

Dry Grasslands of Genolier oakwood (« Bois de Chênes de Genolier ») Comparative study on the impact of management style on biodiversity



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Abstract

As a result of agricultural intensification, European dry grassland areas have been largely lost and many specialized plants and animals are under threat of extinction. The Bois de Chênes of Genolier contains some of the last dry grasslands of the Swiss Plateau, but their plant and animal diversity remains poorly known. Our study aimed at, on one hand, filling this gap and on the other hand, comparing the biodiversity of grasslands managed at different levels of intensity. We found several target species according to the Agriculture-related Environmental Objectives, as well as many red-listed species. The survival of these species depends not only on the non-intensive management of grassland areas, but also on the preservation of flower-rich refuge zones. Existing 'very extensive' dry grasslands must be preserved as guarantors of the area's natural heritage and as sources of locally adapted individuals.

Introduction

From April to September 2009 the conservation organisation A Rocha undertook a census of plant and animal diversity in the dry grasslands of the Bois de Chênes of Genolier. Dry grasslands are among the most species-rich habitat types in central Europe (Pärtel et al. 1999, WallisDeVries et al. 2002, Duelli & Obrist 2003, Myklesstad & Sætersdal 2004, Hopkins & Holz 2006). In Switzerland, as in the rest of Europe, their number has dramatically declined over recent years as a result of agricultural intensification (Stoate et al. 2001, Strijker 2005). Today, they cover only 0.5 % of the country and most are located in the Alps, where intensive management is less easy. The dry grasslands of the Bois de Chênes are among the last ones located in the lowland and are therefore a biodiversity hotspot of the Swiss Plateau.

Agricultural intensification is the primary threat to dry grasslands. Their plant and animal composition is affected both by the use of fertilizers and by the frequency of cutting (Tilman 1996, DiGiulio et al. 2001, Vickery et al. 2001, Rajaniemi 2002, Klimek et al. 2007, Marini et al. 2008). However, extensive practices lead to a reduction in yields and hence to a loss of agricultural value (Jeangros 2002, Hopkins 2009). We face, therefore, a conflict of interest between yield and biological diversity. In order to contain the loss of species, Switzerland established a system of direct payments (OPD) to farmers in return for less intensive management of their grasslands. Farmers must not use any fertilizers, must limit grazing to the autumn only, and must leave the first mowing until at least 15 June (OPD 1998). The results of extensive management, although very positive for many groups of species (Guido & Gianelle 2001, OFAG 2005, Albrecht et al. 2007, Aviron et al. 2007) remain an area of debate. Rare and threatened species are particularly scarce in these extensive grasslands (Pozzi 2004, Birrer et al. 2007, Aviron et al. 2009), which puts into question their real value for biodiversity.

We thus decided to inventory several taxonomic groups in grasslands managed at different intensities (Tab. 1) to (a) evaluate the real differences and (b) give recommendations for the management of the Bois de Chênes, with a view to protecting its biodiversity. For this first year of census, three taxonomic groups were considered: flowering plants, butterflies (with

Zygaenidae) and orthopterans. These groups were chosen because they contain a large number of species adapted to dry grasslands and are sensitive to changes in their environment (Erhardt 1985, Smallidge & Leopold 1997, Guido & Gianelle 2001, Van Swaay 2002). They are therefore good indicators of the state of biodiversity (Baldi & Kisbenedek 1997, Swengel & Swengel 1999, Thomas 2005).

Methods

Study design

Eight sites were chosen among the different dry grasslands of the Bois de Chênes, partly based on the locations defined by previous records performed by the Agronomic Research Station Changins-Wädenswil. These sites were classified by their type of management: Two intensive, four extensive (according to the Swiss pattern of direct payments) and two very extensive (Tab. 1, Fig.1a) and 1b)). Plant and insect censuses were conducted from April to September 2009.

Plants

For the plant inventory, a plot of 5 x 5m was delineated on each site and the species within the plot recorded over the flowering season. In addition, for the two intensive plots (P6 and P7) and three extensive plots (P2, P3 and P8), an abundance analysis using the point-quadrat method of Daget-Poissonnet (Daget & Poissonnet 1971) was carried out. This method requires 50 points along each plot diagonal to be defined and the species in contact with a metal needle are recorded. To avoid an overrepresentation of the plot centre, the points were distributed as follows: From the centre, four intervals of 20cm followed by 21 intervals of 13cm on each semi-diagonal. The specific frequency of each plant species was then calculated.

Butterflies

For the butterfly census a 40m long transect was marked out at each site. An observer walked along the transect for ten minutes recording the species present, and their abundance, within a width of 2m either side. Butterflies were identified by sight, or were caught with a net and released after identification. This process was repeated over the whole study time in order to obtain an accurate representation of species flying at different periods.

Orthopterans

Orthopterans were censused over the grassland area of the Bois de Chênes without following a precise methodology. Specimens were caught by hand or with a net, identified to species level and eventually released.

Identification

The following books were used for species identification: *La Grande Flore en Couleurs* de Gaston Bonnier (Bonnier et al. 1990), *Clé de détermination illustrée des plantes sauvages de nos régions* (Covillot 1991), *Guide des graminées, carex, joncs et fougères* (Fitter et al. 1991), *Exkursionsflora von Deutschland* (Rothmaler 1991), *Flora helvetica* (Lauber & Wagner 1998), *Le nouveau Binz* (Aeschimann & Burdet 2005), *Flora vegetativa* (Eggenberg & Möhl 2007), *Guide des papillons d'Europe et d'Afrique du Nord* (Tolman & Lewington 2004), and *Sauterelles, Grillons et Criquets de Suisse* (Baur et al. 2006).

Data analysis

To assess the importance of nectar resources for butterflies, the correlation between the number of butterfly species and (a) the total number of flowering plant species and (b) the number of nectar-producing plant species was calculated using the Pearson's correlation coefficient.

A presence / absence matrix of flowering plant species and butterfly species was computed, from which we calculated Jaccard's distance between the different plots. The composition of the flowering plant and butterfly species of the different plots was then compared by nonmetric multidimensional scaling (NMDS).

To investigate if red-listed species and non-threatened species differ in their ecology, we classified the butterfly species according to four ecological criteria: Their specificity for dry grasslands (specific or not specific), their number of generations (1, 2, or multi-generations), their feeding regime (mono-, oligo-, or polygophagous) and their mobility (sedentary, slightly mobile, or mobile). The observed sample of threatened- and non-threatened species was compared to a random sample of the species in the different categories.

Results and discussion

113 flowering plant species, 59 butterfly species (including 3 Zygaenidae) and 15 orthopteran species were recorded. We found in each group many target species according to the Agriculture-related Environmental Objectives (OEA) (OFEV & OFAG 2008) (55 flowering plants, 29 butterflies and 9 orthopterans) as well as several red-listed species (6 flowering plants, 15 butterflies and 6 orthopterans) (Tab. 4, Appendix). Twenty of the recorded butterfly species and 5 orthopteran species are typical of dry grasslands and thus heavily depending on the survival of their habitat (Appendix 1, 2 and 3). The different grasslands differed in species diversity for both plants and butterflies, except for P1 and P2, both of which had a very similar butterfly composition (Fig. 5). Intensively managed grasslands clearly contained the lowest and most similar diversity of both plants and butterflies and the highest density of grasses (Fig 2, 3 and 5). The number of red-listed species was highest in very extensive grasslands for both groups (Fig 2). The proportion of threatened butterflies was particularly high for the species tightly linked to dry grasslands (Fig. 10).

The diversity of butterflies closely corroborated the diversity of flowering plants, especially that of nectar-producing species (Fig. 4 and 5). Several butterfly species, one third of which were red-listed species, were recorded only after the 15 June (Fig. 7 and 9). The highest abundance of butterflies was recorded in the last two weeks of June (Fig. 8).

Plants

Intensive grasslands show typical patterns of low plant diversity linked to fertilization and frequent cutting with a total of 24 (P6) and 35 (P7) species and a high density of grasses (Jacquemyn et al. 2003, Dietschi et al. 2007, Reitalu et al. 2008). On the other hand, extensive and very extensive grasslands vary both in species number and composition. Factors such as the type of soil, history, spatial context and isolation of the grassland may explain this variability (Zobel, 1992, Reitalu et al. 2008). Few flower inventories have been carried out in dry grasslands of the lowland, making a comparison with other sites difficult. Data from Swiss Biodiversity Monitoring indicate between 23 and 31 vascular plants per 10m² plots in grasslands located at the hill level. Thus, the dry grasslands of the Bois de Chênes, with up to 60 species per 25m² plots, among which a mean of 45% listed as target species according to the OEA, are surely an important pool of plant biodiversity.

An obvious difference between extensive and very extensive grasslands is the higher number of red-listed species in very extensive grasslands (1 vs 6). We also note that several species recorded on extensive grasslands and listed within the OEA did not bear ripe fruit by 15 June. Their long-term survival is therefore not ensured (Piqueray & Mahy 2010). According to several recent observations, extensive grasslands managed under the OPD guidelines are not sufficient to protect threatened species (Herzog et al. 2005, Aviron et al. 2009).

Five of six red-listed plants are orchids. These species are highly sensitive to variations in their environment, particularly to the mineral composition of the soil (Silvertown et al. 1994, Kull et al. 2006). A single fertilizer application can make them disappear for nearly 10 years (Florian Meier, personal communication). *Orchis ustulata*, the only threatened plant species found on an extensive grassland, has suffered greatly from agricultural intensification (Foley 1990). Its presence shows that, thanks to the cessation of fertilizer applications, plants adapted to nutrient-poor soils can settle in extensive grasslands. To survive, however, they must be able to fruit, which, in grasslands cut on 15 June, is only possible for early species such as *Orchis ustulata*.

Grassland management according to the OPD represents a compromise aiming at protecting biodiversity while ensuring sufficient forage for a viable agriculture. To protect species threatened by a cut on 15 June, some measures such as the protection and creation of hedgerows and uncut margins along grasslands can be effective (Moonen & Marshall 2001, Smart et al. 2002). A flexible schedule in the mowing regime may also be considered but has yielded inconclusive results up to now (Stäheli et al. 2006).

Butterflies

Our results suggest that the Bois de Chênes is an important site for butterflies. The 59 identified butterfly species represent more than half of the dry grassland species pool of the lowland (99 species according to Swiss Biodiversity Monitoring). Moreover, in addition to this large number of species, half of them appear on the list of the OEA and a quarter on the red list of endangered species in Switzerland (Gonseth 1994a), among which is the Glanville fritillary (*Melitaea cinxia*), a species considered extinct on the Swiss Plateau (Centre de Conservation de la Faune et de la Nature 2000).

The very low number of butterfly species in the intensive grasslands confirms the poor value of these grasslands, as shown for many animal groups (Gonseth, 1994, Di Giulio et al. 2001, Jöhl et al. 2004, Pozzi 2004, Britschgi et al. 2006, Marini et al. 2008).

The number of butterfly species is clearly higher in the very extensive grasslands ; ten more species were recorded here than in the extensive grasslands, of which four are on the red-list (*Cupido alcetas*, *Cupido argiades*, *Fabriciana adippe*, *Melitaea diamina*).

Considering the composition of the inventoried species, the proportion of butterflies appearing on the red list is particularly high for the species tightly linked to dry grasslands. The decline of dry grassland is indeed a key factor in the dramatic breakdown of butterfly populations over the last decades, mainly for specialized species (Wenzel et al. 2006, Polus et al. 2007).

The species inventoried in our study are similar to those inventoried by Aviron et al. (2007) in several dry grasslands of the lowland managed according to the OPD guidelines. We found, however, approximately 20 more species (59 vs. 40). Almost all of the species classified in the red list does not appear in the study of Aviron et al. (2007), strongly supporting the observation that cutting extensive grasslands on 15 June is not sufficient to protect endangered species (Gonseth 1994, Aviron et al. 2007). Besides, many butterflies like the combination of forest border and dry grasslands (Aviron et al. 2007), especially the Fritillaries of the *Argynnis* group of which we recorded several species (*Argynnis aglaja*, *Argynnis paphia*, *Boloria dia*, *Brenthis daphne*, *Fabriciana adippe*, *Fabriciana niobe*, *Issoria lathonia*) (Danesch 1986).

As with several previous studies, our results show that butterfly diversity is linked to the diversity of flowering plants, especially nectar-producing species (Erhardt 1985, Croxton et al. 2004, Bergman et al. 2008, Kitahara et al. 2008, Maccherini et al. 2009) (Fig. 5). First, a diverse plant community ensures a supply of nectar over the whole season, and second offers resources to a wider range of the butterfly species which display particular preferences (Loertscher et al. 1995, Dennis et al. 2004, Fartmann & Hermann 2006, Öckinger & Smith 2006). However, other factors play a role in explaining the higher species count on very extensive grasslands (Fig. 4). The main difference between extensive and very extensive grasslands is the manner and period of mowing. While extensive grasslands are uniformly mown around 15 June, often with several subsequent cuttings, the very extensive grasslands are mown irregularly, often later and in a mosaic way, i.e. by leaving some areas uncut (Tab. 1). Heterogeneity of the microhabitat is particularly favourable for organisms with a complex life cycle such as butterflies (Gonseth, 1994,

Wenzel et al. 2006) and contributes largely to maintaining functional biological communities (Fenner & Palmer 1998). We noticed that several butterfly species fly only after 15 June, including one third of the threatened species recorded in our study (Fig. 7 and 9). Moreover, peak abundance of a large number of species occurs in the period from the end of June through July (Fig. 8); nectar needs are therefore particularly high at this time. A cutting on 15 June can be destructive for the larvae of these species and deprive all adults of resources and shelter, especially if it is synchronized across the region (Valtonen et al. 2006, Walter et al. 2007).

Grass strips with high flower diversity provide attractive resources for butterflies and can be a good complement to grasslands cut on 15 June (Ouin & Burel 2002, Aviron et al. 2010). However, their limited area does not guarantee the preservation of viable populations of the scarcely mobile species (Krauss et al. 2003). Furthermore they must contain the plant species necessary for the development of the various butterfly species (Pöyry et al. 2008).

Orthopterans

In addition to an important number of threatened species, the Bois de Chênes contains some orthopterans which only rarely settle on the Swiss Plateau (*Platycleis albopunctata*, *Stauroderus scalaris*, *Stenobothrus lineatus*) (Baur et al. 2006). A late cut and the presence of unmown plots are particularly favourable to orthopterans because adult stages emerge mainly in July-August and their larvae are particularly threatened by a mowing in June (Humbert et al. 2010). Moreover, species such as *Platycleis albopunctata*, which feed on ripe seeds in August, do not find any resources in frequently- and uniformly-cut grasslands (Braschler et al. 2009). Recorded species vary in their ecological preferences. Some are thermophile and closely linked to the warm conditions of dry grasslands (*Metrioptera bicolor*, *Phaneroptera falcata*, *Platycleis albopunctata*, *Stauroderus scalaris*, *Stenobothrus lineatus*), while other species prefer damp sites (*Chrysochraon dispar*, *Euthystira brachyptera*, *Metrioptera roeselii*, *Pholidoptera griseoptera*). The latter species settle in dry habitats only if vegetation is both high and dense enough to provide shade and humidity. A structure-rich environment incorporating bare ground and high grasses, such as is characteristic of dry grasslands left uncut until the end of summer, is particularly favourable to a diverse community of orthopterans (Guido & Gianelle 2001).

Special case: The Pré Jacot (P1 and P2)

The Pré Jacot, in the Bois de Chênes, differs from the other extensive grasslands by having a higher diversity of both flora and fauna. The two other extensive grasslands, P3 and P8, were extensified solely by the cessation of intensive practices from 1990. The Pré Jacot, by contrast, after its conversion to a corn field, was reseeded in 1995, with hay seeds on the Jura side (P1) and a standard seed mix (MST 450 *Salvia*) on the Léman side (P2). Most of the plants which are present there but which are absent from P3 and P8 are

flowers appreciated by butterflies (in particular *Hippocrepis comosa*, *Knautia arvensis*, *Onobrychis viciifolia*, *Silene nutans* and *Thymus pulegioides*), which certainly explains the relative abundance of butterflies in the Pré Jacot. These plants are present in the standard mix as well as in the grasslands from which hay seeds were taken; it is therefore difficult to assess their origin. However, 14 years after reseeding, some species absent from the standard mix are found only on the side (P1) seeded with hay seeds, from which they thus certainly originate. These species are *d'Asperula cynanchica*, *Gallium album*, *Helianthemum nummularium*, *Origanum vulgare*, *Pimpinella saxifraga*, *Sedum sexangulare* and *Stachys recta*. Alongside this, the presence of *Orchis pyramidalis* close to P1 (the first observation of an orchid on the Pré Jacot) should be noted. These observations firstly confirm the study of Isselstein et al (2005). He noticed that the flower diversity of de-intensified grasslands such as P3 and P8, when compared to reseeded grasslands, can remain low for many years as a consequence of persistent nitrate presence in the soil or of the poverty of the soil seed bank. The results of the NMDS analysis show that the plant communities of P8 and P7 are very similar (Fig. 5). Secondly, the observations underline the importance of the existing very extensive grasslands as a source of locally-adapted species for the restoration of extensive flower-rich grasslands (Bekker et al. 1997, Duelli & Obrist, 2003, Piqueray & Mahy 2010).

Conclusions

Our study demonstrated that the dry grasslands of the Bois de Chênes contain threatened species, as well as many specialists of these milieus, the survival of which is closely linked to that of their habitat. Grassland management has a considerable impact on biodiversity. Intensive practices are clearly detrimental to plant and animal diversity and should be avoided. Extensive grasslands (as defined by the OPD) allow the settlement of many plant species and offer favourable conditions for a part of the fauna. However, their biodiversity remains lower than that of the very extensive grasslands, particularly regarding the entomofauna and red-listed species. Moreover, the success of dry grasslands depends on their history, with reseeded grasslands being richer than de-intensified grasslands. Preservation of species-rich grasslands as a source of locally-adapted species plays a vital role in this context.

Owing to the low hay yield, a return to very extensive land use on a large scale is not realistic, but shows that the key factor for biodiversity is heterogeneity. Good heterogeneity, both at the landscape and plot level, allows the establishment of a diverse plant community and provides varying resources over the whole season to the entomofauna, as well as shelter and hibernation sites.

For the management of a site devoted to nature such as the Bois de Chênes, we recommend: a flexible approach to mowing schedules, with a preference for later dates; a reduced cutting frequency; and the preservation of well-structured forest borders and green lanes, ideally managed in the same way as the very extensive grasslands and connected to one another to allow for the

movement of insect populations. The existing very extensive grasslands must be preserved with this kind of management. They are the guarantors of the natural heritage of the Bois de Chênes and of the survival of locally-adapted species.

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Figures and tables

Fig. 1 a): Aerial photograph of the Bois de Chênes with location and reference number of the eight plots. In white: intensive parcels (p6 and P7), in black: extensive parcels (P1, P2, P3 and P8), in grey: very extensive parcels (P4 and P5).

Fig. 1 b): Map of the Bois de Chênes with location and reference number of the eight plots. Intensive parcels: P6 and P7, extensive plots: P1, P2, P3 and P8, very extensive plots: P4 and P5.

Fig. 2: Number of species of a) flowering plants and b) butterflies recorded in the dry grasslands. Management: VE: very extensive, EX: extensive, IN: intensive.

Fig. 3: Specific frequency of grasses and other flowering plants calculated with the method of Daget-Poissonnet.

Fig. 4: Comparison between species richness of butterflies and flowering plants in the different plots. Management: VE: very extensive, EX: extensive, IN: intensive.

Fig. 5: Correlation between butterfly species richness and a) total flowering plant species richness and b) species richness of nectar producing plants. r : Pearson's correlation coefficient.

Fig. 6: Total number of butterfly species and number of species recorded after the 15th June.

Fig. 7: Evolution of butterfly species richness as a function of the sampling date in the very extensive grasslands (VE) and the extensive grasslands (EX). The vertical bar shows the cutting date on the 15th June. No records were performed between the 4 and the 18 July.

Fig. 8: Comparison between butterfly species richness and density in the different plots. Management: VE: very extensive, EX: extensive, IN: intensive.

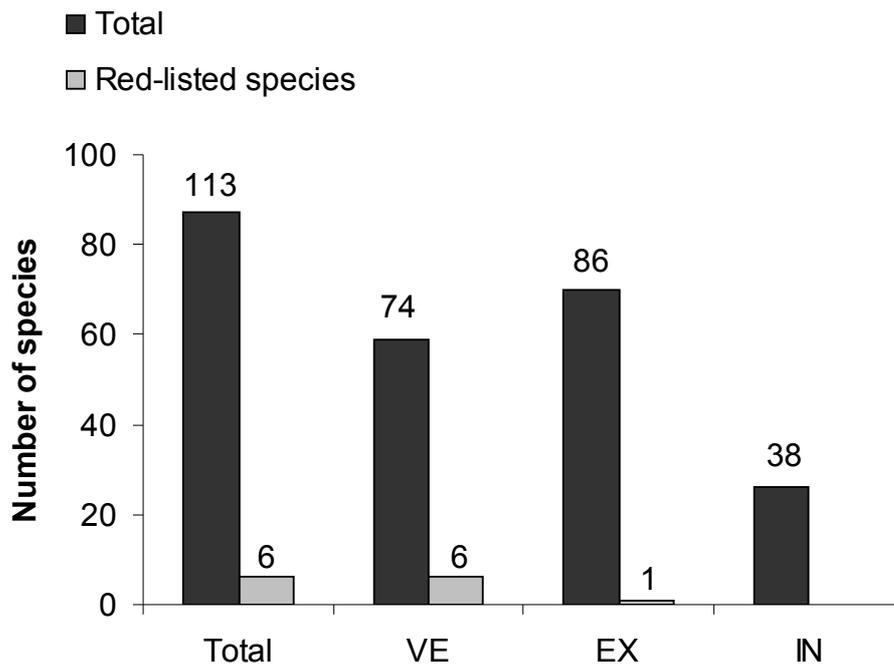
Fig. 9: Non metric multidimensional scaling showing the plot similarity based on a) flowering plant and b) butterfly species. Stress measures the distortion between the positions of real data points from the data presented graphically; the lower the stress, the more accurate is the representation.

Fig. 10: Ratio of observed-to-expected number of threatened and non-threatened species classified according to 4 categories: specificity for dry grasslands, voltinism, nutritional value, and mobility.



Fig. 1 a)

a) Plants



b) Butterflies

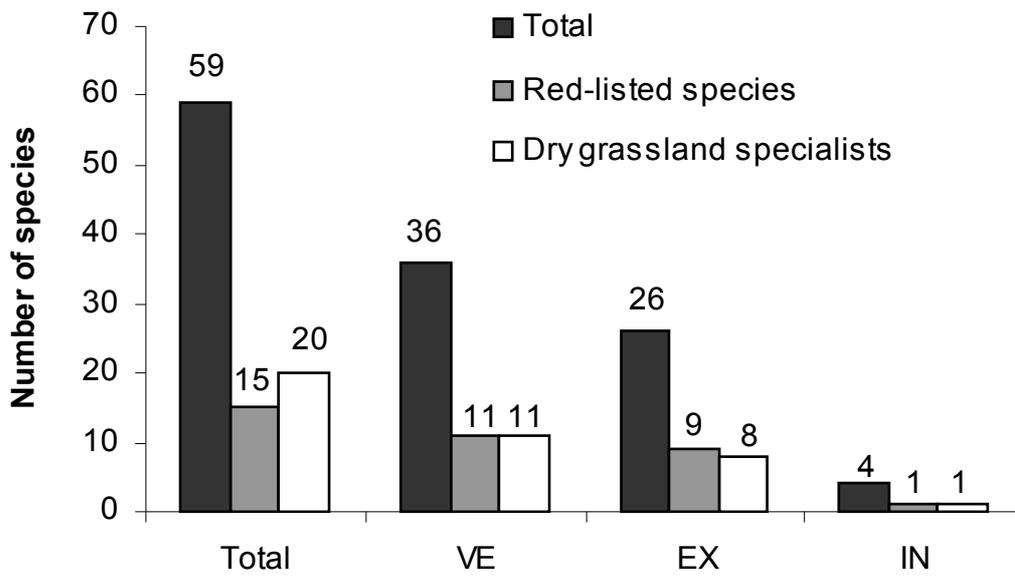


Fig. 2

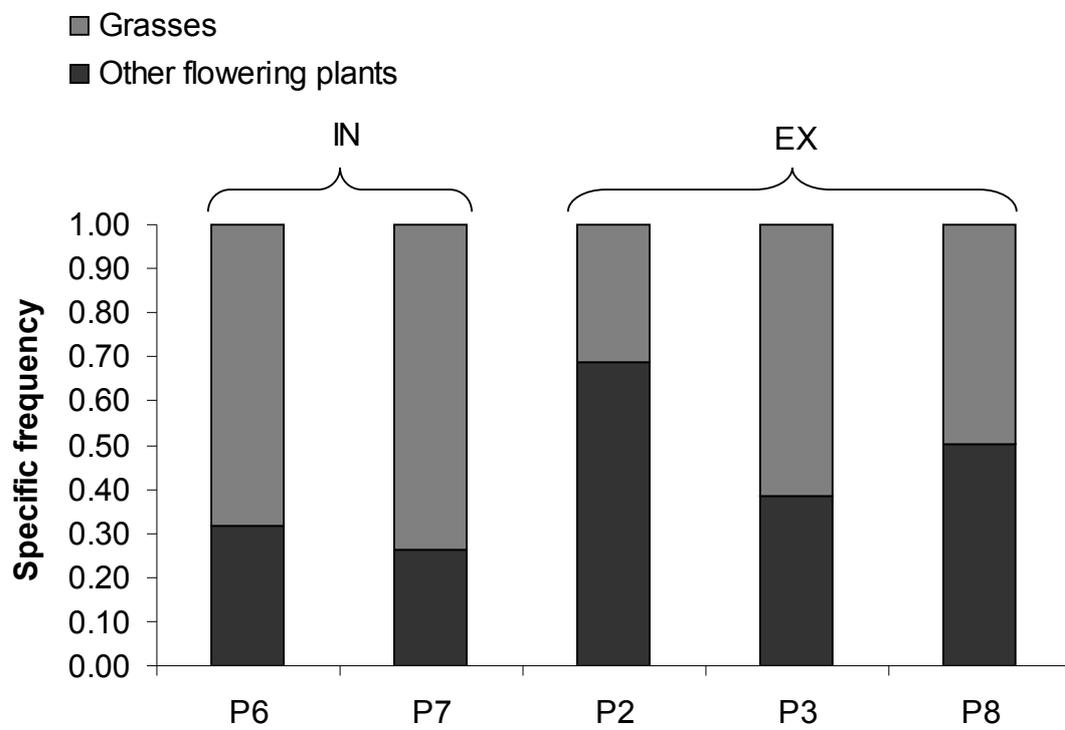


Fig. 3

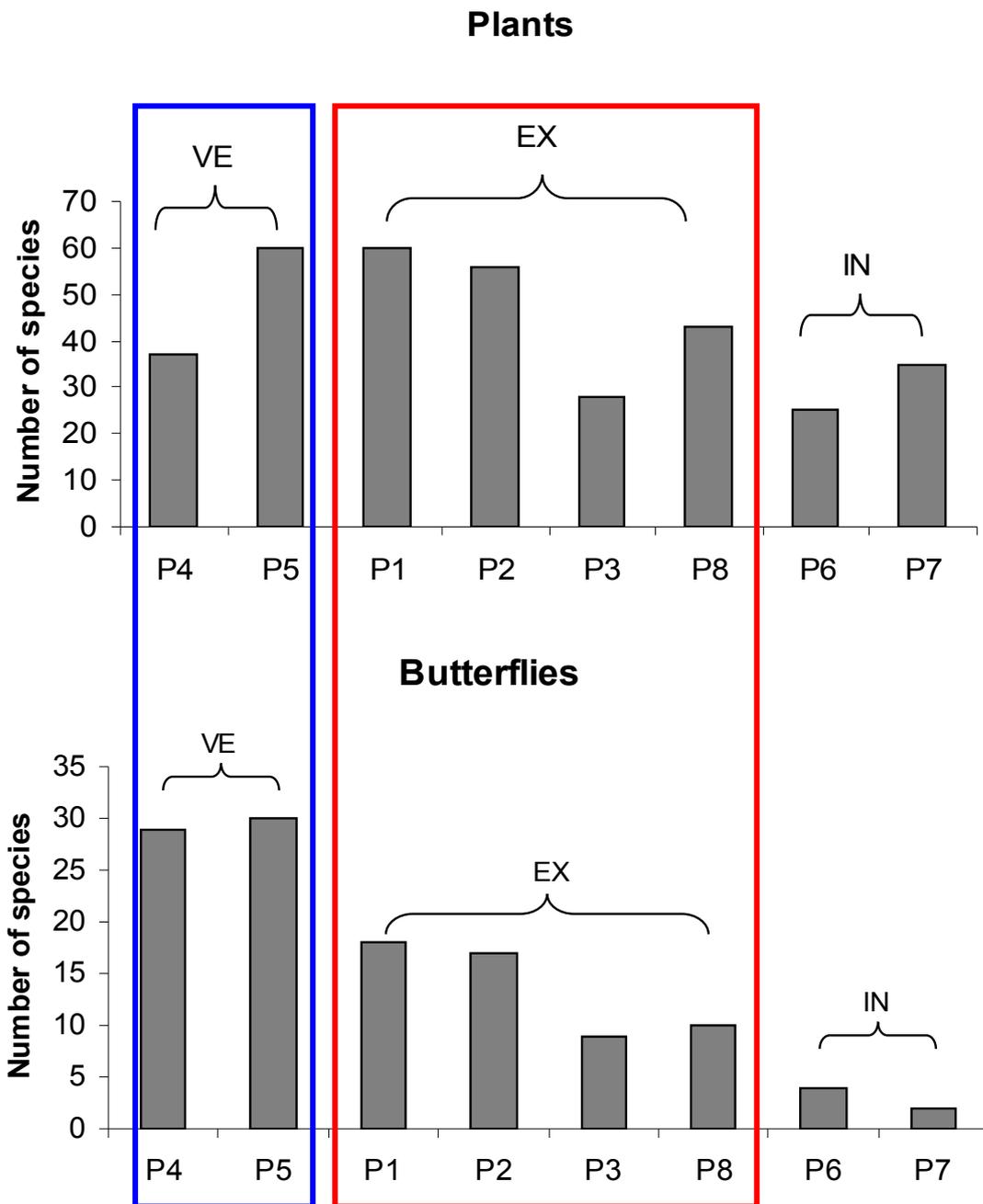


Fig. 4

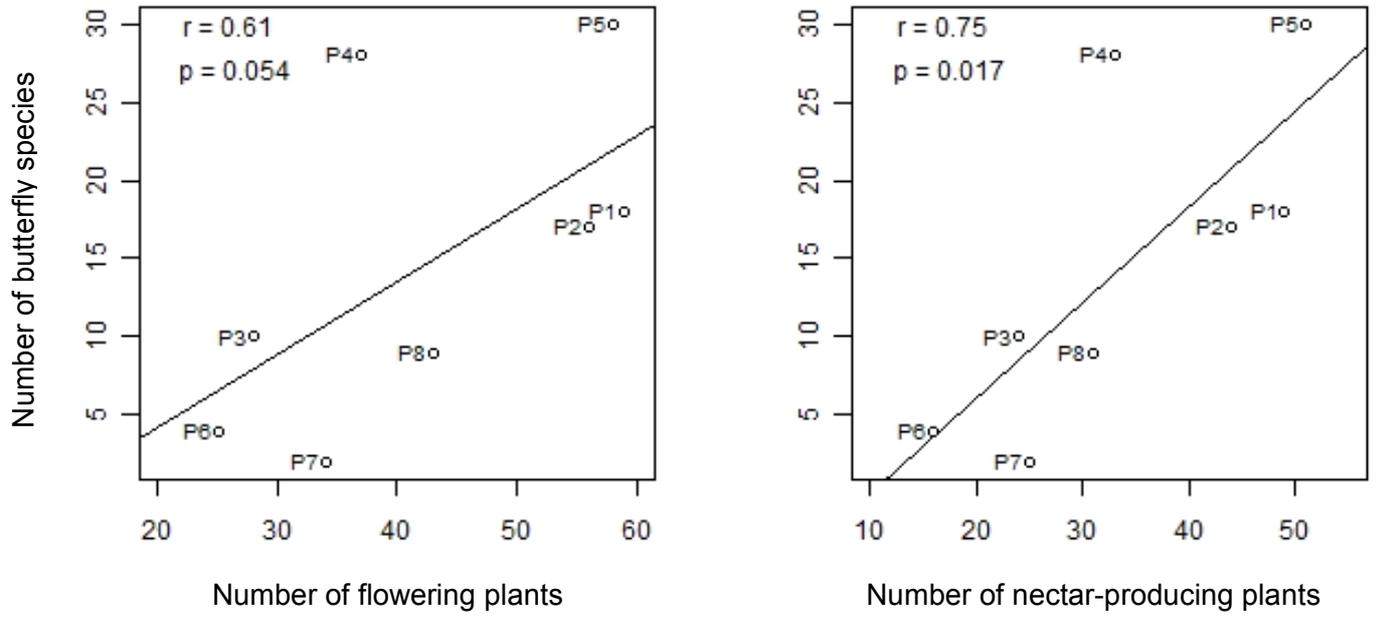


Fig. 5

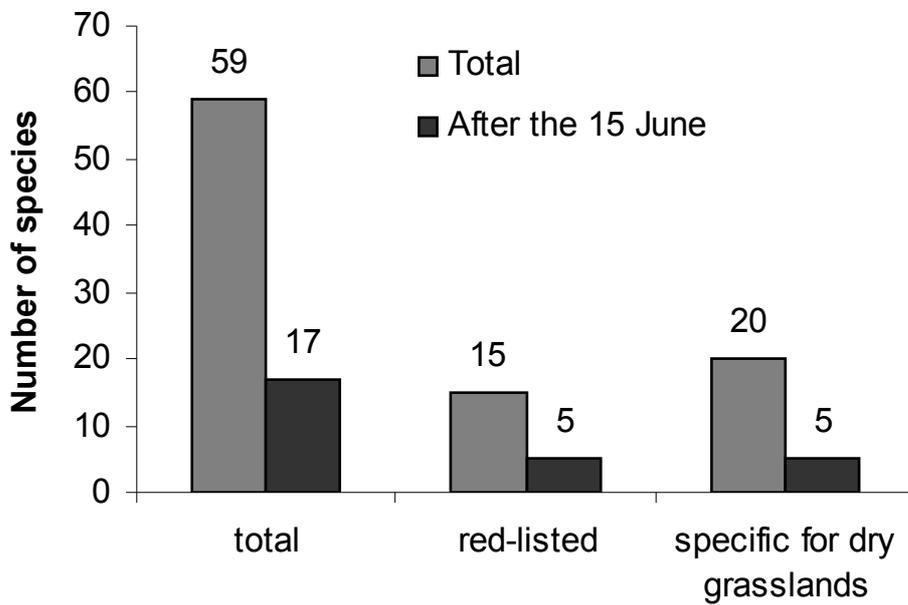


Fig. 6

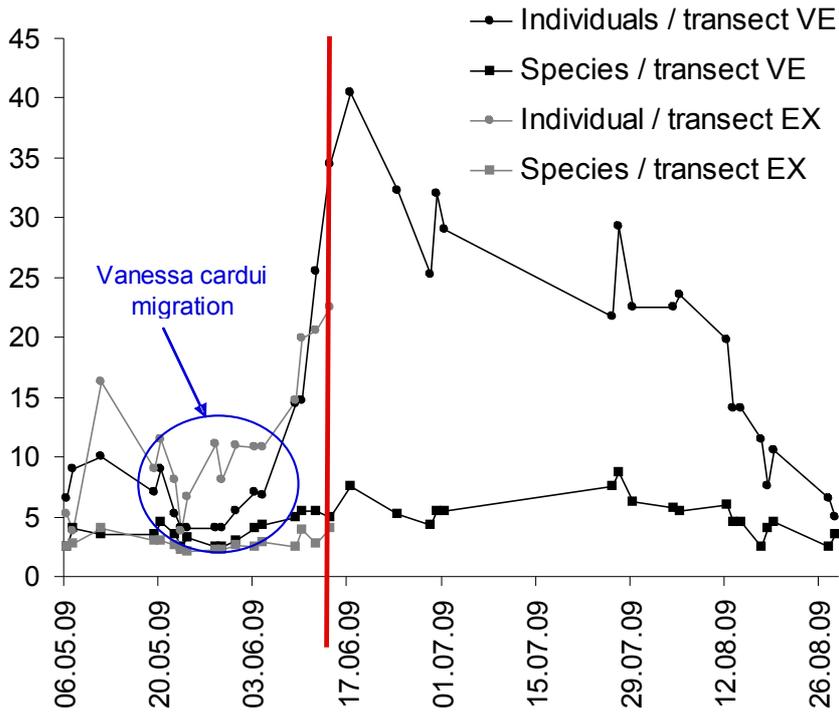


Fig. 7

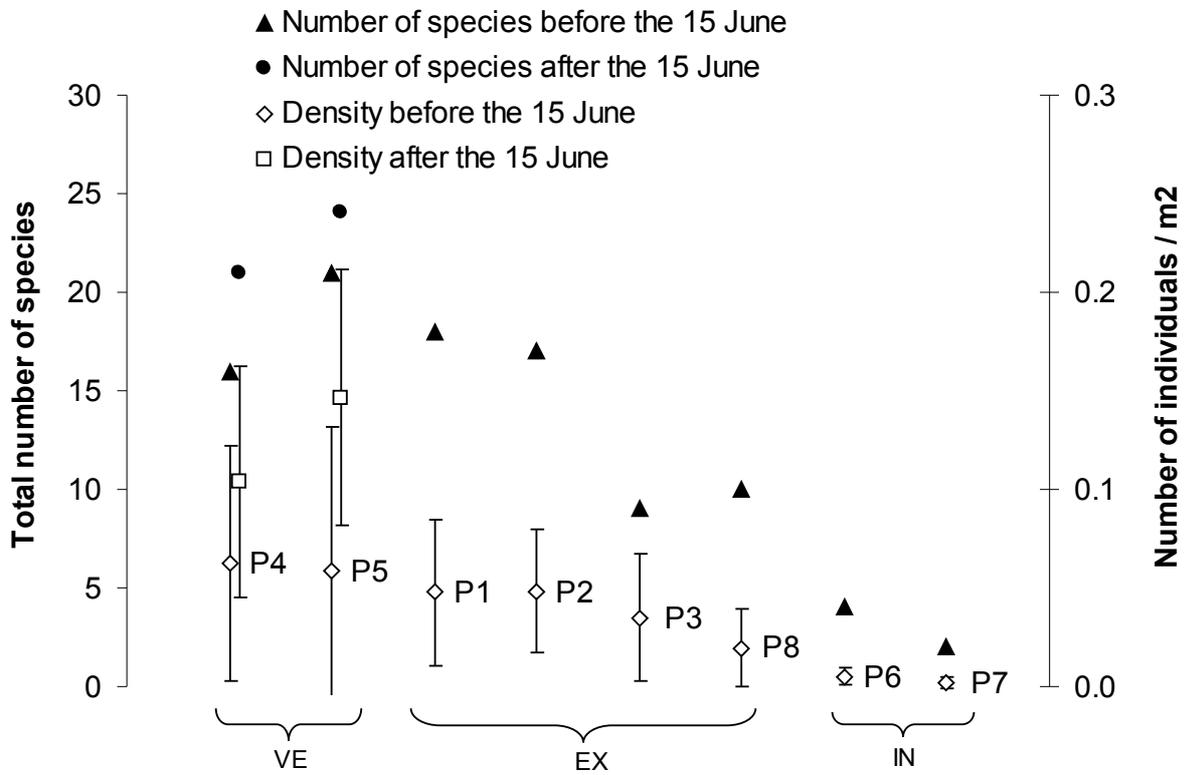


Fig. 8

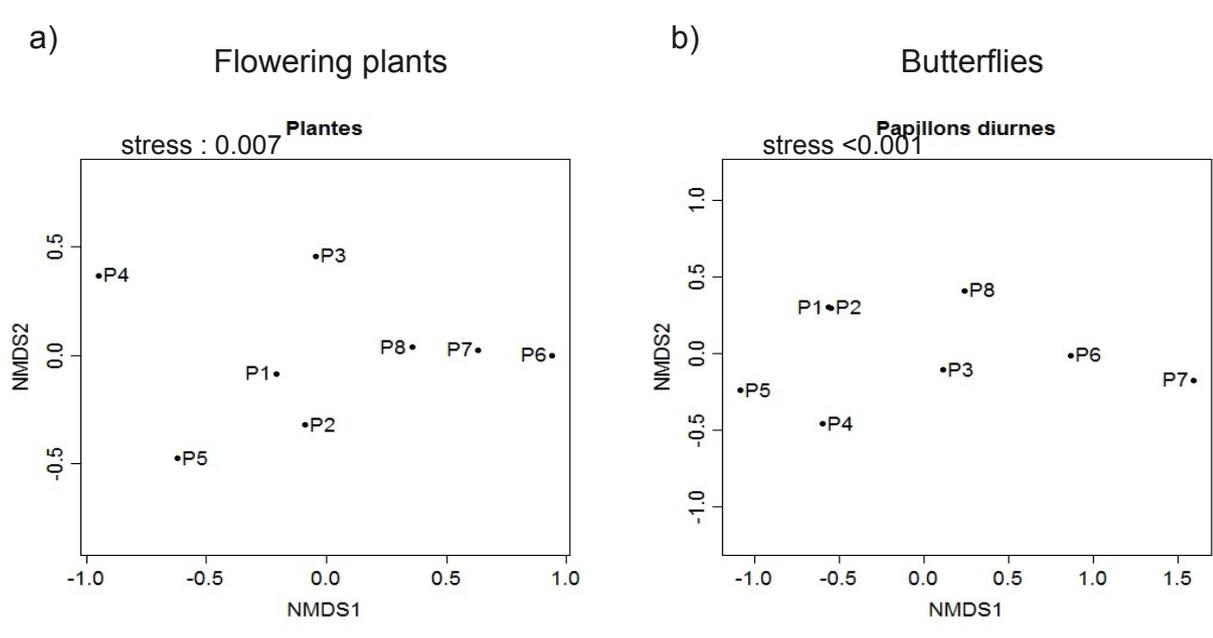


Fig. 9

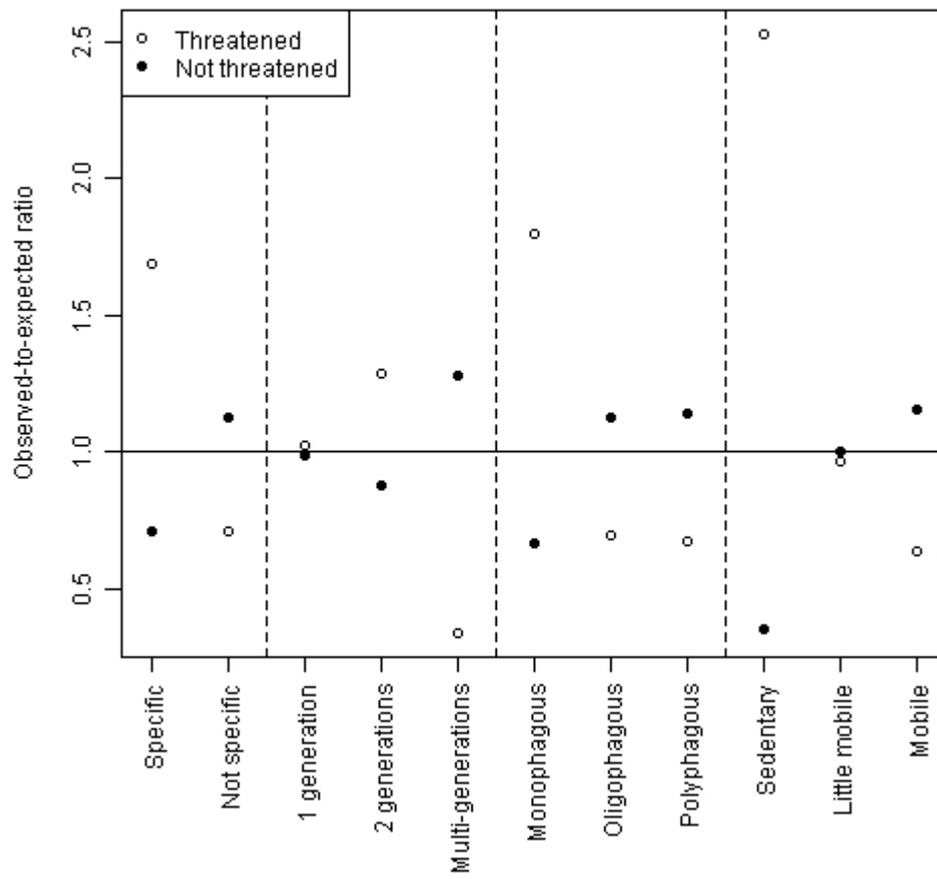


Fig. 10

Tab. 1: Different management modes of the studied dry grasslands. IN, EX, VE: symbols used in the pictures.

Management	Manuring	Mowing
Intensive (IN)	no restrictions	no restrictions
Extensive (EX)	grazing allowed in Autumn only	Not before the 15 June
Very extensive (VE)	none	Irregularly in time, often at the end of the season / mosaic

Tab. 2: Number of flowering plant species recorded in the different plots. The plot names correspond to the local grassland names (Fig. 1 b)). Total: total number of different species.

Management	Plots	Number of species
	Mesobromion (P4)	37
	Pré aux Aulnes (P5)	60
	Total	74
	Pré Jacot 1 (P1)	60
	Pré Jacot 2 (P2)	56
	Amphithéâtre EX (P8)	43
	Pré du Verger (P3)	28
	Total	86
	Longeraie (P6)	25
	Amphithéâtre IN (P7)	35
	Total	41
Total		113

Tab. 3: Number of butterfly species recorded in the different plots. The plot names correspond to the local grassland names (Fig. 1 b)). Total: total number of different species.

Management	Plots	Number of species
	Mesobromion (P4)	29
	Pré aux Aulnes (P5)	30
	Total	36
	Pré Jacot 1 (P1)	18
	Pré Jacot 2 (P2)	17
	Amphithéâtre EX (P8)	10
	Pré du Verger (P3)	9
	Total	26
	Longeraie (P6)	4
	Amphithéâtre IN (P7)	2
	Total	4
Total		59

Tab. 4: Species present in the Swiss red list. Threat level: CR: critically endangered, EN: endangered, VU: vulnerable, NT: near-threatened. * Species not recorded in the plots or in the transects.

Butterflies	Threat level	Plants	Threat level	Orthoptera	Threat level
<i>Boloria dia</i>	EN	<i>Melampyrum cristatus</i>	NT	<i>Chrysochraon dispar</i>	NT
<i>Brenthis daphne</i>	EN	<i>Ophrys holosericea</i>	VU	<i>Euchorthippus declivus</i>	VU
<i>Brintesia circe</i>	EN	<i>Orchis militaris</i>	NT	<i>Euthystira brachyptera</i>	VU
<i>Cupido alcetas</i>	EN	<i>Orchis morio</i>	NT	<i>Gryllus campestris</i>	NT
<i>Cupido argiades</i>	CR	<i>Orchis pyramidalis</i>	NT	<i>Phaneroptera falcata</i>	VU
<i>Cupido minimus</i>	VU	* <i>Orchis simia</i>	VU	<i>Platycleis albopunctata</i>	NT
<i>Fabriciana adippe</i>	VU	<i>Orchis ustulata</i>	NT		
<i>Fabriciana niobe</i>	VU				
<i>Limenitis</i> sp.	EN				
<i>Melitaea athalia</i>	VU				
<i>Melitaea cinxia</i>	EN				
<i>Melitaea diamina</i>	VU				
<i>Plebeius argyrognomon</i>	CR				
<i>Polyommatus coridon</i>	VU				
<i>Polyommatus dorylas</i>	VU				
* <i>Polyommatus thersites</i>	VU				

Appendix 1: Flowering plant species recorded in the different plots. In brackets: uncertain determinations.

		Pré Jacot 1	Pré Jacot 2	Pré aux vergers	Mesobromion	Pré aux aulnes	Longeraie	Amphithéâtre IN	Amphithéâtre EX
Family	Species	P1	P2	P3	P4	P5	P6	P7	P8
Asteraceae	<i>Achillea millefolium</i>	1	1	1	1	1	1	1	1
Rosaceae	<i>Agrimonia eupatoria</i>					1			
Poaceae	<i>Agropyron repens</i>						1	1	
Poaceae	<i>Agrostis capillaris</i>								1
Lamiaceae	<i>Ajuga genevensis</i>	1	1			1		1	1
Liliaceae	<i>Anthericum ramosum</i>				1				
Poaceae	<i>Anthoxantum odoratum</i>	1	1						1
Fabaceae	<i>Anthyllis vulneraria</i>	1	1		1	1			
Brassicaceae	<i>Arabidopsis thaliana</i>		1						
Brassicaceae	<i>Arabis ciliata</i>	1	1	1		1			1
Brassicaceae	<i>Arabis hirsuta</i>	1	1	1		1		1	1
Caryophyllaceae	<i>Arenaria serpyllifolia</i>	1	1	1			1	1	1
Poaceae	<i>Arrhenaterium elatius</i>	1	1			1	1	1	1
Rubiaceae	<i>Asperula cynanchica</i>	1			1	1			
Asteraceae	<i>Bellis perennis</i>						1	1	
Poaceae	<i>Briza media</i>				1	1			
Poaceae	<i>Bromus erectus</i>	1	1	1	1	1	1	1	1
Poaceae	<i>Bromus hordeaceus</i>						1	1	1
Campanulaceae	<i>Campanula rotundifolia</i>					1			
Brassicaceae	<i>Capsella bursa-pastoris</i>							1	1
Cyperaceae	<i>Carex caryophyllea</i>	1	1	1	1	1			
Cyperaceae	<i>Carex halleriana</i>	(1)							
Cyperaceae	<i>Carex spicata</i>		(1)						
Cyperaceae	<i>carica glauca</i>					1			
Asteraceae	<i>Centaurea jacea</i>	1	1		1	1			
Asteraceae	<i>Centaurea scabiosa</i>	1	1	1	1	1			1
Caryophyllaceae	<i>Cerastium brachypetalum</i>						1	1	
Caryophyllaceae	<i>Cerastium fontanum</i>						1		1
Caryophyllaceae	<i>Cerastium glomeratum</i>								(1)

<i>Caryophyllaceae</i>	<i>Cerastium semidecandrum</i>	1	1	1			1	1	1
<i>Convolvulaceae</i>	<i>Convolvulus arvensis</i>						1	1	1
<i>Fabaceae</i>	<i>Coronilla varia</i>						1		
<i>Asteraceae</i>	<i>Crepis biennis</i>		1						
<i>Poaceae</i>	<i>Dactylis glomerata</i>	1	1	1			1	1	1
<i>Apiaceae</i>	<i>Daucus carota</i>		1				1		
<i>Caryophyllaceae</i>	<i>Dianthus carthusianorum</i>	1	1		1		1		
<i>Boraginaceae</i>	<i>Echium vulgare</i>	1	1						
<i>Asteraceae</i>	<i>Erigeron annuus</i>	1	1				1		
<i>Geraniaceae</i>	<i>Erodium cicutarium</i>								1
<i>Euphorbiaceae</i>	<i>Euphorbia cyparissia</i>	1	1	1	1				1
<i>Euphorbiaceae</i>	<i>Euphorbia dulcis</i>						1		
<i>Poaceae</i>	<i>Festuca arundinacea</i>	1	1					1	1
<i>Poaceae</i>	<i>Festuca pratensis</i>	(1)	(1)						
<i>Poaceae</i>	<i>Festuca rubra</i>	1	1	1	1				
<i>Poaceae</i>	<i>Festuca valesiaca</i> <i>agg</i>				(1)		1		
<i>Rubiaceae</i>	<i>Gallium album</i>	1					1		
<i>Rubiaceae</i>	<i>Gallium verum</i>	1		1	1		1		
<i>Geraniaceae</i>	<i>Geranium molle</i>	1						1	1
<i>Cistaceae</i>	<i>Helianthemum nummularium</i>	1			1				
<i>Poaceae</i>	<i>Helictotrichon pubescens</i>	1	1	1			1		1
<i>Asteraceae</i>	<i>Hieracium pilosella</i>	(1)			(1)				
<i>Fabaceae</i>	<i>Hippocrepis comosa</i>	1	1		1		1		
<i>Poaceae</i>	<i>Holcus lanatus</i>		1		1				
<i>Hypericaceae</i>	<i>Hypericum perforatum</i>				1				
<i>Dipsacaceae</i>	<i>Knautia arvensis</i>	1	1		1		1		
<i>Poaceae</i>	<i>Koeleria pyramidata</i>						1		
<i>Asteraceae</i>	<i>Leontodon hispidus</i>	1	1						
<i>Asteraceae</i>	<i>Leucanthemum vulgare</i>	1	1				1		
<i>Poaceae</i>	<i>Lolium perenne</i>		1					1	1
<i>Fabaceae</i>	<i>Lotus corniculatus</i>	1	1	1	1		1		
<i>Juncaceae</i>	<i>Luzula campestris</i>				1				
<i>Malvaceae</i>	<i>Malva moschata</i>	1					1		1
<i>Fabaceae</i>	<i>Medicago lupulina</i>	1	1	1				1	1
<i>Fabaceae</i>	<i>Medicago minima</i>			1					

Fabaceae	<i>Medicago sativa</i>	1	1					1	1
Scrophulariaceae	<i>Melampyrum cristatus</i>				1				
Boraginaceae	<i>Myosotis arvensis</i>					1		1	1
Fabaceae	<i>Onobrychis viciifolia</i>	1	1						
Orchidaceae	<i>Ophrys holosericea</i>					1			
Orchidaceae	<i>Orchis militaris</i>					1			
Orchidaceae	<i>Orchis morio</i>				1				
Orchidaceae	<i>Orchis pyramidalis</i>					1			
Orchidaceae	<i>Orchis simia</i>								
Orchidaceae	<i>Orchis ustulata</i>			1		1			
Lamiaceae	<i>Origanum vulgare</i>	1				1			
Caryophyllaceae	<i>Petiorhagia saxifraga</i>		1						1
Apiaceae	<i>Peucedanum oreoselinum</i>			1	1				
Apiaceae	<i>Pimpinella saxifraga</i>	1				1			
Plantaginaceae	<i>Plantago lanceolata</i>	1	1	1	1	1	1	1	1
Plantaginaceae	<i>Plantago media</i>	1	1			1			
Poaceae	<i>Poa compressa</i>						1		
Poaceae	<i>Poa pratensis</i>	1	1	(1)		1	1	1	1
Poaceae	<i>Poa trivialis</i>	1	1				1		
Polygalaceae	<i>Polygala vulgaris</i>	1	1			1			
Rosaceae	<i>Potentilla erecta</i>								(1)
Rosaceae	<i>Potentilla neumanniana</i>	1		1	1				1
Ranunculaceae	<i>Ranunculus bulbosus</i>	1	1	1			1	1	1
Ranunculaceae	<i>Ranunculus repens</i>								1
Scrophulariaceae	<i>Rhinanthus alectorolophus</i>	1	1	1	1	1		1	1
Polygonaceae	<i>Rumex acetosa</i>					1		1	1
Lamiaceae	<i>Salvia pratensis</i>	1	1	1	1	1		1	1
Rosaceae	<i>Sanguisorba minor</i>	1	1		1	1			
Dipsacaceae	<i>Scabiosa columbaria</i>				1	1			
Crassulaceae	<i>Sedum sexangulare</i>	1							
Asteraceae	<i>Senecio erucifolius</i>					1			
Asteraceae	<i>Senecio jacobaeae</i>					1			
Asteraceae	<i>Senecio vulgaris</i>					1			
Caryophyllaceae	<i>Silene nutans</i>	1	1			1			
Caryophyllaceae	<i>Silene vulgaris</i>	1	1			1		1	1
Lamiaceae	<i>Stachys recta</i>	1			1				

Asteraceae	<i>Taraxacum officinale</i>		1			1	1		
Lamiaceae	<i>Teucrium chamaedrys</i>			1	1				
Lamiaceae	<i>Thymus pulegioides</i>	1	1		1				
Asteraceae	<i>Tragopogon pratensis</i>		1						
Fabaceae	<i>Trifolium campestre</i>	1	1	1	1	1			
Fabaceae	<i>Trifolium dubium</i>	1	1	(1)				1	1
Fabaceae	<i>Trifolium pratense</i>	1	1	1			1	1	1
Fabaceae	<i>Trifolium repens</i>						1	1	1
Poaceae	<i>Trisetum flavescens</i>	1	1					1	1
Valerianaceae	<i>Valerianella locusta</i>		1						
Scrophulariaceae	<i>Veronica arvensis</i>	1	1	1		1	1	1	1
Scrophulariaceae	<i>Veronica persica</i>	1					1	1	1
Scrophulariaceae	<i>Veronica spicata</i>				1				
Fabaceae	<i>Vicia cracca</i>					1			
Fabaceae	<i>Vicia sativa</i>	1	1	1	1	1		1	1
Violaceae	<i>Viola hirta</i>		1		1	1			

Appendix 2: Butterfly species recorded and ecological criteria used in figure 11. In brackets: uncertain data . NA: no data. Threat level: CR: critically endangered, EN: endangered, VU: vulnerable, NT: near-threatened.

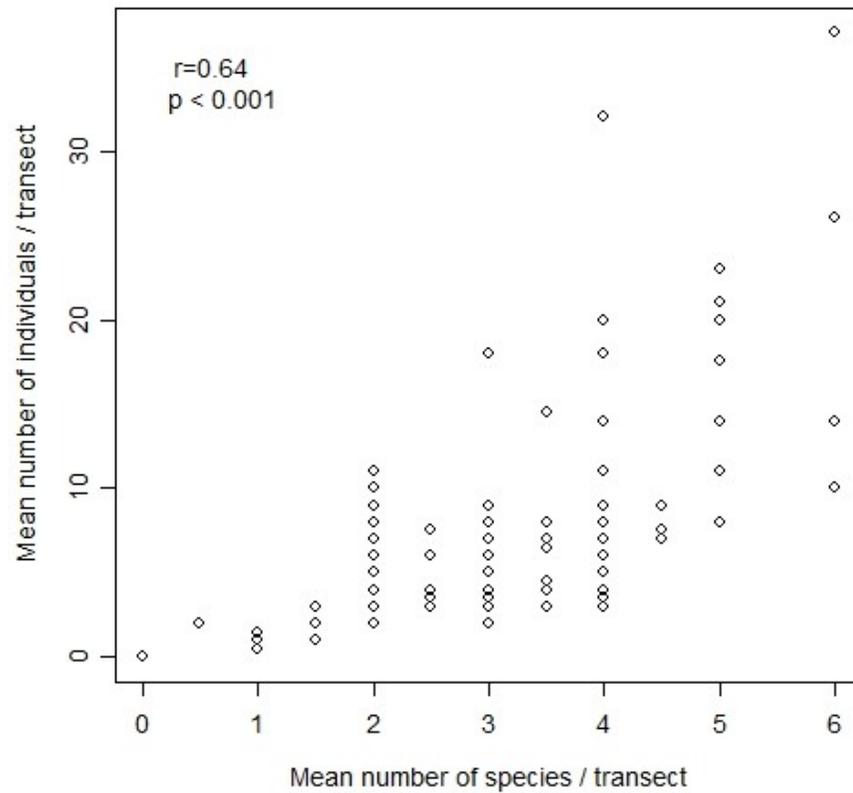
Family	Species	Threat level	Voltinism	Feeding regime	Mobility	Specific for dry grasslands	Hivernation	Flying period
Zygaenidae	<i>Adscita stactices</i>	NA	1	(1)	2	1	caterpillar	May-August
Nymphalidae	<i>Aglais urticae</i>	LC	2	3	4	0	adult	March-October
Pieridae	<i>Anthocharis cardamine</i>	LC	1	2	3	0	pupa	April-July
Satyridae	<i>Aphantopus hyperantus</i>	LC	1	2	2	0	caterpillar	June-July
Arctiidae	<i>Arctia caja</i>	LC	2	3	NA	0	caterpillar	July-August
Nymphalidae	<i>Argynnis aglaja</i>	LC	1	1	2	0	caterpillar	May-July
Nymphalidae	<i>Argynis paphia</i>	LC	1	2	3	0	caterpillars in bark of leave trees	May-August
Nymphalidae	<i>Boloria dia</i>	EN	2	2	NA	1	caterpillar	April-octoblre
Nymphalidae	<i>Brenthis daphne</i>	EN	1	2	NA	(0)	caterpillar (in egg)	June-July
Satyridae	<i>Brintesia circe</i>	EN	1	(1)	NA	1	caterpillar	June-September
Arctiidae	<i>Callimorpha quadripunctaria</i>	NA	NA	3	NA	NA	pupa	July-August
Lycaenidae	<i>Callophrys rubi</i>	LC	1	1	3	0	nymph under stones, leaves, moss, at the base of the HP	March-July
Lycaenidae	<i>Celastrina argiolus</i>	LC	2	2	4	0	pupa	April-May / July-September
Satyridae	<i>Coenonympha pamphilus</i>	LC	3	1	2	0	caterpillar	May-September
Pieridae	<i>Colias crocea</i>	LC	3	3	2	0	Without diapause --> die or slow growing caterpillars if saved from frost	April-September
Pieridae	<i>Colias hyale</i>	LC	3	2	2	1	young caterpillar	March-November
Lycaenidae	<i>Cupido alcetas</i>	EN	3	3	2	0	caterpillar	April-September
Lycaenidae	<i>Cupido argiades</i>	CR	2	3	2	0	caterpillar (L4)	April-September
Lycaenidae	<i>Cupido minimus</i>	VU	2	1	1	(1)	caterpillar	May-August

Satyridae	<i>Erebia medusa</i>	LC	1	2	2	0	caterpillar	June-July
Hesperiidae	<i>Erynnis tages</i>	LC	2	2	2	0	Mature caterpillars on HP	April-September
Nymphalidae	<i>Fabriciana adippe</i>	VU	1	2	4	(1)	caterpillar in egg	July-August
Nymphalidae	<i>Fabriciana niobe</i>	VU	1	2	3	(0)	caterpillar in egg	June-July
Pieridae	<i>Gonepteryx rhamni</i>	LC	1	2	4	0	adult among leaves of persistent trees	January-December
Hesperiidae	<i>Hesperia comma</i>	LC	1	3	2	1	egg or caterpillar	NA
Nymphalidae	<i>Inachis io</i>	LC	2	3	4	0	adult	NA
Nymphalidae	<i>Issoria lathonia</i>	LC	3	2	4	0	caterpillar (L2)	February-October
Satyridae	<i>Lasiommata megera</i>	LC	2	2	3	0	adulte	May-September
Pieridae	<i>Leptidea sinapsis</i>	LC	2	2	3	0	pupa	April-June / July-September
Nymphalidae	<i>Limenitis sp</i>	EN	2	2	4	0	caterpillar	May-July
Lycaenidae	<i>Lycaena phlaeas</i>	LC	3	1	3	1	caterpillar	May-October
Lycaenidae	<i>Lycaena tityrus</i>	LC	2	1	2	0	young caterpillar at the base of HP	April-October
Satyridae	<i>Maniola jurtina</i>	LC	1	2	3	0	caterpillar in soil vegetation	May-October
Satyridae	<i>Melanargia galathea</i>	LC	1	(1)	2	0	caterpillar	June-August
Nymphalidae	<i>Melitaea athalia</i>	VU	1	1	2	0	young caterpillars in a silky web	April-October
Nymphalidae	<i>Melitaea cinxia</i>	EN	1	1	2	0	young caterpillars in a silky web	May-June
Nymphalidae	<i>Melitaea diamina</i>	VU	2	2	1	0	young caterpillars in a silky web	June-July
Lycaenidae	<i>Neozephyrus quercus</i>	LC	1	2	2	0	pupa	June-September
Hesperiidae	<i>Ochlodes venatus</i>	LC	1	2	3	NA	large caterpillar	June-August
Papilionidae	<i>Papilio machaon</i>	LC	3	2	4	0	pupa	April-August
Satyridae	<i>Pararge aegeria</i>	LC	2	2	3	0	pupa	June-August
Pieridae	<i>Pieris brassicae</i>	LC	3	3	4	0	pupa	April-September
Pieridae	<i>Pieris napi</i>	LC	3	3	4	0	pupa	April-October
Pieridae	<i>Pieris rapae</i>	LC	3	3	4	0	pupa	April-October

<i>Lycaenidae</i>	<i>Plebeius argyrognomon</i>	CR	2	1	3	1	egg or young caterpillar	June-July
<i>Nymphalidae</i>	<i>Polygonia c-album</i>	LC	2	3	4	0	adult	March-September
<i>Lycaenidae</i>	<i>Polyommatus bellargus</i>	LC	2	NA	(1)	1	young caterpillar	May-June / juillet-August
<i>Lycaenidae</i>	<i>Polyommatus coridon</i>	VU	1	1	NA	1	egg	June-September
<i>Lycaenidae</i>	<i>Polyommatus dorylas</i>	VU	2	NA	NA	1	young caterpillars under the rosette of HP	April-September
<i>Lycaenidae</i>	<i>Polyommatus icarus</i>	LC	2	2	3	1	caterpillar (L3)	April-October
<i>Lycaenidae</i>	<i>Polyommatus semiargus</i>	LC	1	1	3	1	young caterpillars on HP	June-July
<i>Lycaenidae</i>	<i>Polyommatus thersites</i>	VU	2	2	NA	1	young caterpillars nursed by <i>L. alienus</i> , <i>M. scabrinodis</i> , <i>T. erraticum</i>	April-September
<i>Lycaenidae</i>	<i>Thecla betulae</i>	NA	1	2	(1)	0	egg	August-October
<i>Hesperiidae</i>	<i>Thymelicus lineola</i>	LC	1	2	3	1	caterpillar in egg	May-August
<i>Hesperiidae</i>	<i>Thymelicus sylvestris</i>	LC	1	2	2	1	caterpillars in a cocoon attached to a grass	July-August
<i>Nymphalidae</i>	<i>Vanessa atalanta</i>	LC	1-2	2	4	0	nymph or adult	March-November
<i>Nymphalidae</i>	<i>Vanessa cardui</i>	LC	3	3	4	0	adult, migratory	April-October
<i>Zygaenidae</i>	<i>Zygaena carniolica</i>	NA	1	NA	NA	1	caterpillar	June-August
<i>Zygaenidae</i>	<i>Zygaena filipendula</i>	NA	1	NA	3	1	caterpillar	June-September
<i>Zygaenidae</i>	<i>Zygaena loti</i>	NA	1	NA	NA	1	caterpillar	June-July

Appendix 3: Orthoptran species recorded. Threat level: CR: critically endangered, EN: endangered, VU: vulnerable, NT: near-threatened.

Famiy	Species	Trheat level	Oviposition	Remark
<i>Acridoidea</i>	<i>Chorthippus brunneus</i>	LC	In bareground	developmental growth demands quite high temperature, very mobile
<i>Acridoidea</i>	<i>Chorthippus parallelus</i>	LC	underground	generalist
<i>Acridoidea</i>	<i>Chrysochraon dispar</i>	NT	In the core of a broken stem	like humide sites, litle mobile
<i>Acridoidea</i>	<i>Euchorthippus declivus</i>	VU	underground	
<i>Acridoidea</i>	<i>Euthystira brachyptera</i>	LC	NA	humid and shaded sites, if sunny site □ linked to a dense and high vegetation offering shadow and humidity
<i>Acridoidea</i>	<i>Gomphocerippus rufus</i>	LC	in an open or folded leave	prefers lowland, highly structured sites
<i>Grylloidea</i>	<i>Gryllus campestris</i>	NT	In the soil	thermo-xerophile
<i>Tettigonioidea</i>	<i>Metrioptera bicolor</i>	VU	In a grass stem	linked to dry sites with high vegetation, the vertical structure of vegetation is the main demand
<i>Tettigonioidea</i>	<i>Metrioptera roeselii</i>	LC	In a grass stem	prefers humid sites with high and dense vegetation
<i>Tettigonioidea</i>	<i>Phaneroptera falcata</i>	VU	In vegetation	dry sites, high vegetation
<i>Tettigonioidea</i>	<i>Pholidoptera griseoptera</i>	LC	In the soil of humid sites or in rotten wood	one of the most frequent grasshopper of CH, likes high vegetation humidity
<i>Tettigonioidea</i>	<i>Platycleis albopunctata</i>	NT	In the soil, litter or moss and dry stems	rare in the lowland, linked to dry grasslands, likes high vegetation and feeds mainly on seeds
<i>Acridoidea</i>	<i>Stauroderus scalaris</i>	LC	NA	prefers higher altitudes, mainly in dry grasslands
<i>Acridoidea</i>	<i>Stenobothrus lineatus</i>	LC	NA	rare in the lowland, thermophile, likes short vegetation
<i>Tettigonioidea</i>	<i>Tettigonia viridissima</i>	LC	In the soil	mid-high vegetation



Appendix 4: Correlation between butterfly species richness and abundance. r : Pearson's correlation coefficient. Source data: extensive and very extensive grasslands, period: 06.05.09 – 15.06.09.