School of Biology

Biodiversity of butterflies (Rhopalocera, Hesperiidae and Zygaenidae) into the future biosphere reserve in Val Müstair (Graubünden) – the populations of Val Mora

Master Thesis of Science in Behaviour, Evolution and Conservation

by

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January 2010

Abstract

The aim of this study is to give a first description of the Rhopalocera communities of a region of the future Biosphere reserve Val Müstair-Swiss National Park: Val Mora. The methodology applied here is based on two complementary approaches. The first qualitative approach consists in identifying every species on a 1ha wide surface and gives information about the specific diversity. The second semi-quantitative approach is led on a quarter of the previous hectare and consists in an estimation of the number of butterflies present to obtain information about the relative specific abundance. We selected a set of six sampling stations with an altitude ranging from 2078 to 2233 meters. These stations were sampled at least six times during the active season (from June to September). 6234 individuals of 57 species were thus recorded in 2009. The diversity of the spots varies from 26 to 44 species. We also compared these data with those of 3 studies led on the Swiss National Park (SNP) territory. Despite a unique sampling season and a reduced altitudinal range, the average diversity index and the average population density is higher on our stations than on the stations of the SNP. These results promote the setting of a long term monitoring on alpine meadows of the future Biosphere reserve Val Müstair-Swiss National Park.

I. Introduction

The Lepidoptera order is composed of more than 150’000 species worldwide. The classification of this rich and diversified order is classically divided up two groups: the Heterocera (nocturnal Lepidoptera) and the Rhopalocera (diurnal Lepidoptera). As some of the Heterocera are also active during the light hours of the day the only criteria to distinguish both groups is the form of the antennae. All the species of Rhopalocera present claviform antennae (LPSN, 1987). The Rhopalocera are holometabolous insects linked to the vegetation at the caterpillar and butterfly stages of their development. Indeed, the larvae have usually a phytophage regime linked to one or several host plants while most of the imagos are nectarivorous and provide an important force of pollinisation for the flowering plants (LSPN, 1987). Because of these tight links to the vegetal community the Rhopalocera are successfully used as bioindicators and reflect the condition of the milieux in which they are living (Kerr et al., 2000). Furthermore, they are representative of most of the other insects groups living in open and semi-open areas (Thommas, 2005), habitat involving the great part of the Swiss insect species (Gonseth, 1994).

Due to their biological importance, their visual attractiveness, and their easy observation, they are nowadays a well documented group. Numerous studies and works were carried out in Switzerland the twenty last years, including the complete tomes of the Swiss League for the Protection of Nature (LSPN, 1987; 1999; 2000) about part of the Heterocera and Rhopalocera families. This first quality work makes it easy to identify every species of Switzerland and gives information about their ecology. A red list giving the status of each species of Rhopalocera in the different regions of our country was built (Gonseth in Duelli, 1994) and is going to be actualized. The same project is under construction for the Heterocera species. 49 among the 195 resident species are endangered and 12 are under extinction threat. The major modifications of the agricultural system (mechanisation, use of pesticides, herbicides and chemical manure), the regression of traditional agriculture and the exploitation of vast areas of natural meadows strongly affected the Rhopalocera populations (Gonseth, 1994). A biodiversity monitoring and a database at the Swiss scale already exist and are thus primordial in order to ensure the conservation of species. As a complement of these existing tools, local or regional monitoring must be achieved in the most interesting spots to ensure performing results with a minimal effort. In that purpose, we dispose of a simple and repeatable methodology first established by Besson (1998). This method provides both qualitative data about the specific richness and semi-quantitative data about the relative population densities, allowing thus to point out the temporal populations variations (Pollard and Yates, 1993).

In this study, we applied such a methodology to describe the Rhopalocera populations of the Val Mora, a region of the eastern Graübunden involved in the project of Biosphere Reserve Val Müstair-National Park (Biosfera project, 2009). This isolated region is protected from an excessive human influence and contains a very high floristic and faunistic richness. Moreover, the Rhopalocera fauna of this region was never studied before and the available data is not complete (CSCF).

The aim of this study is thus to contribute to the knowledge of the Rhopalocera fauna of Val Mora by collecting qualitative and semi-quantitative data with a rigorous and reliable sampling method. A set of sampling sites is selected in order to faithfully represent the main milieux of the study area and could be used in further studies or in a long term monitoring in order to optimally distinguish the annual population fluctuations from those linked to other factors (Primack, 2000). In a same way, it would be possible to statistically compare the evolution of the Rhopalocera fauna of Val Mora to the populations of other regions sampled with the same methodology, such as the Swiss National Park.

In order to join sustainable development to biodiversity conservation, the main factors affecting the Rhopalocera populations are identified and some measures are proposed.

II. Material and methods

II.1. General – Study area

Val Mora takes place at south of Val Müstar, at the east end of the Graubünden state and draws the geographical limit between Switzerland and Italy at south and at west (Figure 1), just a few km south-east from the limit of the Swiss National Park.

The Swiss National Park (SNP) was created the first of August 1914 by a federal arrest and is governed by its own legislation. It covers nowadays an unoccupied area of 172.3 square km in which the nature is totally wild and out of human influence since about 100 years. In 1979 the SNP became the first biosphere reserve designed in Switzerland (category 1a of the International Union for the Conservation of Nature IUCN). After the discussion of Rio about sustainability, new conditions and requirements have been formulated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) through the Seville strategy for biosphere reserves, following which the SNP kept trying to adapt the necessary measures to add a buffer zone. A first attempt failed then an initiative of the population of the Val Müstair County (including the territories of Val Mora) targeted to create a biosphere reserve with the SNP as a central core. The aim of this initiative is to design an extension of the existing biosphere reserve in order to create a new Biosphera Reserve Val Müstair-National Park and to allow the distinction between the several zones required by the UNESCO. For geographical and political reasons these zones will not totally surround the central area but the buffer zone in which Val Mora is included has the strength of connecting the SNP to the National Park of the Stelvio (Italy, South Tyrol). The localization and the topography of the Val Müstair present a great potential in this application because its cultivated, rich in species landscapes kept their authenticity.

According to the new law about Parks of national importance, in order to be allowed to become a complement of the existing biosphere reserve, Val Müstair must obtain the regional natural park status in Switzerland. It will thus become the Regional Natural Park “Biosfera Val Müstair”. This park will cover about 190 square km (including the buffer zone and the transition area). Thanks to the mobilization and the support of the local population, the operational phase will probably begin in 2010 (Biosfera Val Müstair application, 2009). One of the strengths of such an extension will be the possibility to associate protection of nature and environment with sustainable development by setting protection and valorization of the cultural landscape.

Climatically, Val Mora as well as Val Müstair is situated in the intra-alpine continental dry zone area, with a weak Mediterranean influence. Its climate has relatively poor precipitations (<80cm/year) and promotes particular fauna and vegetation.

Connected east to Val Müstair by Val Vau at the level of Valchava, it first draws an almost perfect east/west axis over 3.5 km. It turns then north-west and follows a straight line over 5 km up to Alp Mora, before carrying out a slender slope direction south-west. It finally meets the Italian boarder at Pass Val Mora its lower point (1934 meters over the sea level). The entire Val is included between 2078 and 2233 meters while the surrounding mountains culminate at 3180 meters for Piz Murtaröl south and 2957 meters for Piz Turettas north.

The calcareous rocks composing the mountains of this region come under important mechanical constraints linked to the frost and defrost phenomenon, to the winds and the flows issued of the melting of snow. Frequent calcareous landslides happen and lead the vegetation to be rapidly renewed in order to colonize new damaged zones. Thus Val Mora is essentially composed of calcareous landscapes and open alpine landscapes, although forests and humid areas are also represented. Two farms also take place on the Val, grouping 200 cattle heads regularly dispatched on the whole territory of Val Mora from June to September. For decades, this pastoral tradition is settled in Val Mora and contributes to prevent the progression of forests and bushes upon meadows and grasslands. The county of Val Müstair promotes extensive and biological agriculture (about 80% of its farms).

This study focused on the east-west oriented optimal part of Val Mora, i.e. the included section between Val Vau and Alp Mora. Six stations were selected on a six km long surface (Figure 2). All of them are on the alpine level.

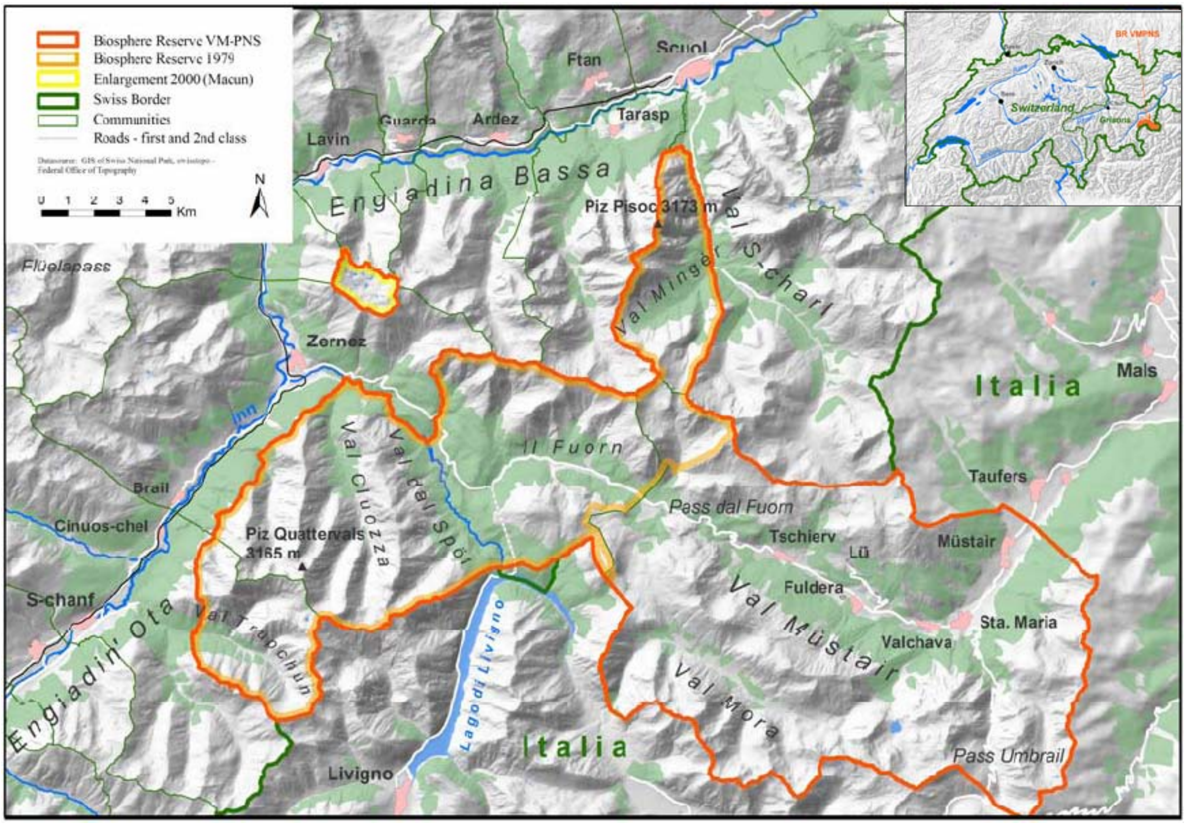


Figure 1: Geographical situation of Val Müstair and Val Mora in Switzerland (frame) and in the east part of the Graubünden. Orange and yellow lines delimit the area of the Swiss National Park (SNP). The red line delimits the area of the future biosphere Val Müstair-SNP reserve including Val Mora

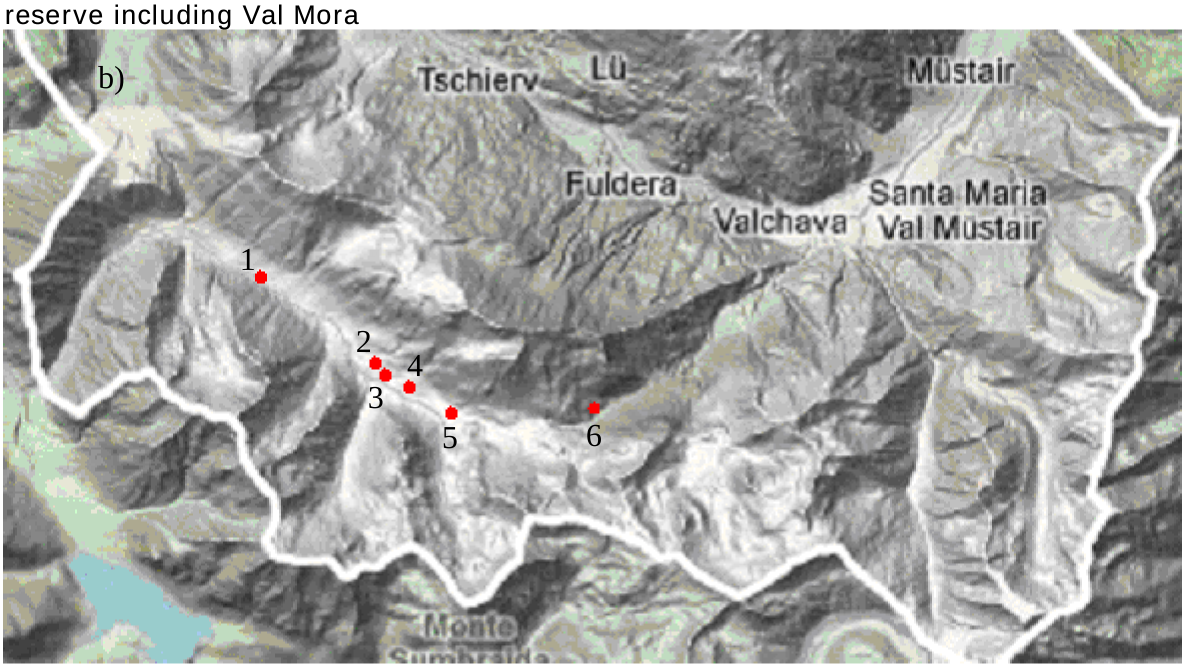


Figure 2: Detailed map of Val Mora and position of the 6 sampling stations (2009). The boarder between Italy and Switzerland is drawn with a white line.

II.2. Localization and choice of the sites

The sites were selected *in situ* during a first reconnaissance the 2nd of June 2009 by Yves Gonseth, Daniel Cherix, Aline Pasche, Yannick Chittaro and the author. Six 1ha wide spots were chosen in order to optimally represent the diversity of open and semi-open milieux composing the Val. We gave preference to the meadows and the altitudinal scanty grasslands, assumed to be optimal biotopes for the Rhopalocera (Gonseth, 1994) and to the spots with a suitable exposure. The selected stations offer various slopes and different types of vegetation. They are distributed along 6 km into the Val (Figure 2) and cover an altitude between 2078 and 2233 meters. In order to reduce the influence of environmental bias on the collected data we selected spots with very similar accessibility and exposure. Each spot is composed of a 1ha wide surface. The whole hectare is used for the qualitative samplings but only a quarter of this surface is used during the semi-quantitative samplings. The four corners and the middle of each spot are delimited by wooden stakes and the corresponding coordinates are loaded by GPS (Global Positioning System) (Annexe 1). The coordinates of the down left corner are given into the sites description.

II.3. Sites description

1

Coordinates: 818530/164288 Altitude: 2078m Dominant alliance: *Seslerion*

The first and most western spot is located near Alp Mora where is located the second farm of the Val (Figure 2). It is a dry meadow with a south-western exposure, strewed with low sized calcareous rock fragments and it presents a regular 10% slope. The station is enclosed on 3 sides by the dense 2.5 meters tall edge of a pine forest. A cow fence also encloses the east border and the fourth side is drawn by the path. Despite the proximity of the farm and frequent observations of cows on the path, the whole station shows only few traces of pasture or stamping. Indeed, the cows prefer rich grasslands located about 50 meters on the lower side of the path.

2

Coordinates: 820700/164542 Altitude: 2151m Dominant alliance: *Seslerion*

That second sampling station cumulates all the characteristics of an open grazed area with pines and *Erica*. The environment is has with a relatively uniform herbaceous level, strewed with big calcareous blocs and presents a west to east increasing gradient of pines into the bush and tree levels. It offers a 5% slope and a south-western exposure (Figure 2). The east side of the spot is delimited by a ravine of fallen stones in which a brook flows from June to July, while the snow melts. A pine forest with big trees (3 meters high at least) makes it difficult to access to the upper part. A few cows were seen down the spot while they were rubbing themselves to the pine branches and looking for shade, on an unusually hot day of July. Light traces of grazing and stamping were recorded on the open part of the station at the same period.

3

Coordinates: 820930/162395 Altitude: 2152m Dominant alliance: *Caricion firmae*

The third station is the last south-western oriented spot before the east-western oriented part (Figure 2). It consists of meadows on a moraine on the upper part and an alluvial zone with pine bushes on the lower part. Uniformly scrubbed, the spot shows a low slope (about 12%). It is delimited at east by fallen rocks, at north by a bank covered with pines of all sizes, at south by the path and at west by a river trench. In order to select an optimally uniformed study area, we delimited for that station a rectangular surface that measures 50 by 200 meters. The selected area is parallel to the eastern line of the fallen rocks that are about to be recolonized and follows thus a north-east/south-west axis.

4

Coordinates: 822152/161942 Altitude 2202m Dominant alliance: *Caricion firmae*

This station that shows a particular composition includes side by side a streaming zone, fallen rocks cones, a scrubbed meadow and a humid area which is fed by a river all summer long. The spot is crossed by the path and delimited at north and east by fallen rocks and at south by the humid area. Colonized by a family of marmots, the spot is fully southern oriented with an approximately 15% steep slope (Figure 2). The alliance diagnostic is based on the upper central part of the station and does not include the humid area.

5

Coordinates: 822557/161808 Altitude: 2233m Dominant alliance: *Seslerion*

This is the most abrupt among the six stations with a slope reaching 50% and a southern exposure (Figure 2). It consists of a hillside with *Ericacea*, covered with dry grassland, overhanging south a vast all season long flooded humid zone colonized by frogs and dragonflies but that is out of the study. It is also the highest spot of this study with an altitude of 2233 meters at the lowest point. Despite the steep slope and a lack of attractiveness of the vegetation, a herd of heifer ventured up the spot a few times and showed ease to get around it. A stag has also been recorded at the top of the station in August, as well as a few marmots. Because of the trampling and the garland-like morphology of the vegetation, big stripes of nude ground are apparent perpendicularly to the slope. A few big calcareous blocks encumber the bottom of the spot.

6

GPS: 824464/162031 Altitude: 2100m Dominant alliance: *Seslerion*

Our last station is also the most eastern one. It is south-eastern exposed and shows a steep slope estimated to 40% (Figure 2). The milieu is composed of an open area with pines and larches. It is crossed by a brook which is never totally dry but shows a highly variable flow. The upper part of the spot is stocked with very high larches (up to 8 meters high) while the lower border is occupied by a dense heap of pine bushes. The whole surface of the study area is scattered with more or less laxly dispersed calcareous blocks of all sizes, which set perfect shelters for the reptiles. Two vipers (*Vipera berus*) were observed in these rocks heaps in June. Traces of trampling, grazing and some cow dung were present all season long along the brook and on the grassland located just upper the station. However, the steep sides with trees did not show such a high intensity of exploitation.

The characteristics of each station are synthesized in the table 1.

Table 1: Characteristics of the sampling stations of Val Mora.
*Slope: Values were estimated *in situ*

Stations	Altitude	Exposure	Slope*	Dominant Vegetative alliance
1	2078 m	SO	10%	*Seslerion*
2	2151 m	SO	5%	*Seslerion*
3	2152 m	SO	12%	*Caricion firmae*
4	2202 m	S	15%	*Caricion firmae*
5	2233 m	S	50%	*Seslerion*
6	2100 m	SE	40%	*Seslerion*

II.4. Floristic approach

The whole area of Val Mora is characterized by highly heterogeneous mosaic-like milieux. The stations we chose in order to faithfully represent the entire Val reflect well that diversity and show for most of them an outstanding mosaic of milieux. The vegetative alliances of each spot were determined afterwards, with the “Guide des milieux naturels de Suisse” (Delarze & Gonseth, 2008). The determination of the vegetal species was done either *in situ*, or according to pictures and dry specimens with the “Flora Helvetica” (Lauber & Wagner, 2000). Only the dominant alliance is given to characterize each station, even when some spots cumulate several secondary alliances. An estimation of the number of cows was established thanks to the information given by the farmers of Alp Mora.

II.5. Sampling method

Faunistic approach: specific diversity

The sampling method employed was established and improved by several supplementary studies (Gonseth et al, 2007). It consists of two complementary approaches which can be achieved in one sampling season: a qualitative approach and a semi-quantitative approach. This method offers the essential assets to any scientific step: it is repeatable and it provides statistically usable and comparable datasets.

The qualitative approach is led on the entire hectare and allows first to build a list of the species that occur on the station. It consists of freely running through the spot as long as necessary, and methodically determining any Rhopalocera (Papilionoidea and Hesperioidea) or Zygaenidae (diurnal Heterocera) species met, in order to define the maximal species richness by station. Only the imagos are taken into account. If needed, individuals are captured with a net and relaxed after being determined with the guides of Lafranchis (2007), Whalley (1989) or Tolman and Lewington (1999). When a doubt subsists or when the individuals belong to visually difficult, even impossible to determine species (*Hesperiidae*, *Zygaenidae*) they are regularly collected, prepared and labelled after being identified with specialized books of the Swiss league for the protection of the nature (SLPN) (LSPN 1987, 1999). In the most difficult cases, the *genitalia* are prepared and analyzed with a binocular. In order to authentify the data, a reference collection composed of at least one individual of each species was deposited in the Zoology Museum of Lausanne.

The nomenclature used is the one adopted by the SLPN (LSPN 1987, 1999). Thus the taxa are the following: *Papilionidae*, *Pieridae*, *Nymphalidae*, *Satyridae*, *Lycaenidae*, *Hesperiidae* and *Zygaenidae*.

The semi-quantitative approach is led on a regular quarter of hectare, which is chosen so that it represents each spot at best. It allows then to estimate the effectives of populations by counting the met individuals. In that purpose, a regular theoretical itinerary is followed through the selected quarter of hectare with a constant 2-3 km/h speed. This itinerary goes all over the quarter of hectare effecting parallel rectilinear trajectories every 10 meters. Only the butterflies which were seen in a 5 meters radius half-circle are counted up along the transect. In order to make the identification and the count of flying individuals easier, Besson developed a method of attribution to morphogroups based on visual criterions (form, colour, patterns, etc.). However, such a process has not been necessary during this study. The relative abundance of species was successfully estimated directly by identifying the species of each individual.

According to the general conditions of application relative to this sampling method, it is recommended to work *in situ* only by hot and sunny weather and by weak or null wind. These parameters fit to the optimal weather for the Rhopalocera. Up to three stations were sampled in one day, depending on the distance between them. Each station was regularly sampled six times between the 12th of June and the 27th of August (Table 2). The aim was to cover the flying periods of every species as well as possible. A seventh sampling was effectuated on the stations 1, 4 and 6 from the 9th to the 10th of September.

Table 2: 2009 sampling dates for each station of Val Mora. There are 6 samplings for each station and one more for the stations 1, 4 and 6.

	Sampling 1	**Sampling 2**	**Sampling 3**	**Sampling 4**	**Sampling 5**	**Sampling 6**	**Sampling 7**
Station 1	16-Jun	29-Jun	15-Jul	30-Jul	6-Aug	27-Aug	9-Sep
Station 2	16-Jun	2-Jul	15-Jul	29-Jul	6-Aug	27-Aug	
Station 3	13-Jun	2-Jul	16-Jul	29-Jul	6-Aug	25-Aug	
Station 4	12-Jun	2-Jul	16-Jul	29-Jul	7-Aug	25-Aug	9-Sep
Station 5	12-Jun	3-Jul	16-Jul	30-Jul	7-Aug	27-Aug	
Station 6	17-Jun	30-Jun	20-Jul	30-Jul	7-Aug	25-Aug	10-Sep

II.6. Data treatment

II.6.1. Simpson's diversity index

Simpson's diversity index measures the probability for two randomly selected individuals to belong to the same species. In our case, it is used to evaluate the faunistic diversity of each station by using as a descriptor the effectives of diurnal *Lepidoptera* inventoried by species and by site. Simpson's diversity index is calculated according to the following formula:

$$D = \Sigma N_i(N_i - 1) / N(N - 1)$$

with N_i: number of individuals of the given species and N: total number of individuals.

That index returns values between 0 and 1 included, the maximal diversity being represented by the value 0 and the minimal diversity taking the value 1. Notice that the index increases more rapidly if we add abounding species to the sample than if we add rare species. It is due to the fact that the index gives less weight to rare species. Moreover, Simpson's index presents the advantage of allowing reliable statistical comparisons between several dataset. We will have the opportunity to test it in chapter IV.3 by comparing our results with those of studies led on the SNP territory.

Intending to obtain more intuitive values, we usually prefer using the Simpson's diversity index represented by S = 1-D:

$$S = 1 - \Sigma (N_i / N)^2$$

The more its value is close to 1, the higher the diversity of the considered site will be. In the opposite way, an index reaching 0 indicates the minimal diversity. (Schlaepfer & Bütler, 2002).

II.6.2. CFA

Correspondences factorial analysis (CFA) was applied to the semi-quantitative data in order to identify the variability tendencies of the faunistic composition of sampled sites. To avoid evicting the species listed during the qualitative sampling only, for which no estimation of abundance was established in the dataset, we attributed to them the value of 1. The treatment of the data and the graphical representation of the results were achieved with the R statistics (version 2.8.0, 2008).

III. Results

III.1. Global results

Overall 57 species of diurnal *Lepidoptera* were observed at least once during the season on the whole study area. These species are distributed among the different families as following: 1 *Papilionidae*, 7 *Pieridae*, 12 *Nymphalidae,* 8 *Satyridae*, 17 *Lycaenidae*, 10 *Hesperiidae* and 3 *Zygaenidae* (Table 3). 6234 individuals were censed during the semi-quantitative samplings. The family of the *Zygaenidae* is clearly dominating with 52% of the censed individuals, followed in decreasing order by the *Papilionidae, Pieridae, Nymphalidae*, *Satyridae*, *Lycaenidae*, *Hesperiidae* and Zygaenidae (Table 3).

Table 3: Number of species and number of individuals among the different families* listed in 2009 on the 6 stations of Val Mora. **Papilionidae* (*Pap.*), *Pieridae* (*Pier.*), *Nymphalidae* (*Nymph.*), *Satyridae* (*Sat.*), *Lycaenidae* (*Lyc.*), *Hesperiidae* (*Hesp.*) and *Zygaenidae* (*Zyg.*).

Families	***Pap.***	***Pier.***	***Nymph.***	***Sat.***	***Lyc.***	***Hesp.***	***Zyg.***	**Total**
Nb of species	1	6	12	8	18	9	3	57
Nb of individuals	4 (<1%)	726 (12%)	795 (13%)	742 (12%)	583 (9%)	126 (2%)	3258 (52%)	6234

The table 4 summarizes the data collected during the 2009 sampling season, from the 16th of June to the 10th of September included. The details of these observations are given in Annexe 2. *Maculinea arion* and *Maculinae rebeli* have both been found but we had insufficient data to estimate their relative population sizes. They are thus listed under the same entry in the results table (Table 4). Same comment about *Aricia agestis* and *Aricia artaxerxes* or *Plebejus idas* and *Plebejus argus*. We noticed that the *idas*/*argus* ratio was at most 1/20. Among the 57 species listed, 16 species (28%) were observed on every 6 stations and 16 were only seen on one single station. From a quantitative point of view, the most frequent species are: *Zygaena exulans* (3062 individuals), *Colias phicomone* (603), *Erebia tyndarus* (391), *Cynthia cardui* (291), *Erebia euryale* (264), *Plebejus argus*/*idas* (254), *Adscita geryon* (172) and *Boloria pales* (162) (Table 4). On the contrary, 12 species were recorded with one single observation: *Colias alfacariensis*, *Clossiana selene*, *Melitaea diamina*, *Erebia pluto*, *Erebia gorge*, *Coenonympha arcania*, *Lycaena tityrus*, *Celastrina argiolus*, *Lysandra bellargus*, *Ochlodes venatus*, *Pyrgus alveus* and *Pyrgus warrenensis*.

Table 4: List of Lepidoptera (Rhopalocera, Heterocera and Zygaenidae) observed in 2009 on the 6 sampling stations (1 to 6). The number of individuals censed on the quarters of hectare is given for each station and each species. The sign « s » indicates that no estimation of abundance has been established because the species had only been seen during the qualitative sampling but not during the semi-quantitative sampling.

Species	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Parnassius phoebus			s	4			**4**
Nb species *Papilionidae*	0	0	1	1	0	0	**1**
Nb individuals *Papilionidae*	0	0	0	4	0	0	**4**
Colias phicomone	62	75	108	80	244	34	**603**
Colias alfacariensis						s	**s**
Colias crocea	1	1		s	s	s	**2**

Pieris rapae	1	70	1	5	1	11	**89**
Pieris bryoniae	2	5		2		21	**30**
Pontia callidice				2		s	**2**
Nb species *Pieridae*	4	4	2	5	3	6	**6**
Nb individuals *Pieridae*	66	151	109	89	245	66	**726**
Mesoacidalia aglaja	41	s		1		3	**45**
Vanessa atalanta	s		2	s	1	s	**3**
Cynthia cardui	11	35	52	73	112	8	**291**
Aglais urticae	1	4	6	9	4	3	**27**
Fabriciana niobe f. eris	55					28	**83**
Boloria pales	3	102	26	16	8	7	**162**
Clossiana selene						s	**s**
Clossiana euphrosyne	5	1				17	**23**
Melitaea diamina						s	**s**
Mellicta varia		3	12	5	5		**25**
Hypodryas cynthia			1	2	6		**9**
Eurodryas aurinia f. debilis	6	16	39	37	29	s	**127**
Nb species *Nymphalidae*	8	7	7	8	7	10	**12**
Nb individuals *Nymphalidae*	122	161	138	143	165	66	**795**
Oeneis glacialis	1			3	8	s	**12**
Erebia euryale	39	49	16	2	1	157	**264**
Erebia pluto	s						**s**
Erebia gorge				1			**1**
Erebia tyndarus	22	162	44	32	39	92	**391**
Erebia pandrose	2	27	13	9	7	3	**61**
Coenonympha arcania	s						**s**
Coenonympha gardetta	10	s				3	**13**
Nb species *Satyridae*	7	4	3	5	4	5	**8**
Nb individuals *Satyridae*	74	238	73	47	55	255	**742**
Callophrys rubi	s	4	1	2	6	12	**25**
Lycaena virgaureae						2	**2**
Lycaena tityrus						s	**s**
Cupido minimus	1	9	2		3	39	**54**
Celastrina argiolus		s					**s**
Maculinea arion/rebeli	s					s	**s**
Plebejus argus/idas	32	54	28	62	55	23	**254**
Aricia agestis/artaxerxes	1	s				7	**8**
Albulina orbitulus			2			22	**24**
Agriades glandon				17	5	s	**22**
Cyaniris semiargus	s	1				1	**2**
Lysandra coridon	35	15	12	13	8	71	**154**
Lysandra bellargus	s						**s**
Polyommatus icarus	8	2		3	4	1	**18**
Polyommatus eros	9	6	2	2		1	**20**
Nb species *Lycaenidae*	13	11	7	7	7	16	**18**
Nb individuals *Lycaenidae*	86	91	47	99	81	179	**583**
Hesperia comma	5	11	8	7	4	11	**46**
Ochlodes venatus			s				**s**
Erynnis tages	2	1	1	2	s	7	**13**
Pyrgus malvoïdes	3						**3**
Pyrgus alveus				1			**1**
Pyrgus warrenensis				s			**s**
Pyrgus serratulae	4			13	7	3	**27**
Pyrgus carlinae		1	3	s	5	1	**10**

Pyrgus andromedae		10	1	14	1	s	**26**
Nb species *Hesperiidae*	5	4	5	7	5	5	**9**
Nb individuals *Hesperiidae*	14	23	13	37	17	22	**126**
Zygaena exulans	9	670	1065	431	800	87	**3062**
Zygaena transalpina						24	**24**
Adscita geryon	135	5	2	2	9	19	**172**
Nb species *Zygaenidae*	2	2	2	2	2	3	**3**
Nb individuals *Zygaenidae*	144	675	1067	433	809	130	**3258**
Total number of species	**39**	**32**	**27**	**35**	**28**	**45**	**57**
Total number of individuals	**506**	**1339**	**1447**	**852**	**1372**	**718**	**6234**

From a global point of view, the number of newly observed species after each sampling for the whole study area points out that most of the species (close to 95%) were already censed after the third sampling (Figure 3). In the same way, we notice that the abundance of individuals exponentially increases until the fourth sampling and adopts then weaker and weaker growth until the sixth sampling (Figure 4). The seventh sampling, led later in the season (from the 9th of September to the 10th of September) (Table 2) provides no additional information, neither in terms of new species nor in terms of effectives. We can then conclude that only 6 samplings are sufficient to obtain a good overview of the butterflies abundance and diversity. That corroborates the conclusions of the studies at the outset of the methodology used to collect our data (Besson, 1998; Bouchard & Macherez, 2001).

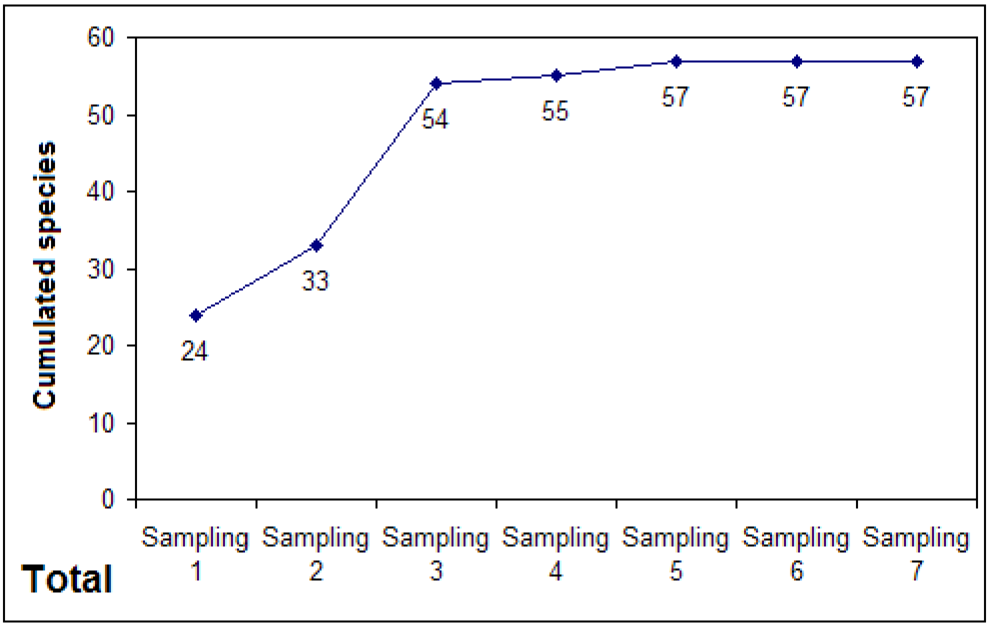


Figure 3: Total number of cumulated species for every 6 stations during the 7 sampling regularly effectuated in 2009 from June the 12th and September the 10th.

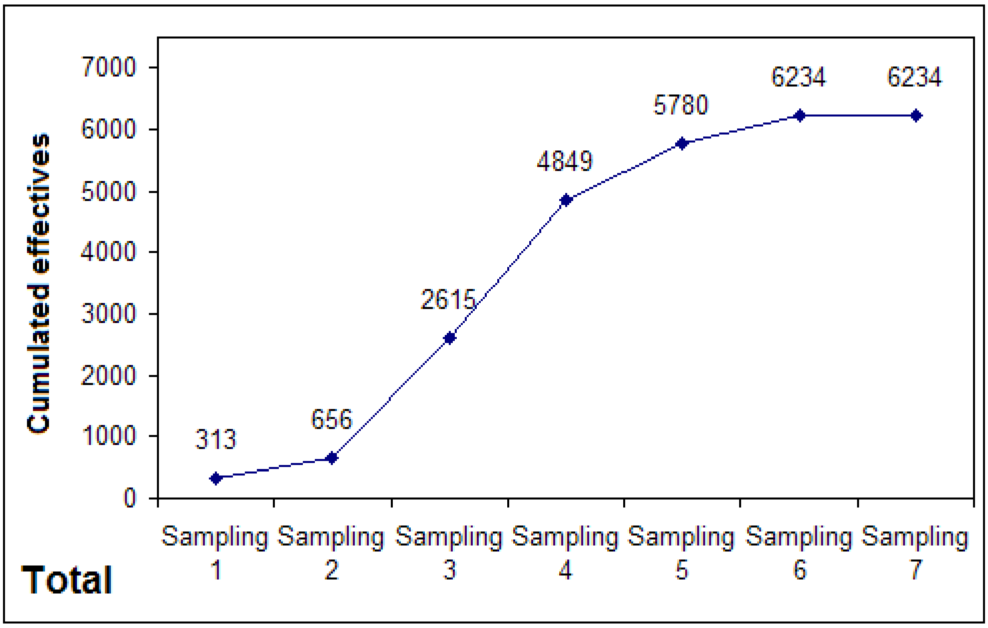


Figure 4: total cumulated effectives for every 6 stations during the 7 sampling regularly effectuated in 2009 from June the 12th and September the 10th.

Considering the results of the 6 stations together (Figure 5) we notice that the maximal specific diversity is reached at the third sampling, mid-july, with 48 species. The minimal number of 9 species is reached mid-september, whereas 21 species were already found with the first sampling at the beginning of June. As for the average effectives, they start with 52 individuals in June and increase massively at the third sampling to reach their maximal value of 2234 individuals at the fourth sampling, at the end of July and finally fall regularly down to zero until the last sampling, at the beginning of September (Figure 5).

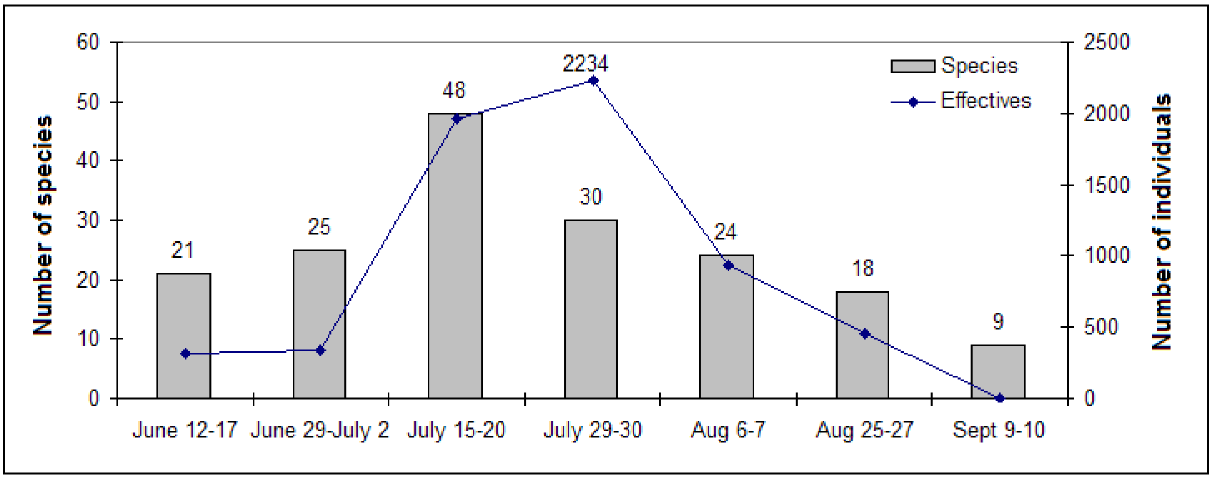
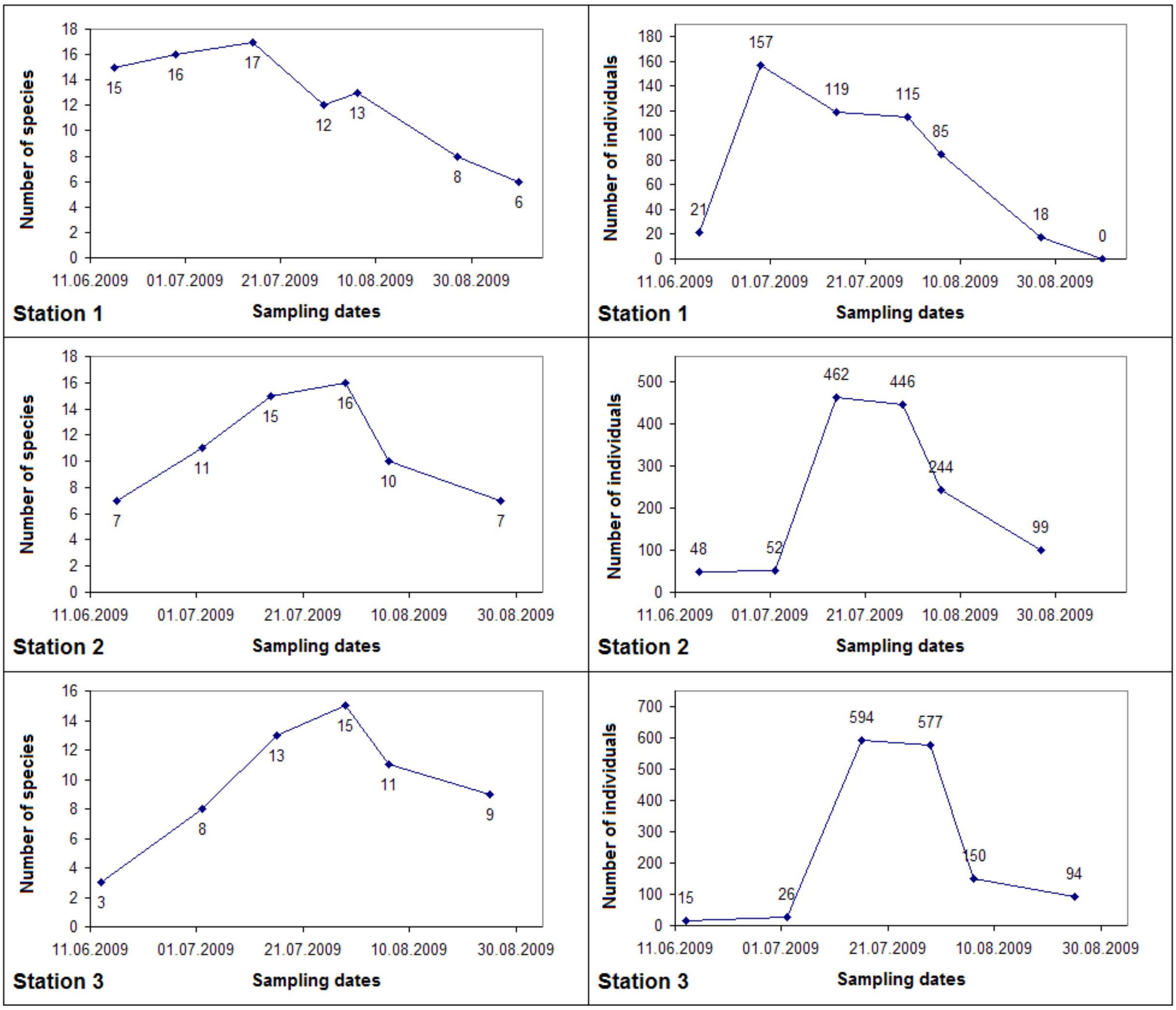


Figure 5: Variation of the numbers of species and individuals observed on the 6 stations together represented for each groups of samplings. The seventh group of samplings only contains data of the stations 1, 4 and 6.

III.2. Results by sampling station

Concerning the specific diversity and the effectives, the stations 6 and 1 differ from the global tendency each in its own way. The first station already shows a high number of species since the first sampling of mid-june, then its specific diversity decreases since mid-july. Its effectives are weaker than those of the other stations but show moreover a very large double pick exploding at the beginning of July and keeping high values until the end of this month (Figure 6). The sixth station shows a relatively constant specific diversity from June to August (14-15 species) with a pick of 34 species in the second third of July. Here again the effectives are relatively weak but remain higher at the end of the season (137 individuals) near the 30th of August than at the beginning of the season until the 21st of July (117 individuals, Figure 6). The other stations follow the tendency in matter of effectives as well as specific diversity (Figure 6).



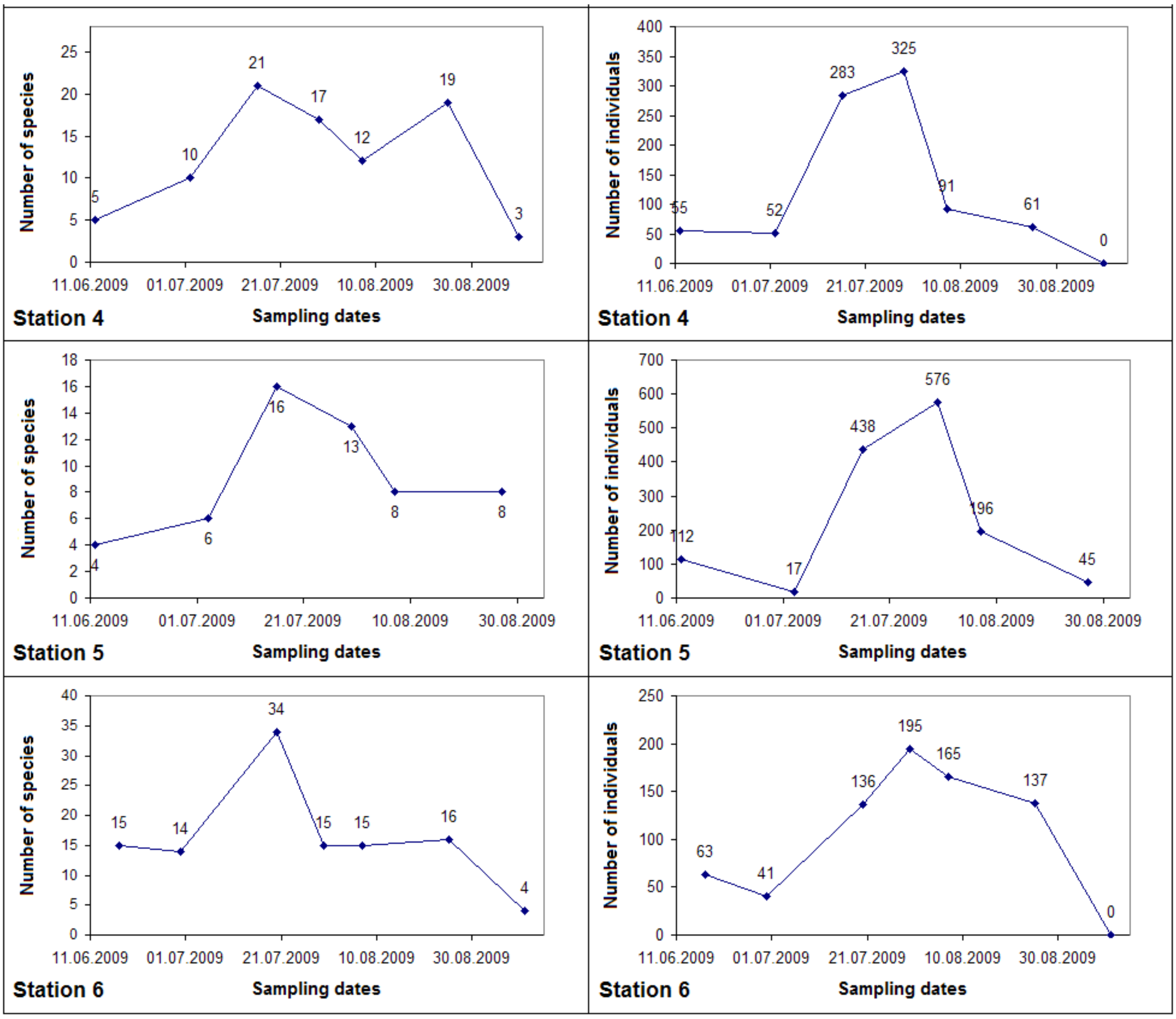


Figure 6: Specific diversity and effectives of each station separately and altogether for the samplings regularly lead in 2009 from the 12th of June to the 10th of September. Data of 6 samplings are shown for each station, 7 for the stations 1, 4 and 6.

Station 1 (2078m)

A total of 39 species were censed on this station, distributed as following: 0 *Papilionidae*, 4 *Pieridae*, 8 *Nymphalidae*, 7 *Satyridae*, 13 *Lycaenidae*, 5 *Hesperiidae* and 2 *Zygaenidae* (Table 4).

Second of the classification in term of number of species, it shows however the lowest effective with 506 individuals or an average of 84 individuals per sampling (excluding the 7th and last sampling effected too late in the season). This particularity can mostly be explained by the fact that only 9 *Zygaena exulans* were observed, while this species highly dominates on almost all the other stations. Nevertheless, the *Zygaenidae* family is dominating with 28% of the listed individuals (Annexe 2). It is actually on this station that the highest effective of *Adscita geryon* was observed (135 individuals, 78% of the total observations for this species). Near after follow the *Nymphalidae* with 24%, higher ratio for that family which does not exceed 17% of the effectives on the other stations. *Erebia pluto*, *Coenonympha arcania* and *Lysandra bellargus* are characteristics of this spot and were censed only once.

Station 2 (2151m)

On this station were listed 32 species distributed into the different families as following: 0 *Papilionidae*, 4 *Pieridae*, 7 *Nymphalidae*, 4 *Satyridae*, 11 *Lycaenidae*, 4 *Hesperiidae* and 2 *Zygaenidae* (Table 4).

The *Zygaenidae* family is dominating again with 675 individuals or 50% of the 1339 individuals censed on the spot (Annexe 2). The *Satyridae* come next with 238 observations (18%). After *Zygaena exulans* and its 670 individuals, *Erebia tyndarus* and *Boloria pales* are the most frequent species with respectively 162 and 102 individuals. No other station reaches such a high effective for these two last species. An erratic individual of *Celastrina argiolus* was observed on the spot despite this species does not appear on any other station (Annexe 2).

Station 3 (2152m)

This station cumulates every record and shows the weaker specific diversity with 27 species distributed this way: 1 *Papilionidae*, 2 *Pieridae*, 7 *Nymphalidae*, 3 *Satyridae*, 7 *Lycaenidae*, 5 *Hesperiidae* and 2 *Zygaenidae* (Table 4).

It reaches however the highest total effective with 1067 individuals or an average specific abundance of 56 individuals (here again more than the 5 other stations). The dominating families are the *Zygaenidae* (74%) and the *Nymphalidae* (10%), whereas the *Lycaenidae* compose only 3% of the effectives (lowest ratio of the study for that family) and the *Hesperiidae* 1% (Annexe 2). *Colias phicomone* (108) and *Cynthia cardui* (52) come first after *Zygaena exulans* (1065) at the top of the dominating species. *Ochlodes venatus* is the only species differential to this station (Annexe 2).

Station 4 (2202m)

A total of 35 species were listed on this fourth station, *i.e.* one more than the average number of species per station (34). Among those 35 species appear 1 *Papilionidae*, 5 *Pieridae*, 8 *Nymphalidae*, 5 *Satyridae*, 7 *Lycaenidae*, 7 *Hesperiidae* and 2 *Zygaenidae* (Table 4).

852 individuals were counted, with 51% of *Zygaenidae* and 17% of *Nymphalidae*. This spot shows the highest *Hesperiidae* ratio with 4% of the effectives (Annexe 2). *Pyrgus alveus* and *Pyrgus warrenensis* are differential to the station. With 4 *Parnassius phoebus* observed on the third, fourth and fifth samplings (Annexe 2), it is also the station on which the highest number of *Papilionidae* was censed

Station 5 (2233m)

This station reaches an amount of 28 species with 0 *Papilionidae*, 3 *Pieridae*, 7 *Nymphalidae*, 4 *Satyridae*, 7 *Lycaenidae*, 5 *Hesperiidae* and 2 *Zygaenidae* (Table 4).

With an effective of 1372 individuals, it is the second most inhabited spot of this study. After the *Zygaenidae* (59%) come the *Pieridae* dominating with 18%, record ratio of the study for this family (Annexe 2). Even if only 3 species of *Pieridae* were listed on this spot the effective of *Colias phicomone* (244 individuals) makes the difference. It is moreover the second dominating species, between *Zygaena exulans* (800 observations) and *Cynthia cardui* (112 individuals) (Annexe 2). There is no differential species but the highest effective of *Hypodryas cynthia* (6 individuals) was recorded on this station during the third sampling (Annexe 2).

Station 6 (2100m)

On this station was censed the highest diversity with a total of 45 species (76% of the species listed all over the study area, Annexe 2) distributed as following: 0 *Papilionidae*, 6 *Pieridae*, 10 *Nymphalidae*, 5 *Satyridae*, 16 *Lycaenidae*, 5 *Hesperiidae* and 3 *Zygaenidae* (Table 4).

Outstanding fact: this is the only station where the *Zygaenidae* family is not dominating and arrives barely at the third position with 18% of a total effective of 718 individuals. The *Satyridae* appear at the top of the classification (36%) followed by the *Lycaenidae* (25%). The *Nymphalidae* reach here their minimal effective of only 9% (Annexe 2). The highest specific diversity of *Zygaenidae* was however recorded in this spot with 3 species, including *Zygaena transalpina* (24 observations) which was never seen on any other spot. Moreover, this sixth station counts the highest number of differential species (6) which are *Colias alfacariensis*, *Clossiana selene*, *Melitaea diamina*, *Lycaena virgaureae*, *Lycaena tityrus* and *Zygaena transalpina* (Annexe 2).

III.3. Simpson's diversity index

The diversity indexes are close to 1 for every station except the third. The average diversity is good as its index reaches 0.715 (Table 5). Here again, the sixth station comes first with a particularly high index of 0.898 whereas the third station is the last one with a poor diversity of 0.449. This result is easily explained since the third station had already the lowest number of species and the highest effective, with a strong domination of Zygaena exulans (Table 4). If we only consider the Rhopalocera and Hesperiidae, the average index increases up to 0.863 and the poorest spot (the fifth station) reaches now a satisfying index of 0.754 (Table 4).

Table 5: Simpson's diversity indexes for the 6 stations (1-6) of Val Mora, with and without the *Zygaenidae* family.

Duvoisin Stations, 2009	1	2	3	4	5	6	Average
Simpson's index with *Zygaenidae*	0.878	0.720	0.449	0.721	0.620	0.899	0.715
Simpson's index without *Zygaenidae*	0.902	0.878	0.863	0.901	0.759	0.874	0.863

III.4. Correspondences factorial analysis (CFA)

The CFA show how to assemble the stations according to their composition in diurnal Lepidoptera.

Considering the entire dataset, the stations are divided up 3 groups; A, B and C (Figure 7). The group A includes the stations 2, 3, 4 and 5 (S2-S5) but the group B is only composed of the station 1 (S1), the lowest and most eastern site of the study. The group C contains the station 6 (S6) only. Excluding the *Zygaenidae* family from the same dataset and applying a new CFA, we obtain 4 groups: G1, G2, G3 and G4 (Figure 8). G1 includes the station 6 (S6), G2 the station 1 (S1) and G3 the stations 2 (S2), while G4 is composed of the stations 3, 4 and 5 (S3-S5).

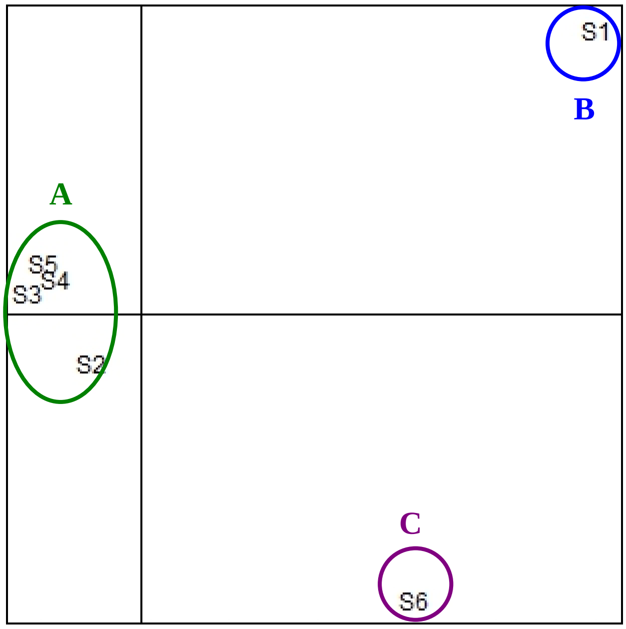


Figure 7: Correspondences factorial analysis (CFA) realized with the data of the semi-quantitative samplings for the 6 stations (1-6) of Val Mora. The 3 groups (A, B and C) are pointed out by circles of different colours.

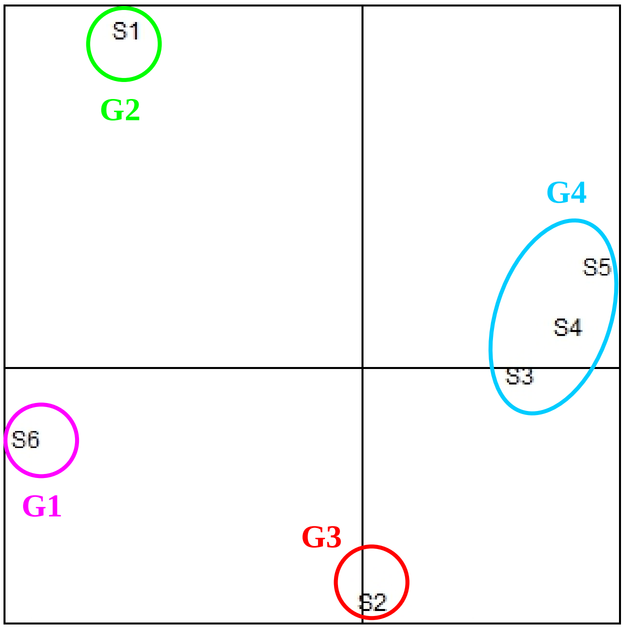


Figure 8: Correspondences factorial analysis (CFA) realized with the data of the semi-quantitative samplings for the 6 stations (1-6) of Val Mora without the *Zygaenidae* family. The 4 groups (G1-G4) are pointed out by circles of different colours.

IV. Discussion

IV.1. Generalities

Faunistic approach

During the 2009 sampling season 57 species of butterflies (45 Rhopalocera, 10 Hesperiidae and 3 Zygaenidae) were censed in Val Mora. These numbers represent 25% of the Rhopalocera of Switzerland, 38% of the Hesperiidae and 10% of the Zygaenidae. Altogether it is a quarter (25%) of the butterflies of

Switzerland. From a closer point of view, a large third (34%) of the species of Rhopalocera censed in Engadine was found in this study (LSPN 1987). These results are even more surprising if we consider that the selected stations cover only 155 meters of difference in altitude. Last but not least: we found 45 species of Rhopalocera on stations which are clearly set at the alpine level (2078 to 2233m), when only 41 species of Rhopalocera are considered as alpine species in Switzerland.

That richness can be explained by the mosaic of milieux creating a high diversity of microhabitats, matched to the suitable east-west orientation of Val Mora. By creating new open and semi-open areas, the numerous falls of calcareous rocks lead the vegetation to be rapidly renewed and to frequently recolonize new damaged areas. The protection measures already in use in this region and the prevalence of biological agriculture in Val Müstair represent as many positive factors for the global biodiversity. Moreover, the Val is connected to the Danube by the northern Tyrol and to The Val of Venosta, another zoogeographically very close dry intra-alpine region, by the pass Il Fuorn (2150m). These routes coupled to the other factors listed upper allow the species flowing and recolonizing the suitable areas when needed. All of these mechanisms promote and maintain a maximal diversity of species and environments.

16 among the 45 species of Rhopalocera and Hesperiidae appear on the Swiss Red List (Gonseth in Duelli, 1994) as endangered on a part of the Swiss territory (mainly Jura and Lowland). They are however present in our samplings, sometimes with big effectives. These facts highlight the refuge role played by this region for numerous endangered butterflies and confirm the extraordinary faunistic importance of the study area.

Globally, 10 species found on every station had a total effective exceeding 100 individuals and can thus be qualified as locally common in Val Mora: *Colias phicomone*, *Cynthia cardui*, *Boloria pales*, *Eurodryas aurinia f. debilis*, *Erebia euryale*, *Erebia tyndarus*, *Plebejus argus*, *Lysandra coridon*, *Zygaena exulans* and *Adscita geryon*. *Cynthia cardui* is a migratory species and an excellent flyer. Unusual effectives of this species were observed all over the country in June 2009. Nevertheless, new generations were observed all season long, with phenotypical variations marking the typical impact of alpine environments on the local generations (reduced size, darker colors). We know thus that *Cynthia cardui* accomplished a complete life cycle in our country explaining its omnipresence and its effectives in the study area. All the other species are common in the meadows and altitudinal scanty grasslands except *Erebia euryale* which likes mountain and subalpine levels but locally establishes itself upon 2400m in the southern grasslands. In our case its profusion on the study area is due to colonization by rich populations established in the woodlands connecting Val Müstair to Val Mora. *Plebejus Argus* and *Lysandra coridon* are both on the Swiss Red List but are not considered as endangered in the Alps. *Zygaena exulans* is clearly the most frequently observed species with an effective reaching 3062 individuals (49% of the total number of observations). It is also the only *Zygaenidae* in Switzerland whose main distribution area is located over the tree limit. This species, generally carrying out two hibernations, is particularly affluent on odd years. Similar high densities were previously reported in the Graubünden on the pass Il Fuorn in 1993 and on the Albula pass in 1987 (LSPN, 1999).

If we exclude the *Zygaenidae* of the total effectives, the remaining 2976 individuals are distributed among the different families as following : <1% *Papilionidae*, 24% *Pieridae*, 27% *Nymphalidae*, 25% *Satyridae*, 20% *Lycaenidae* and 4% *Hesperiidae*. The effectives are thus pretty well dispatched among 4 dominating families. The *Nymphalidae* are followed by the *Satyridae* and the *Pieridae*, then the *Lycaenidae* also well represented. The *Nymphalidae* are not linked to a particular vegetal family but a great number of species eat different kind of *Viola*, *Plantago*, *Cirsium* or *Gentiana* at the larval stage. These genera were omnipresent and representative of the stations all along the season. Knowing that the caterpillars of the *Satyridae* usually eat diverse *Poacea* whereas the *Lycaenidae* depend on the *Fabacea* during their larval development (Lafranchis, 2000), we can deduce that both of these families are well represented in the vegetation of Val Mora without a clear dominance at the global level. Finally, the *Pieridae* eat either *Brassicacea* or *Fabacea*.

Floristic approach

Our study area is located in an *Ericion-Pinion mugo* vegetative alliance area. The major part of its surface is dominated by the *Seslerion*, with some elements of *Mesobromion* and *Caricion firmae*. The *Mesobromion* is not supposed to be found near the *Caricion firmae*, thus we opted for the *Seslerion* (Yves Gonseth, personal communications). Some species typical of the *Nardion* appear on the most eutrophised stations (station 6). These alliances are interesting from a biogeographical (history of the vegetation and climate) and systematic (genetically differenciated ecotypes) point of view, but are supposed to be relatively poor in animal and vegetal species diversity. These observations make our results even more precious and unexpected and highlight once again the high ecological value of Val Mora.

IV.2. CFA and detailed discussion

Despite the topographic uniformity of Val Mora and quiet similar dominant alliances, the correspondences factorial analysis (CFA) applied to the complete semi-quantitative datasets of every 6 stations (Figure 7) pointed out 3 distinct faunistic groups (A, B and C) These groups correspond respectively to the groups 3 and 4 altogether (G3 and G4), the group 2 (G2) and the group 1 (G1) G1 of the second CFA (Figure 8) which does not include the *Zygaenidae* part of the dataset:

A (G3 and G4)

The group A includes the stations 2, 3, 4 and 5 (S2-S5). All these stations are geographically close and dominated at 50% and more by the *Zygaenidae* family, due in every case to the profusion of *Zygaena exulans*. Globally, they present a relatively poor diversity of species and reach the highest densities of individuals. These densities are representative of the number of caterpillars that the vegetation is able to feed and indicate a low grazing level of the milieux by the livestock. The stations of the group A are thus typical of the extensive exploitation on altitudinal scanty grasslands.

Station 2

This is the most distant from the 3 others in this group of the CFA. After the *Zygaenidae*, it contains 18% of *Satyridae* whereas the stations 3, 4 and 5 are dominated by *Nymphalidae* at the second rate. This is why it appears in a distinct group (G3) on the second CFA, which does not take the *Zygaenidae* family into account (Figure 8). After *Zygaena exulans*, the dominant species of this *Seslerion* are *Erebia tyndarus* (162) and *Boloria pales* (102). Both of these species reach here their higher effectives. *Erebia tyndarus* eats diverse *Festuca* species (*Poacea*) at the larval stage and likes dry, rocky meadows and grasslands at the subalpine and alpine levels. *Boloria pales* tolerates a great range of milieux but is common on any grasslands of both subalpine and alpine levels.

Station 3

With the highest total effective and the poorest diversity of species, this station is dominated by the *Zygaena* and *Nymphalidae* families with *Zygaena exulans* as the most common species. *Cynthia cardui* and *Colias phicomone* are representative of this spot of *Caricion firmae*.

Station 4

As for the third station, this spot of *Caricion firmae* is dominated by the Zygaenidae and Nymphalidae families and shows large effectives of *Zygaena exulans*, *Cynthia cardui* and *Colias phicomone*. It diverges somewhat in its high diversity of *Hesperiidae* but does not present sufficient effectives in this family to be clearly differenced from its group.

Station 5

Here again, the dominant species of this second most inhabited spot are *Zygaena exulans* (800), *Colias phicomone* (244) and *Cynthia cardui* (112). The dominance of the *Pieridae* (18%) right after the *Zygaenidae* (59%) is only due to the high density of *Colias phicomone*. Despite a steep slope and a vegetetative alliance dominated by the *Seslerion* this station shows the same characteristic species as the stations 3 and 4.

B (G2)

The groups B and G2 are only composed of the station 1 (S1), the most western spot. This station shows the lower records of *Zygaena exulans* of the study and is only slightly dominated by the *Zygaenidae* (28%) whereas the *Nymphalidae* represent a high 24% of its effectives. No other station reaches such a high ratio of *Nymphalidae*. *Adscita geryon*, rare on the other stations, was the most frequent listed with 135 individuals. Knowing that most part of these individuals were observed at the 2nd sampling, the 29th of June and that its host plant (*Heliantherum nummularium*) was present on the spot, we can conclude that the station 1 is a used as a reproduction site for this monovoltine xerothermophile species. Moreover, 5 species were differential to this spot. These particular characteristics explain its faunistic difference.

C (G1)

The groups C and G1 contain the sixth station (S6) only. It is the lowest spot of this study and the only one to be south-eastern exposed. According to the traces recorded and to the global vegetation of the station, it is also the most eutrophised one. Located near the entrance of Val Mora, it communicates with more sheltered and still lower regions. These parameters could explain why such a high number of species (six) of this station were never seen on the other spots. It is the only station which was not dominated by the *Zygaenidae* family but by the *Satyridae* family, represented by the two dominant species: *Erebia euryale* (157 individuals) and *Erebia tyndarus* (92 individuals). *Erebis euryale* depends on several species of *Cyperacea* and *Poacea*. Despite it preference for both mountain and subalpine levels, it is typical of rich grasslands at the alpine level, until 2400 meters. We can thus conclude that, despite a visible eutrophisation and numerous traces of stamping, this station is not uniformly over-grazed and still presents a high *Poacea* ratio. The cows probably use this spot for drinking but prefer to graze on the most accessible surrounding sites.

IV.3. Comparison with the Swiss National Park

The best station of the study led by Aline Pasche on the SNP territory (Pasche, 2005) reaches 61 individuals. This represents barely 72% of the results of our poorest in effective station. Despite less strict protection measures and exploitation by the livestock this comparison points out the amazing richness of Val Mora and its ecological importance.

The average specific density counts 21 individuals by species into the SNP (Pasche, 2005) and increases to 29 if we consider only the samplings effectuated in the same altitudinal range as the one we investigated (sations 3 and 4). This ratio is only set at 18 individuals by species in the stations of Val Mora but decreases to 9 if we exclude the *Zygaenidae* data. These results are directly linked to the diversity indexes (Table 6), calculated from the same data.

Similarly, we can see that the average diversity index of our stations without *Zygaenidae* (0.863) is higher than the indexes of the Pasche stations (0.841) who did not take the *Zygaenidae* into account. But it is still lower than the average index of the Bouchard and Macherez stations (0.882). If we only consider the Bouchard and Macherez stations located in a similar altitudinal range as ours, this index decreases to 0.861 and is similar to ours.

We use the index with Zygaenidae (0.715) to compare our stations with the Besson stations because he also included the *Zygaenidae* into his data. In that case again, our index is higher of 0.066 points. We can mention that Besson did not record any *Zygaena exulans*. However, he sampled on an even year (*Zygaena exulans* is more abundant on odd years).

Such a comparison involving data of different years is indicative but not fully reliable. To avoid the epiphenomenon bias, it would be useful to verify these conclusions with a long-term monitoring.

Table 6 : Simpson's diversity indexes for the 6 stations of Val Mora, with and without the *Zygaenidae*, the 6 stations of Besson in the Swiss National Park (SNP), the 8 stations of Bouchard and Macherez in the SNP and the 5 stations of Pasche in the SNP.

Duvoisin Stations, 2009	**1**	**2**	**3**	**4**	**5**	**6**	**Average**
Simpson's index with *Zygaenidae*	0.878	0.72	0.449	0.721	0.62	0.899	**0.715**
Simpson's index without *Zygaenidae*	0.902	0.878	0.863	0.901	0.759	0.874	**0.863**

Besson Stations, 1998	**Il Fuorn**	**Stabelchod**	**Alp la Schera**	**Munt la Schera**	**Champlönch**	**Praspöl**	**Average**
Simpson's index	0.812	0.737	0.499	0.736	0.824	0.276	**0.647**

Bouchard and Macherez Stations, 2001	1	2	3	4	5	6	7	8	Average
Simpson's index	0.910	0.893	0.886	0.925	0.892	0.885	0.833	0.835	**0.882**

Pasche Stations, 2004	1	2	3	4	5	Average
Simpson's index	0.832	0.893	0.806	0.807	0.867	**0.841**

IV.4. Livestock and Rhopalocera

The 200 heads of the herd were observed on every station but let more traces on the sixth station, the most eutrophised one located near the first farm of Val Mora.

Faunistic impacts linked to grazing and concrete measures

The pressure of the livestock on the grasslands allows maintaining a high floristic and faunistic diversity by preventing the invasion of the *Poacea* to the prejudice of the *Fabacea*. Thus an optimal grazing level promotes an equitable *Fabacea*/*Poacea* ratio and indirectly maintains balanced populations of *Satyridae*, *Lycaenidae* and *Pieridae*. At the opposite way, the ratio increases when this pressure becomes too high. Consequently to the eutrophisation of the milieu the *Fabacea* family becomes dominant and the *Poacea* become scarce, involving a decrease of the *Satyridae* effectives and promoting both *Pieridae* and *Lycaenidae*. As a global outcome, these results indicate a perfectly balanced exploitation of the stations, and present Val Mora as an example of an optimal grazing pressure.

Our study area is located in an *Ericion-Pinion mugo* vegetative alliance area. We can prevent the progression of bushes and trees on the semi-open and open areas by maintaining an extensive pastoral tradition (Cherix & Vittoz, 2009). The different grazing pressures by the livestock on each area are not an inconvenient and help to maintain a large panel of milieux suitable to each species.

V. Conclusive remarks

Despite an extensive pasture tradition, Val Mora is a hotspot for biodiversity and deserves to be involved in a long-term monitoring.

By selecting such a high number of stations on a relatively small area (6 stations on about 6 kilometre in a straight line) and by focusing on Val Mora only, we ensured to find the maximal biodiversity of the study area. We collected complete data, obtained a reliable description of the Lepidoptera fauna of Val Mora and proved thereby the accuracy of the used methodology.

The localisation of Val Mora in the centre of a network system connecting other biodiversity hotspots is a great asset for this whole region and must not be neglected in the conservation logical of the protected area.

Moreover, Val Mora shows particular milieux which are not studied in the Swiss National Park, such as the humid areas. It would be interesting to consider the communities of these milieux in further studies, selecting adapted taxa.

VI. Acknowledgments

I particularly would like to thank Daniel Cherix and Yves Gonseth for the support, the advices and the logistic assistance that they gave to me during this study. Thanks also to Gervas Rodigari and his family who accepted to let their flat at my disposal in Valchava, to The Val Müstair County for the necessary authorizations and to the farmers of Val Mora for their nice and friendly welcome.

Thanks then to Aline Pasche and Yannick Chittaro for their precious help to prepare the genitalia and identify the difficult species, to Celine Waldvogel, Glenn Listios, Nick Steiner and Pierre Dumoulin for their contribution to the sampling effort.

Thanks finally to Tamara Bardini for her efficient linguistic support.

VII. Bibliography

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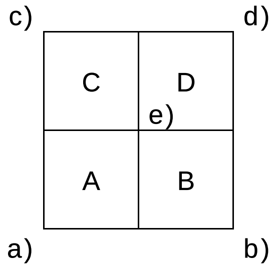
ANNEXE 1

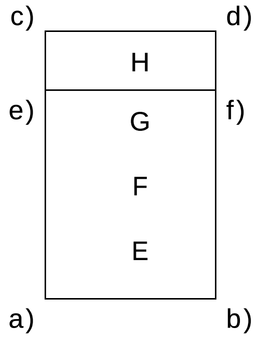
GPS coordinates of every 6 sampling stations and their semi-quantitative quarter of hectare.

Stations	GPS coordinates	
	c) 818601 / 164351	d) 818643 / 164331
1	a) 818530 / 164288	b) 818606 / 164242
	e) 818595 / 164303	A
	c) 820716 / 162637	d) 820758 / 162617
2	a) 820645 / 162574	b) 820721 / 162528
	e) 820710 / 162589	A
	c) 821065 / 162458	d) 821064 / 162405
3	a) 820866 / 162479	b) 820886 / 162444
	e) 821015 / 162463 f) 821019 / 162415	H
	c) 822157 / 161998	d) 822240 / 161940
4	a) 822092 / 161926	b) 822178 / 161873
	e) 822167 / 161934	B
	c) 822451 / 161924	d) 822646 / 161909
5	a) 822529 / 161835	b) 822612 / 161804
	e) 822559 / 161868	C
	c) 824393 / 161947	d) 824441 / 162141
6	a) 824415 / 161862	b) 824463 / 162056
	e) 844428 / 162001	B

Square station
(100 x 100m)



Rectangular
station
(50 x 200m)



ANNEXE 2

List of recorded individuals of each species by sampling and by station. An “s” indicates that the species was seen on the qualitative sampling only.

	Sampling 1						Sampling 2					
Species	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Adscita geryon							118					3
Aglais urticae	s	1				1			1	1		2
Agriades glandon												
Albulina orbitulus						1						2
Aricia agestis/artaxerxes												
Boloria pales								13	2			
Callophrys rubi	s	4	1	2	6	9				s		3
Celastrina argiolus		s										
Clossiana euphrosyne	4					4	1					11
Clossiana selene												
Coenonympha arcania												
Coenonympha gardetta	1						8					
Colias croceus								1				
Colias alfacariensis												
Colias phicomone	s						26				3	s
Cupido minimus	1	s				23	s	8	2		3	9
Cyaniris semiargus							s					1
Erebia euryale												
Erebia gorge												
Erebia pandrose		21	5	s	5	3		6	6	8	2	
Erebia pluto							s					
Erebia tyndarus												
Erynnis tages	2					6		1	1	1		1
Euphydryas aurinia f. debilis	2						s	2	6	24	8	
Euphydryas cynthia												
Fabriciana niobe f. eris												
Heodes virgaureae												
Hesperia comma												
Lycaena tityrus												
Lysandra bellargus							s					
Lysandra coridon												
Maculinea arion/rebeli						s	s					s
Melitaea diamina												
Mellicta varia												
Ochlodes venatus												
Oenis glacialis						s	1			1	s	
Parnassius phoebus												
Pieris bryoniae	1	3				14	1	2		2		6
Pieris rapae												
Plebejus argus/idas							s					
Polyommatus eros												
Polyommatus icarus						s						
Pontia callidice				2								
Pyrgus alveus												
Pyrgus andromedae					1	s		10	1	11		
Pyrgus carlinae												1
Pyrgus malvoïdes	3											

Pyrgus serratulae												
Pyrgus warrenensis												
Speyeria aglaja												
Vanessa atalanta	s						s					
Vanessa cardui	7	19	9	50	100	2	1	7	7	4	1	2
Zygaena exulans							1					s
Zygaena transalpina												
	Sampling 3						**Sampling 4**					
Species	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Adscita geryon	17	4	s	1	2	4		1	1	1	7	8
Aglais urticae										1		
Agriades glandon				13	5	s				4		
Albulina orbitulus						7			2			11
Aricia agestis/artaxerxes		s				6						s
Boloria pales	3	11	1		1	s		37	8	5	4	4
Callophrys rubi												
Celastrina argiolus												
Clossiana euphrosyne						2		1				
Clossiana selene						s						
Coenonympha arcania	s											
Coenonympha gardetta		s				3	1					
Colias croceus					s							
Colias alfacariensis						s						
Colias phicomone	20	34	43	45	130	11	11	30	42	25	75	12
Cupido minimus		s				3		1				4
Cyaniris semiargus		1				s						
Erebia euryale	24	5	1			37	7	29	11	2	1	69
Erebia gorge				1								
Erebia pandrose	2		2	1		s						
Erebia pluto												
Erebia tyndarus						1	9	33	9	8	8	12
Erynnis tages				1	s	s						
Euphydryas aurinia f. debilis	1	5	22	7	17	s		9	10	5	4	
Euphydryas cynthia				2	6				1			
Fabriciana niobe f. eris	6					2	37					6
Heodes virgaureae												
Hesperia comma		1		1	s	1	1	5	3	1	4	3
Lycaena tityrus						s						
Lysandra bellargus	s											
Lysandra coridon						s	7	1				4
Maculinea arion/rebeli						s						
Melitaea diamina						s						
Mellicta varia		1	6	5	2				6		3	
Ochlodes venatus			s									
Oenis glacialis				s	8					2		
Parnassius phoebus			s	2					s	2		
Pieris bryoniae				s		1				s		
Pieris rapae				4		3		70	1			3
Plebejus argus/idas	18	3	1	2	5	4	10	43	22	44	30	9
Polyommatus eros	9					1		1	1	2		
Polyommatus icarus						s	8				4	
Pontia callidice						s						

Pyrgus alveus												
Pyrgus andromedae				3								
Pyrgus carlinae		1	3	s	5							
Pyrgus malvoïdes												
Pyrgus serratulae	1			11	1	3	3			2	4	
Pyrgus warrenensis				s								
Speyeria aglaja	5					1	18	s		1		
Vanessa atalanta												
Vanessa cardui	2	6	1	s	4	1		s			2	
Zygaena exulans	2	380	505	170	240	26	3	185	460	220	430	35
Zygaena transalpina												15

	Sampling 5						**Sampling 6**					
Species	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Adscita geryon		s	1			4						s
Aglais urticae							1	3	5	7	4	
Agriades glandon												
Albulina orbitulus						1						
Aricia agestis/artaxerxes	1											1
Boloria pales		31	11	3	s	3		10	4	8	3	s
Callophrys rubi												
Celastrina argiolus												
Clossiana euphrosyne												
Clossiana selene												
Coenonympha arcania												
Coenonympha gardetta												
Colias croceus							1					s
Colias alfacariensis												
Colias phicomone	5	11	15	7	28	7			8	3	8	4
Cupido minimus												
Cyaniris semiargus												
Erebia euryale	8	13	3			35	s	2	1			16
Erebia gorge												
Erebia pandrose												
Erebia pluto												
Erebia tyndarus	13	64	8	16	15	45	s	65	27	8	16	34
Erynnis tages												
Euphydryas aurinia f. debilis	3		1	1								
Euphydryas cynthia												
Fabriciana niobe f. eris	12					7						13
Heodes virgaureae						s						2
Hesperia comma	4	5	4	3		7			1	2		s
Lycaena tityrus												
Lysandra bellargus												
Lysandra coridon	17			2		12	11	14	12	11	8	55
Maculinea arion/rebeli												
Melitaea diamina												
Mellicta varia		2			s							
Ochlodes venatus												
Oenis glacialis												
Parnassius phoebus				s								
Pieris bryoniae												
Pieris rapae	1			s	1	1				1	s	4

Plebejus argus/idas	4	8	5	16	20	6						4
Polyommatus eros	s	5	1									
Polyommatus icarus				1				2		2		1
Pontia callidice												
Pyrgus alveus				1								
Pyrgus andromedae												
Pyrgus carlinae												
Pyrgus malvoïdes												
Pyrgus serratulae					2							
Pyrgus warrenensis												
Speyeria aglaja	14					2	4					
Vanessa atalanta							s		2		1	
Vanessa cardui			1				1	3	34	19	5	3
Zygaena exulans	3	105	100	41	130	26						
Zygaena transalpina						9						

	Sampling 7					
Species	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Adscita geryon						
Aglais urticae						
Agriades glandon						
Albulina orbitulus						
Aricia agestis/artaxerxes						
Boloria pales						
Callophrys rubi						s
Celastrina argiolus						
Clossiana euphrosyne						
Clossiana selene						
Coenonympha arcania						
Coenonympha gardetta						
Colias croceus						
Colias alfacariensis						
Colias phicomone	s			s		
Cupido minimus						
Cyaniris semiargus						
Erebia euryale						
Erebia gorge						
Erebia pandrose						
Erebia pluto						
Erebia tyndarus						
Erynnis tages						
Euphydryas aurinia f. debilis						
Euphydryas cynthia						
Fabriciana niobe f. eris						
Heodes virgaureae						
Hesperia comma	s					s
Lycaena tityrus						
Lysandra bellargus	s					
Lysandra coridon						
Maculinea arion/rebeli						
Melitaea diamina	s			s		s
Mellicta varia						
Ochlodes venatus						

Oenis glacialis						
Parnassius phoebus						
Pieris bryoniae						
Pieris rapae						
Plebejus argus/idas	s					
Polyommatus eros						
Polyommatus icarus						
Pontia callidice						
Pyrgus alveus						
Pyrgus andromedae						
Pyrgus carlinae						
Pyrgus malvoïdes						
Pyrgus serratulae						
Pyrgus warrenensis						
Speyeria aglaja						
Vanessa atalanta						
Vanessa cardui						
Zygaena exulans	s			s		s
Zygaena transalpina				s		