SEASONAL ACTIVITY OF TWO GROUND DWELLING ARTHROPOD GROUPS AT FOREST STANDS UNDER DIFFERENT MANAGEMENT REGIMES AT THE LOCALITY BÁB (SW SLOVAKIA): THE ANALYSIS OF PRELIMINARY RESULTS AND SOME SUGGESTION FOR LONG-TERM ECOLOGICAL RESEARCH

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The data derived from long-term ecological studies are highly valuable for understanding, assessment and detection of environmental changes and their causes. The study site Báb National Nature Reserve has a long history of detailed ecological research despite the intensity and continuity of the research activities changed during time. From 2007 the intensive ecological research was renewed, and, our research project devoted to assessment of environmental changes continues in these activities. During 2014, we started the intensive research study of ground dwelling arthropods using the method of pitfall traps. The traps were placed at four study plots, representing forest and also clear cut stands, and were emptied weekly from beginning April to the half October. During our study 6300 specimens belonging to 83 spiders species, and 3616 specimens belonging to 53 Carabidae species were captured in 52 pitfall traps. Most of the species performed lower level of species dominance. Pardosa alacris and Urocoras longispinus were the spider species eudominant at both forest stand study plots, whereas Pardosa alacris with Pardosa lugubris were eudominant at clear cut plots. Between ground beetles, Abax parallelepipedus and Carabus ullrichii were eudominant at all study plots. Seasonal activity of both studied arthropod groups was the most intensive during April and May and after summer decrease continued less intensively from half August through September. The same pattern of seasonal activity was recorded when this activity was analysed using only records of eudominant and dominant species. This suggest, that the data from few the most dominant species could be satisfactory for evaluating the seasonal activity of the two arthropod groups. The suggestion is crucial for future continual long term ecological studies. The analysis of our preliminary results also indicate that the choice of study plots could cover overall seasonal activityof this arthropod including seasonal migration between forest and adjacent stands.

Keywords: Araneae, Carabidae, seasonal activity, phenology, forest, clear -cut stand, pitfall traps, Slovakia

INTRODUCTION

Báb research site is a part of National LTER networks that is organizational structure of LTER-Europe (http://www.lter-europe.net/). The site was established in 1967 in framework of the International Biological Programme (IBP) and the research started in the IBP (1967-1970) and UNESCO Man and Biosphere (1971-1974) projects. The intensive research activities were carried out until 1974 (Biskupický, 1975). After complex and intensive ecosystem research in 1967-1974, the research continued in restricted extent done by individual researchers. More complex research was re-established in 2007, when the series of research projects devoted to forest ecosystem changes assessment.

Ground dwelling invertebrates such as carabid beetles and spiders are often surveyed with respect of ecosystem changes. These invertebrates have strong potential as ecological indicators as they are readily surveyed in sufficient numbers for meaningful conclusions to be drawn, have a stable taxonomy and, at least in the case of ground beetles, are readily identified. They are, for example, good local scale indicators of ecosystem disturbance in forested landscapes at both the short and long time scales, responding to both clearcut logging and fire differently (Pearce, Venier, 2006). Carabid beetles are one of the most worthwhile model groups for biological studies The reasons are diverse: relatively stable taxonomy, high species richness, occurrence in most terrestrial environments and geographical areas, the availability of easy collection methods, known sensitivity to environmental changes etc. (Kotze at al., 2011). We can consider the same as true for spiders too.

The aim of the paper is to estimate the seasonal activity of spiders (*Araneae*) and ground beetles (*Carabidae*), and comparing with selected ecological parameters of the two species assemblages outline possible suggestions for effective long-term ecological research.

MATERIALS AND METHODS

The study was carried out at the Báb Research Site, situated approximately 15 km from Nitra city (SW Slovakia). The forest is a rest of former climax woodland covered lowlands and hill areas of the Nitrianska pahorkatina. The deciduous oak hornbeam forest of 66 ha is partly preserved as natural reserve and rest forest area is managed (Eliáš, 2010).

Four 20x20 m^2study plots were chosen at the locality. Two plots were representing clear cut stands. The timber harvesting was made in autumn 2006; the area was than cleaned up from brushwoodbeginning 2007. The plot R1 was representing clear cut stand over-growed with shrub and young tree vegetation (*Acer campestre, Crataegus laevigata, Carpinus betulus, Rosa canina, Quercus cerris, Q. petrea, etc.)*. Plot R2 was representing another clear cut stand but mostly covered by herbal vegetation with few young individuals of *Ailanthus glandulosa*. During the season the plot was gradually overgrowing with *Sambucus ebulus*. Other two plots, L1 and L2, were representing forest stands. L1 plot was representing more or less natural forest stand with established shrub and herb layers. At L2 study plot the shrub layer was absent and herb layer was also scarce; and it was situated near vicinity the clear cut stand R2 for the purpose of arthropod migration study. Arthropods were collected using the method of pitfall traps (180ml plastic cups buried in the soil and filled with vinegar as killing and preserving substance). Thirteen traps were installed at each study plot. The catches were removed weekly from beginning April to the end of October during 2014. The total numbers of *Araneae* and *Carabidae* individuals were counted for every individual study plot and individual dates. These data were the base for seasonal activity description of the two arthropod groups. To analyze the dominance structure of the two arthropod communities, the species dominance was calculated as percentage of the individuals of given species in the sample;

$$D_i = \frac{n_i}{N} \cdot 100\%$$

where $\boldsymbol{n_i}$ represents abundance of species $\boldsymbol{i}$; and $\boldsymbol{N}$ represents total abundance in sample. The species were then sorted according Tischler´s scale for species dominance (Tischler, 1949):

E	eudominant	$10\% \leq D_i \geq 100\%$
D	dominant	$5\% \leq D_i < 10\%$
Sd	subdominant	$2\% \leq D_i < 5\%$
R	recedent	$1\% \leq D_i < 2\%$
Sr	subrecedent	$0\% < D_i < 1\%$

To compare species composition of the observed arthropod communities at the four study plots, Sørensen´s similarity index (So) was applied and it was calculated according the following formula;

$$So = \frac{2c}{a+b} \cdot 100$$

where $\boldsymbol{a}$, $\boldsymbol{b}$ are the numbers of species in the two compared communities, $\boldsymbol{c}$ the number of shared species (Sørrensen, 1948). Phenology data were processed only for spider species when data were substantial for some phenological conclusions.
The meteorological data were derived from online meteorological data available at web page AMET - sdružení Litschmann & Suchý (www.amet.cz).

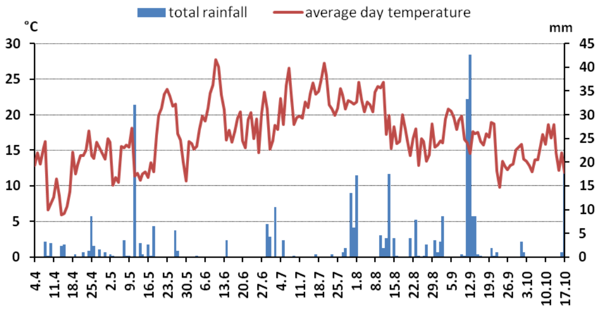

Figure 1 The average day temperature (*y1* axis) and total rainfall (*y2* axis) recorded from April to October 2014 at the locality Báb.

RESULTS

During the study period altogether 6300 spider specimens belonging to 83 species and 3616 ground beetles specimens belonging to 53 species were captured.

As concerning spiders, the highest species richness was observed at the clear cut stands (R1, R2 study plots), where 58 spider species were recorded. At these two study plots the highest number of specimens were also caught (2038 and 2010 individuals). At the forest study plots, less species and almost half less individuals of spiders were captured; 44 species and 971 specimens for L1 study plots; and 52 species and 1287 individuals for L2 study plot. The higher species number was also recorded at clear cut study plots in case of ground beetles (44 and 33 for R1 and R2 study plots) comparing with forest stand plots (27 and 29 for L1 and L2 study plots). Despite, almost twice more individuals was recorded at L1 study plot (982) and threefold more at L2 plot (1555) comparing with clear stand study plots (536 and 543 at R1 and R2 study plots).

Dominance structure

Dominance structure was analysed only for adult forms, both for spider as for ground beetles. The index of species dominance (%) for eudominant and dominant species is given in table 1.

Araneae. *Pardosa alacris* and *P. lugubris* are closely related species of the *P. lugubris* s.l. group and because of high morphological similarity of their females, the determination of females and juveniles was done on species complex level as *Pardosa alacris/lugubris*. The number of females was than divided between the two *Pardosa* species according the males numbers ratio. *Pardosa alacris* and *Urocoras longispinus* were eudominant at both forest stand study plots. *Tenuiphantes flavipes* was another eudominant spider species at study plot L1, and two spider species were dominant at this study plot: *Ozyptila praticola* and *Trochosa terricola*. At study plot L2, *Pardosa lugubris* was another eudominant species; *Tenuiphantes flavipes* and *Diplocephalus picinus* being the dominant spider species. At clear cut stands, *P. alacris;* and *P. lugubris* were the eudominant; and *Diplostyla concolor* dominant spider species.

Table 1 Eudominant and dominant spider (*Araneae*) and ground beetles (*Carabidae*) species observed during 2014 at Bab Research Site at four study plots (L1, L2 forest stands; R1, R2 clear cut stands). (If the number is not given the species belonged to lower species dominance level)

	Index of species dominance (%)			
Carabidae	L1	L2	R1	R2
Abax parallelepipedus	29.1	19.9	18.2	31.7
Anchomenus dorsalis			6.2	
Bembidion sp.				5.7
Carabus coriaceus	6.3	5		
Carabus nemoralis		5.3		
Carabus scheidleri				7.6
Carabus ulrichii	18.4	16.3	12.1	27.3
Harpalus atratus			7.3	6.5
Leistus ferrugineus			6	
Leistus rufomarginatus	6.4			
Molops piceus			5	12.7
Notiophilus rufipes	7.13			
Pterostichus melas		25.4		5.12
Trechus quadristriatus	7.7		5.2	
Araneae				
Urocoras longispinus	14.6	14.7		
Diplocephalus picinus		5.6		
Diplostyla concolor			7.6	7.6
Tenuiphantes flavipes	33.2	8.9		
Ozyptila praticola	6.5			
Pardosa alacris	11.5	26.4	34.8	19.4
Pardosa lugubris		17	35	53
Trochosa terricola	5.3			

Carabidae. *Abax parallelepipedus* and *Carabus ulrichii* were two ground beetles species eudominant at all four study plots. Other eudominant species were *Molops piceus* at R2 study plot, and *Pterostichus melas* at L2 study plot. Comparing with spider species assemblage, the group of dominant ground beetles species was relatively numerous: *Carabus coriaceus*, *C. nemoralis*, *C. scheidleri*, *Trechus quadristriatus*, *Leistus ferrugineus*, *L. rufomarginatus*, *Harpalus atratus*, *Notiophilus rufipes*, *Anchomenus dorsalis* and *Bembidion sp*. (tab 1)

Species composition comparison

According Sørensen´s similarity index, the spider species composition was the closest between two clear-cut stands study plots, achieving the value 78.43% (tab 2), and the lowest value of similarity was stated for two forest stand study plots. In case of ground beetles, the similarity was the highest comparing species composition between two forest stand species (82.14%); and the lowest between R1 clear-cut stand and L1 forest stand plots (tab 2)

Table 2 Sørrensen´s similarity index comparing spider (*Araneae*) and ground beetles (*Carabidae*) species assemblages between two forest stand (L1, L2) and clear-cut stand (R1, R2) study plots observed at 2014 research period at the locality Bab Research Site.

		R2	L1	L2
Araneae				
	R1	78.43%	63.74%	61.86%
	R2		61.54%	61.86%
	L1			60.47%
Carabidae				
	R1	77.92%	56.34%	63.01%
	R2		73.33%	77.42%
	L1			82.14%

Seasonal activity

Both studied arthropod groups were already active from beginning April; from half April rapid increase in arthropod numbers were recorded. The numbers were remaining high during May with gradual decrease from the end of May. The activity was relatively damped through July, beginning August. The activity slightly increased from half August through first half of September.

The text above describes the seasonal activity of both studied arthropod groups in general at the research site. But we can remark the differences when comparing the two arthropod groups and also different stands and study plots.

The peak of activity was recorded earlier in case of ground beetles; on 25th April at the clear-cut stand plots, and on 2nd May at forest stand plots (fig 2). However, the spiders peak of activity became evident in the end of May for clear-cut stand plot R1 (23rd May) and forest stand plot L1 (30th of May). Although the peak of abundance at L2 clear-cut stand plot was recorded already 25th April, 30th of May there were still high numbers of spiders recorded (fig 2). Similarly, at the R2 clear-cut stand plot, the peak of activity was recorded on 9 of May, but on 23rd May the high number of spider individuals were still recorded. Ground beetles were not performed such summer damp of activity and they stay more or less active through whole season. As concerning *Carabidae*, the date 18th July was interesting – we could observe decreasing activity on clear-cut stand plots (R1, R2) and increasing numbers on forest stand plots (L1, L2). This phenomenon was obvious especially in the case of the research plots R2 and L2 being in near vicinity each other. We could state, that the phenomenon was caused by seasonal ground beetles migration to forest.

Phenology

Phenology is presented only for three spider species. The data on particular forms of *Tenuiphantes flavipes* on forest stand study plot L1; *Pardosa alacris* and *P. lugubris* on forest study plot L2 and both clear-cut stand plots (R1, R2), were substantialy complete to create graph (fig 2). Both *Pardosa* species showed similar pattern of phenology: males were active through shorter period from beginning April to the end of June with maximum of activity occuring on May; females were active to the end of August performing peak of activity a month later, approximately. The peak of activity of juvenile forms coincided with the peak of female activity of the two above mentioned spider species. *Tenuiphantes flavipes* showed different pattern of phenology: the males were active during the major part of study period, from the end of April to September; the activity of females continued to the end of study period (half October). The male and female activity of *T. flavipes* seem to have two peaks of activity – during second half of June and in the end of August, the peaks of both forms occured at the same time. The juvenile forms were the most numerous during second half of August.

DISCUSSION

Our study is a part of research project that connects on the re-started research activities at Báb Research Site. As concerning history of research at the site, spider communities (Žitňanská 1970, 1973, 1981) and also carabid communities (Drdul 1970, 1972) were studied in detail during complex ecosystem research. The research of spider has been restored in 2007-2009 (Gajdoš 2010). During last decade Cunev, Šiška (2006) and Majzlan (2010) have studied beetle fauna of Báb including also carabids.

Two eudominant spider species, *Pardosa alacris* and *Pardosa lugubris,* belongs to the most frequent and widespread species in Europe (www.araneae.unibe.ch). *P. lugubris* is a euryvalent forest species that often occurs on the habitat edging forests or open areas; *P. alacris* occurs mainly in deciduous forest. This species was recorded being eudominant at the same locality during 2007-2009, the species *P. lugubris* was not recorded (Gajdoš, 2010). *Urocoras longispinus* was eudominant species in forest stand plots; the same dominance status for this species was recorded in former research study (Gajdoš, 2010). The species is known only from few European countries (www.araneae.unibe.ch). The same level of species dominance was recorded in 2007-2009 in case of *Diplostyla concolor. Tenuiphantes flavipes,* the species dominant or even eudominant at the forest stand plots, there were stated as subdominant during 2007-2009 study. *Trochosa terricola* is nocturnal species, and during former study performed higher level of species dominance comparing to our study (Gajdoš, 2010)

Diplocephalus picinus and *Ozyptila praticola* are also frequent spider species (www.araneae.unibe.ch.); both having lower level of dominance during former research (Gajdoš, 2010) comparing to our results.

The group of the most dominant species was richer in case of *Carabidae*, comparing with spiders, comprising fourteen species (tab 1). In 2007-2008 study period, *Carabus scheidleri*, *C. coriaceus* and *C. ulrichii* were recorded as dominant species; *Abax parallelepipedus*, *Anchomenus dorsali*s, *Leistus rufomarginatus*, *Molops piceus* and *C. nemoralis* were recorded as having lower degree of dominance during former study (Majzlan, 2010) comparing with our results. However, the methods used in former period at the Bab Research Site were not absolutely identical; there is an advantage of approximate comparison, at least.

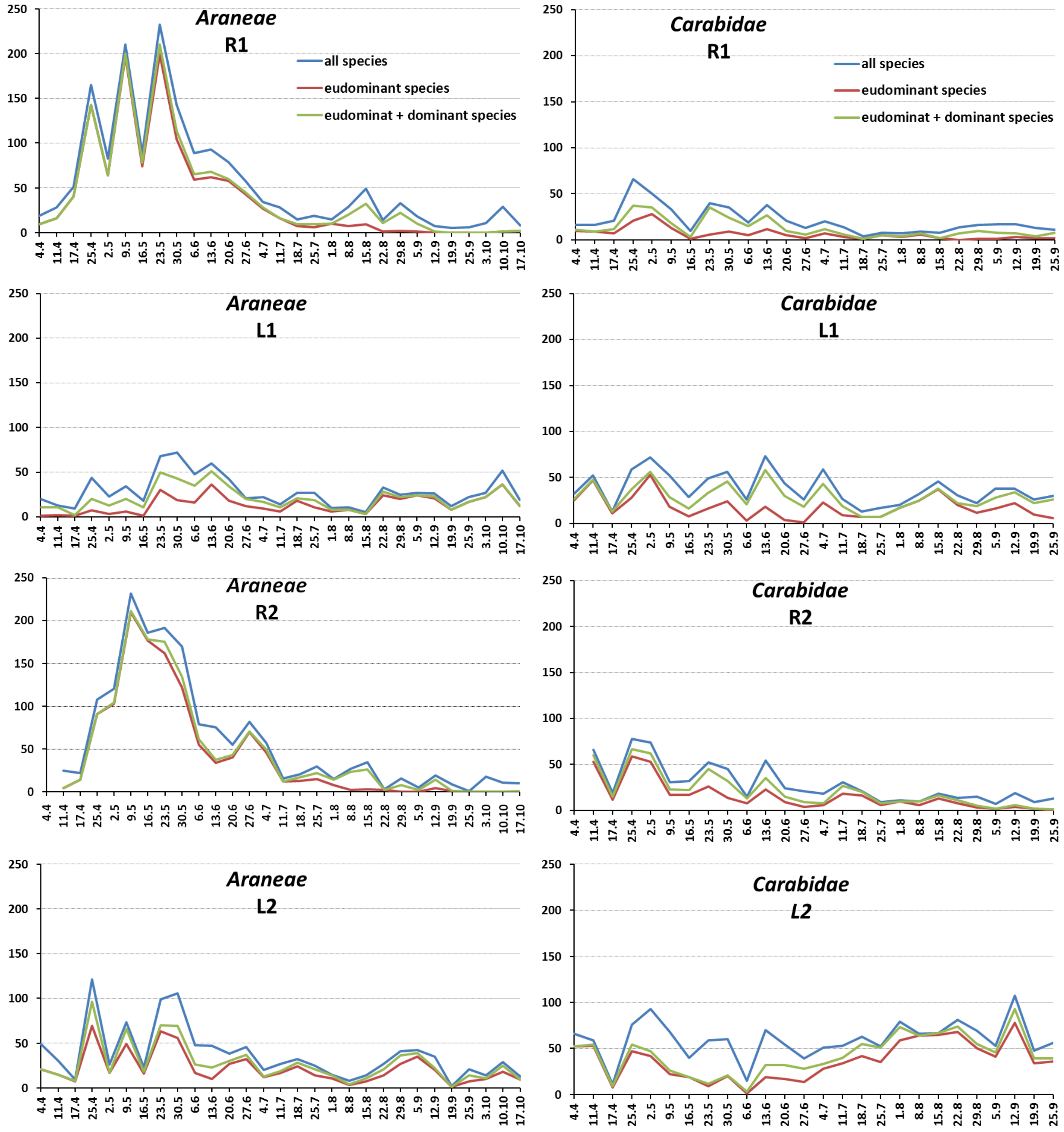

Figure 2 The seasonal activity of spiders (*Araneae*) and ground beetles (*Carabidae*) during 2014 at the locality Báb Research Site. The *y* axis shows the total individuals of the two arthropod groups caught in pitfall traps at four study plots (R1, R2 – clear-cut stands; L1, L2 – forest stands) at given date

We can see several obvious more or less sudden decreases in number of individuals on the curves describing seasonal activity of both arthropod groups (fig 2). The first one was recorded on 17th April in case of forest stand plots and clear-cut stand R2. The week before that day, average day temperature decreased under level 10°C (fig 1); few successive cold days probably negatively influenced the activity. Other two incidences of decrease (2nd and 16th May) were caused by heavy rain occurrence (fig 1); many traps were full up of water and thus out of function. Another decrease, occurring from 30th May to 6th June, was caused by lower nocturnal temperatures during four successive days, when during almost whole night the temperature was remaining around 10° - 11°C (even less in some cases). Thus, the activity of nocturnal species was negatively influenced. The same situation occurred few days after 13th June, but the length of period during night with low temperature lasted shorter. The summer decrease in activity with the restart at the beginning autumn – this aspect is known for many temporal arthropods.

Phenology - the timing of seasonal activities of animals and plants - is perhaps the simplest process in which to track changes in the ecology of species in response to climate change. Responses by individual species to climate change may disrupt their interactions with others at the same or adjacent trophic levels. When closely interacting or competing species display divergent responses or susceptibilities to change, the outcome of their interactions may be altered, as long-term data on both terrestrial and marine organisms indicate. We might expect, therefore, that rapid climatic change or extreme climatic events can alter community composition (Walther et al, 2002). Climate driven phenological changes on higher trophic levels (i.e. secondary consumers) are slower than at lower trophic levels (with the exception of woody plant species), making the former especially vulnerable to phenological decoupling (Thackeray et al., 2010).

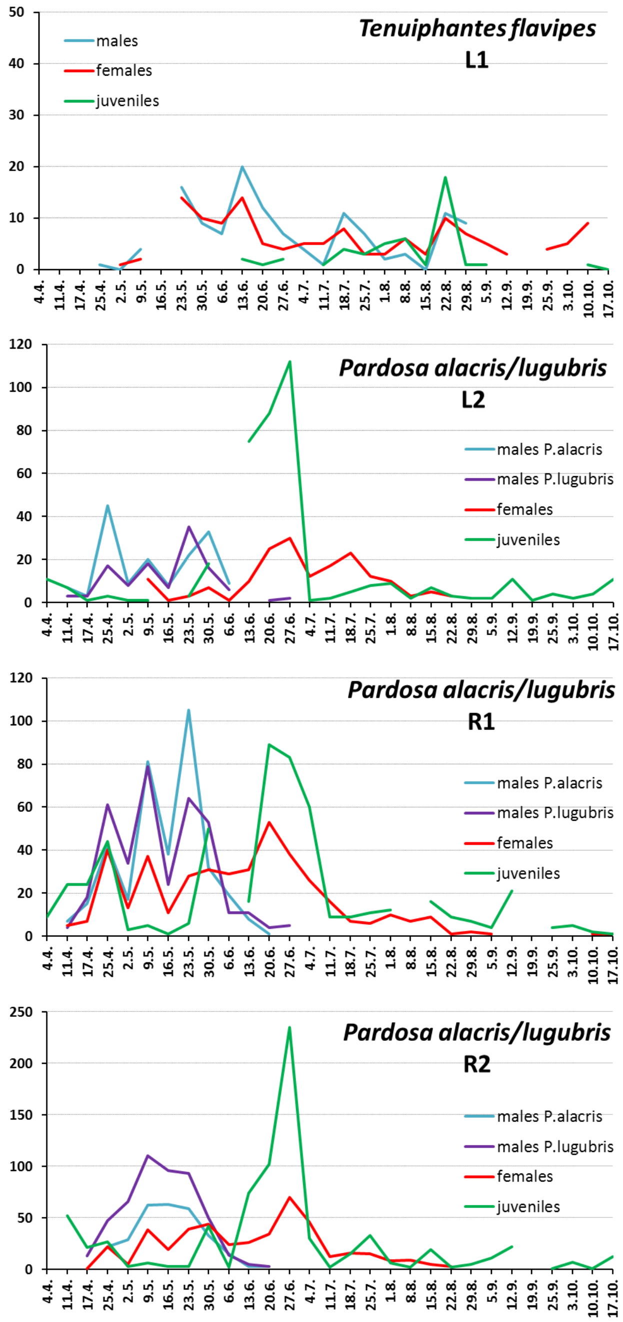

Figure 2 The phenology of two spider species during 2014 at the locality Báb Research Site. The *y* axis shows the total individuals of given forms (males, females, juveniles) caught in pitfall traps at four study plots (R1, R2, L1, L2). Because of the high similarity in morphology the females and juvenile forms of *Pardosa alacris* and *P. lugubris* were determinated as species complex *Pardosa alacris/lugubris*.

There are very few long-term phenological data sets for spiders in central Europe, and such information is needed to understand the effect of global change on these important predators. Ballooning phenology of spider species is only weakly affected by meteorological conditions, except in the case of extreme events; however, ground-living species decreased during the study period. This negative trend can be attributed to some degree to climatic effects, as well as to habitat loss. (Blandenier et al., 2014). Habitat is important factor influencing species richeness and also seasonal activity of arthropods. Šustek (2007) compared carabid assemblages changes after wind desaster in 2004 in High Tatras region. He stated, that wind desaster did not affected species composition as such; it resulted only in considerable decrease of abundance of individual species. The much more destructive factor was the removing the laying timber from major part of area, resulting in damaging litter and upper layer of soil where the forest *Carabidae* develop and search for cover (Šustek, 2007).

Our consideration for future research concept is directed to regular long-term ecological studies. From this point of view there is no possible/effective conduct our future activities in such broad manner as currently. Research continuity maintenance will be possible only when lesser species are studied in detail and lesser variables is observed. As concerning the species – we could for example take in account only the most dominant species. As we can see on Figure 2, the pattern of seasonal activity of eudominant and dominant species was very similar comparing to all species seasonal activity curve (fig 2). The phenological data were also available only from eudominant species (fig 3). But, the „species list" should be completed with species sensitive on extreme events, habitat specialist, representatives of guilds ect. Future detailed analysis of several years results are needed to accurately and effectively manage long-term ecological studies of groud-dwelling arthropods at the Bab Research Station.

CONCLUSION

On the ground of analysis our preliminary research we can conclude the following suggestions concerning future long-term ecological studies at Bab Research Site:

Research site with its long history of ecosystem research including several species groups has good potential for long-term ecological studies.

The seasonal activity was influenced by actual temperature, habitat type and by seasonal migration patterns

The seasonal activity of spiders and ground beetles could be studied when using the data of the most dominant species.

The chosen study plots seem to be adequate considering habitat heterogeneity and overall seasonal activity including seasonal forest – open stand migration.

Further statistical and biological analyses are needed to effective long-term ecological research studies planning.

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