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Caterpillar (Lepidoptera) communities on European Turkey oak (*Quercus cerris*) in Malé Karpaty Mts (SW Slovakia)

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Abstract: Between 2000–2002, the structure of communities of lepidopteran larvae was studied in leaf bearing crowns of *Quercus cerris* in the central and northern part of the Malé Karpaty Mts (SW Slovakia). Caterpillars were collected using the beating method in four study plots. In total, 58 species were found. The families Geometridae, Noctuidae and Tortricidae comprised the highest number of species found. The family Geometridae comprised the highest number of pests. The most abundant species for individual plots were *Lymantria dispar*, *Operophtera brumata*, *Ypsolopha alpella* and *Cyclophora ruficiliaria*. Most of the recorded species belonged to the trophic group of generalists (39 species). Shannon-Wiener's diversity index and Pielou's equitability (evenness) value indicated there were marked differences between the Horný háj study plot (an insular forest with ants as the predators of caterpillars) and other plots. The main ecological gradient along DCA-1 related to the host specificity of caterpillars and consisted of three groups: (a) polyphagous species; (b) specialist species feeding chiefly on oaks or exclusively on oaks and (c) species preferring some oak species, mainly *Q. cerris*. The fragmentation of growth was identified along DCA-2.

Key words: Lepidoptera, larvae, European turkey oak, Malé Karpaty Mts, SW Slovakia.

Introduction

About 300 Lepidoptera species are known to damage the assimilation tissue of oaks in Slovakia (Patočka, 1954, 1980; Reiprich, 2001). Caterpillars are shown to be the most important group of oak defoliators (Patočka et al., 1962, 1999). In Slovakia extensive data are available on the composition of lepidopteran larvae communities on oaks (Patočka et al., 1962, 1999; Kulfan, M., 1990, 1997, 1998, 2002; Kulfan, M. et al., 1997; Kulfan, J., 1992; Cicák et al., 1999). Lepidopteran larval communities on *Quercus cerris* L. have been studied in C Slovakia (Patočka et al., 1962; Kulfan, J., 1992) and Hungary (Csóka, 1990–1991, 1998a, b). Three lepidopteran leaf miners (*Ectoedemia cerris* Zimmermann, 1944, *Phyllonorycter mannii* Zeller, 1846 and *P. abrasellus* Duponchel, 1843) and one foliophagous species *Anacampsis timidella* (Wocke, 1887) were shown as European turkey oak species in C Slovakia (Patočka et al., 1962). Kulfan, J. (1992) found 26 lepidopteran species on *Quercus cerris* in C Slovakia near Zvolen. Fourteen species of macrolepidoptera were found to feed on *Q. cerris* in Hungary (Csóka, 1990–1991). *Lymantria dispar* L. is the most significant defoliator of *Q. cerris* leaves in Hungary (Csóka, 1998a, b). For the remaining groups of insects, communities of nabid bugs and weevils have been studied in leaf bearing crowns of *Q. cerris* in the Malé Karpaty Mts (SW Slovakia) recently (Bulánková & Holecová, 2000; Holecová & Sukupová, 2000).

The main aim of this paper is to investigate the structure of communities of lepidopteran larvae on European turkey oak (*Q. cerris*) in central and northern parts of the Malé Karpaty Mts (SW Slovakia).

Study plots

The study plot Horný háj (HH) near Horné Orešany village (48°28′ N, 17°24′ E) (altitude 240 m a.s.l.) is covered by *Quercus cerris* L., *Carpinus betulus* L., *Quercus dalechampii* Ten. and *Fraxinus excelsior* L. belonging to the subassociation *Querco-Carpinetum melicetosum uniflorae*. It is an extensive complex of insular forest surrounded by vineyards and field plantations. The age of the growth has been estimated to be about 60–80 years.

Study plot Lošonec-lom (LL) near Horné Orešany (48°29′ N, 17°23′ E) (altitude 340 m a.s.l.) is covered mainly by *Quercus dalechampii* Ten. belonging to the subassociation *Querco-Carpinetum caricetosum pilosae*. The age of the growth has been estimated to be about 80–100 years.

Study plot Naháč-Kukovačník (NA) near Naháč village (48°32′ N, 17°32′ E) (altitude 300 m a.s.l.) is covered

Table. 1. Dominance (%), months of occurrence and trophic groups of lepidopteran larvae on *Quercus cerris* at four plots of the Malé Karpaty Mts (SW Slovakia) in 2000–2002.

Species/Plot	HH	LL	NA	NK2	MO	Trophic group
Bucculatricidae						
▶ *Bucculatrix ulmella* Zeller, 1848	0.0	0.0	0.0	0.9	8	G
Ypsolophidae						
▶ *Ypsolopha alpella* (Denis et Schiffermüller, 1775)	23.1	4.1	12.3	6.1	5,6	S2
▶ *Ypsolopha ustella* (Clerck, 1759)	5.1	1.0	1.3	0.0	5	G
Oecophoridae						
▶ *Carcina quercana* (F., 1775)	0.0	1.0	0.6	0.0	6,8	G
▶ *Diurnea lipsiella* (Denis et Schiffermüller, 1775)	2.6	0.0	0.0	0.0	6	G
Coleophoridae						
Coleophora ibipennella Zeller, 1849	0.0	0.0	0.6	0.0	5	G
▶ *Coleophora lutipennella* (Zeller, 1838)	0.0	1.0	11.0	3.5	5	S2
Gelechiidae						
▶ *Anacampsis timidella* (Wocke, 1887)	0.0	0.0	0.6	0.0	5	S2
▶ *Psoricoptera gibbosella* (Zeller, 1839)	0.0	1.0	0.0	0.0	5	G
▶! *Stenolechia gemmella* (L., 1758)	0.0	0.0	0.0	0.9	6	S2
Tortricidae						
▶! *Aleimma loeflingiana* (L., 1758)	0.0	1.0	1.3	0.0	5	S2
▶! *Archips crataeganus* (Hübner, 1799)	0.0	1.0	0.0	0.0	5	S3
▶ *Pandemis cerasana* (Hübner, 1786)	0.0	1.0	0.0	0.0	5	G
Pandemis heparana (Denis et Schiffermüller, 1775)	0.0	1.0	0.0	0.0	7	G
▶ *Ptycholoma lecheanum* (L., 1758)	0.0	1.0	0.0	0.0	5	G
▶! *Tortricodes alternella* (Denis et Schiffermüller, 1775)	0.0	10.2	4.5	5.2	5	G
Pyralidae						
▶ *Conobathra tumidana* (Denis et Schiffermüller, 1775)	0.0	3.1	9.7	2.6	4,5	S2
▶ *Phicita roborella* (Denis et Schiffermüller, 1775)	0.0	0.0	1.3	1.7	5	S2
Drepanidae						
Cymatophorina diluta (Denis et Schiffermüller, 1775)	0.0	0.0	3.2	0.0	5	S2
▶ *Polyploca ridens* (F., 1787)	2.6	0.0	2.6	1.7	5,6	S2
Geometridae						
▶! *Agriopis aurantiaria* (Hübner, 1799)	0.0	1.0	0.6	0.0	5	G
▶ *Agriopis leucophaearia* (Denis et Schiffermüller, 1775)	0.0	6.1	6.5	8.7	5	S3
▶ *Agriopis marginaria* (F., 1776)	0.0	4.1	3.9	0.0	4,5	G
▶ *Alsophila aceraria* (Denis et Schiffermüller, 1775)	0.0	4.1	0.6	0.9	5	G
▶! *Alsophila aescularia* (Denis et Schiffermüller, 1775)	0.0	0.0	0.6	0.0	5	G
Biston betularia (L., 1758)	0.0	0.0	0.0	0.9	8	G
Biston strataria (Hufnagel, 1767)	0.0	0.0	0.0	1.7	5	G
▶ *Campaea margaritata* (L., 1767)	0.0	1.0	0.0	2.6	7	G
▶! *Colotois pennaria* (L., 1761)	2.6	1.0	0.6	0.9	5	G
Cyclophora ruficiliaria (Herrich-Schäffer, 1855)	2.6	7.1	8.4	18.3	6,7,8,9	S2
Ectropis crepuscularia (Denis et Schiffermüller, 1775)	0.0	0.0	0.0	0.9	6	G
▶ *Epirrita dilutata* (Denis et Schiffermüller, 1775)	0.0	1.0	0.6	0.0	5	G
Eupithecia abbreviata Stephens, 1831	0.0	0.0	0.6	0.0	5	S2
▶ *Hypomecis punctinalis* (Scopoli, 1763)	2.6	0.0	0.0	0.0	8	G
Hypomecis roboraria (Denis et Schiffermüller, 1775)	0.0	1.0	0.0	0.0	5	S3
! *Lycia hirtaria* (Clerck, 1759)	2.6	0.0	0.0	1.7	5,6	G
▶!! *Operophtera brumata* (L., 1758)	0.0	15.3	2.6	5.2	4,5	G
Notodontidae						
Drymonia querna (Denis et Schiffermüller, 1775)	0.0	2.0	1.9	0.0	7,8,9	S2
Harpyia milhauseri (F., 1775)	0.0	1.0	0.0	0.0	7	G
! *Phalera bucephala* (L., 1758)	2.6	0.0	0.6	0.0	7	G
Spatalia argentina (Denis et Schiffermüller, 1775)	0.0	0.0	0.6	0.0	7	G
! *Thaumetopoea processionea* (Linnaeus, 1758)	0.0	0.0	0.6	0.9	6	S2
Lymantriidae						
▶!! *Lymantria dispar* (L., 1758)	33.3	3.1	5.8	10.4	5,6	G
Orgyia antiqua (L., 1758)	0.0	0.0	0.0	0.9	7	G
Noctuidae						
Acronicta psi (L., 1758)	2.6	0.0	0.0	0.0	6	G
Amphipyra pyramidea (L., 1758)	0.0	1.0	0.0	0.0	5	G
Bena bicolorana (Fuessly, 1775)	0.0	0.0	0.0	1.7	5,9	S2
▶ *Cosmia trapezina* (L., 1758)	2.6	2.0	4.5	5.2	5	G
▶ *Dichonia convergens* (Denis et Schiffermüller, 1775)	0.0	1.0	0.0	0.0	5	G
Diloba caeruleocephala (L., 1758)	0.0	0.0	0.0	0.9	5	S2
Dryobotodes monochroma (Esper, 1790)	2.6	13.3	3.2	3.5	5	S2
▶ *Eupsilia transversa* (Hufnagel, 1766)	0.0	0.0	0.6	0.0	5	G
▶ *Lithophane ornitopus* (Hufnagel, 1766)	0.0	0.0	1.3	1.7	5	G
▶ *Orthosia cerasi* (F., 1775)	2.6	3.1	2.6	4.3	5	G
▶ *Orthosia cruda* (Denis et Schiffermüller, 1775)	2.6	4.1	1.9	4.3	5	G

Table. 1. (continued)

Species/Plot	HH	LL	NA	NK2	MO	Trophic group
Orthosia gothica (L., 1758)	0.0	0.0	1.3	0.0	5,6	G
Orthosia incerta (Hufnagel, 1776)	5.1	0.0	0.6	1.7	5,6	G
▶ *Pseudoips prasinanus* (L., 1758)	2.6	1.0	0.0	0.0	7,9	G
Total number of individuals	39	98	155	115		

Key: ▶ – common oak species in Slovakia; ! – pest; !! – calamitous pest; HH – Horný háj; LL – Lošonec-lom; NA – Naháč-Kukovačník; NK2 – Naháč-Katarínka 2; MO – months of occurrence: 4 – April, 5 – May, 6 – June, 7 – July, 8 – August, 9 – September; S2 – narrow oligophages; S3 – wider oligophages; G – generalists.

by *Quercus dalechampii* Ten., *Q. cerris* L. and *Carpinus betulus* L. belonging to the subassociation *Querco-Carpinetum melicetosum uniflorae.* It represents a young growth forming a little wood island among the cultivated land. The age of the growth has been estimated to be about 40–60 years.

Study plot Naháč-Katarínka (NK) between Naháč and Dobrá Voda villages (48°33′ N, 17°32′ E) (altitude 320 m a.s.l.) is covered by *Quercus virgiliana* (Ten.) Ten., *Q. cerris* L., *Tilia cordata* Mill. and *Acer campestre* L. belonging to the association *Lithospermo-Quercetum virgilianae.* It is an old forest growth below the monastery ruin. The age of the growth has been estimated to be about 80–100 years.

Methods

During the growing season (April–October) of 2000–2002, lepidopteran larvae were taken from oak trees on the four selected plots at about two-week intervals using the beating method. The beating apparatus was 1 × 1 m. As a standard, 25 beats were performed in each study area (one sample represented 25 beats).

The larvae were identified using the keys by Gerasimov (1952), Patočka (1954, 1980) and Patočka et al. (1999).

The cluster analysis of communities was performed using the computer program NCLAS (Podani, 1993). The clustering method complete linkage in combination with Sörensen's index and Wishart's similarity ratio was used (Wishart, 1969).

Species communities were compared using Detrended Correspondence Analysis (DCA) as an indirect gradient method (Ter Braak & Šmilauer, 1998). Diversity of communities was characterised using the Pielou's index of equitability (e), Shannon-Wiener's index of total species diversity (H') and Simpson's index of dominance (c) (Ludwig & Reynolds, 1988; Poole, 1974).

The nomenclature and systematic classification of the lepidopteran species were used according to Laštůvka (1998). Species classified as pests and calamitous pests and common oak species are in accordance with Patočka et al. (1999). The trophic groups of caterpillars were established according to Brown & Hyman (1986). Three basic groups were distinguished: S2 – narrow oligophages (caterpillars living only on trees of the genus *Quercus*), S3 – wider oligophages (caterpillars feeding on two or more genera from one plant family or taxonomically related families – Fagaceae: *Quercus, Fagus, Castanea*) and G – generalists or polyphagous species (caterpillars living on several plant species from many families).

Table 2. Family dominance (%) of lepidopteran larvae on European Turkey Oak (*Q. cerris*) in the Malé Karpaty Mts in 2000–2002 (based on total number of individuals).

Family/Year	2000	2001	2002	2000–2002
Bucculatricidae	0.00	0.00	0.94	0.25
Ypsolophidae	12.50	17.20	1.89	10.81
Oecophoridae	1.44	0.00	0.00	0.74
Coleophoridae	4.33	9.68	4.72	5.65
Gelechiidae	0.48	2.15	0.00	0.74
Tortricidae	12.02	2.15	2.83	7.37
Pyralidae	10.58	1.08	1.89	6.14
Drepanidae	3.37	2.15	2.83	2.95
Geometridae	21.63	36.56	50.00	32.43
Notodontidae	0.96	3.23	5.66	2.70
Lymantriidae	11.06	6.45	8.49	9.34
Noctuidae	21.63	19.35	20.75	20.88
Total number of individuals	208	93	106	407

Results and discussion

During 2000–2002, a total of 407 caterpillars were collected at four study plots with European turkey oak (*Quercus cerris*). They represented 58 species belonging to 12 families (Tab. 1). The most abundant families were Geometridae and Noctuidae (Tabs 1, 2). A very low abundance was found in species belonging to the families Bucculatricidae, Oecophoridae and Gelechiidae (not typical families for oaks and not typical leaf consumers). The families Geometridae, Noctuidae and Tortricidae encompassed the highest number of species found (17, 14, and 6 species, respectively). The family Geometridae comprised the highest number of pests (Tab. 1). This family predominated in 2002 (Tab. 2). The highest number of individuals was recorded in 2000 which can be attributed mainly to the families Noctuidae, Tortricidae, Pyralidae and Lymantriidae (Tab. 2).

The complete linkage clustering based on binary data (Sörensen's index) and abundance similarity (Wishart's similarity ratio) showed that lepidopteran larvae communities formed a separate group on the study plots Naháč-Katarínka, Lošonec-lom and Naháč-Kukovačník over the three years (Fig. 1). Lepidopteran communities on the plot Horný háj were markedly poorer in number of species in comparison to the other

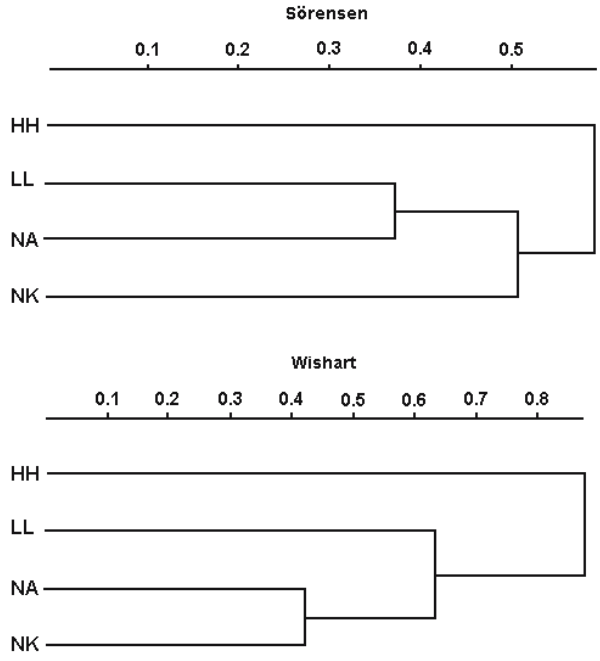

Fig. 1. Classification of lepidopteran communities on individual study plots according to species presence/absence (Sörensen's index) and abundance similarity (Wishart's index) (horizontal axis – dissimilarity scale).

Table 3. Species diversity test (POOLE, 1974) and basic coenological characteristics of lepidopteran taxocoenoses on four study plots in 2000–2002.

Study plots	Value	HH	LL	NA	NK
	e	0.787	0.863	0.865	0.877
	c	0.178	0.072	0.063	0.074
	H'	2.230	2.991	3.075	2.952
HH	2.230	**0.000**	62.059	51.611	56.002
LL	2.991	3.418***	**0.000**	197.229	202.080
NA	3.075	3.999***	0.647 *ns*	**0.000**	247.857
NK	2.952	3.343**	0.281 *ns*	1.037 *ns*	**0.000**

Key: *e* – Pielou's index of eveness; *c* – Simpson's index of dominance; H' – Shannon-Wiener's index of species diversity. Significance levels: *** $P < 0.001$; ** $0.001 < P < 0.01$; * $0.01 < P < 0.05$; *ns* (non-significant). Study plots: HH – Horný háj; LL – Lošonec-lom; NA – Naháč-Kukovačník; NK – Naháč-Katarínka 2.

plots. Generally, caterpillars were poorly represented at Horný háj due to the presence of multiform ants, which are predators of lepidopteran larvae concentrated on this plot (Tab. 1). Only 17 species of Lepidoptera were present here, of which *Lymantria dispar* and *Ypsolopha alpella* were the most numerous species (Tab. 1). The most abundant species were the gypsy moth (*Lymantria dispar*) at Horný háj, an important pest of oak, the winter moth (*Operophtera brumata*) at Lošonec-lom, another important oak pest, the small ermine moth (*Ypsolopha alpella*) at Naháč-Kukovačník and Jersey Mocha (*Cyclophora ruficiliaria*) at Naháč – Katarínka (Tab. 1). A notable oak pest of Slovakia according to PATOČKA et al. (1999), the green oak roller moth (*Tortrix viridana*) was not found in the study sites at all due to population depression. In neighbouring Hungary, only 47 lepidopteran species were found on *Q. cerris* (CSÓKA, 1998b). The gypsy moth appeared to prefer *Q. cerris* stands in Hungary (CSÓKA, 1998a).

In general, when compared with other territories of Slovakia, the observed abundance of caterpillars corresponded to the latent phase of the gradation cycle (cf. PATOČKA et al., 1962; KULFAN, M., 1990, 1998, 2002; KULFAN, M. et al., 1997; KULFAN, J., 1992).

The vast majority of Lepidoptera are monovoltine species with their main occurrence in the spring. Only *Cyclophora ruficiliariai,* a typical representative of oak woods occurred as a bivoltine species (June–September). The bivoltine species *Bucculatrix ulmella* was observed only as a second generation in August (Tab. 1).

Most recorded species belonged to the trophic group of generalists (39 species). Only four species were wider oligophages, of them *Diloba caeruleocephala*, a typical representative on Rosaceae plants probably arrived accidentally on *Q. cerris* from neighbouring *Crataegus* shrubs. Other lepidopteran species (15 species) – narrow oligophages – feed on oaks and are considered to be typical oak species (Tab. 1).

On the basis of values of Shannon-Wiener's diversity and Pielou's equitability (evenness) there were marked differences between Horný háj and the other study plots (Tab. 3). Horný háj was distinguished by the low number of individuals and species (Tab. 1). Lepidopteran larvae communities at Naháč-Kukovačník (a young isolated wood island within the cultivated land) had the highest diversity during the whole research period (Tab. 3). The values of diversity were also associated with the equitability of larvae communities. The value of equitability was highest at Naháč-Katarínka which represented older forest growth (advanced succession). The lowest equitability value of lepidopteran larvae was also found at Horný háj during the whole research period (Tab. 3).

When comparing to *Q. cerris* near Zvolen (C Slovakia), the biological diversity of lepidopteran species on *Q. cerris* in the Malé Karpaty Mts was greater on three of four plots (cf. KULFAN, J., 1992).

The distribution of the study plots and species of lepidopteran caterpillars in the space of the first two axes of detrended correspondence analysis (DCA) is shown in Fig. 2. The groups of species were determined on the basis of the dendrogram of similarity resulting from the position of species in the ordination space of the first four DCA axes.

The majority of species preferring oaks and located along axis 1 (from the point of intersection to the right) were associated not only with old canopied growths (above the axis) but also with isolated young growth (under the axis) (Fig. 2). The majority of polyphagous species were located along axis 2. The main ecologi-

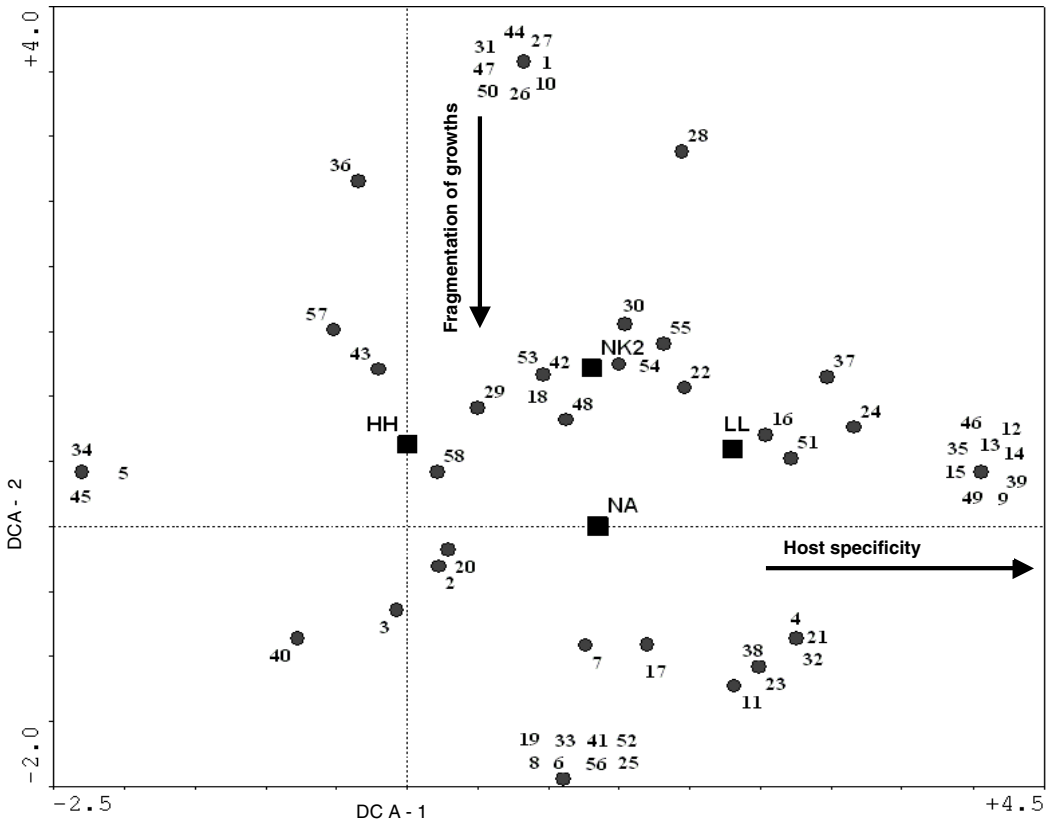

Fig. 2. DCA ordination diagram of the study plots and lepidopteran species score.
Key: 1 – *B. ulmella*, 2 – *Y. alpella*, 3 – *Y. ustella*, 4 – *C. quercana*, 5 – *D. lipsiella*, 6 – *C. ibipennella*, 7 – *C. lutipennela*, 8 – *A. timidella*, 9 – *P. gibbosella*, 10 – *S. gemmella*, 11 – *A. loeflingiana*, 12 – *A. crateaganus*, 13 – *P. cerasana*, 14 – *P. heparana*, 15 – *P. lecheanum*, 16 – *T. alternella*, 17 – *C. tumidana*, 18 – *P. roborella*, 19 – *C. diluta*, 20 – *P. ridens*, 21 – *A. aurantiaria*, 22 – *A. leucophaearia*, 23 – *A. marginaria*, 24 – *A. aceraria*, 25 – *A. aescularia*, 26 – *B. betularia*, 27 – *B. strataria*, 28 – *C. margaritata*, 29 – *C. pennaria*, 30 – *C. ruficiliaria*, 31 – *E. crepuscularia*, 32 – *E. dilutata*, 33 – *E. abbreviata*, 34 – *H. punctinalis*, 35 – *H. roboraria*, 36 – *L. hirtaria*, 37 – *O. brumata*, 38 – *D. querna*, 39 – *H. milhauseri*, 40 – *P. bucephala*, 41 – *S. argentina*, 42 – *T. processionea*, 43 – *L. dispar*, 44 – *O. antiqua*, 45 – *A. psi*, 46 – *A. pyramidea*, 47 – *B. bicolorana*, 48 – *C. trapezina*, 49 – *D. convergens*, 50 – *D. caeruleocephala*, 51 – *D. monochroma*, 52 – *E. transversa*, 53 – *L. ornitopus*, 54 – *O. cerasi*, 55 – *O. cruda*, 56 – *O. gothica*, 57 – *O. incerta*, 58 – *P. prasinanus.*
Eigenvalues of the two first canonical axes are $\lambda_1 = 0.308$, $\lambda_2 = 0.114$. The first two canonical axes account for 61.2% of the total variance of the species data.

cal gradient along DCA-1 related to the host specificity of caterpillars and consisted of three groups: (a) polyphagous species (*Diurnea lipsiella*, *Hypomecis punctinalis, Acronicta psi, Lymantria dispar, Orthosia incerta, Colotois pennaria*); (b) specialised species feeding chiefly on oaks or exclusively on oaks (*Pseudoips prasinanus, Lithophane ornitopus, Thaumetopoea processionea, Phicita roborella, Cyclophora ruficiliaria, Orthosia cruda, Tortricodes alternella, Agriopis leucophaearia*) and (c) species preferring some oak species, mainly *Q. cerris* (*Ypsolopha alpella, Polyploca ridens, Conobathra tumidana, Drymonia querna*). Species in the first group were associated with insular forest (plot HH), species of the second group with two old canopied growths (plots NK and LL) and species of the third group with isolated young oak growth (plot NA). The fragmentation of growths was identified along axis 2 (Fig. 2). Species preferring *Q. cerris* were located on the bottom part of axis 2 and were associated with insular young growth in contrast to the species located on the upper part of axis 2 (old canopied growths) (Fig. 2).

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