EVALUATION OF ACTIVE MANAGEMENT APPLIED TO MEADOWS WITH *PHENGARIS* BUTTERFLIES OCCURRENCE*

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In recent decades, changes in meadows maintenance have reduced the populations of endangered butterfly species *Phengaris nausithous* (Bergsträsser, 1779) and *P. teleius* (Bergsträsser, 1779). Currently, meadows are either abandoned or intensively used. Unfortunately, both these managements are considered unfavourable for grassland butterfly species. In this study, the effect of suitable meadow management on population sizes of both the above mentioned *Phengaris* species was investigated. The experiment was performed at the locality Dolní Labe (Děčín, Czech Republic). The most suitable models, based on the lowest values of Akaike's information criterion corrected for small sample sizes, were selected using MARK statistical software. The results were subsequently compared with data obtained from this locality prior to the management application. Unexpectedly, no significant positive effects were found. To reach the desirable status, suitable management practices should be applied for long-term. To verify the management effect on the population size, the meadows were divided into three groups: (*i*) application of favourable management, (*ii*) mowing in inappropriate term, (*iii*) without management. Based on the statistical evaluation, the management application proved to be the most favourable option for both studied butterflies species.

Phengaris teleius, *Phengaris nausithous*, Dolní Labe, active protection, mowing, succession

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INTRODUCTION

The majority of European butterfly species are vitally dependent on meadows and open grasslands with large plant diversity (van Swaay, 2002; Jansen et al., 2012). The management methods of these localities belong among the most important factors affecting the density of butterfly populations (Wallis De Vries et al., 2007; D'Aniello et al., 2011). During the recent decade, changes of the management have occurred – the meadows are used intensively. Agricultural intensification causes the biodiversity reduction, abandonment of traditional land-use types (Kruess, Tscharntke, 2002; Benton et al., 2003; Saarinen, Jantunen, 2005; Young et al., 2005), and increased land fragmentation, which is considered to be the main threat to reduce the number of butterfly species (Krauss et al., 2005; Pöyry, 2007). On the other hand, the absence of agricultural interventions leads to the onset of succession (Hula et al., 2004; Skórka et al., 2007).

Active protection of the butterfly species consists in the understanding of their requirements and demands, such as the quantity and distribution of their necessary resources (Dennis et al., 2006; Jansen et al., 2012). The blue butterflies of the genus *Phengaris* are considered as European flagship species for butterfly protection in open grasslands (Spitzer et al., 2009; Thomas et al., 2009; van Swaay et al., 2010). The Scarce large blue, *Phengaris teleius* (Bergsträsser, 1779) and the Dusky large blue, *Phengaris nausithous* (Bergsträsser, 1779) are sympatric living species, occurring in wet meadows (Kajzer-Bonk et al., 2013). Their host plant is Great Burnet (*Sanguisorba officinalis*) (e.g. Thomas, 1984) and both of these species are also myrmecophilous (Elmes et al., 1998;

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Wynhoff et al., 2011). According to the European Red List of Butterflies (van Swaay et al., 2010) and Red List of the Czech Republic (Farkač et al., 2005), *P. teleius* belongs among vulnerable species and *P. nausithous* among near threatened species.

To select favourable meadows management, it is necessary to monitor many factors that affect the survivability and the size of butterfly populations (Van Langevelde, Wynhoff, 2009). The establishment of varied networks including grasslands, patch and road edges, is also very important (Hanski et al., 1994; Nowicki et al., 2013). These measures reduce the fragmentation and support the metapopulation density system (Nowicki et al., 2014). The timing and quantity of blue butterfly meadows interventions belong among essential factors as well. The meadows should be ideally cut once a year, but it is also possible to do the cut every two or three years (Johst et al., 2006; Novák et al., 2007; Vrabec et al., 2008). The negative impact on blue butterflies was reported when meadows were cut twice a year (Dierks, Fischer, 2009). According to Beneš et al. (2002) and Konvička et al. (2005) the optimal time for cutting meadows is May or September. September is also reported by Kőrösi et al. (2014) as an ideal cutting time for *P. teleius* prosperity. Mowing meadows amid the flying season is inconvenient, because it causes not only the lack of nectar sources and oviposition opportunities for adults, but it mainly leads to egg destruction and larval mortality as well (Johst et al., 2006; Dover et al., 2010). Therefore, it is important to make the first mowing in a suitable term providing the host plant sufficient time to restore before the beginning of the flight season (Dierks, Fischer, 2009). The proper mowing timing also influences the host ants (Wynhoff et al., 2011; Kőrösi et al., 2014). When cutting in the second half of September, abundance of *Myrmica* ants in meadows increases (Grill et al., 2008). Beneš et al. (2002) and Konvička et al. (2005) considered mosaic mowing as most suitable for blue butterflies. This cutting method basically replaces traditional agriculture (Pöyry, 2007) with the principle in combination of both unmaintained and maintained vegetation – mowing at different times per year (Morris, 2000; Saarinen, Jantunen, 2005; Farruggia et al., 2012). However, using no management in meadows is also unsuitable, because it causes succession onset, consequently it leads to overgrowing of meadows by woody plants (Provoost et al., 2011; Schirmel, Fartmann, 2014).

The populations of blue butterflies at the Dolní Labe locality have been subjected to long-term monitoring. A favourable meadow management was designed with mowing mode supporting the growth of population and applied in selected meadows in 2014 and 2015. To evaluate the designed management, these hypotheses were tested: (a) yearly mowing in a suitable term will in long-term increase the blue butterfly populations; (b) blue butterfly populations will not be able to survive in meadows which are mown in inappropriate time or in meadows without management.

MATERIAL AND METHODS

Study species

According to the European red list of butterflies (van Swaay et al., 2010), *Phengaris teleius* and *P. nausithous* belong to vulnerable and/or near-threatened species categories. Both these butterflies belong among particularly protected species in the Czech Republic and *P. nausithous* being more distributed (Beneš et al., 2002).

The investigated species are both social parasites with similar life cycles, however, some different aspects in their behaviour are known as well (Beneš et al., 2002). Both species are monophagous, their only host plant is Great Burnet (*Sanguisorba officinalis*) (e.g. Thomas, 1984). Females lay their eggs on the host plant head, larvae hatch and live there till L3 stadium. Immediately after ecdysis to L4, they fall down to the ground, where they are subsequently adopted by *Myrmica* ants (Thomas et al., 1989; Pech et al., 2007). *P. nausithous* larvae could be adopted only by *M. rubra*, while *P. teleius* larvae were found mainly in anthills of *M. scabrinodis*, but also in those of *M. rubra*, *M. ruginodis* or *M. rugulosa* (Tartally, Varga, 2005; Witek et al., 2008, 2011; Wynhoff et al., 2011). Parasitic larvae live for 10–22 months, until they pupate (Thomas, 1984; Sliwinska et al., 2006). Flying season of adult butterflies is the same for both species – since the beginning of July to the end of August. However, certain variability within various regions has been described (Batáry et al., 2009). It is known that the choice of location for oviposition is affected by host plants developmental stages and the host ants presence. While *P. teleius* females oviposit rather to young flower heads, those of *P. nausithous* prefer older host plant heads (Figurny, Woyciechowski, 1998). Both species oviposit only to host plants near *Myrmica* anthills (Van Dyck et al., 2000; Wynhoff et al., 2008; Van Dyck, Regniers, 2010). Ensuring the presence of all resources of vital importance to the blue butterfly genus *Phengaris* is thus largely influenced by meadows management.

Study area

The suitable meadows management research was realized at the locality Dolní Labe (502.34´51°´´N, 1450.99´12°´´E), which is a part of the Protected Landscape Area (PLA) Labské pískovce, near the

Table 1. Management methods applied to *P. teleius* and *P. nausithous* at the Dolní Labe locality in 2009–2015

Patch No.	2009	2010	2011	2012	2013	2014	2015
1	*iii*	*iii*	*iii*	*i*[ad]	*i*[ac]	*i*[ac]	*i*[ac]
2	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*
3	*iii*	*iii*	*iii*	*i*[ad]	*i*[ac]	*i*[bc]	*i*[ac]
4	*iii*	*iii*	*iii*	*i*[ad]	*i*[ac]	*i*[ad]	*i*[bc]
5	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*
6	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*
7	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*
8	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*
9	*iii*	*iii*	*iii*	*iii*	*iii*	*i*[ad]	*i*[ac]
10	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*
11	*iii*	*iii*	*iii*	*iii*	*iii*	*i*[ac]	*i*[ac]
12	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*	*ii*
13	*iii*	*iii*	*iii*	*iii*	*iii*	*i*[ac]	*i*[ac]
14	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*
15	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*
16	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*	*iii*

(*i*) mowing 1× per year (mowing entire patch[a], rotation[b]), applied in spring[c] or autumn[d]; (*ii*) mowing in inappropriate term (during flight season); (*iii*) localities without management

town of Děčín (Czech Republic). Population parameters research of the genus *Phengaris* in this area started in 2008 when only 6 patches were monitored. This flight season therefore was not included into the calculations and statistical analyses. The area is divided into 16 patches with confirmed occurrences of blue butterflies (Fig. 1). The area of the investigated patches ranges from 140 to 19 084 m² and maximum distance between the patches is 5.21 km. To compare the results of the management practices, all the patches were divided into three groups/types: (*i*) mowed 1× per year (mowing entire patch, rotation – applied in spring or autumn), rotation mowing implies successive mowing of different meadow fragments (B u b o v á et al., 2015); (*ii*) mowed in inappropriate term (during the flight season); (*iii*) patches without any management (Table 1).

Patches of type (*i*) (formerly belonging to types (*ii*) and (*iii*)) were firstly mowed in 2012. These patches are mowed periodically once a year in the spring (May) or autumn (September). The first patches mown were the meadows near the Labe River. Depending on the meadows condition, they were mowed once or twice per year since 2012. Currently, six meadows are managed in this way. Another five patches belonging to type (*ii*) are mainly privately owned and uncoordinatedly mown several times per year. The six remaining patches of type (*iii*) are unkept and weed overgrown, vegetation at this places consists mainly of *Urtica dioica*, *Impatiens glandulifera royle, Rubus idaeus* or gone wild fruit trees. Since the beginning of monitoring, no management interventions were observed there.

During monitoring of the Dolní Labe locality in 2008–2011 (2008 excluded from calculations), no targeted management interventions were applied there. In autumn 2012, parts of selected meadows were mowed in cooperation with PLA Labské pískovce. Since 2013, other meadows have been involved in the suitable management program. Therefore, they are mowed once per year in spring or autumn, according to the actual situation. In 2015, the Directorate of Waterways of the Czech Republic started to support this project. Currently, suitable management has been applied at six patches, and enrolment of further patches in the immediate vicinity of the Labe River is scheduled in the following years. The owners of the meadows with *Phengaris* butterfly occurrence outside the Labe River valley, with lacking or inappropriate management, are intended to be addressed, too.

Field methods

We used Mark-Release-Recapture method to find out *Phengaris* butterflies population size at the investigated patches. The monitoring was carried out in the following terms: 2009 (9/7–19/8), 2010 (9/7–12/8), 2011 (8/7–5/8), 2012 (14/7–10/8), 2013 (5/7–15/8), 2014 (3/7–18/8), and 2015 (6/7–14/8). During these days, all investigated patches were observed daily, except continuous rain days. The blue butterflies were captured with an entomological hand-held net. A waterproof pen was used to identify the caught unmarked specimens with a unique code on the ventral side of hind-wings. Capture time, sex, wing wear, weather conditions, butterfly behaviour, and patch were recorded. In case of recapturing marked individuals, we enrolled aforementioned parameters to the recording sheet as well.

Data analysis

Population estimates. To estimate the size of population, all obtained data for both studied butterfly species *P. teleius* and *P. nausithous* were evaluated in the statistical program MARK, which is able to provide information about population size using Capture-Mark-Recapture method (White, Burnham, 1999; Cooch, White, 2007). Concretely, we used Cormack-Jolly-Seber model (Live Recaptures), whose principle is a live animal capturing (Schwarz, Seber, 1999). Basic parameters of the models are survival (*φi*) and capture probability (*pi*). For each parameter there exist different standard patterns assumed, for example: (.) parameter constant over time and equal for all groups; (g) parameter constant over time, but varying among groups; (t) parameter changing over time, but equal for all groups; (g*t) parameter changing over time and varying among groups; (g+t) parameter changing over time and varying among groups too, but over time it is constant. There exist 25 different combination models. The selection of the most appropriate model for each data set was based on Akaike's information criterion corrected for small sample sizes (AICc) (Hurvich, Tsai, 1989). The model with the lowest AICc is the one which best fits the empirical data (Nowicki et al., 2005). The best model for population estimation was selected after parameters customization at two patches with the highest density of investigated species. In the case that selected models for these patches were different, we preferred the model used for the patch with the highest captured butterflies number and AICc, ΔAICc, Estimate, Standard Error, 95% Confidence Interval (CI)–, 95% CI+ values as well (see Table 2). After we had selected the most suitable model, the final value of real ($\hat{N}_{total}$) indicating the seasonal population size was calculated (Nowicki et al., 2005).

Statistical analysis

To determine the efficiency of the management, $\hat{N}_{total}$ values calculated in program MARK were used. Subsequently, the $\hat{N}_{total}$ values were statistically analyzed. The significance level α = 0.05 was selected for all tests.

Population size comparison after the management change. Verification of the first hypothesis (a – yearly mowing in a suitable term will in long-term increase the population of butterfly species *P. teleius* and *P. nausithous*) was performed in two steps. The analysis

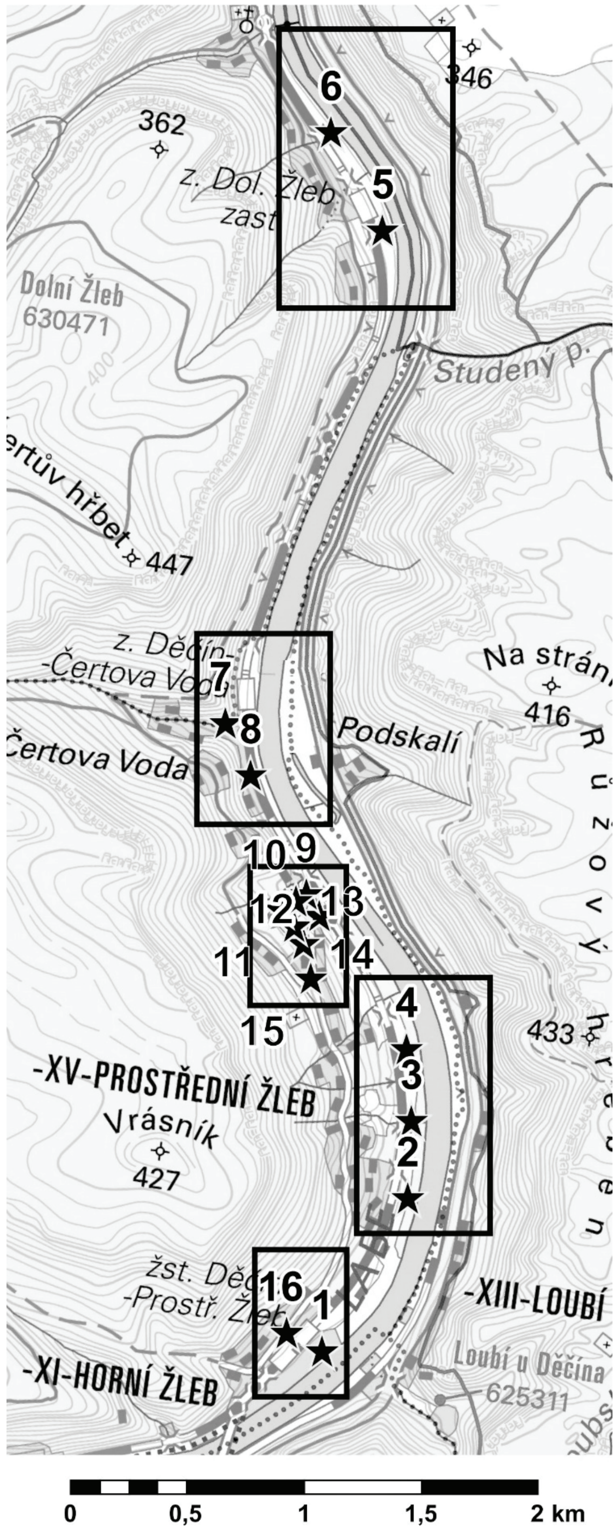

Fig. 1. Locality Dolní Labe (50 51´ 2.34´´N, 14 12´ 50.99´´E) near the town of Děčín, dislocation patches 1–16

Table 2. The best models calculated by MARK software and the individual parameters for *P. teleius* and *P. nausithous* during flight seasons at Dolní Labe locality in 2009–2015

	Selected model		$\hat{N}_{total}$	Best patch*	AICc	ΔAICc	Estimate		Standard error		95% CI			
	survival (*φi*)	capture probability (*pi*)					(*φi*)	(*pi*)	(*φi*)	(*pi*)	95% CI–		95% CI+	
											(*φi*)	(*pi*)	(*φi*)	(*pi*)
2009														
P. teleius	(.)	(.)	368	4	91.42	0.00	0.85	0.28	0.06	0.08	0.69	0.15	0.93	0.47
P. nausithous	(.)	(.)	1370	13	381.14	24.24	0.60	0.44	0.04	0.06	0.52	0.33	0.67	0.55
2010														
P. teleius	(.)	(.)	889	4	138.48	0.00	0.75	0.21	0.06	0.06	0.60	0.12	0.86	0.35
P. nausithous	(t)	(t)	1952	4	376.85	19.95	0.87	0.73	0.00	0.22	0.86	0.24	0.86	0.96
2011														
P. teleius	(.)	(.)	196	4	69.86	0.00	0.84	0.62	0.08	0.11	0.61	0.39	0.95	0.80
P. nausithous	(.)	(.)	273	6	191.50	0.00	0.83	0.53	0.04	0.07	0.74	0.41	0.89	0.66
2012														
P. teleius	(.)	(.)	233	4	67.21	0.00	0.60	0.46	0.13	0.16	0.35	0.19	0.81	0.76
P. nausithous	(g)**	(.)	298	4	119.14	1.57	0.83/ 0.51	0.36	0.54/ 0.16	0.09	0.70/ 0.24	0.21	0.91/ 0.78	0.55
2013														
P. teleius	(.)	(.)	406	15	59.86	2.93	0.81	0.12	0.13	0.08	0.45	0.03	0.96	0.36
P. nausithous	(.)	(.)	952	4	514.08	1.89	0.77	0.28	0.03	0.04	0.70	0.21	0.82	0.36
2014														
P. teleius	(.)	(.)	391	13	159.13	1.74	0.70	0.55	0.06	0.08	0.58	0.39	0.80	0.71
P. nausithous	(.)	(t)	1486	6	1883.98	0.66	0.81	0.89	0.01	0.01	0.78	0.54	0.83	0.98
2015														
P. teleius	(.)	(.)	371	3	467.51	0.00	0.87	0.30	0.02	0.03	0.81	0.24	0.91	0.37
P. nausithous	(.)	(.)	602	3	946.55	1.48	0.81	0.46	0.18	0.03	0.77	0.41	0.84	0.52

$\hat{N}_{total}$ = real population size, AICc = Akaike's information criterion corrected for small sample sizes, CI = confidence interval

*patch with the highest number of captured butterflies, which was essential in the final model selection; the following parameters are provided for this patch; the population estimation was evaluated using data from this locality

**estimate, standard error, and CI values are presented both for males and females

principle was a comparison between flight seasons with management and those without any management. Firstly, we statistically evaluated (independent two-sample *t*-test) data from the patches under management since 2012 (No. 1, 3, and 4 in Table 1). In the next step, patches managed since 2014 (No. 9, 11, and 13) were evaluated in the same way.

Comparison of targeted management efficiency. To verify the second hypothesis (b – the blue butterflies populations will not be able to survive in meadows mowed in inappropriate time or in those without management), we compared the population sizes at patches which were divided into three groups from the management viewpoint: (*i*) suitable management, (*ii*) inappropriate management, and (*iii*) no management (see Table 1). The data were subjected to the analysis of variance (ANOVA) test. We used one-way ANOVA and Scheffé's test (for patches comparison) and main effect ANOVA, Fisher's LSD test, and confirmation Scheffé's test for dependence verification of population size in the management types (*i*); (*ii*); (*iii*) and flight season.

RESULTS

Population estimates

Using the MARK program, the most suitable models were selected (Table 2) and $\hat{N}_{total}$ values for studied butterfly species and flight seasons calculated. For the survival parameter (φ) and the capture probability (p), the model (.)(.) was the most suitable. This model is

Table 3. Statistical analyses for verification of two hypotheses regarding flight seasons 2009–2015 of *P. teleius* and *P. nausithous* at Dolní Labe locality. The calculations were performed using two-sample *t*-tests and the analysis of variance (one-way and the main effects; significance level α = 0.05)

	F	*P*	*P* (sided)*	*P*
(a) Comparison of population size after management changes[a]				
After 2012				
Phengaris teleius	2.887	0.119		> 0.05
Phengaris nausithous	2.295	0.202		> 0.05
After 2014				
Phengaris teleius	5.118	0.082		> 0.05
Phengaris nausithous	18.310	0.005	0.229*	> 0.05
(b) Comparison of targeted management efficiency				
Comparison of type management on patches[b]				
Phengaris teleius	10.727	0.000		< 0.05
Phengaris nausithous	5.750	0.004		< 0.05
Comparison of population size, depending on management type and flight season[c]				
Phengaris teleius				
Year	0.497	0.799		> 0.05
Type of management	2.469	0.126		> 0.05
Phengaris nausithous				
Year	0.766	0.610		> 0.05
Type of management	0.733	0.500		> 0.05

[a]two-sample *t*-test, independent

[b]ANOVA one-way and Scheffé's test

[c]ANOVA main effects and Fisher's LSD test

*newly calculated level of significance for the case of inhomogeneous variances

constant over time and equal for all groups, with equal daily survival and capture probability. It was selected for populations of both investigated butterfly species in 2009, 2011, 2013, and 2015 and for *P. teleius* in 2010, 2012, and 2014. Three other models were applied to *P. nausithous*. For the flight season 2010, model (t)(t) with both daily survival and capture probability varying among sampling days was applied. This model varies over time, but for all groups. Model (.)(g), i.e. the model constant over time and varying for the group, was selected for the season 2012. Finally, (.)(t) model was selected as the most suitable for 2014, with equal daily survival and capture probability varying among sampling days. This model varies over time but equally for all groups. Using the selected models, the $\hat{N}_{total}$ value (real population size) was calculated for all patches and individual flight seasons. These values have been subsequently used to verify the suggested hypotheses.

Statistical analysis

The results of the statistical analyses are shown in Table 3.

Population size comparison after the management change. In the first step of the hypotheses verification, data obtained at patches No. 1, 3, and 4 were analyzed. Statistical analyses were performed separately for both investigated species and no significant effects of management on the investigated patches were found (*P. teleius* and *P. nausithous*: $P > 0.05$). Significant differences between flight seasons before and after management changes were not found in the next step (patches No. 9, 11, and 13) as well (*P. teleius* and *P. nausithous*: $P > 0.05$). However, the population size comparison between the patches with management onset in 2012 and in 2014 reveals certain differences (see Table 3). Meadows managed since 2012 are more successful (*P*-value) than the patches managed since 2014. The trend of differences between population sizes is displayed in Fig. 2.

Comparison of targeted management efficiency. Statistical analyses used for the comparison of management types efficiency (Scheffé's test) demonstrated statistically significant differences ($P > 0.05$) between the management method (*i*) – yearly mowing, and methods (*ii*) and (*iii*) (unsuitable mowing period and no mowing, respectively). The suitable management (*i*) was found most effective for *P. teleius,* on the other hand, method (*ii*) appeared to be the worst one. For *P. nausithous*, significant differences ($P > 0.05$) were found between methods (*i*) and (*iii*). The worst for this species is when the meadows are unmanaged (*iii*). The analyses performed in order to demonstrate the investigated butterfly population dependence on management type and flight season did not show significant differences. Even though Fisher's LSD test showed some deviations during flight season in methods (*ii*) and (*iii*), Scheffé's test and homogeneity of variance test found out no significant differences.

DISCUSSION

In terms of increasing long-term viability of studied butterflies at the locality Dolní Labe, the results of our study showed that timing monitoring and suitable mowing management selection are necessary for the long term. We also verified years mowing efficiency but, unfortunately, no significant effects were found during our four-year-long observation. This fact is in contradiction with results reported by Kőrösi et al. (2014), who found out positive effects of management on *Phengaris teleius* population during just a three-year period. The same authors also recommended mowing in September as the most suitable management. On the contrary, Novák et al. (2007), after three years of investigation, did not find clear effects of management on the blue butterfly population sizes. In our study, we determined noticeable differences between meadows managed since 2012 and those managed since 2014. The positive influence of long-term appropriate meadows mowing is shown in Fig. 2. The patches, which were involved in management only since 2014, had been unkempt and weed overgrown, so the transformation to an optimum condition is still in progress (Pöyry et al., 2005; Stefanescu et al., 2009). However, low population sizes in 2015 could play a significant role in the unclear effect of management which had been firstly applied the previous year 2014. For *P. nausithous*, the $\hat{N}_{total}$ value was more than half lower than in 2014 (see Table 1 – 2014: $\hat{N}_{total} = 1486$; 2015: $\hat{N}_{total} = 602$). For *P. teleius* the values were similar. The population size may be reduced even due to climatic change, which has currently been highly discussed (Cormont et al., 2013; Kajzer-Bonk et al., 2013; Nieto-Sánchez et al., 2015), however this factor has not been investigated at the Dolní Labe locality. To detect a climate change would require a several-year local monitoring. Although the effect on the population size of the investigated butterflies was not statistically confirmed, the host plants number increased noticeably using management. The *Sanguisorba officinalis* presence is essential for the studied species development (Figurny, Woyciechowski, 1998; Batáry et al., 2009; Dierks, Fischer, 2009), however, according to Nowicki et al. (2005) the correlation between the host plant density and the blue butterfly populations size does not exist, which is also demonstrated by our results. *Myrmica* ants are the other essential factor, which could be influenced by meadows management practices (Elmes et al., 1998; Johst et al., 2006; Wynhoff et al., 2011). Positive effects were found out by Dauber et al. (2006). On the other hand, no effect of management is reported by Dahms et al. (2005).

The present research revealed that patches with active suitable management are highly sought for by the studied butterflies. The lowest occurrence of *P. teleius* individuals was found at meadows mowed in the middle of flight season while meadows without management were evaluated as worst patches for *P. nausithous* survival. For *P. teleius*, our results correspond with those reported by Skórka et al. (2007), who did not consider succession as a serious threat. No significant influence of primary succession on blue butterfly populations was also reported by Dover et al. (2010). On the other hand, period without management longer than three years could have fatal consequences for blue butterflies (Bergman et al., 2004; Kőrösi et al., 2014). The hypothesis (b) – butterfly species *P. nausithous* and *P. teleius* are unable to survive in a long-term at patches with inappropriate or no management – was confirmed.

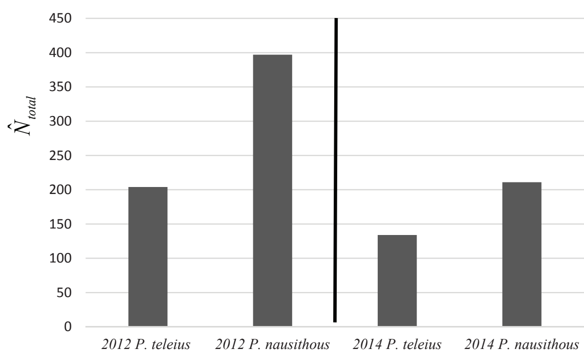

Fig. 2. Graphical comparison of management application success rates at localities mown since 2012 and those managed since 2014. The data shown are for *P. teleius* and *P. nausithous* at the locality Dolní Labe

CONCLUSION

To protect the butterflies of meadow habitats, the natural environment must be maintained. There is a need to replace the intensive mowing regime and ensure a return of traditional land-use practices. Butterfly populations of *P. teleius* and *P. nausithous* are decreasing due to inadequate mowing regime changes. Their meadows are either mowed in inappropriate terms (in the middle of flight season) or even not mowed at all. Unfortunately, meadows abandonment is usually connected with successional changes and landscape fragmentation increase. To determine a management favourable for blue butterflies, it is necessary to take into account all landscape requirements and the mowing regime selection should be realized on total compromises basis, which reflects the character of a particular locality.

P. teleius and *P. nausithous* population parameters have been monitored on 16 patches at Dolní Labe locality since 2008. To increase the studied butterfly populations, targeted management was applied to selected localities. Since 2012, three patches near the Labe River have been annually mowed (mowing entire patch, rotation) in spring or in autumn. In 2014, other three patches, which are located off the Labe River shores, were involved into the management. The population sizes were analyzed using program MARK, which allowed us to compare the population success at the patches before and after the mowing application. The effects of both applied managements (since 2012 and since 2014) on the population size were not significant. However, butterfly population increases were evident in patches mowed since 2012 compared to those mowed since 2014. These results showed that the long-term management at investigated localities is essential and its effect will be apparent in a time horizon longer than four years. To comprehensively compare all the investigated meadows at the Dolní Labe locality, the patches were divided from the management viewpoint into three groups: (*i*) application of favourable management, (*ii*) mowing in inappropriate term, (*iii*) without management. The statistical analyses results confirmed the (*i*) variant as the most favourable option for both butterfly species studied.

For protection and enhancing the number of blue butterflies on the area of Dolní Labe, it is also necessary to properly set the mowing term. Therefore, it will be important to verify the mowing effect in spring and in autumn to determine more appropriate management methods. Several new localities, mainly near the Labe River, are planned to be involved into the mowing regime in the next flight season. Also negotiations with the owners of meadows mowed during the flight season or left without management will be continued. Similarly, we will extend the cooperation with the PLA Labské pískovce and the Directorate of Waterways of the Czech Republic, which should follow our common objective – to increase the size of investigated butterfly populations by suitable management application and mowing optimization.

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