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Diversity comparison of nocturnal macrolepidoptera communities (Lepidoptera: Macroheterocera) in different forest stands

Bálint Horváth

University of West Hungary, Institute of Silviculture and Forest Protection,
Sopron H-9400 Bajcsy-Zs. u. 4., Hungary, e-mail: macrolepidoptera@gmail.com

Horváth, B: *Diversity comparison of nocturnal macrolepidoptera communities (Lepidoptera: Macroheterocera) in different forest stands.*
Abstract: Macrolepidoptera communities were examined and diversity was compared in three different indigenous forest stands (Oak, Beech and mixed forests) in the Sopron Mountains (Hungary). The monitoring was carried out from May to November, 2008, using portable light traps and identified a total of 349 species and 8046 individuals in 12 families. The results suggest that the mixed forest stand has higher diversity of macromoth species. The species richness was the highest in the mixed forest stand, followed by beech and oak forests. The measures of diversity were determined using Shannon and Simpson diversity models. To compare diversity values, Hutchenson's t-test was used. Furthermore, the diversity values were ranked by Rényi's diversity ordering. The results found higher diversity in the mixed forest stand, while the beech forest stand had lower diversity of macromoth communities. Ranking of the oak forest stand was not possible.

Keywords: Sopron Mountains, indigenous forest stands, macromoths, diversity ordering, forest management

Introduction

Forests play an important role in Earth's ecosystems. These habitats are composed of plants, fungi, vertebrates and invertebrates, all of which interact closely with each other. Many authors have studied forest ecosystems, including forest ecology and management as well as indicators of biodiversity (e.g., Niemelä 1997, Bawa & Seidler 1998, Usher & Keiller 1998, Gascon et al. 1999, Fermon et al. 2000, Kitching et al. 2000, Lindenmayer et al. 2000, Summerville & Crist 2002, Summerville & Crist 2003, Dunn 2004, Summerville et al. 2004, Beck et al. 2006, Ober & Hayes 2009, Taki et al. 2010, Fiedler & Truxa 2012). Nevertheless, the impact of management on indigenous forests and the relationship between indicator species and habitats are not well established (Bawa & Seidler 1998, Fermon et al. 2000, Lindenmayer et al. 2000).

Forest communities in Hungary are often under pressure from intensive forest management, which might have a significant influence on insect communities. Currently, conservation biology places great emphasis on the maintenance of biodiversity (Primm et al. 2004). Invertebrates play very important roles in forests as consumers or as prey of several other animal groups. Insects are an abundant and diverse group. Moreover, numerous insect species are adapted to special environmental conditions, so they are suitable as indicators of biodiversity (New 2009, Park et al. 2009). Lepidoptera species

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are one of the most researched insect orders in the world; they have been widely used in ecological studies (KITCHING et al. 2000, SUMMERVILLE & CRIST 2003, SUMMERVILLE et al. 2004, PARK et al. 2009). Although butterflies are more often investigated (e.g., LARSEN 1996, HADDAD 1999, JEANNERET et al. 2003, TUDOR et al. 2004, BENES et al. 2006, CLEARY & GENNER 2006), moth species play a more significant role in forest ecosystems because the species richness of butterflies is lower in forests (SCOBLE 1992, SCHMITT 2003).

Approximately 3500 species of Lepidoptera are found in Hungary, including 1172 macromoth (VARGA 2010) and 2244 micromoth species (PASTORÁLIS 2010).

In this study, nocturnal macromoth species were examined in three different forest stands; this paper supports the hypothesis that there is a higher diversity of macromoth communities in mixed forest stands.

Materials and methods

Study sites

The investigation was conducted in an area of approximately 5000 hectares in the Sopron Mountains (Fig. 1), in the Lower Austroalpides. Approximately 90% of the area is forested (DÖVÉNYI 2010). Intensive use of forests near Sopron was started in the 12th or 13th century. After 1850, many indigenous forests were replaced with pine trees, and the proportion of the forest that was deciduous continually decreased until the 1980's. This is the primary reason why the composition of several forests is different from that of the natural forests in the Sopron Mountains (TAMÁS 1955, SZMORAD 2011).

The investigation of conifer forests was avoided in this study, and we focused only on three indigenous, deciduous forest stands. All the sites were old forests – over one hundred years – and the studied areas were between 7.2 and 7.6 hectares:

The mixed forest stand (Ház-oldal; N47°40'27", E16°27'59", 400 m, 7.3 ha), with a high number of plant species, was the stand that most resembled the natural forests (STANDOVÁR 2000, SZMORAD et al. 2002).

The beech forest stand (Hermes-hill; N47°39'6", E16°28'39", 490 m, 7.6 ha) was unmixed and dominated by the European Beech (*Fagus sylvatica*). The herb and shrub layer was subnudum.

The oak forest stand (close to the Fáber meadow; N47°39'58", E16°33'10", 385 m, 7.2 ha), with an abundant herb layer – dominated by *Melica uniflora* (60%) – also contained a low number of tree species and was dominated by the Sessile Oak (*Quercus petraea*).

Sampling method

Nocturnal Lepidoptera species were sampled 9 times, from May to November, 2008, using portable light traps (using 12 W black light, operated by 12 V battery). Although light traps operated with various light sources have different levels of attraction for Lepidoptera families (NOWINSZKY & EKK 1996, PUSKÁS & NOWINSZKY 2011), UV light traps are widely used for sampling moth communities (SUMMERVILLE & CRIST 2003). Two traps were used in each forest stand, and there were 50 m between each trap. Samples in the three habitats were taken simultaneously for 4 days; therefore, the number of sampling nights was 36 for each study site. Light trapping was regularly carried out during the night (from sunset to sunrise) and ceased during heavy rain.

Fig. 1: Sampling sites in the Sopron Mountains. I. Mixed forest stand; II. Beech forest stand; III. Oak forest stand

Data analysis

Communal and ecological parameters of Lepidoptera communities were examined in each of the sampling sites, which were calculated by Past software (Paleontological Statistics Software) (HAMMER et al. 2001). There were some species for which identification was not possible by macro-morphological features (*Eupithecia* spp. and *Mesapamea secalis* agg.). The total numbers of specimens in these genera were used for the data analyses.

The number of species and sampling occasions were displayed with species accumulation curves, using the sample rarefaction by COLWELL et al. (2004) (Fig. 2).

The measure of diversity was determined by the Shannon and Simpson indices. These indices are composed of species richness and evenness components (JOST 2010), which were also calculated ($J=H'/\ln S$ – where S is species richness). The equitability was established using the PIELOU (1966) formula. The proportion of abundance in each sampling sites was displayed using a rank-abundance plot. Logarithmical models were selected for the rank-abundance investigation using a fitting test.

To compare Shannon's diversity values, a t-test was calculated ($p=0.01$) (HUTCHESON 1970).

To rank the collected macromoth communities, Rényi's diversity ordering (TÓTHMÉRÉSZ 1997) was used. Diversity profiles are a graphical display of a family of diversity indices; values are calculated from the frequencies of each component species and an alpha scale parameter, which ranks from zero to infinity. An assemblage of higher diversity has a diversity profile that is above the profiles of other assemblages (TÓTHMÉRÉSZ 1995).

Results

Throughout this study, a total of 349 Lepidoptera species and 8046 individuals were identified in 12 families. The highest number of species was detected in the mixed forest stand, followed by beech and oak forests. The number of individuals found in each forest did not correlate with the number of species. The highest number of registered specimens was in the beech forest stand, followed by mixed and oak forest stands (Table 1).

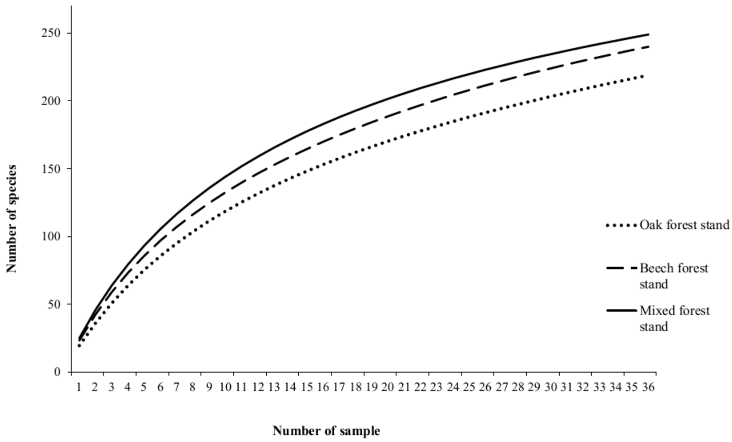

Fig. 2: Species accumulation curves (sample rarefaction) of nocturnal Lepidoptera species in the study sites

The calculated diversity indices (Shannon and Simpson) do not show unambiguous results. The Shannon diversity index value was highest in the mixed forest, while the Simpson diversity index produced different results (Table 1). These data can be explained by the different sensitivity of the diversity formulas to dominant and rare species, and the equitability. The Shannon diversity formula calculates using the degree of evenness of species abundances, while the Simpson index is heavily weighted towards the most abundant species in the sample (PEET 1974).

Table 1: Ecological structural characteristics of macromoth communities in the different forest stands

	Mixed forest stand	Oak forest stand	Beech forest stand
No. of species	249	219	240
No. of individuals	2612	1975	3459
Shannon index	4.414	4.364	4.008
Simpson index	0.9722	0.9752	0.9604
Pielou's equitability index	0.8	0.8098	0.7314

A measure of equitability showed a trend similar to that of the Simpson diversity values. The value of Pielou's index was lower in the beech forest stand than in the two other sites (Table 1).

There were some differences in the proportions of dominant and rare species between the sampling sites. Most species were rare, as indicated by the step initial gradients in the rank abundance plots (Fig. 3a-c). The proportion of abundant and rare species was the most balanced in the oak forest, followed by the mixed and beech forests.

Comparing the Shannon diversity values revealed significant differences between mixed and beech forest stands as well as between oak and beech forest stands (p=0.01). There was no significant difference between mixed and oak forest stands (Table 2).

Table 2: Comparison of Shannon diversity values using Hutchenson's t-test (*significant difference – p=0,01)

	Mixed	Beech
Beech	10.2750*	
Oak	1.3452	8.5763*

Rényi's diversity ordering found a significant difference between mixed and beech forests, but ranking of mixed and oak forests as well as oak and beech forests was not possible (Fig. 4).

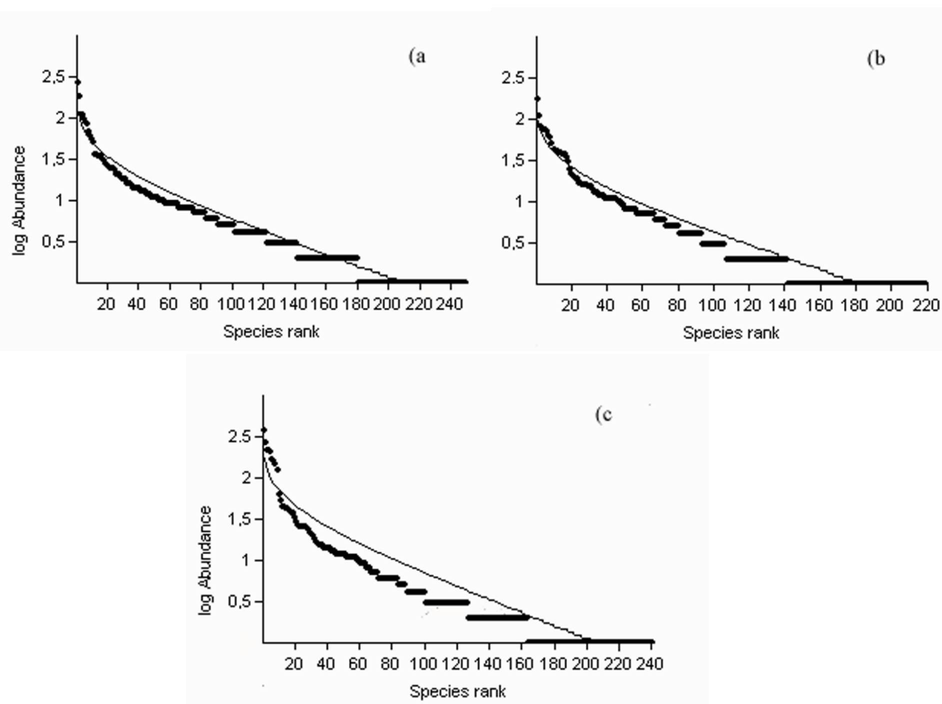

Fig. 3: Rank-abundance plots showing the number of captures of each species of macro moth in mixed (a), oak (b) and beech (c) forest stands

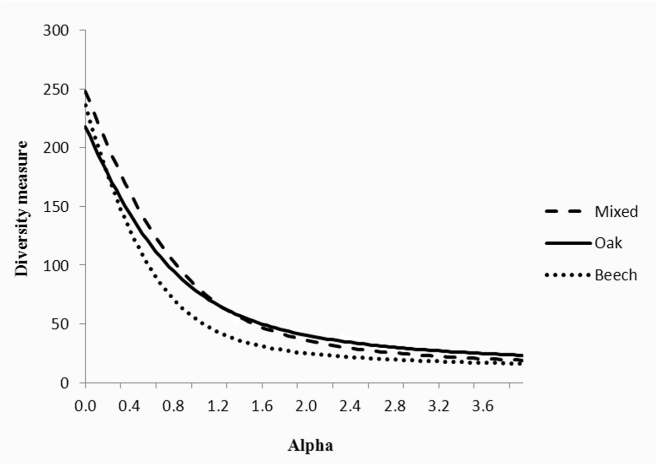

Fig. 4: Diversity profiles of the sampled moth communities in the sampling sites

Discussion

Macromoths in the Sopron area are well studied – approximately 800 species are known (MÉSZÁROS & SZABÓKY 1981, LESKÓ & AMBRUS 1998, SÁFIÁN et al. 2006, SÁFIÁN & SZEGEDI 2008, SÁFIÁN et al. 2009). In the content of the numerous papers on the fauna of the region, comparative studies on nocturnal Lepidoptera species have not been published before in this study area.

The hypothesis that there would be a higher diversity of macromoth species in the mixed forest stand was partly true. The results of the diversity indices and diversity comparisons clearly delineate the ranks of the mixed and beech forest stands. The diversity profile of the oak forest stand crossed both of the other profiles in the graphical display; therefore, ranking the oak forest stand using Rényi's ordering was not possible. The number of species and individuals was the lowest in the oak forest; however, the diversity indices values were higher for the oak forest than for the beech forest, which can be explained by the higher equitability value. The lower number of species was unexpected because most of the herbivorous Lepidoptera species develop on oak (CSÓKA 1998). The lower diversity values in the beech forest stand may be due to the subnudum herb layer and the low number of shrub and tree species.

A similar study was performed by SUMMERVILLE & CRIST (2003). They found a significant relationship between moth community composition and forest structure, especially the floristic composition. Forest management plays an important role in the maintenance of favourable forest structure for Lepidoptera and plant communities. Forest structure primarily depends on the logging method used. Unlogged or selectively cut forest stands are more favourable for forest moth assemblages (SUMMERVILLE & CRIST 2002). Logging determines the vegetation beneath the forest canopy, which is a causal factor for the moth community structure in forested ecosystems (USHER & KEILLER 1998, OBER & HAYES 2009). The final results of this study also emphasise the important role played by the number of plant species and the vegetation structure. To verify the role of the mixture rate and diversity of vegetation on Lepidoptera species requires further investigation.

Despite the lower diversity found in the beech forest stand, beech forests play an important role among the forests of the Sopron Mountains; for example, it is important for the proper climate and species composition and the high production of biomass.

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