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Diversity of moths communities (Insecta, Lepidoptera) above tree line in Belianske Tatry Mts. (Hlúpy transect), the Western Carpathians

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Abstract. The research is focused on the evaluation of lepidopteran fauna investigated above the tree line in transect Hlúpy hill, which is situated in the central part of the Belianske Tatry Mountains. The investigation was carried out during 2016 and 2017. Light traps were used for trapping. Four to five traps were run simultaneously at different altitudinal gradients during four terms of night trapping. During the field investigation 203 species belonging to 30 families were identified. Many of the species were discovered over night using ultraviolet light. The most numerous test subjects came from the Noctuidae and Geometridae families. In total, 112 (55.72%) species and 2 127 (82.38%) individual moths were captured belonging to these families. A few eurytopic species, mainly *Noctua pronuba*, *Apamea monoglypha* and *Noctua fimbriata* (Noctuidae), were mos common, and significantly raised the proportion of all moth individuals. These three species comprised 46.65% of all individuals collected. The presence of these very abundant species may indicate disturbed habitats following the end of grazing in the 1950-60s.

Key words: Lepidoptera, mountains, alpine zone, subalpine zone, limestone, diversity partitioning

Introduction

The species composition, to a large extent, is due to the character of rock substratum. This can be best seen in the rock swards of the High Tatras, where there are definitely more Lepidoptera species on lime than crystalline substratum (Buszko and Nowacki 2010). In the High Tatras there are two lime areas with remarkable moth communities – the largely inaccessible Červené vrchy in the central Tatras, as well as Belianske Tatry, which is a more suitable area for investigations, due to a location on the edge of Tatras with quick access.

High Tatras National park is one of the best known parks in Slovakia with regard to recent knowledge about moths and butterflies. There is an abundance of research concerns butterflies (Rhopalocera), but few papers deal with each superfamiliy which consist of less known species. While we were focused on all moths except for the well known group, Rhopalocera, we have been trying to assemble scattered studies or only short reports about Belianske Tatry and moths.

In the past, Krampl and Marek (1988) summarized their sightings of the family Geometridae quite thoroughly. The authors mention exact characteristic of all species from this family, including a description of altitudes where specimens were collected. This is important for our assessment of changes which have been occuring over the last 30 years. Many locations that were selected by us, are same as those which have been visited by these authors, though nighttime trapping was not conducted in the same place. Krampl and Marek (1988) conducted their night investigations mostly in the vicinity of Plesnivec – Skalné vráta. This location is similar, but slightly warmer, and about 4 kilometres away from our study area, situated at a lower altitude (1 620 m) equal to that of the easernmost hill at Belianske Tatry.

New knowledge about moth communities in the zone above tree line of the Belianske Tatry range has been put together in our paper. Our results, gained from two years of fieldwork, were compared to those from older studies and unpublished manuscripts from the High Tatras. Our aim is to evaluate changes in species composition in accordance with Krampl and Marek's older study of Geometridae (Krampl and Marek 1988), detect new species in the High Tatras, and an evaluation of the 2016 and 2017 seasons. Comparing should lead to an assessment of how different conditions influence moth communities in alpine habitats.

Material and Methods

Description of the study area

Belianske Tatry constitutes it's own mountain range with a length of 14 km. The highest peaks are Havran (2 152 m), Ždiarska vidla (2 142 m) and Hlúpy (2 061 m). Široké sedlo (1 825 m), in the middle of the range is the lowest peak on this ridge. Nearby, Kopské sedlo (1 750 m) connects this geomorphologic part with the High Tatras. The Zadné Meďodoly valley borders the northeast side of the

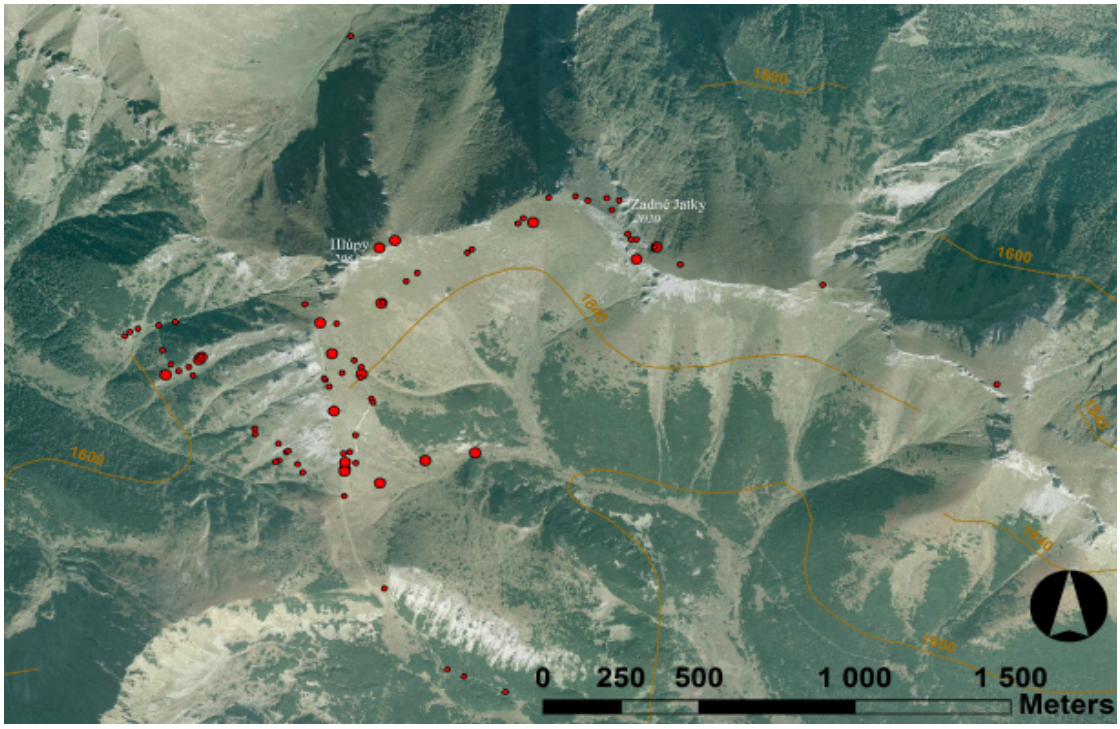

Fig. 1. Study area with 19 sites where the night investigation was realised (bigger dots) and findings of the moths found by netting on evenings, mornings (smaller dots).

mountains and splits Belianske Tatry and the High Tatras. The Predné Meďodoly borders the southwest side. While Belianske Tatry is composed of dolomites and limestone, the High Tatras are mostly formed of granodiorits (Kocian *et al.* 2010).

Predné Meďodoly valley and changes in the landscape structure are described in detail by Boltižiar (2006). A description of the secondary vegetation succession in the Belianske Tatry Mountains three decades after extensive grazing is provided by Hadač (1990).

Our selected study area includes various microhabitats and microclimates with significant altitudinal gradient. It is situated in the middle part of Belianske Tatry (Fig. 1, contain localities Predné Meďodoly, Zadné Meďodoly, Kopské sedlo, Hlúpy, Zadné Jatky, Monkova dolina) with an altitudinal range from 1 600 to 2 061 m. Each sampling site is distinguished by GPS coordinates measured by the Garmin Edge 510. The temperature was measured directly at the study site, (Zadné Jatky, Hlúpy) and other parameters like moisture and wind direction were taken from the Slovak Hydrometeorological Institute (station Tatranská Javorina).

Sampling and processing of moths

In this study, superfamilies were investigated as follows: Hepialoidea, Adeloidea, Gracillarioidea, Yponomeutoidea, Gelechioidea, Pterophoroidea, Choreutoidea, Tortricoidea, Pyraloidea, Lasiocampoidea, Bombycoidea, Geometroidea and Noctuoidea. To collect material in the field bucked light traps were used (UV lights 12V/8W BLB connected by lead-acid batteries 12V/4.5Ah). Chloroform was inserted into the buckets to immobilize the insects and they were transferred to egg cartons for preservation. This method provides almost uniform conditions and results in same time for each sampling site. We worked with 4-5 traps overnight. Because of insufficient time for fast processing material, it was necessary to freeze samples until processing. For exact determination of species, we macerated samples of abdomens in 10% potassium hydroxide and compare genital structures to the literature, using a stereomicroscope and a compound microscope. Afterwards, the preparates were preserved in glycerol filled tubes. The appendix lists which specimens were dissected. Part of the studied material is displayed in the author's private collection or at the Institute of High Mountain Biology Tatranská Javorina unless stated otherwise.

The following literature has been used for the determination of species: Nepticulidae (Laštůvka and Laštůvka 1997; only *Stigmella tatrica* – Tokár *et al.* 2017), Scythridae (Bengtsson 1997), Gelechiidae (Elsner *et al.* 1999; only *Sattleria dzieduszycki* – Povolný 2002), Tortricidae (Razowski 2008; Razowski 2009), Pterophoridae (Nel 2003), Pyralidae and Crambidae (Slamka 2008), Drepanidae, Geometridae (only *Entephria nobiliaria* – Hausmann and Viidalepp 2012), Sphingidae and Notodontidae (Fajčík and Slamka 1996), Noctuidae (Fajčík 1998), resting families with help of an internet source (www.mothdissection.co.uk 2018). With determination of species *Micropterix aureatella*, *Incurvaria vetulella*, *Psychoides verhuella*, *Bijugis bombycella*, *Argyresthia conjugella*, *Elachista argentella*, *E. irenae*, *Biselachista zonulae*, *Coleophora striatipennella*, *Prolita sexpunctella*, *Scrobipalpula diffluella*, lepidopterists Zdenko Tokár; *Phyllonorycter junoniella* Aleš Laštůvka; *Perizoma affinitata*, *Acronicta aceris*, *Noctua janthinana* Marek Dvořák and *Agonopterix astrantiae* Jan Šumpich helped.

Each species collected in the night traps was counted and listed in the matrix chart, and only species observed directly using the entomological net during the evenings or mornings were not included in this quantitative processing (Table 2, Fig. 2, Fig. 3). In Table 2 are included both cases.

Schedule of the field investigations

Altogether, 8 visits in the field were carried out. The samples were collected over a period of two years: July 11, August 20, and September 1 in 2016, and in June 9, July 5, July 19, August 9, and August 15 in 2017. Sampling was conducted twice with the assistance of Zdenko Tokár, and his findings fromJuly 5th 2017 and August 9th 2017 are included in this paper.

11. VII.16 – quite windy during the day, calm and mild, with no wind in the evening, but in the later part of the night, the winds began again.
20. VIII.16 – at noon, sunny. Shortly after noon windier and cloudy. Afternoon to evening, gradually cleared with no wind.
01. IX.16 – afternoon patchy clouds but calm, afternoon to evening calm westerly wind, that stopped after dark though cloud cover increased and it became foggy. The second half of the night, clear but windy.
09. VI.17 – all day patchy cloud - cloudy, silent wind, warm.
05. VII.17 – cooler, windy, patchy cloud – cloudy, but on the peak of the hill and by descending partially silence.
19. VII.17 – afternoon cloudy, in the evening completely clear almost calm, time to time windy over night.
09. VIII.17 – in the morning clear, by rising over the Vyšné Kopské sedlo saddle toward Zadné Jatky created local foggy cloud from the valley. At the peak firstly foggy, letter by descending the fog disintegrated. Warm.
15. VIII.17 – in the evening cloudy, calm, after dark, gradually brightening till completely clear and quite a strong wind and cold over night.

Statistical analysis

For each spot we counted the total number of species (S) and individuals (ni). From the relative abundance of each species, we calculated alfa diversity using Simpson's diversity index which measures the probability that two randomly selected individuals belong to the same species. Formula and ranges of the abundance categories are taken over Losos *et al.* (1984). For other analysis (ANOVA) was used program STATISTICA 8.0 (StatSoft Inc. 2008).

Results

In our field investigation 203 species belonging to 30 families were identified. The majority of species were discovered overnight, using ultraviolet light. Noctuidae and Geometridae, were the most numerous family, and 112 (55.72%) species and 2 127 (82.38%) of all collected moths belonged to these two families (Table 1). The mass occurrence of a few eurytopic species, mainly *Noctua pronuba*, *Apamea monoglypha* and *N. fimbriata* (Noctuidae), significantly raised the proportion of all moth individuals. These three species made up 46.65% of all collected individuals. The presence of these very abundant species may indicate disturbed habitats. All three species develop on different grasses, which are now expanding after the end of extensive grazing (about 1970) by mainly *Calamagrostis cf. varia*. It must be noted that abundance of *A. monoglypha* was approximately 2 times higher, *N. pronuba* 10 times higher, and *N. fimbriata*, 20 times higher on the north side of Zadné Jatky ridge than on the south side; although two comparable study plots were only a few metres apart.

The division of observed species to dominant classes shows an interesting detection. Over 2016, there was the distribution of species with different abundance quite equitable, while in 2017 few very abundant species from eudominant class prevailed. It could also be influenced by one sampling site situated on the north slope, close to ridge Zadné Jatky, with the most spacious radius of ultraviolet light. If we look at species division, there is clear decline in subrecedent class in 2017.

Dominance	species	ni	D
year 2016			
eudominant (> 10%)	*Apamea monoglypha*	260	17.87
	Noctua fimbriata	150	10.31
dominant (5-10%)	*Noctua pronuba*	122	8.39
	Entephria caesiata	118	8.11
	Mesapamea secalis	82	5.64
subdominant (2-5%)	*Dioryctria abietella*	68	4.67
	Eulithis populata	67	4.61
	Udea uliginosalis	48	3.30
	Xestia c-nigrum	35	2.41
	Dasypolia templi	35	2.41
recedent (1-2%)	*Platyptilia sp.*	25	1.72
	Amphipyra berbera	21	1.44
	Triphosa dubitata	19	1.31
	Anaplectoides prasina	17	1.17
	Perizoma minorata	17	1.17
	Xanthorhoe montanata	16	1.10
	Diarsia brunnea	15	1.03
subrecedent (< 1%)	124	290	23.37
year 2017			
eudominant (> 10%)	*Noctua pronuba*	471	41.76
	Udea uliginosalis	156	13.83
	Noctua fimbriata	137	12.15
dominant (5-10%)	*Apamea monoglypha*	65	5.76
subdominant (2-5%)	*Coenotephria salicata*	39	3.46
	Mesotype verberata	39	3.46
	Pharmacis sp.	31	2.75
	Entephria caesiata	25	2.22
recedent (1-2%)	*Mesapamea secalis*	14	1.24
	Triphosa dubitata	14	1.24
	Noctua interposita	12	1.06
subrecedent (< 1%)	53	134	11.08

Tab. 1 The survey of the species according to the scale of classes of dominance, with numbers of the caught individuals (ni) each year and value of dominance.

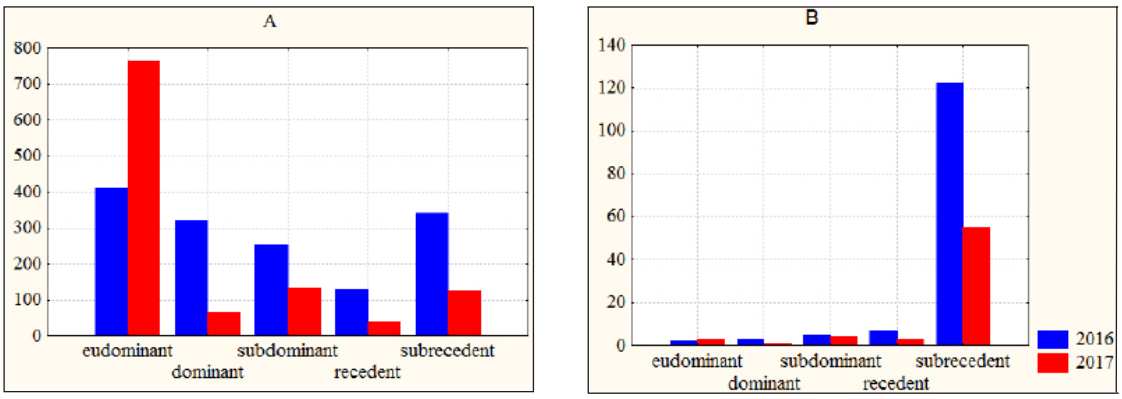

Fig. 2. Number of individuals (A) and species (B) belonging to dominant classes.

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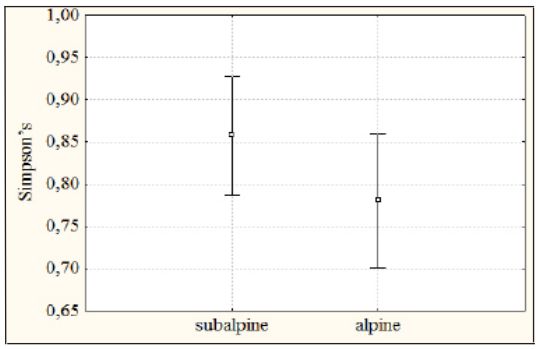

Fig. 3. Mean Simpson's diversity indices (with 95 percent confidence limits) in subalpine and alpine zone (9 and 7 study plots evaluated).

ANOVA analyse shows the differences in Simpson's diversity index (Fig. 3). The lower value of index in alpine zone could also be influenced by infiltration of a few very abundant species from lower altitudes (from the north part).

Description of selected findings

Rare species typical for high altitudes in Tatras

Stigmella tatrica (Tokár, Laštůvka and van Nieukerken, 2017) – Nepticulidae
Material: 1 ex. 9. VIII. 2017, Zadné Jatky

Lampronia splendidella (Heinemann, 1870) – Prodoxidae
Material: 7 ex. 5. VII. 2017, Zadné Jatky
Moths were observed on the ridge and south slope of Zadné Jatky peak and one under the Hlúpy near the saddle directed to Zadné Jatky at the altitude approximately 1 950 m.

Callisto coffeella (Zetterstedt, 1839) – Gracilariidae
Material: 2 ex. 5. VII. 2017, Belianska kopa
Moths netted on the south foot of Belianska kopa over daytime.

Kessleria zimmermanni (Nowicki, 1864) – Yponomeutidae
Material: 1 ex. 20. VII. 2017, Zadné Jatky
Only one moth was netted in the early morning hours on the ridge of Zadné Jatky close to the peak. Endemic species of Tatras.

Coleophora svenssoni Baldizzone, 1985 – Coleophoridae
Material: the caterpillars in cases feeding on *Astragalus frigidus*, 20. VIII. 2016, Zadné Jatky
Boreomontane species occurs, except for Belianske Tatry Mts., only in the Alps and Lapland. The population in Belianske Tatry is the biggest in the Carpathians. Other informations were evaluated by Marek and Krampl (1990).

Sattleria dzieduszyckii (Nowicki, 1864) – Gelechiidae
Material: 1 ex. 19. VII. 2017, Zadné Jatky, UV
Alpine species occuring mainly on granit basis of High and Low Tatras in range 1 700 – 1 900 m. (Tokár *et al.* 1996). Probably not native here, only infiltrated from the neighbouring granite zone.

Epinotia mercuriana (Frölich, 1830) – Tortricidae
Material: 2 ex. 20. VIII. 2016, Zadné Jatky; 19. VII. 2017, Kopské sedlo
On an altitude of around 1 750 metres was recorded already in 19. VII., while on the ridge of the Zadné Jatky was recorded one month later, 20. VIII. At the lower altitudes in subalpine zone, shows low abundance, at the ridges was one of the most abundant species.

Argyroploce noricana (Herrich-Schäffer, 1854) – Tortricidae
Material: 5 ex. 5. VII. 2017, Zadné Jatky
Arctoalpine species. Observed solely on the north slope of Zadné Jatky, with sparse vegetation. The most common moth in arctic tundra (Kullberg *et al.* 2013).

Eupithecia undata (Freyer, 1840) – Geometridae
Material: 1 ex. 11. VII. 2016, Kopské sedlo

One of the most remarkable species. We have discovered only a second individual in Tatras. Very similar to species *E. fennoscandica* occurring on cliffs in Lapland (Mironov 2003).

New species or unexpected species

The species have been compared to manuscripts of Slovak lepidopterists to reveal new species. The new species are signed by (*).

**Phylloporia bistrigella* (Haworth, 1828) – Incurvariidae
Material: 1 ex. 5. VII. 2017, Hlúpy, Tokár leg.
Moth has been found near the path leading under the peak Hlúpy, approximately at the altitude of 1 950 m. A very surprising finding in such high altitude, where the host plant absents. The species is feeding on birches. Third finding in Slovakia.

**Psychoides verhuella* Bruand, 1851 – Tineidae
Material: 1 ex. 19. VII. 2017, Zadné Meďodoly
Ocurring mainly in lower altitudes on limestones where *Asplenium* grows.

**Scrobipalpula diffluella* (Frey, 1870) – Gelechiidae
Material: 1 ex. 11. VII. 2016, Hlúpy, UV; 1 ex. 5. VII. 2017, Hlúpy
The first moth flew to the light trap under Hlúpy – in altitude 1 860 m., the second was found on a similar spot, but approximately 100 metres higher. Third place in Slovakia where the species occurs (Tokár *et al.* 2015).

**Pennithera firmata* (Hübner, 1822) – Geometridae
Material: 1 ex. 11. VII. 2016, Zadné Meďodoly, UV

**Venusia blomeri* (Curtis, 1832) – Geometridae
Material: 1 ex. 11. VII. 2016, Hlúpy, UV
One individual attracted to light. Quite rare species developing on *Ulmus*. The moth had to infiltrate from neighbouring area, where the host plant grows, probably Ždiar.

**Cucullia asteris* (Denis and Schiffermüller, 1775) – Noctuidae
Material: 1 ex. 11. VII. 2016, Predné Meďodoly, UV
Although the species ascends to the mountains, the genus *Cucullia* is more thermophilous.

**Lacanobia aliena* (Hübner, 1809) – Noctuidae
Material: 1 ex. 11. VII. 2016, Predné Meďodoly, UV; 1 ex. 19. VII. 2017, Zadné Meďodoly, UV
*Hadena compta (Denis and Schiffermüller, 1775) – Noctuidae
Material: 1 ex. 11. VII. 2016, Predné Meďodoly, UV

**Mythimna vitellina* (Hübner, 1808) – Noctuidae
Material: 3 ex. 1. IX. 2016, Kopské sedlo, Hlúpy, UV
Migrant from the Mediterranean, more common the last 20 years.

**Noctua interjecta* Hübner, 1803 – Noctuidae
Material: 4 ex. 19. VII. 2017, Zadné Jatky, UV
Moths attracted to light on the ridge of Zadné Jatky. The species is spreading eastwards. So far, the sixth locality of the species in Slovakia.

Catocala sponsa (Linnaeus, 1767) – Noctuidae
Material: 1 ex. 11. VII. 2016, Predné Meďodoly, UV
Very surprising finding in high mountains. The species occurs mainly in warm oak forests.

Amphipyra berbera Rungs, 1949 – Noctuidae
Material: 21 ex. 11. VII. 2016, more localities, UV; 2 ex. 19. VII. 2017, UV

**Chersotis rectangula* (Denis and Schiffermüller, 1775) – Noctuidae
Material: 1 ex. 19. VII. 2017, Zadné Meďodoly, UV
Local and rare species mainly in warm areas.

Expected, but not confirmed species

Scythris oelandicella Müller-Rutz, 1922 – Scythrididae – all our dissected *Scythrids* belonged to species *S. fallacella*

Colostygia austriacaria ssp. *distans* (Krampl and Marek 1991) – Geometridae

Discussion

In the study by Krampl and Marek (1988), species are divided into three categories according to the altitudinal level: A – montane (1 000 – 1 450 m), B – subalpine (1 450 – 1 800 m) and C – alpine (1 800 – 2 000 m). We focused specifically on the subalpine and alpine zone, but our range of altitudes was slightly different: subalpine (1 550 – 1 850 m) and alpine level (1 850 – 2 000 m). In addition, our data were transformed for the purpose of comparison. Also worth noting is that the most significant stenotopic species from the Geometridae family are often heliophilous at high altitudes and these species are not possible to find at night. This means that great portion of Geometridae stenotopic species in our study area might be compared.

Krampl and Marek (1988) collected 139 Geometrids from their entire study site in Belianske Tatry. At an altitude of above 1 450 m, 71 species were confirmed (69 from subalpine and 14 from alpine zone). Our investigation (Table 2) revealed 41 Geometrids

2016 – 2017 \ 1982 – 1985	5	4	3	2	1	0	
0	2	4	1	0	0	0	7
1	2	4	6	0	1	5	18
2	4	3	4	1		1	13
3	4	0	1				5
4	3	1					4
5	1	2					3
	16	14	12	1	1	6	50

Table 2. Pivot table for the family Geometridae. Bold numbers represent abundance categories, where 0 = no individual; 1 = 1 ni; 2 = 2-5 ni; 3 = 6-20 ni; 4 = 20-50 ni; 5 = above 50 ni (Krampl and Marek 1988). Shaded numbers represent number of occasions. Total compared species – 50.

from altitudes of above 1 600 m (33 from subalpine and 23 from alpine zone). While we focused mainly on the zone above the tree line, few species from the altitude of 1 450 – 1 600 could be overlooked. For instance two – *Perizoma incultaria* (Herrich-Schäffer, 1848) and *Ematurga atomaria* (Linnaeus, 1758) were observed only in this zone. *Colostygia turbata* (Hübner, 1799) was found at this and only one other site, bringing the total species observed to 43.

We have not confirmed the presece of seven species found by Krampl and Marek (1988) within our study area: *Colostygia kollariaria* (Herrich-Schäffer, 1848), *Melanthia alaudaria* (Freyer, 1846), *Spargania luctuata* (Denis and Schiffermüller, 1775), *Eupithecia indigata* (Hübner, 1813), *E. tantillaria* Boisduval, 1840, *Odezia atrata* (Linnaeus, 1758) and *Odontopera bidentata* (Clerck, 1759). It should be mentioned that the rare species *M. alaudaria* have been observed by us at lower altitudes (up to 1 220 m). measured at Monková dolina. On June 9, 2017 it was the most abundant species observed in Javorová dolina, while one year ago only one individual was observed.

In contrast, according to our investigation, six new species were identified that were not collected by Krampl and Marek (1988) in Belianské Tatry: *Biston betularia* 1 (Linnaeus, 1758), *Campaea margaritaria* 2 (Linnaeus, 1761), *Chloroclysta miata* 3 (Linnaeus, 1758), *Pennithera firmata* 4 (Hübner, 1822), *Venusia blomeri* 5 (Curtis, 1832) and the higher stated *Ematurga atomaria* 6 (Linnaeus, 1758). These are species that develop on plants generally not native to the zone above the tree line, including: *Betula* 1; *Fagus* and other broadleaf trees and shrubs 2; *Vaccinium, Salicaceae, Betulaceae* 3; *Pinus* 4; *Ulmus* 5 and diverse plant food (polyphagous species) 6 (Patočka and Kulfan 2009). Therefore these species, except for *E. atomaria* are certainly not native to the study area and must have flown here from another location.

When our catalogue of species is compared to the from the paper by Turčáni *et al.* (1997) conducted in a neighbouring area in the Červené vrchy mountains, we found significant variation. A relative number of big species from Noctuidae are less abudant, while the authors also observe higher relative numbers of smaller species (for instance from the families Gelechiidae, Coleophoridae). This data could indicate changes in moth communities. The opposite situation seems to be occuring in the lowlands, where bigger species disappear more rapidly than small species (pers. comm. Buschmann, Liška or other lepidopterists).

Many species with high ecological value, that are, generally very common, have been confirmed. For instance *Plutella xylostella* (Linnaeus, 1758) and *Autographa gamma* (Linnaeus, 1758) are common and abundant almost everywhere in Slovakia, without any special habitat requirements. Sightings of some nocturnal moth species in our study area were remarkable and unexpected. Mainly finding of thermophilous Noctuid *Catocala sponsa* (Linnaeus, 1767), which is very rare in the mountains. It is spread mainly in oak forests of south Slovakia. Many of the observed species are typical for mountain spruce forests, which surround our study area. The largest category is represented by subalpine and alpine species.

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References

Bengtsson, B.A. 1997: Scythrididae. In: *Microlepidoptera of Europe, Vol. 2.* (eds. P. Huemer, O. Karsholt and L. Lyneborg), pp. 301. Apollo Books, Stenstrup.

Boltižiar, M. 2006: Changes of high mountain landscape structure in the selected area of the Predné Meďodoly valley (Belianske Tatry Mts) in 1949–1998. *Ekológia (Bratislava),* **25**: 16-25.

Buszko, J. and Nowacki, J. 2010: Fauna motyli (Lepidoptera) polskich gór na tle pasm górskich Europy. *Wiad. entomol.*, **29**: 27-38.

Elsner, G., Huemer, P. and Tokár, Z. 1999: Die Palpenmotten (Lepidoptera, Gelechiidae) Mitteleuropas. Bestimmung-Verbreitung-Flugstandort-Lebensweise der Raupen. Slamka, Bratislava

Fajčik, J. 1998: Motyle strednej Europy, II. zväzok/Die Schmetterlinge Mitteleuropas, II. Band (Noctuidae). Polygraphia SAV, Bratislava.

Fajčík, J. and Slamka, F. 1996: Motýle strednej Európy: Drepanidae, Geometridae, Lasiocampidae, Endromidae, Lemoniidae, Saturniidae, Sphingidae, Notodontidae, Lymantriidae, Arctiidae. Vol. 1. Slamka, Bratislava.

Hadač, E. 1990: Secondary vegetation succession in the Belianske Tatry Mts. three decades after grazing. *Folia Geobot. Phytotax.*, **25**: 349-356.

Hausmann, A. and Viidalepp, J. 2012: The geometrid moths of Europe. Vol. 3. Apollo Books.

Kocian, J., Bohuš, I., Ksiažek, J., Ładygin, Z., Grocholski, M. 2010: Štíty a doliny. In: *Tatry-príroda* (eds. A. Koutná, B. Chovancová, Z. Ładygin and J. Šmatlák), p. 45. Baset.

Krampl, F. and Marek, J. 1988: K poznání fauny píďalek Belianskych Tater (Lepidoptera, Geometridae). *Zborník Prác Tatranského národného Parku,* **28**: 159-189.

Krampl, F. and Marek, J. 1991: A new subspecies of Colostygia austriacaria from the Tatra Mts, Czechoslovakia (Lepidoptera, Geometridae). *Acta entomol. Bohemoslov.*, **88**: 43-52.

Kullberg,J., Filippov, B. Y.,Zubryj, N. A. and Kozlov, M.V. 2013: Faunistic notes on Lepidoptera collected from arctic tundra in European Russia. *Nota lepid.* **36**: 127–136.

Laštůvka, A. and Laštůvka, Z. 1997: Nepticulidae Mitteleuropas Ein illustrierter Begleiter. Konvoj, Brno.

Losos, B., Gulička, J., Lellák, J. and Pelikán, J. 1984: Ekologie živočichů. 1. vyd. Státní pedagogické nakladatelství, Praha.

Marek, J. and Krampl, F. 1990: Coleophora svenssoni in central Europe, with notes on its biology (Lepidoptera, Coleophoridae). *Acta entomol. Bohemoslov.*, **87**: 290-297.

Nel, J. 2003. Atlas des lépidoptéres Pterophoridae de France. Association Roussillonnaise d'entomologie. Suppléments á la Revue de l'Association Roussillonnaise d'Entomologie, France.

Mironov, V. 2003: The Geometrid Moths of Europe. Volume 4: Larentiinae II (Perizomini and Eupitheciini). Apollo Books.

Patočka, J. and Kulfan, J. 2009: Lepidoptera of Slovakia: bionomics and ecology. Veda. Bratislava.

Povolný, D. 2002: Iconographia tribus Gnorimoschemini (Lepidoptera, Gelechiidae) Regionis Palaearcticae. Slamka, Bratislava.

Razowski, J. 2008: Tortricidae of the Palaearctic Region, Volume 1 Tortricini and general part. Slamka, Bratislava.

Razowski, J. 2009: Tortricidae of the Palaearctic Region, Volume 2, Cochylini. Slamka, Bratislava.

Slamka, F. 2008: Pyraloidea of Europe (Lepidoptera), Volume 2. Crambinae & Schoenobiinae. Slamka, Bratislava.

Tokár, Z., Laštůvka, A. and van Nieukerken, E.J. 2017: A new pygmy leafmining moth, Stigmella tatrica sp. n., from the alpine zone of the Tatra Mountains (Lepidoptera, Nepticulidae), *Nota Lepi.*, **40**: 131-140.
Tokár, Z., Laštůvka, A., Pastorális, G., Šumpich, J., Štefanovič, R. and Elsner, G. 2015: Records of Microlepidoptera new to the fauna of Slovakia. *Folia faunistica Slovaca,* **1**: 37-47.
Tokár, Z., Slamka, F. and Pastorális, G. 1996: New and remarkable records of Lepidoptera from Slovakia in 1994. *Entomofauna carpatica*, **8**: 88-107.
Turčáni, M., Liška, J., Skyva, J. and Patočka, J. 1997: Lepidopteran fauna of the Červené vrchy mountains (the Tatras National Park). *Biologia, Bratislava,* **52**: 213-261.
www.mothdissection.co.uk 2018: Moth Dissection UK. http://mothdissection.co.uk. (retrieved: 25.02.2018).

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APPENDIX

Appendix 1. Checklist of observed species: direct observations are not highlighted (+), findings from the light traps are bolded (+), dissected species (D), leg. et coll. Zdenko Tokár (ZT).

	Supalpine zone				**Alpine zone**					**Date**		**Note**
Family Species	1600 – 1650	1650 – 1700	1700 – 1750	1750 – 1800	1800 – 1850	1850 – 1900	1900 – 1950	1950 – 2000	2000 – 2061	2016	2017	
Micropterigidae												
Micropterix aureatella (Scopoli, 1763)	+							+			5. VII	
Hepialidae												
Pharmacis fusconebulosa (de Geer, 1778)		**+**					+			11. VII		
Ph. carna (Denis & Schiffermüller, 1775)		**+**		**+**		**+**				11. VII		
Pharmacis sp.		**+**		**+**				**+**			19. VII	
Hepialus humuli (Linnaeus, 1758)				+							19. VII	
Nepticulidae												
Stigmella aeneofasciella (Herrich-Schäffer, 1855)									+		9. VIII	ZT
S. arbusculae (Klimesch, 1951)								+			5. VII	ZT
S. tatrica (Tokár, Laštůvka & van Nieukerken, 2017)								+			9. VIII	
Adelidae												
Cauchas rufimitrella (Scopoli, 1763)		+									5. VII	D
Nematopogon robertella (Clerck, 1759)		**+**								19. VII		
Prodoxidae												
Lampronia rupella (Denis & Schiffermüller, 1775)							+			12. VII		
L. splendidella (Heinemann, 1870)								+	+		5. VII	
Incurvariidae												
Incurvaria vetulella (Zetterstedt, 1839)						+	+				5. VII 20. VII	D
I. praelatella (Denis & Schiffermüller, 1775)			+							11. VII		D
Phylloporia bistrigella (Haworth, 1828)							+				5. VII	ZT
Psychidae												
Bijugis bombycella (Denis & Schiffermüller, 1775)								+			5. VII	
Epichnopterix sp.	+										9. VI	

Tineidae																
Psychoides verhuella (Bruand, 1851)		+												19. VII		
Gracillariidae																
Callisto coffeella (Zetterstedt, 1839)		+												5. VII		
Phyllonorycter hilarella (Zetterstedt, 1839)	+													9. VI		
Ph. junoniella (Zeller, 1846)												+	20. VIII			
Yponomeutidae																
Kessleria zimmermanni (Nowicki, 1864)										+				20. VII		
Swammerdamia compunctella Herrich-Schäffer, 1855							+							5. VII	D	
Argyresthiidae																
Argyresthia glabratella (Zeller, 1847)							+							5. VII	ZT	
A. conjugella Zeller, 1839		+		+				+					11. VII	19. VII	D	
Plutellidae																
Plutella xylostella (Linnaeus, 1758)		+	+	+	+	+	+	+	+				11. VII	5. VII		
													20. VIII			
Rhigognostis marmorosella (Wocke, 1850)							+							9. VI		
Glyphipterigidae																
Glyphipterix bergstraesserella (Fabricius, 1781)			+				+						11. VII	5. VII		
Depressariidae																
Agonopterix astrantiae (Heinemann, 1870)		+											1. IX			
A. doronicella (Wocke, 1849)	+												1. IX			
Elachistidae																
Elachista exactella (Herrich-Schäffer, 1855)										+				5. VII	ZT	
E. adscitella Stainton, 1851		+												19. VII		
E. albifrontella (Hübner, 1817)	+													19. VII		
E. argentella (Clerck, 1759)	+													9. VI		
E. dimicatella Rebel, 1903	+		+	+	+		+						11. VII	5. VII		
														19. VII		
E. irenae Buszko, 1989			+									+	11. VII	5. VII		
														9. VIII		
Biselachista zonulae Sruoga, 1992	+		+				+	+	+					5. VII		
													20. VIII	19. VII		
														9. VIII		
Ethmiidae																
Orophia ferrugella (Denis & Schiffermüller, 1775)				+									12. VII			
Scythrididae																
Scythris fallacella (Schläger, 1847)	+		+	+						+			11. VII	19. VII	D	
													20. VIII	9. VIII	D	
Coleophoridae																

Coleophora frischella (Linnaeus, 1758)						+				11. VII		D
C. svenssoni Baldizzone, 1985									+	20. VIII		
C. sylvaticella Wood, 1892					+					11. VII		D
C. virgaureae Stainton, 1857		+	+	+		+				11. VII		D
C. striatipennella Nylander, 1848								+			9. VIII	
C. nubivagella Zeller, 1849								+	+	12. VII	5. VII	
Gelechiidae												
Teleiopsis bagriotella (Duponchel, 1840)		+	+	+				+		11. VII 20. VIII		
Prolita sexpunctella (Fabricius, 1794)									+		5. VII	D
Scrobipalpula diffluella (Frey, 1870)						+	+			11. VII	5. VII	
Sattleria dzieduszyckii (Nowicki, 1864)								+			19. VII	D
Acompsia tripunctella (Denis & Schiffermüller, 1775)		+	+	+						11. VII 20. VIII	19. VII	D
Tortricidae												
Aethes smeathmanniana (Fabricius, 1781)				+			+			11. VII	5. VII	
Eana osseana (Scopoli, 1763)		+		+	+	+	+	+		11. VII 20. VIII 1. IX	19. VII 15. VIII	
E. argentana (Clerck, 1759)							+			1. IX		
E. penziana (Thunberg & Becklin, 1791)		+						+		1. IX	19. VII	D
Eulia ministrana (Linnaeus, 1758)									+		5. VII	
Clepsis rogana (Guenée, 1845)		+								20. VIII		
C. senecionana (Hübner, 1819)		+									9. VI	
Aterpia anderreggana Guenée, 1845				+			+	+		12. VII	5. VII	
A. corticana (Denis & Schiffermüller, 1775)			+							11. VII		
Apotomis sauciana (Frölich, 1828)								+			5. VII	ZT
Phiaris schulziana (Fabricius, 1776)								+			5. VII	
Ph. bipunctana (Fabricius, 1794)		+								11. VII		
Argyroploce noricana (Herrich-Schäffer, 1854)							+	+			5. VII	
Eriopsela quadrana (Hübner, 1813)	+					+					9. VI	
Epinotia mercuriana (Frölich, 1830)			+	+		+	+	+	+	20. VIII	19. VII 9. VIII	
E. tedella (Clerck, 1759)			+	+		+				11. VII	5. VII	
Zeiraphera griseana (Hübner, 1799)	+	+								1. IX		

Eucosma aspidiscana (Hübner, 1817)	+		+	+							11. VII	9. VI			
Epiblema turbidana (Treitschke, 1835)	+											19. VII	D		
Pseudococcyx mughiana (Zeller, 1868)						+						5. VII			
Ancylis myrtillana (Treitschke, 1830)	+	+									11. VII	9. VI			
Lathronympha strigana (Fabricius, 1775)	+	+	+	+	+	+					11. VII	19. VII 15. VIII			
Dichrorampha montanana (Duponchel, 1843)				+			+				20. VIII	5. VII	D		
Choreutidae															
Anthophila fabriciana (Linnaeus, 1767)			+								20. VIII				
Epermeniidae															
Phaulernis fulviguttella (Zeller, 1839)	+			+		+	+					5. VII			
Pterophoridae															
Platyptilia calodactyla (Denis & Schiffermüller, 1775)				+							11. VII				
Platyptilia sp.		+	+			+					11. VII				
Pyralidae															
Dioryctria abietella (Denis & Schiffermüller, 1775)	+	+	+	+		+					11. VII 1. IX				
Crambidae															
Gesneria centuriella (Denis & Schiffermüller, 1775)						+					11. VII				
Eudonia vallesialis (Duponchel, 1832)							+	+				5. VII 19. VII			
E. sudetica (Zeller, 1839)		+	+	+		+					11. VII 20. VIII				
Crambus lathoniellus (Zincken, 1817)						+					11. VII				
Catoptria permutatellus (Herrich-Schäffer, 1848)						+					11. VII		D		
C. radiella (Hübner, 1813)		+	+	+		+		+	+		11. VII	9. VIII			
C. petrificella (Hübner, 1796)	+			+	+	+		+	+		11. VII	5. VII 19. VII			
Orenaia alpestralis (Fabricius, 1787)		+	+				+				11. VII	5. VII 19. VII			
Udea alpinalis (Denis & Schiffermüller, 1775)	+	+	+	+				+	+		11. VII	5. VII 19. VII			
U. uliginosalis (Stephens, 1834)		+	+	+		+	+	+	+		11. VII	5. VII 19. VII 15. VIII			
U. decrepitalis (Herrich-Schäffer, 1848)		+									11. VII				
Udea sp.						+					11. VII				
Lasiocampidae															
Trichiura crataegi (Linnaeus, 1758)							+				1. IX				
Cosmotriche lobulina (Denis & Schiffermüller, 1775)				+								19. VII			

Sphingidae																		
Agrius convolvuli (Linnaeus, 1758)											+	+	+	1. IX	15. VIII			
Hyles gallii (Rottemburg, 1775)								+						11. VII				
Drepanidae																		
Thyatira batis (Linnaeus, 1758)			+											11. VII				
Geometridae																		
Biston betularia (Linnaeus, 1758)								+						11. VII				
Alcis repandata (Linnaeus, 1758)										+				11. VII				
Ematurga atomaria (Linnaeus, 1758)	+														9. VI			
Campaea margaritaria (Linnaeus, 1761)								+						11. VII				
Charissa glaucinaria (Hübner, 1799)				+										11. VII				
Elophos dilucidaria (Denis & Schiffermüller, 1775)			+												19. VII	D		
E. vittaria (Thunberg & Sebaldt, 1792)								+						11. VII		D		
E. operaria (Hübner, 1813)												+			19. VII			
Psodos quadrifaria (Sulzer, 1776)								+			+	+			5. VII			
Glacies canaliculata (Hochenwarth, 1785)													+		5. VII			
G. noricana (Wagner, 1898)										+				12. VII				
G. alpinata (Scopoli, 1763)													+		5. VII			
Xanthorhoe designata (Hufnagel, 1767)	+														9. VI			
X. spadicearia (Denis & Schiffermüller, 1775)	+	+												11. VII	9. VI			
X. montanata (Denis & Schiffermüller, 1775)		+	+	+						+		+		11. VII	19. VII			
X. fluctuata (Linnaeus, 1758)				+										11. VII				
Epirrhoe molluginata (Hübner, 1813)										+				11. VII				
Entephria nobiliaria Herrich-Schäffer, 1852												+			19. VII	D		
E. flavicinctata (Hübner, 1813)												+			19. VII	D		
E. caesiata (Denis & Schiffermüller, 1775)	+	+	+	+	+	+	+	+						11. VII	19. VII			
														1. IX	15. VIII			
Coenotephria salicata (Denis & Schiffermüller, 1775)		+	+	+								+		11. VII	19. VII			
Eulithis prunata (Linnaeus, 1758)	+	+		+										1. IX				
E. populata (Linnaeus, 1758)	+	+	+	+	+	+	+	+						20. VIII	9. VIII			
														1. IX	15. VIII			
Ecliptopera silaceata (Denis & Schiffermüller, 1775)												+			19. VII			
Chloroclysta miata (Linnaeus, 1758)	+											+		1. IX				

Dysstroma citrata (Linnaeus, 1761)		+	+											1.IX			
D. truncata (Hufnagel, 1767)		+	+	+	+					+				11.VII	19.VII		
														1.IX			
Pennithera firmata (Hübner, 1822)		+												1.IX			
Thera variata (Denis & Schiffermüller, 1775)		+		+										11.VII			
														1.IX			D
Colostygia turbata (Hübner, 1822)										+					19.VII		
Hydriomena furcata (Thunberg & Borgstroem, 1784)		+												1.IX			
Triphosa dubitata (Linnaeus, 1758)			+	+	+		+	+	+					11.VII	19.VII		
														1.IX	15.VIII		
Perizoma affinitata (Stephens, 1831)			+											11.VII			
P. alchemillata (Linnaeus, 1758)					+									11.VII			D
P. minorata (Treitschke, 1828)			+	+		+	+		+					11.VII	5.VII		
															19.VII		
P. albulata (Denis & Schiffermüller, 1775)					+		+							11.VII			
Mesotype verberata (Scopoli, 1763)			+	+	+	+	+	+	+	+				20.VIII	9.VIII		
														1.IX	15.VIII		
Eupithecia pyreneata Mabille, 1871					+									11.VII			D
E. undata (Freyer, 1840)					+									11.VII			D
E. veratraria Herrich-Schäffer, 1848			+		+									11.VII			D
E. absinthiata (Clerck, 1759)					+									11.VII			D
Eupithecia sp.					+									11.VII			
		+												1.IX			
Aplocera praeformata (Hübner, 1826)		+	+	+	+		+	+	+					11.VII	19.VII		
														1.IX	15.VIII		
Venusia blomeri (Curtis, 1832)							+							11.VII			
V. cambrica Curtis, 1839			+											11.VII			
Notodontidae																	
Notodonta ziczac (Linnaeus, 1758)					+										19.VII		
Noctuidae																	
Acronicta aceris (Linnaeus, 1758)					+									11.VII			
Catocala sponsa (Linnaeus, 1767)			+											11.VII			
Scoliopteryx libatrix (Linnaeus, 1758)		+				+								1.IX	15.VIII		
Polychrysia moneta (Fabricius, 1787)		+	+											1.IX			
Diachrysia chrysitis (Linnaeus, 1758)							+							11.VII			
Autographa gamma (Linnaeus, 1758)			+	+		+	+							11.VII	19.VII		
															15.VIII		
A. pulchrina (Haworth, 1809)				+										11.VII			

A. bractea (Denis & Schiffermüller, 1775)			+			+			+	+			11. VII 1. IX			
Cucullia umbratica (Linnaeus, 1758)				+		+							11. VII	19. VII		
C. asteris (Denis & Schiffermüller, 1775)				+									11. VII			
Amphipyra berbera Rungs, 1949			+	+		+			+				11. VII	19. VII		
A. tragopoginis (Clerck, 1759)	+			+		+			+				11. VII 1. IX	19. VII		
Charanyca ferruginea (Esper, 1785)				+									11. VII			
Euplexia lucipara (Linnaeus, 1758)			+										11. VII			
Hyppa rectilinea (Esper, 1788)			+	+		+							11. VII			
Cosmia trapezina (Linnaeus, 1758)						+							11. VII			
Sunira circellaris (Hufnagel, 1766)									+				1. IX			
Dasypolia templi (Thunberg & Sebaldt, 1792)	+		+			+		+		+			1. IX	15. VIII		
Lithophane socia (Hufnagel, 1766)						+				+			1. IX			
Mniotype adusta (Esper, 1790)				+		+							11. VII			
Apamea monoglypha (Hufnagel, 1766)	+		+	+		+			+				11. VII 1. IX	19. VII		
A. crenata (Hufnagel, 1766)			+	+		+							11. VII			
A. lateritia (Hufnagel, 1766)			+	+		+							11. VII			
A. rubrirena (Treitschke, 1825)			+	+		+							11. VII	19. VII		
Oligia strigilis (Linnaeus, 1758)						+							11. VII			D
Mesapamea secalis (Linnaeus, 1758)			+	+		+			+				11. VII	19. VII		D
Photedes captiuncula (Treitschke, 1825)	+		+											19. VII		
Lacanobia aliena (Hübner, 1809)			+			+							11. VII	19. VII		
L. oleracea (Linnaeus, 1758)	+												1. IX			
L. thalassina (Hufnagel, 1766)				+									11. VII			
Hada plebeja (Linnaeus, 1761)				+		+							11. VII			
Hadena compta (Denis & Schiffermüller, 1775)				+									11. VII			
H. confusa (Hufnagel, 1766)						+								19. VII		
Melanchra persicariae (Linnaeus, 1761)				+					+				11. VII			
Mamestra brassicae (Linnaeus, 1758)			+			+		+	+		+	+	11. VII	19. VII 15. VIII		
Polia hepatica (Clerck, 1759)				+									11. VII			
Mythimna conigera (Denis & Schiffermüller, 1775)						+							11. VII			

M. ferrago (Fabricius, 1787)				+							11. VII					
M. albipuncta (Denis & Schiffermüller, 1775)	+			+							1. IX					
M. vitellina (Hübner, 1808)				+					+		1. IX					
Cerapteryx graminis (Linnaeus, 1758)				+					+		11. VII 1. IX					
Eriopygodes imbecilla (Fabricius, 1794)		+		+							11. VII	19. VII				
Diarsia mendica (Fabricius, 1775)		+	+	+		+		+			11. VII	19. VII				
D. brunnea (Denis & Schiffermüller, 1775)		+	+	+		+					11. VII					
Noctua pronuba (Linnaeus, 1758)	+	+	+	+	+	+	+	+			11. VII 1. IX	19. VII 15. VIII				
N. interposita (Hübner, 1790)	+	+		+		+	+	+			11. VII 1. IX	19. VII				
N. fimbriata (Schreber, 1759)	+	+	+	+		+		+			11. VII 1. IX	19. VII				
N. interjecta Hübner, 1803								+				19. VII				
N. janthina (Denis & Schiffermüller, 1775)						+					11. VII					
Chersotis rectangula (Denis & Schiffermüller, 1775)				+								19. VII				
Ch. cuprea (Denis & Schiffermüller, 1775)		+					+				1. IX					
Rhyacia simulans (Hufnagel, 1766)				+							11. VII					
Epipsilia grisescens (Fabricius, 1794)	+	+									1. IX					
Standfussiana lucernea (Linnaeus, 1758)			+			+		+			11. VII	19. VII				
Eurois occulta (Linnaeus, 1758)			+								11. VII					
Opigena polygona (Denis & Schiffermüller, 1775)				+					+		1. IX	19. VII				
Xestia speciosa (Hübner, 1813)		+	+								11. VII					
X. alpicola (Zetterstedt, 1839)				+								19. VII				
X. c-nigrum (Linnaeus, 1758)	+	+		+	+		+	+			11. VII 1. IX	15. VIII				
X. triangulum (Hufnagel, 1766)		+	+	+							11. VII	19. VII				
X. baja (Denis & Schiffermüller, 1775)		+									11. VII					
Anaplectoides prasina (Denis & Schiffermüller, 1775)		+	+	+		+					11. VII	19. VII				
Agrotis ipsilon (Hufnagel, 1766)	+	+		+			+	+			1. IX	19. VII				
Panthea coenobita (Esper, 1785)		+									11. VII					
Calliteara pudibunda (Linnaeus, 1758)						+					11. VII					
Arctia caja (Linnaeus, 1758)	+			+							1. IX					
Callimorpha dominula (Linnaeus, 1758)			+								11. VII					