Acta Zoologica Academiae Scientiarum Hungaricae 53 (3), pp. 257–269, 2007

LONG-TERM LIGHT TRAP STUDY ON THE MACRO-MOTH (LEPIDOPTERA: MACROHETEROCERA) FAUNA OF THE AGGTELEK NATIONAL PARK

S. SZABÓ[1], E. ÁRNYAS[1], B. TÓTHMÉRÉSZ[2] and Z. VARGA[1]

[1]*Department of Evolutionary Zoology and Human Biology, University of Debrecen H-4032 Debrecen, Egyetem tér 1, Hungary; E-mail: arnyaser@delfin.klte.hu*
[2]*Department of Ecology, University of Debrecen, H-4032 Debrecen, Egyetem tér 1, Hungary E-mail: tothmerb@delfin.klte.hu*

We analyzed the night-active Macrolepidoptera fauna in the Aggtelek karst region (near the village Jósvafő) by Jermy-type light-trap in 1990, 1993 and during 1999–2004. In each year the trap operated from 5 March until 5 November. During the eight years altogether 127 929 specimens were collected belonging to 594 species, which is about 60% of the Hungarian fauna. 216 species occurred in each year. Noctuidae and Geometridae were most rich in species and most abundant. Arctiidae, Lasiocampidae, Notodontidae and Sphingidae were also represented in a considerable proportion. The analysis of the flight activity curves shows two summer peaks and also a smaller spring and an autumn peak. The faunal type composition of the species and their abundance, respectively, was the following: Transpalearctic (48.15%, 55.68%), Boreo Continental (18.86, 8.16%), South Continental (2.02%, 0.67%), West Palaearctic (28.96%, 35.14%), Xeromontane (1.01%, 0.05%) and Extrapalaearctic (1.01%, 0.31%). The eco-faunal components: euryoecious (11.62%, 20.03%), silvicolous (17.34%, 20.12%), nemoral (8.08%, 9.86%), quercetal (12.46%, 12.66%), helophilous (5.56%, 1.85%), boreomontane (1.18%, 1.12%), altoherbosa (5.22%, 3.49%), meso-hygrophilous (6.73%, 6.26%), steppic (10.44%, 7.17%), lichenophagous (2.02%, 14.13%), other (19.36%, 3.32%).

Key words: Aggtelek National Park, Macrolepidoptera faunistics, seasonal and yearly fluctuations, weather elements, faunal types and elements, eco-faunal composition

INTRODUCTION

Night-active Macrolepidoptera fauna has been studied for more than 40 years in the Aggtelek karst region. Systematic lepidopterological collectings started in 1958 (VARGA 1961, 1963, GYULAI *et al*. 1974, 1979), whereas light trap surveys in the Tohonya-valley (near Jósvafő) have been carried out since 1970 (VARGA 1999, VARGA & GYULAI 1978, VARGA & SZABÓ 1997, ÁRNYAS *et al*. 2005). During the investigated years (1990, 1993, 1999–2004) we studied the composition of the traditional Macrolepidoptera in terms of the abundance ratio of certain species and we analysed the light-active nocturnal lepidoptera assemblage in relation to the geographical distribution and habitat connections of species. We also investigated the variations in species-composition and diversity patterns during the eight years and we have compared these data with the climatic data collected at the research station. Our main aim was to study the seasonal fluctuations and multi-year changes in terms of the biogeographical composition and habitat connections.

MATERIAL AND METHODS

The light trap was operated at the southern slope of the Tohonya-valley in the Aggtelek karst region, NE Hungary. The site is located about 1 km from Jósvafő village towards the north (48°05'N 20°46'E, 230 m). Due to the allocation of the light trap (Papp Ferenc Karst Research Station) providing overlook on a large territory, lepidoptera species of various habitats have been collected.

The landscape is varied with several forests (60%), non-forest plant communities (30%) and large cultivated areas (10%) (UJVÁROSY 1998, VARGA *et al*. 1998). The typical vegetation of higher hilltops and northern hillsides is the oak-hornbeam forest (*Querco petraeae-Carpinetum*). The most extended communities of southern slopes are the xerothermic oak forests (*Corno-Quercetum*). Submontane beech forests (*Melico-Fagetum*), sub-Carpathian ravine-forests (*Phyllitidi-Aceretum subcarpathicum*) and linden-ash forests of rupicolous screes (*Tilio-Fraxinetum*) cover only restricted areas. On southern slopes, the light-penetrated white oak scrub forests (*Ceraso-Quercetum pubescentis*) are extensive, which alternate with patches of Pannonian semi-dry meadows (*Cirsio pannonicae-Brachypodion*), steppic and rupicolous grasslands (*Festucion valesiacae, Festucion pallentis*). Alder gallery forests and hygrophilous tall forb associations grow along streams (VARGA 1997, VARGA-SIPOS & VARGA 1997).

Jermy-type light trap was operated on the Tohonya ridge on everyday basis (RONKAY 1997, SOUTHWOOD & HENDERSON 2000, NOWINSZKY 2003). The trap was set up 10 meters from the research station, and it was operated with a twilight switch. Lepidoptera were collected from early evening hours until the radical decrease of their flight at dawn. In the investigated years we used the data collected from 5 March to 5 November, i.e. 246 days in each year. The light trap was powered by a mercury vapour bulb of 125 W and the collections were stored daily for later processing. The captured material was generally in a good quality, and all the specimens were identified (except for *Eupithecia* species). The categorisation of faunal elements and components given by VARGA *et al*. (2005) was followed. The data base was compiled to show the quantity of species caught in the light trap in relation to the values of meteorological factors on the given days. We analysed the species-constancy curve of the study period (BALOGH 1958); in a species constancy curve the occurrence the number of species is plotted against the number of years when the species was caught. The climatological data series (daily average temperature and rainfall) were provided by the meteorological station (No: 52813) at the same research station (about 50 m from the light trap).

The R program package was used during the statistical calculations (IHAKA & GENTLEMAN 1996). In the analysis of flight curves, we pooled the collections on every second day, and we smoothed the curves with robust weighted regression and smoothing scatterplots (CLEVELAND 1979). The scatter of the caught individuals is demonstrated by box diagrams, where counting was based on 5 data items.

On the basis of the Hungarian Macrolepidoptera checklist (VARGA *et al*. 2005) we compared the composition of the local fauna with the Hungarian fauna regarding the proportions of faunal types, faunal elements and faunal components.

RESULTS

During the 8 years we collected 127 929 specimens of Macrolepidoptera (Table 1). The total number of species was 594; 216 out of them occurred each studied year, whereas 58 species were collected in only a single year (Fig. 1). During the studied 8 years we detected the occurrence of about 60% of the Hungarian fauna which demonstrates the extraordinary richness of moth species in a restricted area.

The highest species richness and number of individuals were found in 2003, when 22571 individuals of 441 species were collected. The annual precipitation was 475.7 mm in 2003, which was about 130 mm less than the mean annual precipitation measured in the study area (606.5 mm). Arid weather conditions were favourable for the abundance of gradational species of broadleaved forests, e.g. *Operophthera brumata* (LINNAEUS, 1758), *Thaumetopoea processionea* (LINNAEUS, 1758), *Agrochola macilenta* (HÜBNER, 1809). The analysis of the findings indicated that the year of 2004, despite the relatively low species numbers of assemblages, showed a great abundance of specimens (Table 1). This year represented a peak of specimen numbers in some Geometridae and Noctuidae species: *Agriopis leucophaearia* ([DENIS & SCHIFFERMÜLLER], 1775) (1714 specimens), *Agriopis marginaria* (FABRICIUS, 1776) (1713 specimens), *Alsophila aescularia* ([DENIS & SCHIFFERMÜLLER], 1775) (2245 specimens), *Apocheima hispidarium* ([DENIS & SCHIFFERMÜLLER], 1775) (1872 specimens), *Orthosia cruda* ([DENIS & SCHIFFERMÜLLER], 1775) (2593 specimens). All these species are also typical for broadleaved forests. Concerning the average temperature of January, 2003 and 2004 were the coldest years (2003: –3.43 °C, 2004: –2.27 °C). The distribution of precipitation was even during these years; its quantity was close to the typical average (2003: 75.2 mm, 2004: 90.9 mm). In 1989–2004, the study on monthly precipita-

Table 1. Characteristics of the trapped assemblages and a few environmental variables. Number of species (S); trapped specimens (N) annual mean temperature (A), the mean temperature of winter months (B) (°C), total annual (C) and winter precipitation (D) (mm)

Year	S	N	A	B	C	D
1990	391	12502	9.4	0.03	647.4	68.9
1993	465	12573	8.8	–2.13	487.1	39.9
1999	409	15125	9.1	–2.77	714.4	69.9
2000	366	12837	9.8	–1.93	600.1	93.9
2001	372	12264	8.9	0.17	599.4	144.8
2002	429	18599	9.7	–1.60	586.0	29.8
2003	441	22571	9.0	–3.43	475.7	75.2
2004	390	21458	8.5	–2.27	680.9	90.9

tion showed that the most arid summer periods were the summers in 1992–1994. The quantity of summer precipitation was as follows: 1992: 127 mm, and 1993: 158 mm, 1994: 137 mm. The above quantities were about 100 mm less than the summer precipitation average measured in the study area (228.1 mm). Considering the capture data, 1993 was a rather poor year regarding the collected specimens (12573 specimens); however, the number of collected species reached its record number (465 species). Several rare xeromontane species of steppic and rupicolous grasslands were collected during this year, e.g.: *Gnophos furvatus* ([DENIS & SCHIFFERMÜLLER], 1775), *Rhyacia latens* (HÜBNER, 1809), *Chersotis margaritacea* (DE VILLERS, 1789), *Ch. multangula* (HÜBNER, 1803), *Chersotis rectangula* ([DENIS & SCHIFFERMÜLLER], 1775), *Dichagyris forcipula* ([DENIS & SCHIFFERMÜLLER], 1775), *Dichagyris nigrescens* (HÖFNER, 1888).

In most of the studied years analyses on annual flight curves based on individual and species numbers showed a smaller spring peak and an autumn peak as well as two summer peaks (Fig. 2). The individual numbers of the summer peaks considerably exceeded that of the spring and autumn values. The difference between the summer peaks was sometimes smaller, and resulted in a wide-range "plateau-like" maximum. The peak in spring was at the end of March or the very beginning of April; the two summer peaks manifested at the end of May and in early July, whereas the autumn peak was in early September.

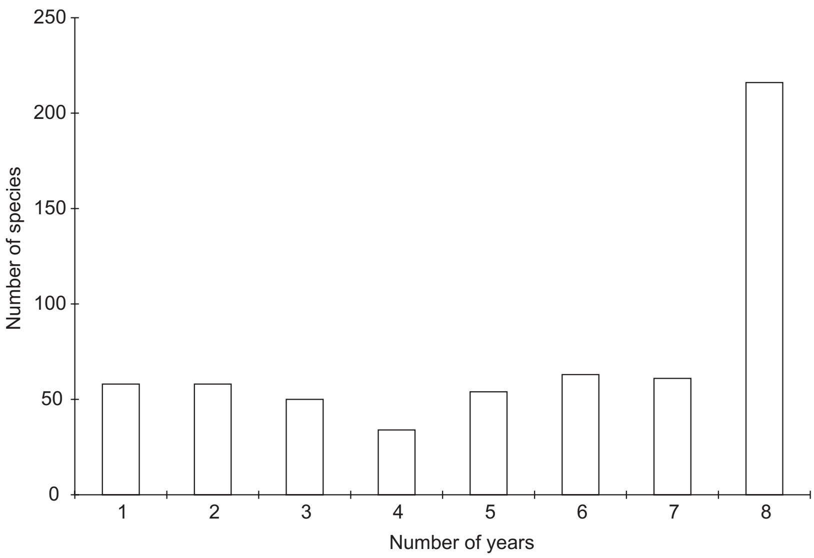

Fig. 1. Species constancy of the macro-moth's (Lepidoptera: Macroheterocera) at the Aggtelek National Park based on a light trap operated at the southern slope of the Tohonya-valley. The graph shows the number of those species, which were caught in a given number of years

Table 2. Distribution of Lepidoptera families during 8 years of light trapping in NE Hungary and their minimum and maximum values. The year when the minimum or maximum achieved is indicated in parenthesis after the minimum or maximum value on the basis of min.-max. Notations: S_{HU} – number of species in the Hungarian nocturnal Macrolepidoptera fauna; S_{TM} – number of species in the trapped material; N_{TM} – number of specimens in the trapped material

	Total			Minimum		Maximum	
	S_{HU}	S_{TM}	N_{TM}	S_{TM}	N_{TM}	S_{TM}	N_{TM}
Geometridae	326	183	37135	110 (1990)	2395 (2001)	133 (2003)	10586 (2004)
Noctuidae	512	288	55451	170 (2000)	5688 (2000)	240 (1993)	9635 (2003)
Nolidae	10	6	162	0 (1990)	0 (1990)	3 (2002)	45 (2000)
Sphingidae	18	11	2342	7 (1990)	175 (2004)	11 (2002)	390 (2001)
Arctiidae	50	28	23351	18 (2001)	1850 (2001)	25 (2002)	5880 (2002)
Ctenuchidae	1	1	492	1	26 (1999)	1	105 (2002)
Lasiocampidae	18	15	3761	9 (2001)	213 (1990)	14 (2002)	1089 (2003)
Notodontidae	35	31	2201	16 (2000)	129 (2000)	28 (1990)	569 (2003)
Drepanidae	7	7	993	5 (2000)	36 (2004)	6 (2004)	205 (2003)
Lemoniidae	2	2	238	1 (2001)	9 (2000)	2 (2003)	73 (1990)
Lymantriidae	13	10	1029	7 (2000)	76 (2003)	9 (2002)	285 (2004)
Saturniidae	5	3	68	1 (1990)	1 (1999)	3 (2003)	28 (2003)
Thyatiridae	10	8	704	5 (1990)	29 (2001)	7 (2000)	184 (2003)
Endromididae	1	1	2	0 (1999)	0 (1999)	1 (2003)	1 (2003)

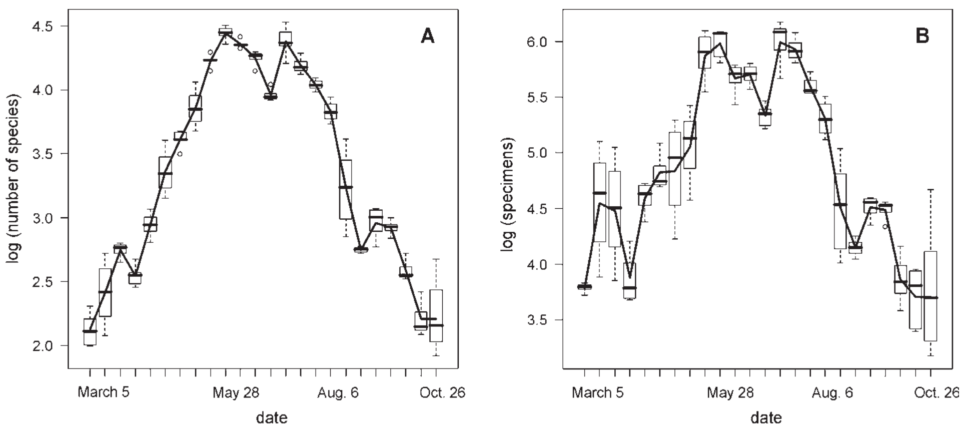

Fig. 2. Activity curves. (A) Changes of the number of species, and (B) specimens in 2003. Catches were summed up on every second day, and box diagrams were based on 5 data items. The curves were smoothed by the lowess method

The family spectrum of species collected by the light trap is presented in Table 2. Noctuidae and Geometridae are represented with the highest numbers of species and specimens, but the species of Arctiidae, Lasiocampidae, Notodontidae and Sphingidae showed a significant proportion as well. During the 8 years merely a few specimens of *Endromis versicolora* (LINNAEUS, 1758), *Aglia tau* (LINNAEUS, 1758), *Saturnia pyri* ([DENIS & SCHIFFERMÜLLER], 1775) and *Lemonia dumi* (LINNAEUS, 1758) were captured though they are colourful components of the moth assemblages.

The other aspect of the high species diversity is the occurrence of several faunal types. Their composition showed that 48.15% of the collected species were Transpalearctic (286 species, 55.68% of individuals), 18.86% Boreo-continental "Siberian" (112 species, 8.16% of individuals), 2.02% Southern Continental (12 species, 0.27% of individuals), 28.96% West Palaearctic (172 species, 35.14% of individuals), 1.01% Xeromontane (6 species, 0.05% of individuals) and 1.01% Extrapalaearctic (6 species, 0.31% of individuals).

From the West Palearctic faunal type, the Holo-Mediterranean species (23.06%, 137 species) represented nearly one-fourth of the faunal elements in the study material. Some species of this group have a restricted distribution in the country with a northernmost boundary of distribution in this region, e.g. *Catocala nymphagoga* (ESPER, 1787), *Ennomos quercarius* (HÜBNER, 1813), *Peribatodes umbrarius* (HÜBNER, 1809), *Polyphaenis sericata* (ESPER, 1787). The Ponto-Mediterranean faunal elements were represented by 30 species (5.05%). Several species of this group reach here a northern boundary of distribution, as well, e.g. *Phalera bucephaloides* (OCHSENHEIMER, 1810), *Ocneria rubea* ([DENIS & SCHIFFERMÜLLER], 1775), *Dichonia convergens* ([DENIS & SCHIFFERMÜLLER], 1775), *Dioszeghyana schmidtii* (DIÓSZEGHY, 1935). They occurred evenly at low specimen numbers. Only two Atlanto-Mediterranean species (0.34%) occurred during the study period, *Aplocera efformata* (GUENÉE, 1857) and *Eulithis mellinata* (FABRICIUS, 1787). *E. mellinata* was caught in the trap only once in June 1999, whereas *A. efformata* was scarce but occurred each year (except for 2000). The ratio of Extra-Mediterranean-European species was 0.93%. *Operophtera fagata* (SCHARFENBERG, 1805) and *Watsonalla cultraria* (FABRICIUS, 1775) were found regularly with 15–20 specimens annually, while *Xestia xanthographa* ([DENIS & SCHIFFERMÜLLER], 1775) highly fluctuated during the years (more than 70 specimens were registered in 1990 and 2003).

Concerning the eco-faunal components, the proportion of nemoral species (mesic/humid forest) reached nearly 10% (8.08%, 48 species, 9.86% of individuals). Some relatively rare species, e.g. *Colostygia olivata* ([DENIS & SCHIFFERMÜLLER], 1775), *Euphyia unangulata* (HAWORTH, 1809), *Amphipyra perflua*

(FABRICIUS, 1787), *Notodonta torva* (HÜBNER, 1800) occurred at low numbers. In recent years *Epirrita diluta* ([DENIS & SCHIFFERMÜLLER], 1775), *Cosmia pyralina* ([DENIS & SCHIFFERMÜLLER], 1775) and *Sabra harpagula* (ESPER, 1786) represented a more considerable proportion of the assemblage. Silvicolous species have occurred in 17.34% (103 species, 20.12% of individuals). They mostly consisted of widespread and common Euro-Siberian species, such as *Lycia hirtaria* (CLERCK, 1759), *Lymantria dispar* (LINNAEUS, 1758), *Cosmia trapezina* (LINNAEUS, 1767), *Eupsilia transversa* (HUFNAGEL, 1766), *Orthosia gothica* (LINNAEUS, 1758).

Characteristic species in the karst region were the quercetal species feeding on oak, with the proportion of 11.78%. Up to 70 species (12.66% of the individuals) of them were captured by the light trap. The following species were the most abundant: *Orthosia cerasi* (FABRICIUS, 1775), *Orthosia cruda* ([DENIS & SCHIFFERMÜLLER], 1775), *Eriogaster rimicola* ([DENIS & SCHIFFERMÜLLER], 1775), *Egira conspicillaris* (LINNAEUS, 1758), *Hoplodrina respersa* ([DENIS & SCHIFFERMÜLLER], 1775), *Thaumetopoea processionea* (LINNAEUS, 1758). From the components of sub-Mediterranean white oak forests 8 species (1.35%) were collected at low numbers (0.09% of individuals), e.g. *Asphalia ruficollis* ([DENIS & SCHIFFERMÜLLER], 1775), *Cyclophora suppunctaria* (ZELLER, 1847), *Ennomos quercarius* (HÜBNER, 1813), *Phalera bucephaloides* (OCHSENHEIMER, 1810), *Ocneria rubea* ([DENIS & SCHIFFERMÜLLER], 1775) and *Dryobotodes monochroma* (ESPER, 1790). The species characteristic to the xerothermic steppic slopes (62 species, 10.44%, 7.17% of individuals) were often abundant in the region, e.g. *Semiothisa glarearia* ([DENIS & SCHIFFERMÜLLER], 1775), S*cotopteryx bipunctaria* ([DENIS & SCHIFFERMÜLLER], 1775), *Idaea aureolaria* ([DENIS & SCHIFFERMÜLLER], 1775), *Lemonia taraxaci* ([DENIS & SCHIFFERMÜLLER], 1775), *Euxoa aquilina* ([DENIS & SCHIFFERMÜLLER], 1775), *Watsonarctia deserta* (BARTEL, 1902).

The occurrence ratio of marshy forest and marshy meadow species was merged (33 species, 5.56%, 1.85% of individuals) because some species occur both in marshy forests and in marshy meadows. The collected marshy meadow species were represented mostly by a few specimens only, e.g. *Eucarta amethystina* (HÜBNER, 1803), *Eucarta virgo* (TREITSCHKE, 1835), *Hydraecia micacea* (ESPER, 1789), *Simyra albovenosa* (GOEZE, 1781), *Xestia sexstrigata* (HAWORTH, 1809). The latter species was observed only from 2000, due to its recent expansion in the Carpathian Basin. The species of altoherbosa (tall-forb) faunal components (31 species, 5.22%, 3.49% of individuals) belong mainly to the Euro-Siberian and Boreo-continental faunal types, e.g. *Polia bombycina* (HUFNAGEL, 1766), *Lacanobia contigua* ([DENIS & SCHIFFERMÜLLER], 1775) and *Cerapteryx graminis* (LINNAEUS, 1758) which occurred at high individual numbers. The boreo-montane species (7 species, 1.18%, 1.12% of individuals) are mostly restricted to the northern part of the country, e.g. *Phyllodesma ilicifolium* (LINNAEUS, 1758), *Dysstroma truncatum* (HUFNAGEL, 1767), *Cucullia lucifuga* ([DENIS & SCHIFFERMÜLLER], 1775), *Photedes captiuncula delattini* (VARGA, 1970), *Mniotype adusta* (ESPER, 1790), *Eriopygodes imbecilla* (FABRICIUS, 1794), *Chersotis cuprea* ([DENIS & SCHIFFERMÜLLER], 1775).

Lichenophagous species (12 species, 2.02%, 14.13% of individuals) are frequent in the area, e.g. *Laspeyria flexula* ([DENIS & SCHIFFERMÜLLER], 1775), *Cryphia algae* (FABRICIUS, 1775), *Setina irrorella* (CLERCK, 1759), *Cybosia mesomella* (LINNAEUS, 1758), *Eilema* spp. Widely dispersed euryoecious species (69 species, 11.62%, 20.03% of individuals) of the region are e.g. *Amphipyra pyramidea* (LINNAEUS, 1758), *Agrotis exclamationis* (LINNAEUS, 1758), *Peribatodes rhomboidarius* ([DENIS & SCHIFFERMÜLLER], 1775), *Rhodostrophia vibicaria* (CLERCK, 1759), *Laothoe populi* (LINNAEUS, 1758), *Macrothylacia rubi* (LINNAEUS, 1758), *Spilosoma lubricipedum* (LINNAEUS, 1758).

Those faunal components of which the individual number did not amount to 1% (except for the earlier mentioned pubescental species) were the following: poplar-willow feeding 0.95% (42 species), birch-alder feeding 0.08% (15 species), rupicolous grassland 0.11% (12 species), forest-steppe-fringe 0.79% (9 species), coniferous-feeding 0.21% (8 species), migrant 0.80% (8 species), arundiphilous 0.02% (5 species), detritophagous 0.26% (4 species), juniper-feeding 0.01% (2 species), psammophilous 0.002% (1 species), fungivorous 0.004% (1 species).

DISCUSSION

During the studied 8 years we could detect up to 60% of Hungarian fauna from the Tohonya valley, from a rather restricted area with several habitat types. This high species number is clearly the consequence of the rather varied composition of the Macrolepidoptera assemblage both in faunal types and eco-faunal components. The proportions of Mediterranean (s.l.) vs. Boreo-Continental (“Siberian”) elements generally show reverse tendencies in whole Europe (DE LATTIN 1967). This general trend will be slightly modified in the Carpathian basin, especially in the marginal areas of the basin where the overlap of several different biogeographical influences was observed (VARGA 1995, 2003, 2006). Such areas were regarded as biogeographically transitional, e.g. between the Noricum, Illyricum and Pannonicum (the region Őrség), or between the Carpathicum and Pannonicum (as the Aggtelek karst and the northern part of the Zempléni Mts).

VARGA and GYULAI (1978) already pointed out that the evenness of the faunal elements in the local faunas is conspicuously high in some regions of Hungary and it is generally connected with the high number of species. This statement was confirmed by our recent results. The proportion of boreo-continental ("Siberian") and Mediterranean (s.l.) elements also is quite balanced here (18.86% vs. 23.06%). They represent nearly the same proportions of species compared with the Hungarian fauna. 50.45% of the boreo-continental species known from Hungary were observed here in a rather low hilly altitude (230 m), as opposed to the 52.27% representation of West Palearctic species. These balanced proportions can be interpreted as transitional situation between the Pannonicum (with a slight over-representation of Holo- and Ponto-Mediterranean species) and Carpathicum with an unusually high representation of the boreo-continental (incl. boreo-montane) species.

The comparison of species and individual numbers also shows some other conspicuous relations. It is quite trivial that the widely distributed Trans-Palaearctic species are clearly over-represented in individual numbers (55.68% vs. 48.15% of species). The same relation was shown also in euryoecious eco-faunal components (20.03% vs. 11.62%) and in "generalist" silvicolous species (20.12% vs. 17.34%). Over-representation in individual numbers was shown also in West-Palearctic species (35% vs 28.96%). However, it is characteristic that the Boreo-Continental species were observed regularly in low individual numbers, the 8.16% of individuals are related to 18.86% of species!

Considering the eco-faunal components, mostly woodland species were observed, as woods are the dominant habitats of the region. The proportions of the woodland ecofaunal components also show a high evenness. Besides silvicolous (20.12%) and nemoral species (9.86%), the presence of species of xerothermic oak forests (12.66% of quercetal components) and lichenophagous species (14.13%) are also significant.

A significant part of the woodland species were found in mostly large specimen numbers in the years with precipitation deficience. However, it needs further analyses whether it was the consequence of the gradation of some defoliating species or it was simply the consequence of the stronger flight activity by higher summer temperatures of these years. As a result of hot and dry periods in the 1980s and 1990s, some migrant ("Extra-Palearctic") species have occurred increasingly. Oppositely, the moths inhabiting cool-humid habitats have shown a decreasing tendency from the 1980s. A similar tendency can be observed in the case of altoherbosa species, as well, inhabiting marshy meadows and marshy forests (VARGA & SZABÓ 1997). Moths inhabiting steppic and rupicolous habitat types generally occurred in relatively small percentage. Besides some faunistically significant steppic species (see: Results), the presence of xeromontane species was characteristic, as well. Some of these species have a rather limited occurrence in the Carpathian Basin (e.g. *Rhyacia latens, Chersotis fimbriola, Dichagyris musiva, D. nigrescens*). Those faunal components, which did not reach 1%, are mostly constituted by species which were not observed in each year. These were attracted by light poorly since probably their habitats were not in the vicinity of the light trap.

Significant fluctuations were shown in the annual species richness and abundance. The extreme values of total catches were between 12502 (1990) and 22571 (2003) specimens. The latter year was also characterised by a high species number (441). However, in 2004, a rather high individual number (21458) was observed as well, acquainted by a relatively low number of species (390). This year was an extreme gradation year of several defoliating species from which the 5 species mentioned in the Results produced 47.24% of the total capture results of this year. These data suggest that both was the (indirect?) consequence of the drought of the former year. However, the difference between extreme individual numbers of years was during our studies 1.8-fold only. Studies on other light trap stations showed greater differences. LESKÓ *et al*. (2001) reported that this value was more than 8-fold in case of the light trap in Tompa (52000 in 1968 and 6000 specimens in 1994), whereas it proved to be about 8–10-fold in Felsőtárkány (LESKÓ *et al*. 1994, 1998, 1999). These values were presumably influenced by the long term population dynamics of moth species prone to gradation which showed extremely high peaks e.g. during the decade 1961–1970 in the light traps of the forest protection service (VARGA & UHERKOVICH 1974). These extreme fluctuations were probably damped in the karstic area by the more nature-like conditions which is clearly shown e.g. in the rather balanced proportions of the different woodland faunal components. Conspicuously, even the extreme gradation of *Lymantria dispar* which has caused severe damages in nearly the whole Borsod-Abauj-Zemplén county in 2004 and 2005 could not extend into the Aggtelek karst (national park!) area. Here we also have to note that both in the light trap and also by personal observations several light-active ichneumonid wasps (Ophioninae) were regularly observed in large individual number.

Fluctuations in species numbers were found, as well. The greatest difference occurred between 2000 and 2001 (368 spp.) and 1993 (465 spp.). The rate of fluctuations was only 1.2-fold in the studied period, which was clearly lower than the value measured by LESKÓ *et al*. (2001) in the analyses of the light trap catches in Felsőtárkány (350 and 150 spp., rate of fluctuation: 1.6 –fold), but did not reach the more than 3-fold value (460 and 150 spp.) obtained in the analyses of the Várgesztes light trap. The very moderate fluctuations in the generally high species numbers are mostly characterised by a high number of species observed in each year (216 species) which shows a high peak, and also by a rather even proportions of species, captured in 5, 6, 7, etc. years. The same situation was also observed in the accidental species which occurred in 1–3 years only. Therefore, the distribution of the species constancy radically differs from the "classical" U-shaped curve with a high number both of constant-subconstant and accidental species (BALOGH 1958). This change with an evident maximum of constant species can be interpreted as a signal of nature-like conditions in the moth assemblages which was also supported by other quantitative data mentioned above.

Of course, the rate of species and specimen fluctuations are mostly due to climatic fluctuations. Since our data set is continuously growing and it can be compared with reliable data set of meteorological data from the same site, these surveys will be continued in this direction.

*

Acknowledgements – The authors are thankful for Ms ILDIKÓ WANTUCHNÉ-DOBI for the meteorological data and Mr. CSABA BÁRKÁNYI for the cautious handling of the light trap.

REFERENCES

ÁRNYAS, E., SZABÓ, S., TÓTHMÉRÉSZ, B. & VARGA, Z. S. (2005) Light-trap surveys of the Lepidoptera fauna at the Aggtelek National Park. *Folia Entomologica Hungarica* **66**: 196–206.

BALOGH, J. (1958) *Lebensgemeinschaften der Landtiere*. Akademie Verlag Berlin, Budapest, 560 pp.

CLEVELAND, W. S. (1979) Robust locally weighted regression and smoothing scatterplots. *Journal of American Statisticial Association* **74**: 829–836.

GYULAI, I., GYULAI, P., UHERKOVICH, Á. & VARGA, Z. (1979) Újabb adatok a magyarországi nagylepkék elterjedéséhez II. (Lepidoptera). [New data to the knowledge of the distribution of macrolepidoptera in Hungary II.] *Folia Entomologica Hungarica* **32**(2): 219–227.

GYULAI, P., UHERKOVICH, Á. & VARGA, Z. (1974) Újabb adatok a magyarországi nagylepkék elterjedéséhez (Lepidoptera). [Neuere Angaben zur Verbreitung der Gross-Schmetterlinge (Macrolepidoptera) Ungarns.] *Folia Entomologica Hungarica* **27**(2): 75–83.

IHAKA, R. & GENTLEMAN, R. (1996) R: A language for data analysis and graphics. *Journal of Computational and Graphical Statistics* **5**: 299–314.

LATTIN, G. DE (1967) *Grundriss der Zoogeographie*. G. Fischer Verlag, Stuttgart, 602 pp.

LESKÓ, K., SZABÓKY, CS., SZENTKIRÁLYI, F. & KÁDÁR, F. (2001) Az erdészeti fénycsapdahálózat hasznosítása a rovarok hosszú távú monitorozásában: Nagylepke-együttesek változásai Tompa, Felsőtárkány és Szentpéterfölde esetében 1962–2000 között. [Using the forestry light trap network in the long term monitoring: Variations in Macrolepidoptera faunas in the case of Tompa, Felsőtárkány and Szentpéterfölde between 1962 and 2000.] Kutatási jelentés, 44 pp. [In Hungarian]

LESKÓ, K., SZENTKIRÁLYI, F. & KÁDÁR, F. (1994) Gyapjaslepke (Lymantria dispar L.) populációk fluktuációs mintázatai 1963–1993 közötti időszakban Magyarországon. [Fluctuation patterns of gypsy moth (Lymantria dispar L.) populations between 1963 and 1993 in Hungary.] *Erdészeti kutatások* **84**: 163–176. [In Hungarian]

LESKÓ, K., SZENTKIRÁLYI, F. & KÁDÁR, F. (1998) Araszoló lepkefajok fluktuációmintázatának elemzése hosszú távú (1961–1997) magyarországi fénycsapdázási és kártételi idősorokban. [Analysis of fluctuation patterns of geometrid moth species on long-term (1961–1997) time series of Hungarian light trappings and damage estimations.] *Erdészeti kutatások* **88**: 319–333. [In Hungarian]

LESKÓ, K., SZENTKIRÁLYI, F. & KÁDÁR, F. (1999) A kis téli araszoló lepke (Operophthera brumata L.) hosszú távú (1962–1997) populáció fluktuációinak jellemzése az erdészeti fénycsapda-hálózat mintavételei alapján. [Long-term (1962–1997) population-fluctuation characteristics of winter moth (Operophthera brumata L.) based on the samplings of forestry light-trap network.] *Erdészeti kutatások* **89**: 169–182. [In Hungarian]

NOWINSZKY, L. (2003) A fénycsapda mint gyűjtőeszköz. [The light trap as a collecting tool.] Pp. 19–32. *In* NOWINSZKY, L. (ed.): *A fénycsapdázás kézikönyve* [*The handbook of light trapping*.] Savaria University Press, Szombathely. [In Hungarian]

RONKAY, L. (1997) *Nemzeti biodiverzitás-monitorozó rendszer VII. Lepkék*. [National biodiversity monitoring system VII. Lepidoptera.] Magyar Természettudományi Múzeum, Budapest, 71 pp. [In Hungarian]

SOUTHWOOD, T. R. E. & HENDERSON, P. A. (2000) *Ecological Methods*. Blackwell, Oxford, xv + 575 pp.

UJVÁROSY, A. (1998) Földrajzi helyzet, éghajlati viszonyok. [Geographical situation, climatic relations.] Pp. 22–25. *In* BAROSS, G. (ed.): *Az Aggteleki Nemzeti Park*. [*The Aggtelek National Park*.] Mezőgazda Kiadó, Budapest. [In Hungarian]

VARGA, Z. (1961) Állatföldrajzi vizsgálatok az Északborsodi Karszt nagylepke-faunáján. (Zoogeographische Untersuchungen über Macrolepidopteren-Fauna des Nordungarischen Karstgebietes.) *Folia Entomologica Hungarica* **14**: 345–386. [In Hungarian]

VARGA, Z. (1963) Újabb adatok az Északi-Középhegység Macrolepidoptera-faunájához. (Neuere Angaben über die Macrolepidopteren-Fauna des Nordungarischen Mittelgebirges.) *Folia Entomologica Hungarica* **16**: 145–156. [In Hungarian]

VARGA, Z. (1995) Geographical patterns of biodiversity in the Palaearctic and in the Carpathian Basin. *Acta Zoologica Academiae Scientiarum Hungaricae* **41**: 71–92.

VARGA, Z. (1997) Biogeographical outline of the invertebrate fauna of the Aggtelek karst and surrounding areas. Pp. 87–95. *In* TÓTH, E. & HORVÁTH, R. (eds) *Research, Conservation, Management*. Aggtelek National Park Directorate, Aggtelek.

VARGA, Z. (1999) The Lepidoptera of the Aggtelek National Park. Pp. 443–504. *In* MAHUNKA, S. (ed.): *The Fauna of the Aggtelek National Park, II*. Hungarian Natural History Museum, Budapest.

VARGA, Z. (2003) A Kárpát-medence állatföldrajza. [Zoogeography of the Carpathian Basin.] Pp. 89–119. *In* LÁNG, I., BEDŐ, Z. & CSETE, L. (eds): *Növény, állat, élőhely. Magyar Tudománytár III*. [*Plants, animals, habitats. Hungarian Science Repertory III*.] MTA Társadalomkutató Központ, Budapest. [In Hungarian]

VARGA, Z. (2006) A Kárpát-medence faunatörténete és állatföldrajza. [Faunal history and zoogeography of the Carpathian Basin.] Pp. 44–75. *In* FEKETE, G. & VARGA, Z. (eds) *Magyarország tájainak növényzete és állatvilága*. [*The vegetation and fauna of Hungarian landscapes*.] MTA Társadalomkutató Központ, Budapest. [In Hungarian]

VARGA, Z. & GYULAI, I. (1978) Die Faunenelemente-Einteilung der Noctuiden Ungarns und die Verteilung der Faunenelemente in Lokalfaunen. *Acta Biologica Debrecina* **15**: 257–295.

VARGA, Z., RONKAY, L., BÁLINT, ZS., LÁSZLÓ, M. GY. & PEREGOVITS, L. (2005) *Checklist of the Fauna of Hungary Vol. 3. Macrolepidoptera*. Hungarian Natural History Museum, Budapest, 114 pp.

VARGA, Z. & SZABÓ, S. (1997) Changes in species composition and abundance of Lepidoptera in the Aggtelek karst. Pp. 137–142. *In* TÓTH, E. & HORVÁTH, R. (eds): *Research, Conservation, Management*. Aggtelek National Park Directorate, Aggtelek.

VARGA, Z. & UHERKOVICH, Á. (1974) Die Anwendung der Lichtfallen in der ökologischen Landschaftsforschung. *Folia Entomologica Hungarica* **27**: 159–171.

VARGA, Z., VARGA-SIPOS, J., HORVÁTH, R. & TÓTH, E. (1998) Az Aggteleki-karszt élővilága. [The living world of the Aggtelek karst.] Pp. 254–316. *In* BAROSS, G. (ed): *Az Aggteleki Nemzeti Park*. [*The Aggtelek National Park*.] Mezőgazda Kiadó, Budapest. [In Hungarian]

VARGA-Sipos, J. & VARGA, Z. (1997) Phytocenology of semi-dry grasslands in the Aggtelek karst area. Pp. 59–78. *In* TÓTH, E. & HORVÁTH, R. (eds): *Research, Conservation, Management*. Aggtelek National Park Directorate, Aggtelek.

Revised version received May 12, 2006, accepted May 29, 2007, published October 30, 2007