TRAVAUX DU MUSÉUM NATIONAL D'HISTOIRE NATURELLE «GRIGORE ANTIPA»
THE JOURNAL OF "GRIGORE ANTIPA" NATIONAL MUSEUM OF NATURAL HISTORY

Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 62 (2): 191–211 (2019)
doi: 10.3897/travaux.62.e48604

RESEARCH ARTICLE

Diversity and distribution of Orthoptera communities of two adjacent mountains in northern part of the Carpathians

Anton Krištín[1], Benjamín Jarčuška[1], Peter Kaňuch[1]

1 *Institute of Forest Ecology SAS, L. Štúra 2, Zvolen, SK-96053, Slovakia*

Corresponding author: *Anton Krištín* (kristin@ife.sk)

Received 19 November 2019 | Accepted 24 December 2019 | Published 31 December 2019

Citation: Krištín A, Jarčuška B, Kaňuch P (2019) Diversity and distribution of Orthoptera communities of two adjacent mountains in northern part of the Carpathians. Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 62(2): 191–211. https://doi.org/10.3897/travaux.62.e48604

Abstract

During 2013–2017, assemblages of bush-crickets and grasshoppers were surveyed in two neighbouring flysch mountains – Čergov Mts (48 sites) and Levočské vrchy Mts (62 sites) – in northern part of Western Carpathians. Species were sampled mostly at grasslands and forest edges along elevational gradient between 370 and 1220 m a.s.l. Within the entire area (ca 930 km^2) we documented 54 species, representing 38% of Carpathian Orthoptera species richness. We found the same species number (45) in both mountain ranges with nine unique species in each of them. No difference in mean species richness per site was found between the mountain ranges (mean ± SD = 12.5 ± 3.9). Elevation explained 2.9% of variation in site species richness. Elevation and mountain range identity explained 7.3% of assemblages composition. We found new latitudinal as well as longitudinal limits in the distribution for several species. Occurrence and distributional patterns of some noteworthy species (*Isophya stysi*, *Pholidoptera transsylvanica*, *Poecilimon schmidtii*, *Polysarcus denticauda*, *Pseudopodisma nagyi*, *Chorthippus tatrae*), as well as habitat specialists (*Chorthippus pullus*, *Tetrix tuerki*) are discussed.

Keywords

grasshoppers, bush-crickets, zoogeography, ecology, Central Europe

Introduction

The Carpathian Mountains are the largest mountain range in Central and Southeastern Europe and an important center of endemism and biodiversity for many plant and animal groups (Ronikier 2011, Mráz and Ronikier 2016, Jarčuška et al. 2019). The northern part of Carpathian Mts has been less studied area for distributional data of Carpathian Orthoptera untill 2000 (Mařan 1956, Bazyluk and Liana 2000, Jarčuška et al. 2015). Today we know that several species and even genera of Orthoptera have the northernmost range limit there (Hochkirch et al. 2016). For example, two species of *Pseudopodisma* (Galvagni and Fontana 1996), then *Poecilimon schmidtii*, *Isophya stysi* and *Pholidoptera transsylvanica* (Krištín and Kaňuch 2013, 2019, Jarčuška et al. 2015, Krištín and Jarčuška 2016, Krištín et al. 2019).

The northern part of Western Carpathians in Slovakia and southern Poland is characterized by cooler climate, different types of grasslands and forest habitats along elevational gradients up to 2655 m a.s.l. Relatively diverse environmental conditions may explain rich species diversity of insect and particularly Orthoptera assemblages (Gavlas et al. 2007, Krištín 2010). Grassland habitats, broadleaved forests and their ecotones are relatively well preserved there, being a regional hotspot for central European orthopteran fauna (Bazyluk 1971, Bazyluk and Liana 2000, Nagy 2005, Kenyeres et al. 2009, Krištín and Iorgu 2014, Jarčuška et al. 2015). Several Orthoptera species have been described there (e.g. *Isophya pienensis*, *Isophya posthumoidalis*, *Chorthippus tatrae*, *Isophya fatrensis*, *Chorthippus smardai* – Mařan 1954, Bazyluk 1971, Chládek and Harz 1983, Chládek 2007, Chládek 2014) and some of these Carpathian endemics are expected to have significant populations there (Jarčuška et al. 2015, Krištín and Iorgu 2014, Chládek 2014, Hochkirch et al. 2016). Elevational patterns in diversity of taxa may be apparent on a range of spatial scales (Gaston and Williams 1996). At the finest scale the number of insect species associated with a particular habitats may decline with rising elevation (Hodkinson 2005). The distributions of many terrestrial organisms are currently shifting in latitude or elevation in response to changing climate (Hickling et al. 2006, Chen et al. 2011). Therefore, regularly updated knowledge about the range boundaries is important for understanding the effects of climate change on species distributional patterns (Keppel et al. 2012, Fournier et al. 2017), especially in mountain systems (Schmitt 2009, Ronikier 2011).

In this study we analyzed species composition and abundance of Orthoptera assemblages in Čergov Mts and Levočské vrchy Mts in relationship to the elevation and we discussed the importance of these two mountain ranges for Carpathian Orthoptera diversity.

Material and methods

Study area and sites

Species assemblages were studied in two Carpathian mountains (Čergov Mts, ca 301 km² – 48 sites and Levočské vrchy Mts ca 625 km² – 62 sites) (Fig. 1). Altogether 110 sites were sampled along an elevational gradient ranging from 370 to 1220 m a.s.l. (49.0274–49.3381° N, 20.38074–21.23336° E; Appendix 2, 3). Most of the study area is located on flysch bedrock, with similar elevational gradients in both mountains (Čergov 1157 m a.s.l., Levočské vrchy Mts 1289 m a.s.l.). Both mountain ranges are mostly forested landscapes. Levočské vrchy Mts are covered more with secondary coniferous forests and influenced by cold climate of High Tatra Mts from the west while Čergov Mts. are predominantly covered with broadleaved forests influenced by warm climate of Pannonian area from the southeast. Following these characteristics, we studied substantially more sites in adjacent coniferous forests in Levočské vrchy Mts (48.4 vs 8.3% in Čergov Mts.) and on other hand more sites in broadleaved forests in Čergov Mts (56.3 % vs 11.2% in Levočské vrchy Mts), with similar ratio of mixed and azonal forests (Appendix 2, 3).

Data collection

Field survey was carried out mostly in June – August in 2013–2017 (4 sites in 2009), when 24 of 110 study sites (12 in each mountain range) were visited repeat-

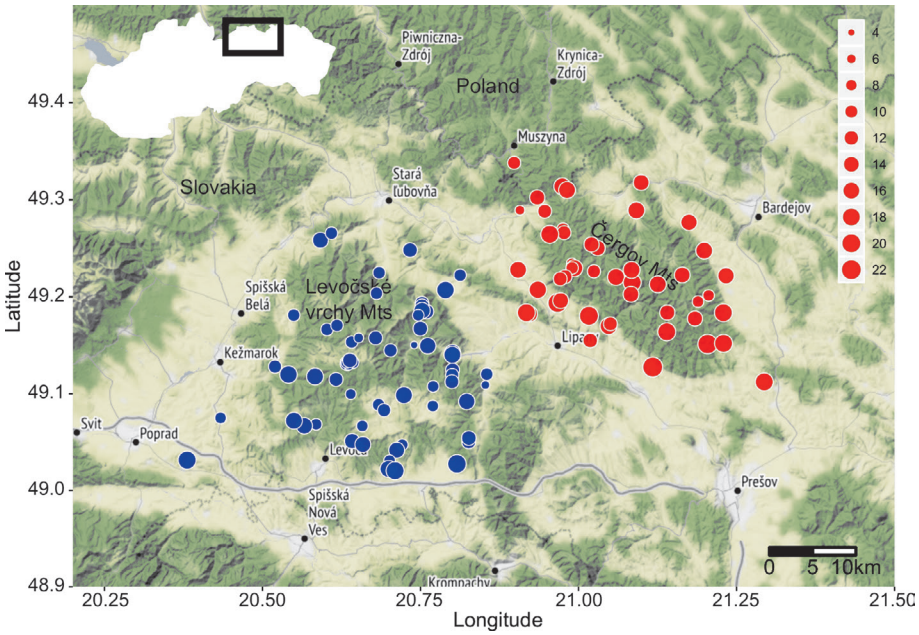

Figure 1. Species richness (circles) in Levočské vrchy (62 sites; blue) and Čergov Mts (48 sites; red) in northern Carpathians and their location within Slovakia and Poland.

edly (up to 3 visits, Appendix 2, 3). The material was sampled mostly by sweeping herb and shrub vegetation by three or four persons (ca. 2000 sweeps per site). This method was supplemented with acoustical identification, beating from lower part of trees and shrubs and individual collection of specimens in characteristic habitats of the site. We spent at least two hours of collection at each site. Abundance of individual species on the site was expressed by using the following classification scale: 1 – very rare (less than 3 adult specimens), 2 – rare (3–10 specimens), 3 – abundant (11–100 specimens), 4 – very abundant (more than 100 specimens). Relative semiquantitative values of abundance listed in the results represent the highest recorded values of the adults per visit corresponding to one site (Appendix 4, 5).

Specimens were identified directly in the field or fixed using 75% ethanol and determined in the lab using identification keys (Harz 1969, 1975, Heller et al. 2004). The system and the nomenclature was used according to Cigliano et al. (2019), the geographical data about the origin and distribution follow the work by Harz (1969, 1975), Ingrisch and Köhler (1998) and Rácz (1998) (Appendix 1, 4, 5).

For each surveyed site, the elevation was derived from the map. Frequency of species occurrence (%F) was calculated for whole dataset and for each mountain range separately.

Data analysis

Difference in number of species between two mountain ranges was tested using general linear model (GLM) with Poisson distribution and log-link function. Ensifera and Mantodea species (only for analysis purpose, single representative of Mantodea was pooled with Ensifera), Caelifera and all species were used as response variables also in separate analyses. The mountain range was used as categorical variable and elevation as continuous variable in the analysis. Function *Anova* from package 'car' (Fox and Weisberg 2019) with type III sum of squares and *contr.sum* contrasts were used to test statistical significance of variables in the GLM. Pseudo-R^2 was calculated using package DescTools (Signorell et al. 2019)

Statistical significance of differences in orthopteran assemblage structure (i.e semiquantitative abundance of species) between the two mountain ranges and along elevational gradient was tested using function *manyglm* from package 'mvabund' (Wang et al. 2019). It has been shown that generalised linear models framework is a flexible powerful framework for analysing abundance data and have greater power than distance-based community methods (e.g. used in ANOSIM and SIMPER procedures; Wang et al. 2012). A multivariate linear model with mountain range, elevation and interaction between them as explanatory variables was fitted with negative binomial distribution of data. Variation in multivariate response explained by an explanatory variable in the model – R^2 – was calculated using the package's function *best.r.sq*. Subsequently, species with the greatest contribution to the dissimilarity observed between mountains and along elevational gradient were identified. All analyses were performed in R environment (R Core Team 2019).

Results

A total number of 54 Orthoptera (24 Ensifera and 30 Caelifera) and one Mantodea species were detected across 110 studied sites in both studied mountains (Appendix 1, 4, 5). In spite of different number of sampling sites (48 Čergov, 62 Levočské vrchy Mts.) and twice larger area of Levočské vrchy mountain range, we found the same species number (45) in both areas with nine unique species in each of them (Appendix 1, 4, 5, Fig. 1). However, the mean (±SD) number of Orthoptera and Mantodea species per site was 14.3 (±3.76) and 11.2 (±3.61) in Čergov and Levočské vrchy Mts, respectively (Fig. 2). No significant differences in number of all species together and also number of Ensifera and Mantodea species had been observed between two mountain ranges. Only the elevation affected species richness and the pattern of association between elevation and species richness was the same for both mountain ranges (Table 1).

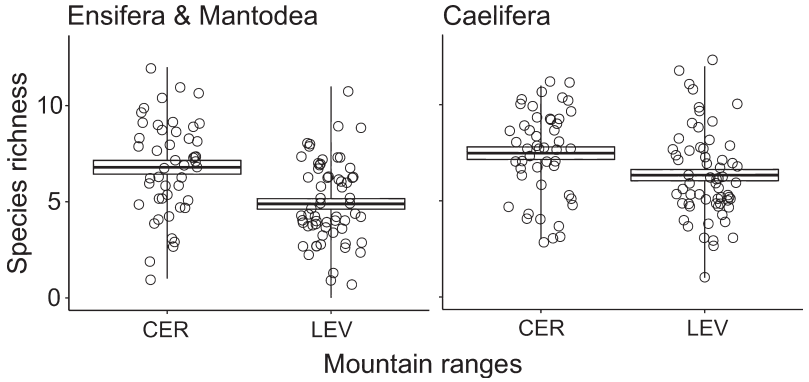

Figure 2. Species richness of Ensifera and Mantodea (left) and Caelifera (right) in two studied mountains. Means, ±SE (box) and range (min-max; whiskers) are presented.

Table 1. Outputs of GLM with Poisson distribution with log link function, modelling number of species, Ensifera and Mantodea, and Caelifera separately using mountain range and elevation as explanatory variables.

	All species		**Ensifera, Mantodea**			**Caelifera**
	$F_{1, 106}$	p	$F_{1, 106}$	p	$F_{1, 106}$	p
Mts	0.142	0.707	0.088	0.768	0.076	0.784
elevation	**7.425**	**0.008**	**0.088**	**0.039**	**4.736**	**0.032**
Mts* elevation	0.284	0.595	4.356	0.522	0.039	0.845
Pseudo-R^2	0.045		0.042		0.018	

Mean number of both Ensifera/Mantodea and Caelifera species per site was higher in Čergov Mts (further CER) than Levočské vrchy Mts (further LEV) – 6.8 (SD = 2.47) vs 4.9 (2.16) and 7.5 (2.25) vs 6.3 (2.30) for Ensifera and Caelifera, respectively (Fig. 2).

Elevation was negatively associated with number of species in both mountain ranges, however association was weak (Fig. 3, $R^2 = 0.029$, $P < 0.001$).

The multivariate linear model revealed that the Orthoptera and Mantodea assemblages composition were affected by mountain range (ANOVA, df = 1, 108, likelihood-ratio test (LRT) = 260.2, P = 0.001), and elevation (df = 1, 107, LRT = 246.3, P = 0.001). Interaction between mountain range and elevation was not statistically significant (df =1, 101, LRT = 50.7, P = 0.052). The model variables explained 7.3% of variability in assemblages' composition (elevation and mountain range explained 4.5% and 3.9%, respectively).

Species with the greatest contribution to the dissimilarity observed in species abundance between two mountain ranges (CER and LEV) were *Pholidoptera transsylvanica* (LRT = 55.619, P = 0.001; %F CER/LEV = 50/0%), *Isophya camptoxypha* (LRT = 18.425, P = 0.003; %F = 0/23%), *Chorthippus tatrae* (LRT = 11.109, P = 0.026; %F = 0/15%), *Omocestus viridulus* (LRT = 12.735, P = 0.010; %F = 46/76%), *Stenobothrus lineatus* (LRT = 10.57, P = 0.038; %F = 40/13%, *Decticus verrucivorus* (LRT = 10.545, P = 0.038; %F = 79/63%), less also *Phaneroptera falcata* (LRT = 9.508, P = 0.054, %F = 39.6/9.7), *Poecilimon schmidtii* (LRT = 8.763, P = 0.076, %F = 10.4/0) and *Platycleis grisea* (LRT = 8.685, P = 0.076, %F = 10.4/0).

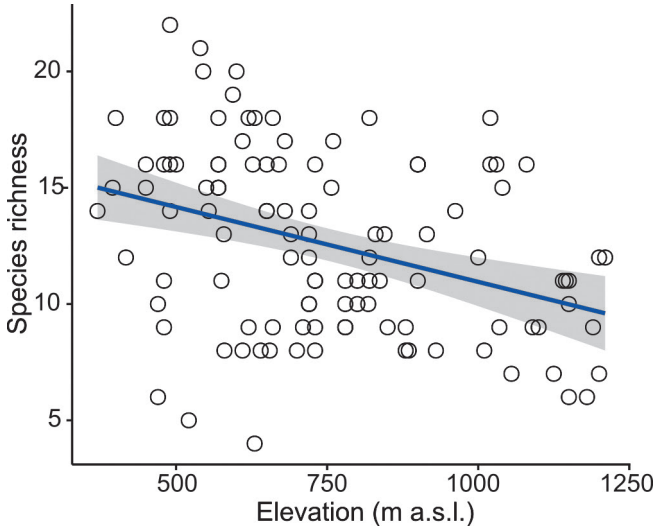

Figure 3. Association between species richness of Orthoptera and Mantodea and elevation of 110 sampled sites in Čergov Mts and Levočské vrchy Mts. Elevation explained 2.9% of species richness in GLM model.

The species *Leptophyes albovittata* (LRT = 45.887, P = 0.001), *P. falcata* (LRT = 28.116, P = 0.001), *P. transsylvanica* (LRT = 12.913, P = 0.017), *Tetrix tenuicornis* (LRT = 14.416, P = 0.011), *Chorthippus dorsatus* (LRT = 16.393, P = 0.004) differentiated assemblages in relation to elevation – all these species except *P. transsylvanica* were more frequent and abundant in lower elevations.

Several other species were distinct for both mountain ranges (*Isophya stysi*, *Pseudopodisma nagyi* for CER, *Tetrix subulata* for LEV, Fig. 4), having low frequency and abundance. Some other didn't have interpretation value, while occurríng in only one site (e.g. *Conocephalus fuscus*, *Chorthippus vagans*, *O. caerulescens, Chorthippus oschei* in CER, *Pholidoptera aptera*, *Arcyptera fusca*, *Miramella alpina,* in LEV, see Appendix 1, 4, 5).

Discussion

Species richness

This is the first report on Orthoptera assemblages along the Slovak-Polish borderline between SE Poland (Theuerkauf et al. 2005) / NE Slovakia (Jarčuška et al. 2015, Jarčuška 2019) and Tatra Mts (Krištín 2010) and it is filling the gap in knowledge from this part of Western Carpathians (Hochkirch et al. 2016, Jarčuška et al.

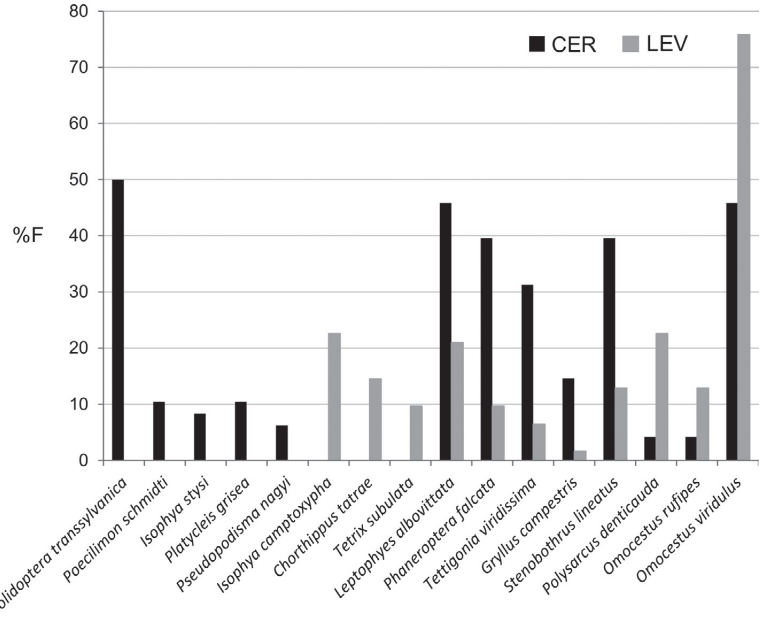

Figure 4. Frequency of eight most distinct species and other 8 selected Orthoptera species with substantialy different frequencies (>40% difference, right columns) in the two studied mountains. Ten distinct species with only one site occurrence are not shown.

2019). Altogether 142 Orthoptera species were found in Carpathians (Krištín and Iorgu 2014). A negative latitudinal trend in species richness in Carpathian Mts from 91 species/100 km^2 grid cell in the south to 47 species/cell in the northwest (Jarčuška et al. 2019) was registered. We found 54 Orthoptera species, i.e. 38% out of 142 species known from the Carpathian Mts (Krištín and Iorgu 2014) in both studied mountain ranges (ca 930 km^2). For comparison, in the adjacent Tatra Mts and NE Slovak/SE Polish Carpathians a similar species richness was found, i.e. 45 species in Tatra Mts (Krištín 2010), and 54 species in NE Slovak/SE Polish Carpathians (Theuerkauf et al. 2005, Jarčuška et al. 2015, Jarčuška 2019). Slightly higher numbers of species were found in mountain ranges with similar area (km^2) but located southward from the study area, e.g. 67 species in Cserhát Mts. in N Hungary (Szövényi et al. 2013), 60 species in Börzsöny Mts. (Erdélyi et al. 2017) or 56 in Poľana Mts., Central Slovakia (Krištín and Hrúz 2005). Each one of these areas has a characteristic species composition, dependant on the distance from the Pannonian basin. Although the study area does not represent a hot spot for Orthoptera biodiversity in Europe, we found two species of European importance there (*P. transsylvanica* and *I. stysi*).

Differences of species assemblages in two mountain ranges

Dissimilarity in species composition between the two studied mountain ranges (20% of species in each mountain range = 9), could be explained by their different position and distance from the Pannonian basin and High Tatra Mts, by cooler climate in Levočské vrchy Mts and warmer climate in Čergov Mts. Three once believed south-eastern Carpathian and Pontomediterranean species *P. transsylvanica* (F = 50% of 48 sites), *P. schmidtii* (10.4%), *I. stysi* (8.3%), were found only in Čergov Mts. These mountains were found to be the nortwesternmost boundary of their global range that follows relatively continual distribution from the southeast (Hochkirch et al. 2016). This knowledge supports the results of quantitative regionalization of the Carpathians based on Orthoptera, that these south-eastern Carpathian species are distributed more westward from the former outlined boundary between Western and Eastern Carpathians (Jarčuška et al. 2019). Furthermore, some thermophilous species were found in Čergov Mts mostly in significantly higher frequencies and abundance (*P. grisea*, *L. albovittata*, *P. falcata*, Fig. 4) than in cooler Levočské vrchy Mts. Only in Levočské vrchy Mts we found distinct Western Carpathian endemic *Ch. tatrae* (on 15% of 62 sites, having the easternmost range limit there), or mountainous species *I. camptoxypha* (23%), and other mountainous species found in lower frequencies or accessoric, but having the eastern and northern range limit there (*Miramella alpina*, *Arcyptera fusca*; Hochkirch et al. 2016). Furthermore, we found several species with significantly different frequencies and abundances such as mountainous species *Omocestus viridulus* and *Polysarcus denticauda* dominating in Levočské vrchy Mts and *P. nagyi* in Čergov Mts, which is the northernmost boundary of its fragmented range in Europe (Hochkirch et al. 2016). Habitat specialists such as *Chorthippus pullus* and *Tetrix tuerki* were found only in azonal posi-

titions of gravel banks along creeks on the piedmont in both mountain ranges (in the Torysa and Poprad river catchments), also the study area belongs to the strongholds of these species in Western Carpathians. Carpathian Dancing Grasshopper *C. oschei* (single male) was found only in one site and only in the Čergov Mts, together with more abundant and related *C. albomarginatus* (> 10 specimens). This record may widen our knowledge on the hybrid zone of these two species, but it needs further research.

Elevational patterns

In this small scale study (ca 930 km^2 of both mountains) we confirmed general pattern of negative correlation between the species richness and increasing elevation (e.g. Hodkinson 2005, Nufio et al. 2010, Fournier et al. 2017). Only or mostly in higher elevations (> 900 m a.s.l.) *Metrioptera brachyptera*, *P. aptera*, *M. alpina*, *A. fusca* were found. As expected, we found thermophilous species such as *I. stysi*, *Platycleis grisea*, *Poecilimon intermedius*, *Ch. oschei*, *Stenobothrus crassipes* mostly or only in lower elevations (< 500 m a.s.l.).

Acknowledgements

The research was supported by the Grant Agency VEGA (grants no. 2/0097/16 and 2/0076/19). The authors are grateful to Peter Tuček, Elena and Ionuț Iorgu, who helped with field collections.

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Appendix 1. Frequency (%) of 55 Orthoptera and Mantodea species in Čergov / Levočské vrchy mountains (n = 48 sites for Čergov Mts, n = 62 sites for Levočské vrchy Mts.; 18 distinct species for mountain range are in bold).

Barbitistes constrictus Br. v. Wattenwyl, 1878: 14.6/9.7; *Conocephalus fuscus* (Fabricius, 1793): 2.1/0; *Decticus verrucivorus* (Linnaeus, 1958): 79.2/62.9; ***Ephippiger ephippiger* (Serville, 1831): 0/1.6; *Isophya camptoxypha* (Fieber, 1853): 0/22.6;** *Isophya kraussii* Brunner von Wattenwyl, 1878: 6.3/1.6; *Isophya pienensis* Mařan, 1954: 39.6/29; ***Isophya stysi* Čejchan, 1957: 8.3/0**; *Leptophyes albovittata* (Kollar, 1833): 45.8/21; *Meconema thalassinum* (Degeer, 1773): 6.3/8.1; *Bicolorana bicolor* (Philippi, 1830): 22.9/12.9; *Metrioptera brachyptera* (Linnaeus, 1758): 18.8/19.4; *Roeseliana roeselii* (Hagenbach, 1822): 93.8/93.5; *Phaneroptera falcata* (Poda, 1761): 39.6/9.7; ***Pholidoptera aptera* (Fabricius, 1793): 0/1.6**; *Pholidoptera griseoaptera* (Degeer, 1773): 91.7/79; ***Pholidoptera transsylvanica* (Fischer, 1853): 50/0**; ***Platycleis grisea* (Fabricius, 1781): 10.4/0**; ***Poecilimon intermedius* (Fieber, 1853): 0/1.6; *Poecilimon schmidti* (Fieber, 1853): 10.4/0**; *Polysarcus denticauda* (Charpentier, 1825): 4.2/22.6; *Tettigonia cantans* (Fussli, 1775): 89.6/83.9; *Tettigonia viridissima* Linnaeus, 1758: 31.3/6.5; *Gryllus campestris* Linnaeus, 1758: 14.6/1.6; *Tetrix bipunctata* (Linnaeus, 1758): 2.1/2.7; ***Tetrix subulata* (Linnaeus, 1758): 0/9.7**; *Tetrix tenuicornis* Sahlberg, 1893: 12.5/6.5; *Tetrix tuerki* (Krauss, 1876): 4.2/4.8; *Tetrix undulata* (Sowerby, 1806): 4.2/3.2; ***Arcyptera fusca* (Pallas, 1773): 0/1.6**; *Chorthippus albomarginatus* (Degeer, 1773): 12.5/3.2; *Chorthippus apricarius* (Linnaeus, 1758): 79.2/71; *Chorthippus biguttulus* (Linnaeus, 1758): 54.2/35.5; *Chorthippus brunneus* (Thunberg, 1815): 45.8/16.1 ; *Chorthippus dorsatus* (Zetterstedt, 1821): 62.5/41.9; *Pseudochorthippus montanus* (Charpentier, 1825): 20.8/21; ***Chorthippus oschei* Helversen, 1985: 2.1/0**; *Pseudochorthippus parallelus* (Zetterstedt, 1821): 91.7/85.5; *Chorthippus pullus* (Phillipi, 1830): 2.1/4.8; ***Chorthippus tatrae* (Harz, 1971): 0/14.5**; *Chorthippus vagans* (Eversmann, 1848): 2.1/0; *Chrysochraon dispar* (Germar, 1834): 95.8/75.8; *Euthystira brachyptera* (Ocskay, 1826): 100/97; *Gomphocerippus rufus* (Linnaeus, 1758): 35.4/19.4; ***Mecostethus parapleurus* (Hagenbach, 1822): 4.2/0; *Miramella alpina* (Kollar, 1833): 0/1.6; *Oedipoda caerulescens* (Linnaeus, 1758): 2.1/0**; *Omocestus haemorrhoidalis* (Charpentier, 1825): 14.6/4.8; *Omocestus rufipes* (Zetterstedt, 1821): 4.2/12.9; *Omocestus viridulus* (Linnaeus, 1758): 45.8/75.8; ***Pseudopodisma nagyi* Galvagni et Fontana, 1996: 6.3/0**; ***Stenobothrus crassipes* (Charpentier, 1825): 0/1.6**; *Stenobothrus lineatus lineatus* (Panzer, 1796): 39.6/12.9; ***Stenobothrus stigmaticus* (Rambur, 1838): 0/1.6**; *Mantis religiosa* (Linnaeus, 1758): 2.1/1.6

Appendix 2. The sampling locations in Čergov Mts.

No.	Locality	Habitat characteristic	Adjacent forest	GPS		Altitude	
			B=broadleaved, C= coniferous, M=mixed, A=azonal	N	E	m a.s.l.	Sampling date
1	Muszyna (PL)	xeric forest steppe with mixed forest	M	49.3381	20.8981	470	23.07.2015
2	Dubne I (PL)	mezic grasslands in mixed forest	M	49.3139	20.9742	627	1.07.2016 + 21.07.2016 + 12.07.2017
3	Dubne II (PL)	mezic grasslands in mixed forest	M	49.3101	20.9819	660-680	12.07.2017
4	Leluchow (PL)	unmown meadows, mixed forest edges	M	49.3024	20.9347	579	21.07.2016 + 12.07.2017
5	Mlynská	gravel banks near the village	A	49.3178	21.0991	370	31.07.2013
6	Čirč- Manková 1	forest meadow in beech-spruce forest	C	49.2699	20.9755	780	01.07.2016
7	Čirč - Manková 2	mesic grassland in beech forest	B	49.2662	20.9771	730	1.07.2016 + 2.08.2017
8	Čirč - Soliská creek bank	gravel bank with Myricaria in beech forest	A	49.2645	20.9545	610-620	1.07.2016 + 2.08.2017
9	Slatina Šarišské Jastrabie	bog and wetland	A	49.2279	20.9043	570	30.07.2009
10	Bradlo range (Kyjov South)	xeroterm forest steppes	M	49.2073	20.9356	610	30.07.2009 + 28.09.2015
11	Ruská voľa nad Popradom	wet grassland and beech fir spruce forest edge	B	49.2883	20.9465	550-600	21.07.2016
12	Minčol Mt. top	grasslands on the mountain top	B	49.2345	20.9893	1100-1150	28.09.2015
13	Minčol Mt. SW	grasslands in beech forest SW of the top	B	49.2295	20.9934	1050-1120	28.09.2015
14	Minčol Mt. W	grasslands in beech forest W of the top	B	49.2298	20.9899	1035	28.09.2015
15	Sokolia dolina valleay 800	mezic grassland in beech forest	B	49.2209	20.9788	790-800	28.09.2015
16	Sokolia dolina valley 730	xeric edge of beech spruce forest	M	49.2185	20.9711	730	28.09.2015
17	Dvoriská	montane meadows in beech forest, Vaccinium	B	49.2205	21.0593	1020	31.07.2013
18	Čergov - sedlo Priehyby	montane meadows in beech forest	B	49.2149	21.0848	815-820	31.07.2013 + 14.07.2014 + 13.07.2017
19	Solisko - Veľká Javorina	montane meadows, moor in beec forest,	B	49.2130	21.1254	1000-1056	02.08.2017
20	Lukov	pastures in mixed forests	M	49.2892	21.0915	490	31.07.2013
21	Livov	edges of beech fir forest + pastures	B	49.2278	21.0840	650	31.07.2013
22	Livovská Huta 1	mezic meadow in beech forest	B	49.2503	21.0302	720	02.08.2017
23	Livovská Huta south	small meadow in beech spruce forest	M	49.2263	21.0244	818	13.07.2017
24	Livovská Huta north	small meadow in beech spruce forest	B	49.2541	21.0206	830	13.07.2017 + 2.08.2017
25	Kríže	grasslands (ski slopes) in mixed forest	M	49.2225	21.1640	600-700	12.07.2017

Appendix 2. (continued)

No.	Locality	Habitat characteristic	Adjacent forest	GPS		Altitude	
			B=broadleaved, C= coniferous, M=mixed, A =azonal	N	E	m a.s.l.	Sampling date
26	Hertník 1	ecotones of oak-pine forest and fields	M	49.2218	21.2334	450	31.07.2013
27	Hertník 2	small meadow in beech forest	B	49.2015	21.2058	640	12.07.2017
28	Richvaldská mokraď	wetland	A	49.2769	21.1748	395	31.07.2013 + 12.07.2017
29	Hervartov	grassland in beech fir forest ecotone	M	49.2477	21.1989	480	31.07.2013
30	Kamenica - East	xeroterm gravel steppe with bush	B	49.1937	20.9667	545	30.07.2009 + 28.09.2015
31	Kamenica - castle hill	xeric rocky meadows around castle	B	49.1961	20.9717	630-725	28.09.2015
32	Krivany 1	abandoned pastures, Juniper in pine forest edge	C	49.1825	20.9226	490	13.07.2017
33	Krivany 2	steep xeric pine forest steppe	C	49.1837	20.9175	490	13.07.2017
34	Lysá - ski slopes	montane grasslands and beech forest edges	B	49.1639	21.1396	1010-1040	30.07.2009 + 31.07.2013
35	Drienica	mezic grassland and beech forest edge	B	49.1275	21.1174	490	30.07.2009 + 31.07.2013
36	Majdan North	wet meadows in beech forest	B	49.2027	21.0830	554	14.07.2014 + 13.07.2017
37	Ľutina- South	xeric grassland in beech- larch forest	M	49.1699	21.0475	450	31.07.2013
38	Majdan - Ľutina	wet meadow in beech forest	B	49.1839	21.1404	690	13.07.2017
39	Ľutina - gravel bank	gravel bank with abandoned grassland	A	49.1722	21.0504	480	13.07.2017
40	Hanigovce	xeric meadows with juniper on limestone	B	49.1804	21.0165	590-620	13.07.2017
41	Hanigovce I	pasture along the pine forest edge	C	49.1549	21.0185	417	13.07.2017
42	Demjat. Kopce	xeric rocky grasslands along broadleved hedges	B	49.1122	21.2938	400	30.07.2009
43	Terňa - dolina Ternianky	old oorchards and edges of beech forest	B	49.1513	21.2042	540	12.07.2017
44	Závadka	pastures and edges of beech birch forest	B	49.1520	21.2294	660	12.07.2017
45	Fričkovce	grasslands on ski slopes and beech forest edge	B	49.1836	21.2292	550-580	12.07.2017
46	Hertník III	clearing and meadow in beech forest	B	49.1951	21.1891	730	12.07.2017
47	Čergov Mt. - saddle	montane grassland on ski slopes and beech forest edge	B	49.1776	21.1842	910-920	12.07.2017
48	Orlov-Andrejovka	gravel pits and willow growth edges	B	49.2893	20.9073	470	30.07.2013

Appendix 3. The sampling locations in Levočské vrchy Mts.

No.	Locality	Habitat characteristic	Adjacent forest	GPS		Altitude	
			B=broadleaved, C= coniferous, M=mixed, A=azonal	N	E	m a.s.l.	Sampling date
1	Kotník 650	clearings on the edge of beech spruce forest	M	49.2585	20.5917	650	29.07.2013
2	Kotník 880	meadow and pine spruce forest edge	C	49.2657	20.6091	880	29.07.2013
3	Bajerovce East	wet meadow in valley and spruce forest edge	C	49.2223	20.8127	620	30.06.2016
4	Ľubovnianske kúpele saddle	meadows on ski slopes in mmixed forest	M	49.2483	20.7335	680-700	01.07.2016
5	Jakubany forest meadow	montane wet meadow in spruce forest	C	49.2037	20.6804	730	01.07.2016
6	Jakubany gravel banks	gravel bank with Myricaria along Jakubianka creek	A	49.2249	20.6845	660	01.07.2016
7	Valalská voda Nature reserve	wetland and wet meadow with willov bush	A	49.2070	20.7895	680	15.06.2012
8	Ľubická dolina 720	wet meadow along the creek	A	49.1280	20.5198	720	14.07.2017
9	Ľubická dolina 760	grassland on spruce forest edge	C	49.1198	20.5411	760	29.07.2013 + 14.07.2017
10	Ľubická dolina 900	grassland on fir spruce forest edge	C	49.1177	20.5831	900	29.07.2013
11	Ihľany SE	ruderal grassland	C	49.1811	20.5494	710	14.07.2017
12	Pod Brezovcom	wet meadow in spruce forest crossroad	C	49.1664	20.6021	850	14.07.2017
13	Točňa	meadows in spruce forest edges	C	49.1706	20.6179	1090	14.07.2017
14	Derežová - Václavák ridge	montane ridge meadows and spruce forest edge	C	49.1534	20.6410	1190	14.07.2017
15	Javorina	montane meadows in spruce forest	C	49.1313	20.6342	1200	29.07.2013
16	Monument SNP	clearcuts in spruce forest with small meadow	C	49.1147	20.6164	1140	29.07.2013
17	Torysky - SW of Škapová	short grassland along spruce forest	C	49.1323	20.6427	1100	29.09.2015
18	Vinné (Torysky N)	short grassland along spruce forest	C	49.1293	20.6362	1150	29.09.2015
19	Škapová W	clearcuts and forest meadows in spruce forest	C	49.1317	20.6330	1200	29.09.2015
20	Jankovec	grasslands and bogs in spruce forest	C	49.1577	20.6523	1170-1190	29.09.2015
21	Tichý potok W Nižná Hrabina	southern pastures on mixed forest edge	M	49.1521	20.7745	570	30.06.2016
22	Hanigovská chata	meadow in beech larche spruce forest	M	49.1447	20.7026	720	30.06.2016
23	Škapová	clearcut in beech fir forest	M	49.1576	20.6790	820	30.06.2016
24	Piesočný vrch	montane meadow in spruce forest	C	49.1344	20.6383	1140-1156	30.06.2016
25	Trombitová	clearcuts and small meadows in spruce forest	IL	49.1344	20.6383	1200-1220	30.06.2016
26	Torysky S	wet meadows near Torysa river	M	49.0886	20.6837	780	15.06.2012
27	Čierna kopa S	montane meadows with Vaccinium in spruce forest	C	49.1848	20.7594	900-1100	15.06.2012 + 14.07.2017
28	Tichý potok - Blažov	meadows along Torysa river with broadleaved trees	B	49.1495	20.7614	565-570	30.07.2009
29	Tichý potok W, nad Blažovom	gravel banks along creek	A	49.1503	20.7400	630	15.06.2012 + 14.07.2017
31	Levoč. Vrchy1_pod Kuligura	montane meadows Calamagrostis in spruce forest	C	49.1859	20.7525	970-1100	15.06.2012 + 13.07.2017
30	Levoč. Vrchy2_ Kuligura	montane meadows Vaccinium in spruce forest	C	49.1907	20.7524	1100-1185	15.06.2012 + 13.07.2017

Appendix 3. (continued)

No.	Locality	Habitat characteristic	Adjacent forest	GPS		Altitude	
			B=broadleaved, C= coniferous, M=mixed, A =azonal	N	E	m a.s.l.	Sampling date
32	Levoč. vrchy3 beech forest	small meadows in beech forest	B	49.1811	20.7464	920-940	15.06.2012 + 13.07.2017
33	Levoč. vrchy4 _Stredný vrch S	wet meadow along creek in beech forest	B	49.1673	20.7497	720	15.06.2012 + 13.07.2017
34	Levoč. vrchy5 Kralovec	gravel banks of Torysa river	A	49.1499	20.7616	570	15.06.2012 + 13.07.2017
35	Kuligura-Kopa	edges of spruce forest with Vaccinium, Vaccinium	C	49.1932	20.7524	1145	20-21.07.2013
36	Spišské ridge	montane meadows along larch and spruce forest	C	49.1075	20.7700	1000-1020	29.09.2015
37	Nižný Slavkov N	meadows along willow growths	B	49.1089	20.8527	521	20-21.07.2013
38	Brezovička S	ruderalized meadows around the road	B	49.1201	20.8548	480	28.06.2013
39	Švábovská stráň Nature reserve	mesophilous hay meadow in spruce pine forest	C	49.0313	20.3807	620-650	29.07.2013 + 14.07.2014
40	Vrbovské mokrade wetland	wetland and wet meadows with willow	B	49.0750	20.4337	655	29.07.2013
41	Brinky	montane meadows in spruce forest	C	49.0996	20.6397	1055	29.09.2015
42	Uloža N	montane meadows in spruce forest	C	49.0509	20.6418	845	21.07.2016
43	Krúžok saddle, Uloža NW	montane meadows in spruce forest	C	49.0474	20.6588	962	15.06.2012 + 21.07.2016
44	Závada	mown meadows on ski slopes in mixed forest	M	49.0666	20.6580	865-900	29.09.2015
45	Levočské kúpele Spa	grassland in mixed forest	M	49.0683	20.5849	610	14.07.2017
46	Voliarňa	madow in beech oak forest	B	49.0667	20.5662	757	14.07.2017
47	Dvorce ridge	meadows in mixed forest	M	49.0720	20.5497	900	14.07.2017
48	Torysky - Nižné Repaše	meadows along larch spruce forest	C	49.0829	20.6924	780	30.06.2016
49	Olšavica - Brutovce	meadows and ruderals along fields	M	49.0873	20.7695	885	30.06.2016
50	Olšavica - Nižné Repaše	grasslands in spruce forest	C	49.0985	20.7237	730	30.07.2009
51	Paršivá - saddle	grasslands in saddle and spruce forest edge	C	49.0502	20.8263	837	13.07.2014
52	Bijacovce	pastures, meadows with juniper in mixed forests	M	49.0274	20.8076	594	13.07.2014
53	Lúčka - forest house	meadow in mixed forest	M	49.0471	20.7210	700	14.07.2017
54	Jablonov N	meadows along mixed oak pine spruce forest	M	49.0416	20.7123	720	14.07.2017
55	Jablonov N Vavrincov potok	wetland along mixed forest	M	49.0308	20.7010	580	14.07.2017
56	Jablonov I	xeric meadow and adjacent wetland	M	49.0222	20.6994	500	14.07.2017
57	Jablonov II	pastures along the creek near village	A	49.0203	20.7097	480	14.07.2017
58	Nižný Slavkov	banks of Kunišovský potok creek with Myricaria	A	49.0920	20.8232	530-570	13.07.2017
59	Petruška saddle	clearings and meadows in mixed forest	M	49.0541	20.8265	820	12.07.2017
60	Brezovica - Kamenná	mesic meadow with spring, abandoned fields	M	49.1245	20.8007	780	30.08.2017
61	Brezovica - Banská	mezic grassalnd in mixed forest	M	49.1192	20.8001	800	30.08.2017
62	Brezovica - Šľamov	montane meado on ridge in spruce forest	C	49.1124	20.7997	900	30.08.2017

Appendix 4. The Orthoptera samples in Čergov Mts. Semiquantitative abundance of species is presented: 1 – very rare (less than 3 adult specimens), 2 – rare (3–10 specimens), 3 – abundant (11–100 specimens), 4 – very abundant (more than 100 specimens).

Locality No.	*Barbitistes constrictus*	*Conocephalus fuscus*	*Decticus verrucivorus*	*Ephippiger ephippiger*	*Isophya campioxypha*	*Isophya kraussi*	*Isophya pienensis*	*Isophya stysi*	*Leptophyes albovittata*	*Meconema thalassinum*	*Bicolorana bicolor*	*Metrioptera brachyptera*	*Roeseliana roeselii*	*Phaneroptera falcata*	*Pholidoptera aptera*	*Pholidoptera griseoaptera*	*Pholidoptera transsylvanica*	*Platycleis grisea*	*Poecilimon intermedius*	*Poecilimon schmidti*	*Polysarcus denticauda*	*Tettigonia cantans*	*Tettigonia viridissima*	*Gryllus campestris*	*Tetrix bipunctata*	*Tetrix subulata*	*Tetrix tenuicornis*	*Tetrix tuerki*	*Tetrix undulata*	*Acrydtena fusca*	*Chorthippus albomarginatus*	*Chorthippus apricarius*	*Chorthippus biguttulus*	*Chorthippus brunneus*	*Chorthippus dorsatus*	*Pseudochorthippus montanus*	*Chorthippus oschei*	*Pseudochorthippus parallelus*	*Chorthippus pullus*	*Chorthippus tatrae*	*Chorthippus vagans*	*Chrysochraon dispar*	*Euthystira brachyptera*	*Gomphocerippus rufus*	*Mecostethus parapleurus*	*Miramella alpina*	*Oedipoda caerulescens*	*Omocestus haemorrhoidalis*	*Omocestus rufipes*	*Omocestus viridulus*	*Pseudopodisma nagyi*	*Stenobothrus crassipes*	*Stenobothrus lineatus*	*Stenobothrus stigmaticus*	*Mantis religiosa*	*Species number; total 55*
1			2						4				3	4		3						3	1														3															10
2	1		3									2	3	3		3	2					3		2							2				1		3				3	3						2				2				16
3			3						3	1		2	3			3	2					3		2			1				3				2		4				2	3						2				2				16
4			3										3	2								3									3	2	1	2			3				3	4	3													13
5			1						2				3	1		3						1					2				1	1		2							2	2	2						2							14
6							2						2			4	2					2													2							2	3						3							9
7			2				2						3			3	3					2													1		1				2	3						3							11
8			3				1		3				2			2						2	1				1	2			3	3	2	1			3	4			2	2						2							18
9			2								4		3	2							2	2								2	3	1	2	3	2		3				3	3										4				16
10			2						4		2		2	3		2		2						1								4	2	3	2		2				2	4					2				3				17
11			1										3				2					3									2	2		2		4				3	3						3							11
12												3	3			2																		1						3	3						3							7
13	1		2								1	3	2			1	2					1									2			2		2				3	3	2					3				3			16
14													1			2						1									1			1		1				1	3	2													9
15			1													2	1														2	2	2		1	2				1	2	3													11
16																2	2											1			2	2	1	2		3				1	3	2													11
17			3				3					4	3			4	4					4									3		3			4			2	3	3					2		4			1				16
18			4				3				2	2	4			4	3				3	3									3		2		1	4				3	4					1	1	4						18
19			3			1	2					3	3	1		3	4					3									4				1	4				3	4							3			1			16
20			4						3				2	3		3						2									2	2	2	1	2	4				2	3	2									2			16
21			4				2		3				2			2	2					2	1								2		2	2		3				3	3	2						3							16
22													2			3	2					2									3	2	1			2				2	3	2	1							3					13
23			2				2						1			3	2					3									3					2				1	2														10
24							2						3			3	3					2									3	2	1			3				2	3	3								2					13
25			3			1	1						3			3	3					3								2	1			2		3				2	3							2							14

Appendix 4. (continued)

Locality No.	*Barbitistes constrictus*	*Conocephalus fuscus*	*Decticus verrucivorus*	*Ephippiger ephippiger*	*Isophya camptoxypha*	*Isophya kraussi*	*Isophya pienensis*	*Isophya stysi*	*Leptophyes albovittata*	*Meconema thalassinum*	*Bicolorana bicolor*	*Metrioptera brachyptera*	*Roeseliana roeselii*	*Phaneroptera falcata*	*Pholidoptera aptera*	*Pholidoptera griseoaptera*	*Pholidoptera transsylvanica*	*Platycleis grisea*	*Poecilimon intermedius*	*Poecilimon schmidti*	*Polysarcus denticauda*	*Tettigonia cantans*	*Tettigonia viridissima*	*Gryllus campestris*	*Tetrix bipunctata*	*Tetrix subulata*	*Tetrix tenuicornis*	*Tetrix tuerki*	*Tetrix undulata*	*Arcyptera fusca*
26			4						2				4			2						2								
27													2			4	3			2		2								
28			1						3				3			3						2	1	1						
29			2						4				4	4		4	2			1		3								
30			3						3		2		2	2		2		1				2	1	1						
31			1								1					1		1				1								
32			1					1	3		2		4	2		2						2	2							
33			3				1	1	3		2		3	3		3		1				2	1							
34	1		3				3					4	2			2	3					3								
35			3				1		2		2		2	2		2	2					2	1	2			1			
36			1				1						2			3	3					2	1						1	
37			2						4				3	3		4						3	1							
38	1		3				2						3			4	2					3								
39			2				1		3				2			2						2								
40		1	2				2	1	3			2	3	3		2						2	2	2						
41									2				2	2		2						2								
42			3						3		4		3	2		2		2					1							
43	1		3					1	4				4	3		4				2		3	2		2		2			
44	1		3						3	2	3		3			3						3	2				1			
45			3			3	1		3				3	2		3				2		3	2							
46													2			4	3			2		2								
47	1		3				2			2			3			4	3					3	2							
48													1															2		
absolute frequency F	7	1	38	0	0	3	19	4	22	3	11	9	45	19	0	44	24	5	0	5	2	43	15	7	1	0	6	2	2	0
relative frequency F%	15	2	79	0	0	6	40	8	46	6	23	19	94	40	0	92	50	10	0	10	4	90	31	15	2	0	13	4	4	0

Locality No.	*Chorthippus albomarginatus*	*Chorthippus apricarius*	*Chorthippus biguttulus*	*Chorthippus brunneus*	*Chorthippus dorsatus*	*Pseudochorthippus montanus*	*Chorthippus oschei*	*Pseudochorthippus parallelus*	*Chorthippus pullus*	*Chorthippus tatrae*	*Chorthippus vagans*	*Chrysochraon dispar*	*Euthystira brachyptera*	*Gomphocerippus rufus*	*Mecostethus parapleurus*	*Miramella alpina*	*Oedipoda caerulescens*	*Omocestus haemorrhoidalis*	*Omocestus rufipes*	*Omocestus viridulus*	*Pseudopodisma nagyi*	*Stenobothrus crassipes*	*Stenobothrus lineatus*	*Stenobothrus stigmaticus*	*Mantis religiosa*	*Species number; total 55*
26	3	2	1		4		1	4				3	3	2											1	15
27								3				2	2													8
28		2	1		2	1		3				3	3	2												15
29		2	2	1	1			3				4	4	4												16
30	2	4	2	2	2			4				2	3					1					2			20
31		2	3	3	3			3				1	3	1				3								14
32		2						4				2	4										2			14
33		2	1		1			3				3	3										3			18
34		3	2	2	2			4				2	4							4	4		2			18
35	2	3	2		2			4				2	3	3						2			3			22
36		2	1		2			3				2	2													14
37		2	2	2	3			3				2	4	2						1						16
38		2				2		3				3	3							1						13
39			4	3								2	3					2								11
40		3	1		3			3				3	3							2			2			20
41		3	3		2			3				2	3										2			12
42	2	4	3	2	3			3				1	3				2						3			18
43		2			2			4				3	3	3	1					2			3			21
44			1	2	1			4				2	3					3					2			18
45		1			2			4				2	3						1	3			2			18
46								3				2	2													8
47								3				3	3							2						13
48			2	2				2					1													6
absolute frequency F	6	38	26	22	30	10	1	44	1	0	1	46	48	17	2	0	1	7	2	22	3	0	19	0	1	14,3
relative frequency F%	13	79	54	46	63	21	2	92	2	0	2	96	100	35	4	0	2	15	4	46	6	0	40	0	2	3,76

Appendix 5. The Orthoptera samples in Levočské vrchy Mts. Semiquantitative abundance of species is presented: 1 – very rare (less than 3 adult specimens), 2 – rare (3–10 specimens), 3 – abundant (11–100 specimens), 4 – very abundant (more than 100 specimens).

Locality No.	*Barbitistes constrictus*	*Conocephalus fuscus*	*Decticus verrucivorus*	*Ephippiger ephippiger*	*Isophya camptoxypha*	*Isophya kraussi*	*Isophya pienensis*	*Isophya stysi*	*Leptophyes albovittata*	*Meconema thalassinum*	*Bicolorana bicolor*	*Metrioptera brachyptera*	*Roeseliana roeselii*	*Phaneroptera falcata*	*Pholidoptera aptera*	*Pholidoptera griseoaptera*	*Pholidoptera transsylvanica*	*Platycleis grisea*	*Poecilimon intermedius*	*Poecilimon schmidti*	*Polysarcus denticauda*	*Tettigonia cantans*	*Tettigonia viridissima*	*Gryllus campestris*	*Tetrix bipunctata*	*Tetrix subulata*	*Tetrix tenuicornis*	*Tetrix tuerki*	*Tetrix undulata*	*Arcyptera fusca*	*Chorthippus albomarginatus*	*Chorthippus apricarius*	*Chorthippus biguttulus*	*Chorthippus brunneus*	*Chorthippus dorsatus*	*Pseudochorthippus montanus*	*Chorthippus oschei*	*Pseudochorthippus parallelus*	*Chorthippus pullus*	*Chorthippus tatrae*	*Chorthippus vagans*	*Chrysochraon dispar*	*Euthystira brachyptera*	*Gomphocerippus rufus*	*Mecostethus parapleurus*	*Miramella alpina*	*Oedipoda caerulescens*	*Omocestus haemorrhoidalis*	*Omocestus rufipes*	*Omocestus viridulus*	*Pseudopodisma nagyi*	*Stenobothrus crassipes*	*Stenobothrus lineatus*	*Stenobothrus stigmaticus*	*Mantis religiosa*	*Species number; total 55*
1	1		1										3			3						4									3							2				1	3	4						3	3						14
2													3			2						3									3				1								3						2	3						9
3			1										4			3						3									2						2				2	4						4						9
4			2							1	2		4			3					2	4				1										2				3	4						4						12
5										1			3			2						2				2									2				2	4						4						9
6													2			2						2				2		2										3	2						3						9
7			2								1	2	4	2		3					3	2	2								2	2		3	2		3				2	4						4						17
8													3			3						3								2	3			2		3				3	3						2						11
9					2		1						4			2						4									4	2	1	2	2		3		1		3	4	2					3	3						17
10													3			3					1	2								1	4		1	4			3		3		3	4	2				1	1	4						16
11													3			1						2									3			2			2				3	3						3						9
12													3			4						2									3						2		1		3	3						4						9
13					2								3			3						1									3						2				1	3						3						9
14			1										3			2						1									3						2		1			3						3						9
15			1		2		2						3			2						2									3						2				2	4					2	4						12
16													3			2						4									3						2		1		1	4	1				1	4						11
17													1			1															3	2					1				1	3	2					2						9
18													1																		2	2					2					3	3											6
19													1																		2	1					2				1	3	2											7
20													1																		2				2		2					2	1											6
21			3			1		3	1					4		3						4									3	1	1		2		4				3	3	1											15
22			2			1							4			3					2	3															3				3	4						2						10
23				2		2										4						2						2			2					2		3		1	3						3						11
24	1			2		2					3	3				3					2																			2	4						4						10
25			1	2									3			3					1	1									2		1					2			2	4						4						12
26			1										2			3						2									2					2					2	2						2						9
27				3									3		1	4					2	3			2	2		2				1										4						3						12
28			2					2					3									3			2						3	1	3	2		4				2	3					1	3			2			15
29																											2					1					3										1			4
31			2			3				2	3	4				4					3	4							2		3					3					4						4			2	1		15
30			2	3		2					3	2				3						2														1					4					1	4						11
32						3							3			3						3														2				2	4						3						8

Appendix 5. (continued)

Locality No.	*Barbitistes constrictus*	*Conocephalus fuscus*	*Decticus verrucivorus*	*Ephippiger ephippiger*	*Isophya camptoxypha*	*Isophya kraussi*	*Isophya pienensis*	*Isophya stysi*	*Leptophyes albovittata*	*Meconema thalassinum*	*Bicolorana bicolor*	*Metrioptera brachyptera*	*Roeseliana roeselii*	*Phaneroptera falcata*	*Pholidoptera aptera*	*Pholidoptera griseoaptera*	*Pholidoptera transsylvanica*	*Platycleis grisea*	*Poecilimon intermedius*	*Poecilimon schmidti*	*Polysarcus denticauda*	*Tettigonia cantans*	*Tettigonia viridissima*	*Gryllus campestris*	*Tetrix bipunctata*	*Tetrix subulata*	*Tetrix tenuicornis*	*Tetrix tuerki*	*Tetrix undulata*	*Arcyptera fusca*	*Chorthippus albomarginatus*	*Chorthippus apricarius*	*Chorthippus biguttulus*	*Chorthippus brunneus*	*Chorthippus dorsatus*	*Pseudochorthippus montanus*	*Chorthippus oschei*	*Pseudochorthippus parallelus*	*Chorthippus pullus*	*Chorthippus tatrae*	*Chorthippus vagans*	*Chrysochraon dispar*	*Euthystira brachyptera*	*Gomphocerippus rufus*	*Mecostethus parapleurus*	*Miramella alpina*	*Oedipoda caerulescens*	*Omocestus haemorrhoidalis*	*Omocestus rufipes*	*Omocestus viridulus*	*Pseudopodisma nagyi*	*Stenobothrus crassipes*	*Stenobothrus lineatus*	*Stenobothrus stigmaticus*	*Mantis religiosa*	*Species number; total 55*
33			1		1		3		3				4			3						4									2																							12
34			1						3				2	1		2						2			3	2	2	2			4	2	2			3	3					2													16
35	1		4								1	2	2			2																				4					1	4			2			4						11
36													2			2						2									1	3		2	4		4																		8
37			4										1								3	2																			4														5
38			2						1				3								4						1				3			3							3														9
39			3								4	4	4			1			1			1	3								2	2	3	1	2		3				3	4					3			2			18
40			1										3										3											1	2		3				3	4												8
41			1										1																		2						3					2	2											7
42			2		1							1	3								2	3									4	2		1			4				3	4					3						13
43			2		1							1	3			3					3	3									4	2		1			4				3	4					3						14
44			1									2	2									1															3				3	3					1						8
45	2						2						2			3						2									3						3					2											8
46			2		2		2		2				3			4						2			1						3			2			3		2		2	3					2						15
47	2		2		2		2		2				3			4						3			1						3			2			3		2		2	3					4						16
48			1										3			3						2									3			1			3				1	3					1						10
49			2																		3	2									2			1			2				1	3											8
50			3				1					3	3			1						3									4	2	2	3	2		3				2	3					2			2			16
51			3			1	2						3			2						3									4						3				3	4					4						11
52	1		2	2			2		3	1	2		3			3						2	1								3	2		2			3				2	3	2							2			19
53							1			1			3			3						2															4					2					2						8
54			2		2		2		3				3	2		3						2		1										2			4				2	3					2						14
55			1						3				4			3						3																			4	3					4						8
56			2						3		2		2			3					1	2									3	3	2	3	1		2				2	2							3				16
57			3						2		2		3	2		2						2			1		2				2	2	2	2			3				2	2					2			2			18
58			2						3				4	3		3						3					1				3	1		3			4				3	4					3			1			15
59			3										4			3						2				1					4			3			4				1	3				1	4						12
60			1										2			1						3										1			3			2				1	2	2					2						11
61												1	2			1						2										1						2				1	1					2						10
62			1									1	2									2									1	3					2				2	2					3				1	1	11
absolute frequency F	6	0	39	1	14	1	18	0	13	5	8	12	58	6	1	49	0	0	1	0	14	52	4	1	6	6	4	3	2	1	2	44	22	10	26	13	0	53	3	9	0	47	60	12	0	1	0	3	8	47	0	1	8	1	1	11,3
relative frequency F%	10	0	63	2	23	2	29	0	21	8	13	19	94	10	2	79	0	0	2	0	23	84	6	2	10	10	6	5	3	2	3	71	35	16	42	21	0	85	5	15	0	76	97	19	0	2	0	5	13	76	0	2	13	2	2	3,61