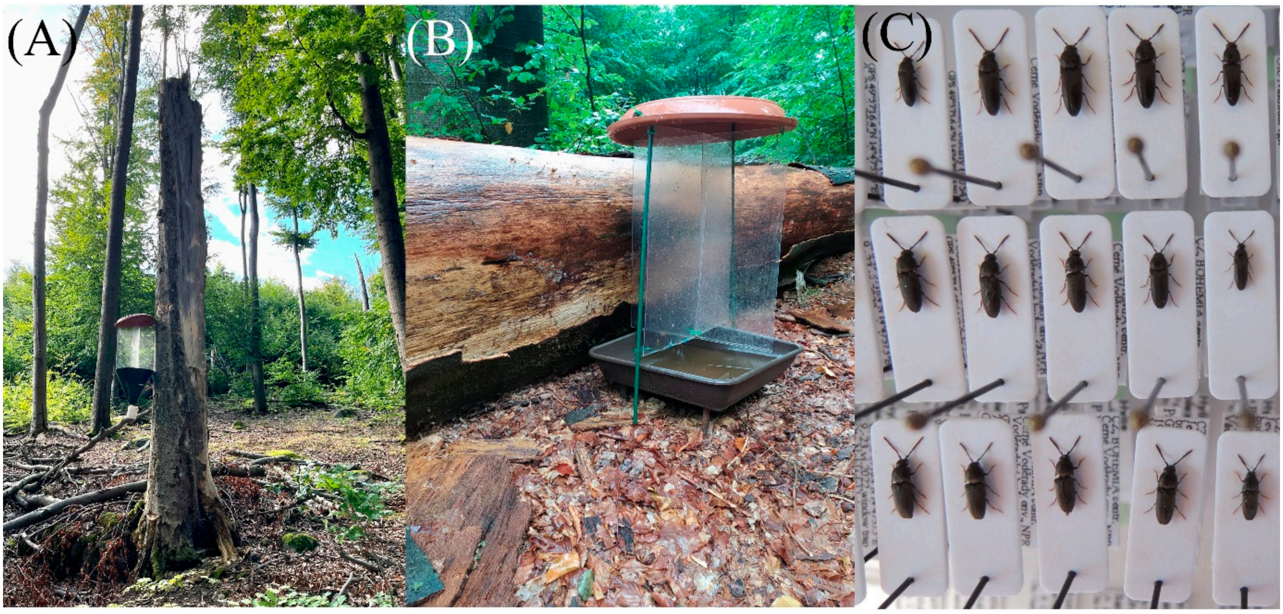

Figure 2. Illustration of the traps used in snag (**A**), lying log (**B**) and specimens of Eucnemids prepared for identification (**C**).

2.4. Data Analysis

The following software was used for data analyses: R 4.0.2 [41]. We tested the differences in abundance and number of species of the studied Eucnemidae between logs and snags using a generalized linear effect model (Poisson distribution and log link function) implemented in the package glmmTMB [42]. To assess the significance of preferences for snags/logs in each recorded species, the indicator species values approach was employed using the package "indicspecies" with the "multipatt" function with 9999 permutations [43]. For the species richness curves and gamma diversity assessment among snags/logs, we used the method by Chao et al. [44] based on the Hill numbers q = 0 (species richness) and q = 1 (the exponential of Shannon's entropy index) with the package "iNEXT" [45]. The curves were generated from incidence and abundance data. Subsequently, we used the method of estimating the total number of Eucnemidae species in the study site based on the incidence of each species captured in the study (sample coverage), according to Chao and Jost [46].

The analyses below were performed in Canoco 5 [47]. To determine the preference of each Eucnemidae species, we employed a constrained unimodal correspondence analysis (CCA) with a gradient of 4.3 SD units based on abundance and incidence data. Both input datasets were used without logarithmic transformation. CCA analyses were computed with 4999 unrestricted Monte Carlo permutations with the first constrained axis test. A symbol plot with two axes was used to visualize CCA results. The ordination method, detrended correspondence analysis (DCA), was employed to evaluate and intersperse the species across deadwood characteristics. We first used a comparison between unimodal unconstrained (DCA) vs. unimodal constrained analysis (CCA) to evaluate the highest explained variability in the data. The analysis revealed that 51% of the total variability was explained in the first two canonical axes, with DCA accounting for 47.99% and CCA for 33.60%. The ordination analysis was tested with the Monte Carlo permutation test, applying 4999 unrestricted permutations. A generalized linear model was used to evaluate and determine the significance (p-value) of Eucnemid's response to each deadwood characteristic. We used approaches based on abundance data (quasi-Poisson distribution) and incidence data (binomial distribution). Models were performed based on stepwise selection according to the lowest AIC [48].

3. Results

In total, 348 adults of Eucnemids belonging to eight species were recorded (Table 2). Trap captures between snags and logs did not show significant differences in abundance (p = n.s.) and the number of species (p = n.s.) (Figure 3). Most species preferred lying logs: based on abundance data, pF 6.5, $p < 0.001$ (Figure 4A), and based on incidence data, pF 5.5, $p < 0.001$ (Figure 4B). The significant association with the studied deadwood types among the recorded Eucnemids is shown in Table 3. The cumulative curve (gamma diversity) showed full species richness of old-growth beech stands with no increasing trend in the number of species (coverage-based 100%; eight species). Lying logs showed a higher species richness (q = 0) and, in particular, a significantly higher diversity of Eucnemids (q = 1; Figure 5A). Based on the abundance data, the difference has increased and is statistically significant q = 0 and q = 1 (Figure 5B). The ordination space of DCA illustrated that most Eucnemids species were clustered between higher moisture and advanced decay of deadwood. Deadwood characteristics and species preferences are shown via DCA (Figure 6). Deadwood moisture positively affected the occurrence and abundance of *Clypeorhagus clypeatus* and the abundance of *Hylis foveicollis* (Table 4). The presence of cavities, the thickness and length of deadwood, and canopy openness negatively affected the preference of most Eucnemids species recorded (Figure 6). For other deadwood parameters, there was no clear positive or negative effect on most of the species recorded (Table 4).

Table 2. Species of Eucnemidae and their number of individuals (incidence) recorded in the study.

Species	Abbreviation	Czechia RL	German RL	Log	Snag	Sum
Hylis olexai	*HylsOlex*	EN	NT	30 (17)	149 (10)	179
Melasis buprestoides	*MelsBupr*			24 (13)	87 (23)	111
Hylis foveicollis	*HylsFove*	EN	NT	25 (13)	0	25
Hylis cariniceps	*HylsCarn*	CR	EN	9 (5)	2 (2)	11
Isorhipis melasoides	*IsorMels*	EN	EN	8 (3)	3 (2)	11
Eucnemis capucina	*EucnCapc*	EN	EN	0	5 (5)	5
Clypeorhagus clypeatus	*ClypClyp*	*	-	3 (2)	1 (1)	4
Microrhagus lepidus	*MicrLepd*	EN		2 (2)	0	2

RL—Red List; Czechia: Hejda et al. [18]; Germany: Schmidl et al. [40]; * new species for the CZ Nakládal and Vávra, [20], (-) not included in RL.

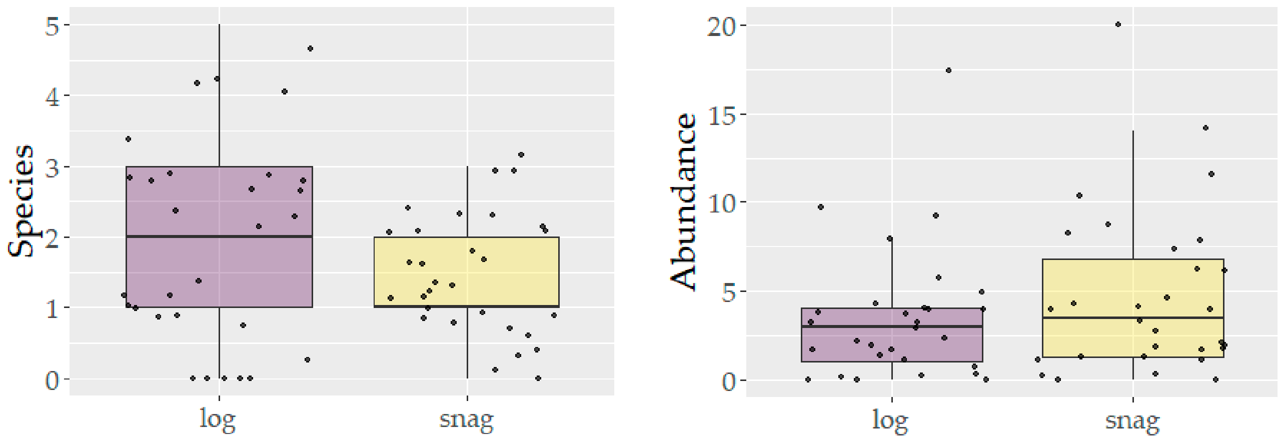

Figure 3. Number of species and number of individuals captured among the logs and snags. Solid lines in boxes represent median values; boxes indicate interquartile range (25%–75%), and whiskers min–max values. One outlier (snag 123 indi.) was removed from the abundance for better readability (right graph).

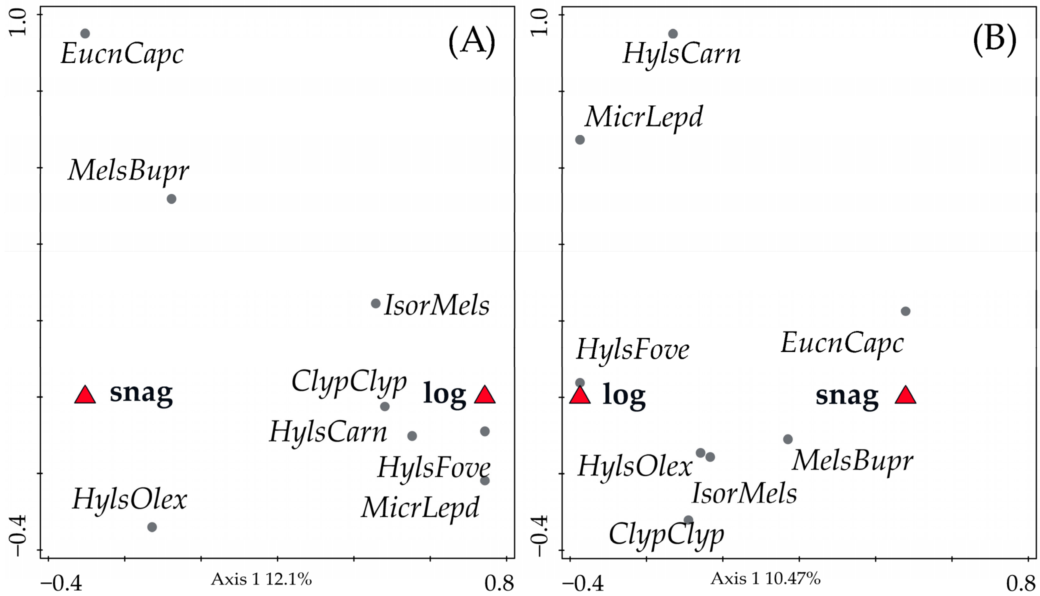

Figure 4. Species symbol plot summarizing the preference of beetle species. CCA's first two axes plotted—abundance data (**A**) and incidence data (**B**).

Table 3. Indicator species values of recorded species of the Eucnemidae and their importance in preferences per snags/logs. * $p < 0.05$, *** $p < 0.001$. Significant values are in bold.

	Logs			
	Stat	***p*-Value**	**Stat**	***p*-Value**
	incidence		abundance	
Hylis foveicollis	0.537	**0.0001** ***	0.438	**0.0001** ***
Hylis olexai	0.254	0.0719		
Microrhagus lepidus	0.189	0.2387	0.189	0.2340
Hylis cariniceps	0.163	0.2559	0.214	0.1201
Clypeorhagus clypeatus	0.081	0.6115	0.112	0.4847
Isorhipis melasoides	0.066	0.6695	0.105	0.5720
	Snags			
Melasis buprestoides	0.326	**0.0189** *	0.439	**0.0004** ***
Eucnemis capucina	0.302	0.0539	0.302	0.0512
Hylis olexai			0.125	0.6061

Table 4. Results of the generalized linear models. Abundance data (quasi-Poisson distribution) and incidence data (binomial distribution) were used. Significant values are in bold ($p < 0.05$). Positive (+: green) or negative (−: red) responses are indicated via *p*-value. *p*-values close to significance ($p < 0.07$) are also shown.

		Moisture	**Diameter**	**Length**	**Volume**	**Canopy**	**Cavity**	**Fungi**	**Bark Loss**	**Decay Class**	**Bryophytes**
Clypeorhagus clypeatus	Abundance	**+0.008**									+0.054
	Incidence	+0.068									
Eucnemis capucina	Abundance								**−0.004**		
	Incidence						+0.062		**−0.018**		

Table 4. *Cont.*

		Moisture	Diameter	Length	Volume	Canopy	Cavity	Fungi	Bark Loss	Decay Class	Bryophytes
Hylis cariniceps	Abundance										
	Incidence										
Hylis foveicollis	Abundance		**−0.047**		−0.058		**−0.022**				
	Incidence	**+0.022**	**−0.020**		**−0.046**	**−0.036**	**−0.016**		**+0.018**		
Hylis olexai	Abundance					**+0.001**					
	Incidence						**−0.008**				
Isorhipis melasoides	Abundance										
	Incidence										
Melasis buprestoides	Abundance	**−0.002**									**−0.025**
	Incidence	−0.064						**−0.013**	**−0.035**		**−0.002**
Microrhagus lepidus	Abundance								**+0.002**		
	Incidence								**+0.023**		

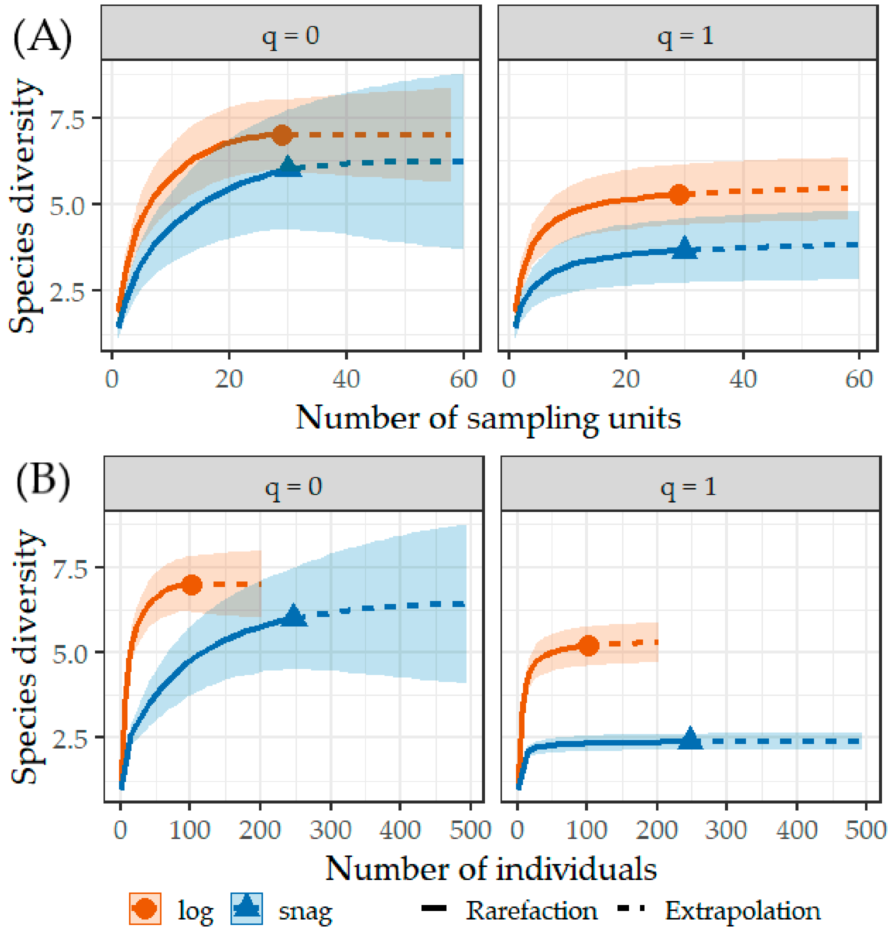

Figure 5. Sample-size-based rarefaction and extrapolation sampling gamma diversity of Eucnemidae—showing the Hill numbers' incidence data (**A**) and abundance data (**B**), q = 0 (species richness) and q = 1 (the exponential of Shannon's entropy index). Colored shaded areas represent the 95% confidence intervals. Solid symbols represent the total number of species and extrapolation (dashed lines) up to double the reference sample size.

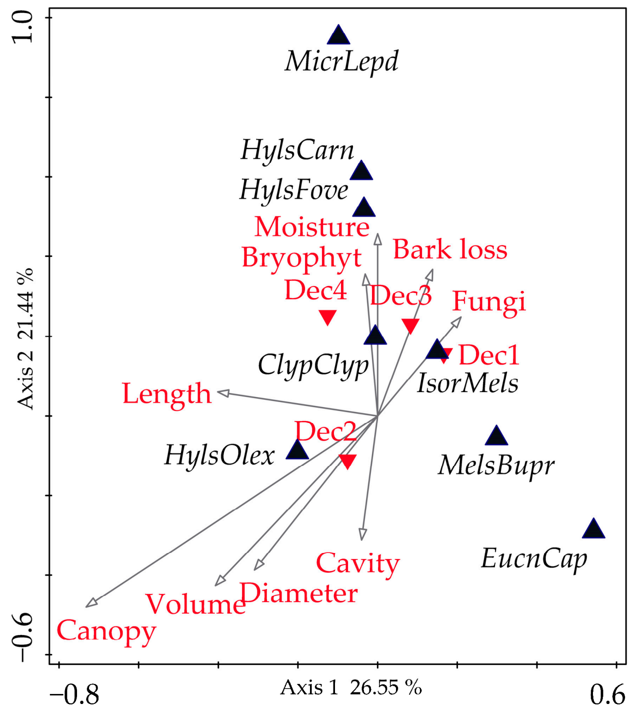

Figure 6. Results of detrented correspodence analysis show the first two canonical axes. The black triangles are Eucnemids species. Red triangles are decay classes, and arrows are environmental continuous characteristics of deadwood.

4. Discussion

We captured 348 beetles representing eight species over a two-year study with 59 traps. With more than a thousand traps distributed throughout Europe, [22] captured 15 species and 1816 individuals in beech-dominated forests. Our study area consists of relatively recent, pure autochthonous beech-protected stands [31] compared to Müller et al. [22], where a wide range of other tree species was represented <50%. This likely led to the higher capture of Eucnemids species, not only those associated with beech stands and beechwood. Another factor affecting the higher species counts in the study by [22] may be the inclusion of sites in Eastern Europe, renowned for its highly conserved forest complexes [49]. Eucnemids have a minimum of at least two years of development [13]. This could affect analyses comparing deadwood host substrates. We sampled the Eucnemids separately each year. We assume that Eucnemids' development is continuous over time and that annual fluctuations are insignificant at the study site. Thus, we also assume that the position of deadwood and its characteristics are important factors, as opposed to different sampling years.

Therefore, our study provides insight into the typical species composition of Eucnemidae in beech forests without further bias. Supporting evidence for the significance of the habitat in the studied beech stands is found compared to similar studies conducted in natural conditions and beech reserves. Procházka and Schlaghamerský [50] identified four species of Eucnemidae with 102 individuals, while Müller et al. [51] found five species with 14 individuals. *Melasis buprestoides*, *Hylis olexai*, and *H. foivecollis* proved to be the most abundant Eucnemids in our study. Our results correspond with [22], who also found the same Eucnemids species to be the most abundant in beech forests a decade earlier. *M. buprestoides* is the most common species in the family and has been observed mainly on snags. In contrast, the other species, especially *H. olexai* and *H. foivecollis*, were more abundantly trapped on lying logs, although most of the 123 individuals of *H. olexai* were captured by one trap on a snag with a large and heavily sunlit cavity. The association of *H. foivecollis* with lower deadwood volumes, as indicated by Procházka and Schlaghamerský 2019 [51], contrasts with our findings, which suggest that the moisture content of the deadwood may play a more significant role in this Eucnemid in beech stand. Results showed that the species *E. capucina* and *M. buprestoides* were associated with snags. These species are cavity-dwelling and thus may be negatively affected by the higher moisture content of fallen logs. Additionally, cavities were practically absent in fallen logs. *E. capucina* has a strong preference for cavity trees [23,52], which is also supported by the results of our study. On the contrary, *M. buprestoides* appears to prefer drier deadwood at the transition between hard wood and soft, partially decomposed wood; therefore, this species favors habitat trees to cavity trees [52]. *Clypeorhagus clypeatus*, a species recently discovered in the Czech Republic [20], was recorded during the study, and our records are the first for all of Bohemia [53]. This species is poorly known, with only a few specimens documented [17]. It is mainly associated with beech forests and beech deadwood in areas without interrupted forest continuity characterized by minimal forest management. The bionomy of this species is not well-described by Mertlik [39].

The preference of most Eucnemids for deadwood position was observed in lying logs. Similar faunistic findings of Eucnemids favoring lying logs have been reported in previous studies, e.g., [21,54] or other beetle species *Tragosoma depsarium* (Cerambycidae) [55]. The position of deadwood influences both its moisture content and the process of wood decomposition [55]. In contrast, [56] found standing oak deadwood generally richer in saproxylic beetles than in lying deadwood. Franc [57] reported differences in favor of lying logs in the case of oak deadwood. In general, oak deadwood is recognized for its richness in saproxylic beetle species [58]. We focused on beech deadwood, which exhibits significantly faster decomposition processes compared to oak [59]. This characteristic may have implications for Eucnemids, as higher moisture content is a very important parameter of lying logs. In addition, natural beech stands are characterized by low heterogeneity due to their darkness. Therefore, in our study, canopy openness was an insignificant variable for most of the recorded Eucnemids species. Consequently, the beech Eucnemids do not seem to support the thesis that sun exposure is a critical element for endangered species [9,60].

Dry and wet periods are likely to influence the preferences of Eucnemids. In current drought periods, deadwood moisture becomes a limiting factor, potentially leading Eucnemids to prefer lying logs. This is probably due to lying logs having a more stable temperature throughout the year and not fluctuating much compared to snags [55]. Conversely, during wet periods, they may exhibit a stronger preference for snags, seeking sunlight as a source of heat and a drier woody substrate. In general, deadwood absorbs water depending on the degree of decomposition and also helps maintain the forest microclimate by evaporation [61]. Likewise, the beech Eucnemids species may be more likely associated with shadier and wetter conditions and to seek out moist pieces of deadwood. We identified the higher moisture levels and higher levels of deadwood decomposition as important variables influencing the presence of *C. clypeatus*, *H. foivecollis*, *H. cariniceps*, and *M. lepidus*. While lying beech deadwood is known to be relatively unstable over time, quickly becoming an unsuitable habitat for beetles [62] and more closely resembling the soil environment [62], standing deadwood increases the persistence of deadwood in stands over several decades [63]. However, our findings indicate that snags exhibit low moisture content, resulting in a lower abundance of Eucnemids. Climate change, particularly alterations in the seasonal distribution of precipitation, may also have an influence on the life of Eucnemids. The overall drier climate in recent times [64] may also negatively impact the Eucnemids. The primary driver of deadwood moisture is rainfall [65]. Nevertheless, their high requirements for deadwood quality and, often, forest continuity appear to be the main limiting factors for their existence [13]. Bark loss was found to be one of the influential variables, especially affecting the species *M. lepidus*. The absence of bark may also affect deadwood moisture. The loss of bark exposes the wood, allowing rainfall to penetrate deeper layers of the wood directly. We observed bark loss on logs with higher moisture content, which also indicates advanced decomposition. However, the microclimate inside deadwood is also affected by forest characteristics [55].

5. Conclusions

The study investigated the habitat requirements of a truly rare saproxylic family in beech stands. Moisture conditions within lying logs play an important role in the successful occurrence and survival of Eucnemidae species. The increasing prevalence of drier and precipitation-free periods in recent times [64,66] may impact the overall abundance and richness of Eucnemids species. Consequently, their preferences are directed primarily to lying logs, which, being in contact with the ground, absorb moisture and provide a favorable environment for the life cycle of beech Eucnemids.

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