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Faunistic study on butterflies collected in Northern Italy rural landscape

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Abstract

Butterflies were inventorised in nine sites of three different habitat types of the Emilia-Romagna rural landscape (Northern Italy). Sites were situated in three different landscape contexts, from high to low landscape complexity. A total of 39 butterflies species were collected, including some rare species for the region. Diversity indices and correspondence analysis showed that the butterfly fauna was influenced by the habitat type and not by the landscape complexity of the area around the site. The higher diversity was registered in an hedgerow with a grassy margin. Grassy margins of crops showed the higher mean frequency of catches, probably because of the high number of flowers available. Butterflies seem to be poorly influenced by the landscape characteristics around the sites because of the adults mobility. Field margins are suggested as suitable habitats for butterfly conservation.

Key words: butterflies, landscape management, field margins.

Introduction

As their biology has been extensively investigated, butterflies are among the best-known insect groups. Many authors have considered butterflies as being the best group of insects for examining the patterns and the distribution of terrestrial biotic diversity (Robbins and Opler, 1997). There are about 13,750 species of true butterflies in the world. Because of their dependence to climatic, vegetational and ecological characteristic of the environment butterflies are employed by many authors as bioindicators (Pollard, 1977; Pollard and Yates, 1993; Robbins and Opler, 1997). Moreover, as many species are sensitive to anthropic disturbance, butterflies are largely considered for nature conservation purposes (Robbins and Opler, 1997).

Over the last century, most attention has been given to the difference in species richness between tropical and temperate regions (Robbins and Opler, 1997). Besides this aspect, butterflies can be also used as biological indicators in rural landscapes (Balletto, 1983; Dover, 1992; Groppali, 1995; Dover *et al*., 1999; Croxton *et al*., 2004; Fabbri e Scaravelli, 2002).

There is an increasing body of evidence suggesting that connectivity and quality of habitats in agricultural landscapes have a significant effect on survival of animal species, including arthropods (Andow, 1991; Altieri, 1999; Landis *et al*., 2000; Rossing *et al*., 2003). Research effort appear to focus on either functional diversity, aimed at establishing strategies for farmers to enhance ecosystem functioning for pest suppression, or on conservation biological issues, aimed at minimizing extinction probability of conservation species.

The general aim of this study is to inventorise the butterfly fauna of three different types of field margins within a rural landscape in Modena and Reggio Emilia provinces (Northern Italy). Furthermore, the role of the surrounding landscape measured by its complexity on the butterfly fauna is investigated. Special attention is given to the rare species and practical recommendations for their conservation are mentioned.

Materials and methods

The study was carried out in 2002 and 2003, by sampling butterflies in nine arable sites within Modena and Reggio Emilia rural landscape (figure 1). Three different types of habitats were sampled:
- Hedgerow with grass and wild flower strip
- Hedgerow without grass and wild flower strip
- Grass and wild flower strip (weed margin) (table 1).

Hedgerows are linear corridors with a dominance of tree and shrub. In our study, they are either accompagnyied by an adjacent grass and wild flower strip (first habitat type) or not (second habitat type). Grass and wild flower strips are field margins or channel margins without shrubs and trees.

The sites were situated in three different landscape contexts:
1. High complexity landscape: well connected corridors and presence of many hedgerows;
2. Low complexity landscape: isolated corridors and presence of few hedgerows;
3. Intermediate complexity landscape (table 1).

The areas around the sites were classified by Geographical Information System (GIS) (figure 1). A GIS is a set of computer program that collect, store, retrieve, transform, display, an analyse spatial data system. This broad definition includes a range of software functions: at one end are mapping, image processing, digitizing, and computer design software; at the other end of spectrum is integrative GIS software (Liebhold *et al*., 1993). In this context GIS are an increasingly used tool that

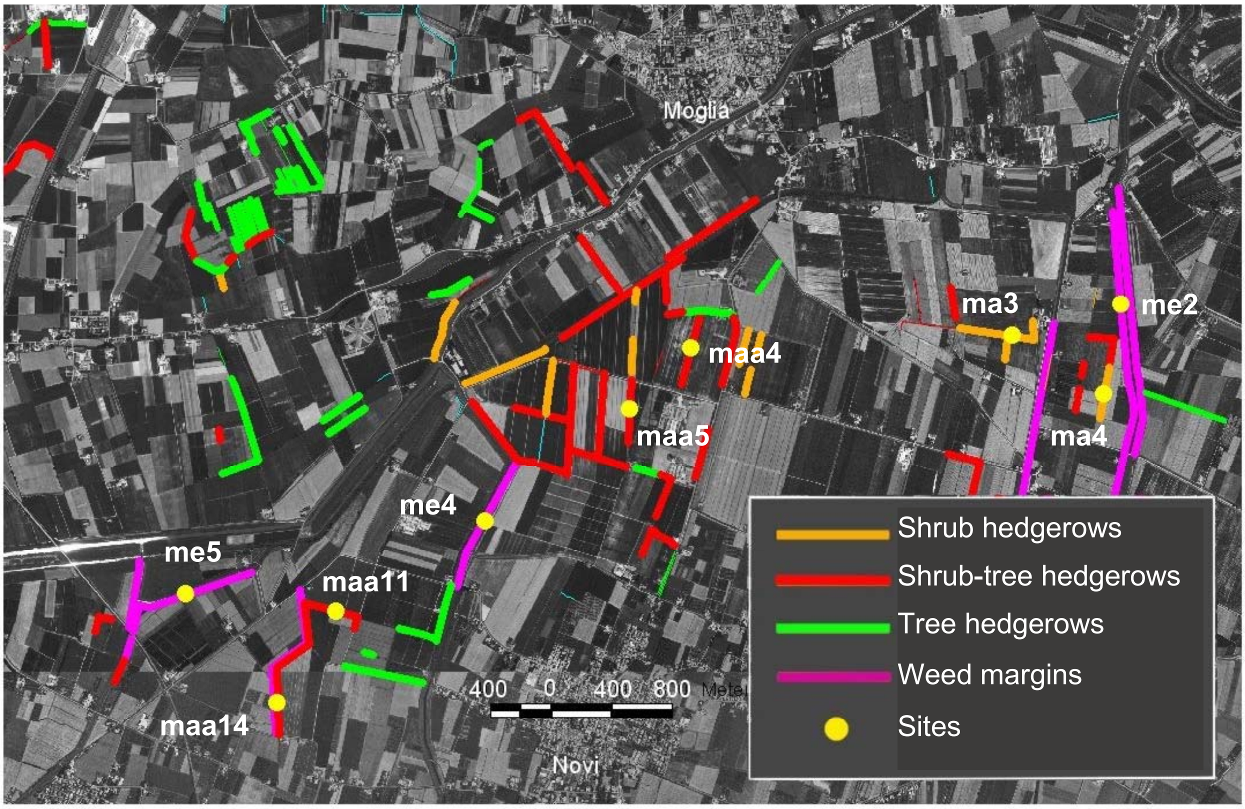

Figure 1. GIS map of the investigated landscape, showing the sites sampled and the main ecological features of the investigated area, including linear corridors, trees hedgerows, shrub hedgerows, weed margin complex. Spots indicate the sampling sites.

integrates the complex information from different data sets at different geographical scales. For example in conservation biology, Geographical Information System have been recently applied to examine the impact of a series of factors related to ecological conditions and land use on species diversity and rarity patterns at the landscape scales (Vanderpoorten *et al*., 2004).

Butterflies were monitored between April and September by hand net. Samplings were carried out every three weeks, by collecting adults on a fixed transect of 200 meters within the investigated sites, following Pollard (1977) and Pollard and Yates (1993) methodology.

The time of each sampling was 30 minutes. In the present study, the "catch and release" method was used: the collected adults were identified in field and released at the end of the sampling, with the exception of some uncertain species, which were collected and identified in laboratory. Samplings were carried out in sunny conditions at fixed time, walking on a fixed trajectory and observing both sides of the transect. Five samplings were carried out in 2002 and seven in 2003. The nomenclature followed the Balletto and Cassulo (1995) check list.

Data analysis

The butterfly species diversity was compared among sites with the Shannon and Eveness indices (Magurran, 1988). Correspondence Analysis (CA) (Pielou, 1984; Manly, 1994) were carried out to ordinate the sites on the basis of butterfly fauna. This method of ordination was employed on the Lepidoptera frequency catches matrix $\boldsymbol{p}$ x $\boldsymbol{n}$, where $\boldsymbol{p}$ = species and $\boldsymbol{n}$ = sites.

Table 1. Sites investigated in 2002 and 2003.

Plant typology	Plant typology codes	Landscape complexity	Site codes	Exposure of the transept
Hedgerow without grass and wild flower strip	H	High	maa4	North-South
Hedgerow without grass and wild flower strip	H	Low	maa11	East-West
Hedgerow without grass and wild flower strip	H	Intermediate	ma4	North-South
Hedgerow with grass and wild flower strip	H+w	Intermediate	ma3	East-West
Hedgerow with grass and wild flower strip	H+w	High	maa5	North-South
Hedgerow with grass and wild flower strip	H+w	Low	maa14	North-South
Grass and wild flower strip	Wm	Intermediate	me2	North-South
Grass and wild flower strip	Wm	High	me4	North-South
Grass and wild flower strip	Wm	Low	me5	East-West

Results and discussion

A total of 39 butterfly species, belonging to six families, were collected (table 2). The most represented families were Lycaenidae (11 species) and Nymphalidae (9 species). The most abundant species were *Polyommatus icarus* (Rottemburg) (23% of the catches), *Coenonympha pamphilus* (L.) (20%) and *Pieris rapae* (L.) (11%) (table 2). These species accounted alltogether for 54% of the catches (figure 2). *P. icarus* is one of the commonest species in the Italian rural landscapes. The number of species sampled ranged from 13 (maa4 site in 2002) to 34 (maa14 site in 2003) (table 3). Shannon index values ranged from 1.89 (maa11 in 2002) to 2.70 (maa14 in 2003), showing in general a limited range of values. The higher diversity values (number of butterfly species and Shannon index value) were recorded in a hedgerow with grass and wild flower strip (maa14 site) within a low

Table 2. Lepidoptera species sampled and relative abundances in the sampled sites; numbers represent the sum of the individuals collected as a sum of 2002 and 2003 seasons.

No.	Species	maa5	maa11	maa14	maa4	ma4	ma3	me2	me4	me5	Total
	HESPERIIDAE										
1	*Pyrgus malvoides* (Elwes et Edwards)	4	0	5	1	5	2	9	14	6	**46**
2	*Spialia sertorius* (Hoffmannsegg)	0	0	0	0	0	0	1	1	0	**2**
3	*Carcharodus alceae* (Esper)	0	0	0	0	1	1	1	4	1	**8**
4	*Erynnis tages* (L.)	2	1	3	1	3	2	3	6	1	**22**
5	*Thymelicus lineolus* (Ochsenheimer)	25	21	48	10	19	14	23	18	19	**197**
6	*Ochlodes venatus* (Bremer et Grey)	11	5	21	4	3	3	4	16	6	**73**
	PAPILIONIDAE										
7	* *Papilio machaon* L.	0	0	1	2	2	1	2	10	2	**20**
8	* *Iphiclides podalirius* (L.)	6	1	12	1	2	9	1	8	1	**41**
9	* *Zerynthia polyxena* (Denis et Schiffermüller)	0	0	0	0	0	0	0	1	0	**1**
	PIERIDAE										
10	*Pieris brassicae* (L.)	2	3	12	2	2	1	2	1	2	**27**
11	*Pieris edusa* (F.)	0	0	3	0	1	0	4	2	2	**12**
12	*Pieris napi* (L.)	1	0	20	4	0	1	0	2	0	**28**
13	*Pieris rapae* (L.)	52	53	110	55	60	68	76	53	33	**560**
14	*Colias crocea* (Geoffroy)	2	1	40	2	7	12	27	103	69	**263**
15	* *Colias hyale* (L.)	0	0	6	0	0	2	8	7	7	**30**
	LYCAENIDAE										
16	* *Lycaena dispar* (Haworth)	0	0	25	0	0	0	0	3	3	**31**
17	*Lycaena phlaeas* (L.)	11	1	20	1	19	3	2	6	4	**67**
18	* *Lycaena tityrus* (Poda)	0	1	1	0	1	0	0	1	5	**9**
19	*Leptotes pirithous* (L.)	7	0	111	0	5	3	3	12	2	**143**
20	*Lampides boeticus* (L.)	0	0	1	0	0	0	0	0	0	**1**
21	* *Cupido argiades* (Pallas)	0	0	8	0	0	0	23	10	7	**48**
22	* *Celastrina argiolus* (L.)	0	0	1	1	0	0	0	0	0	**2**
23	*Plebejus argus* (L.)	0	2	12	0	1	1	54	33	180	**283**
24	* *Lycaeides idas* (L.)	0	0	1	0	0	0	3	0	8	**12**
25	*Aricia agestis* (Denis et Schiffermüller)	1	1	9	0	4	4	11	6	10	**46**
26	*Polyommatus icarus* (Rottemburg)	36	47	208	22	99	136	179	214	242	**1183**
	NYMPHALIDAE										
27	*Inachis io* (L.)	4	3	21	6	22	51	4	18	3	**132**
28	*Vanessa atalanta* (L.)	15	6	15	5	27	11	0	1	1	**81**
29	*Vanessa cardui* (L.)	3	2	10	3	8	5	5	54	9	**99**
30	*Polygonia c-album* (L.)	16	4	17	3	15	12	0	0	0	**67**
31	**Argynnis paphia* (L.)	1	0	1	0	0	0	0	0	0	**2**
32	* *Melitaea athalia* (Rottemburg)	0	0	1	0	3	0	3	94	6	**107**
33	*Melitaea didyma* (Esper)	1	6	5	2	3	2	21	132	8	**180**
34	* *Melitaea phoebe* (Goeze)	1	0	1	1	0	1	2	40	6	**52**
35	* *Apatura ilia* (Denis et Schiffermüller)	1	0	4	2	3	2	0	0	0	**12**
	SATYRIDAE										
36	*Coenonympha pamphilus* (L.)	33	32	82	29	89	102	146	280	239	**1032**
37	* *Pararge aegeria* (L.)	41	17	4	8	13	1	0	0	0	**84**
38	* *Lasiommata maera* (L.)	0	0	2	0	0	0	0	0	0	**2**
39	*Lasiommata megera* (L.)	9	18	51	6	11	9	4	12	3	**123**
	Total	**285**	**225**	**892**	**171**	**428**	**459**	**621**	**1162**	**885**	**5128**

* = species considered rare in Northern Italy rural landscapes.

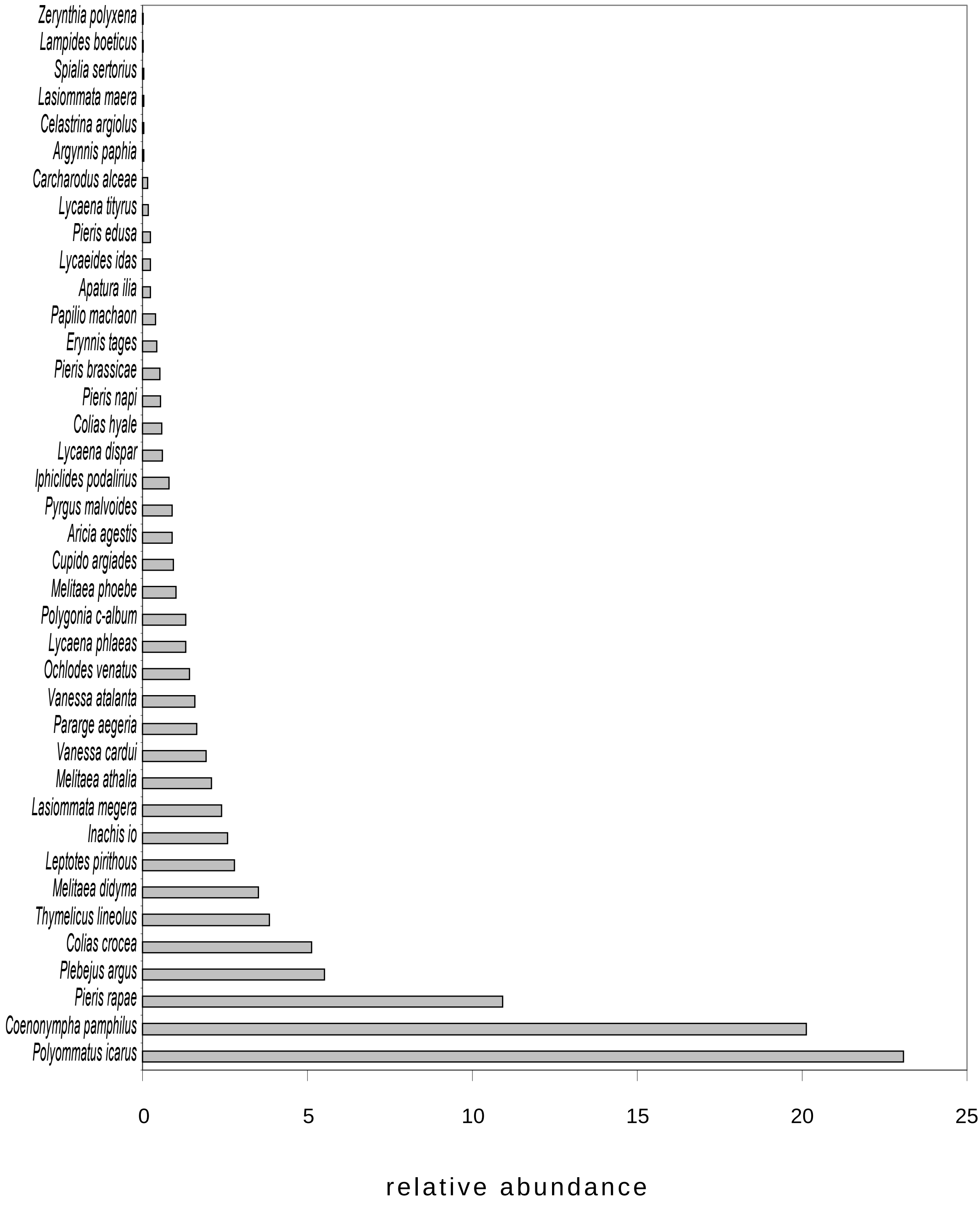

Figure 2. Relative abundance of the Lepidoptera species sampled in 2002 and 2003.

landscape complexity area, in both years (table 3). The lowest number of butterfly species was recorded in a hedgerow without grass and wild flower strip (maa11) within the low landscape complexity area). The lowest Shannon index values were recorded in two hedgerows without grass and wild flower strip (maa11 and ma3), both in a intermediate landscape complexity area.

Within the sites surrounded by a high landscape complexity 29 and 34 species were recorded, in 2002 and 2003 respectively; 28 (2002) and 32 (2003) within the sites surrounded by a intermediate landscape complexity; 32 (2002) and 31 (2003) within the sites surrounded by a low landscape complexity. Our data seem to demonstrate that the landscape complexity surrounding the

Table 3. Diversity indices calculated on Lepidoptera fauna in 2002 and 2003. H' = Shannon index; E = Eveness.

Sites	Total No. of species sampled		H'		E	
	2002	2003	2002	2003	2002	2003
maa5	18	21	2.36	2.51	0.82	0.82
maa11	12	17	1.89	2.06	0.76	0.73
maa14	27	34	2.70	2.59	0.82	0.74
maa4	13	19	2.19	2.24	0.85	0.76
ma4	23	24	2.50	2.23	0.80	0.70
ma3	18	22	2.04	2.16	0.71	0.70
me2	21	23	2.27	2.03	0.75	0.65
me4	24	27	2.47	2.27	0.78	0.69
me5	23	26	2.16	1.83	0.69	0.56

Table 4. Diversity indices of Lepidoptera fauna calculated on the "Landscapes Complexity" typologies, in 2002 and 2003. The numbers express the sum of the specimens collected in the sampling dates in 2002 and 2003. H' = Shannon index; E = Eveness.

Landscape complexity	Total No. of species sampled		Mean no. of individuals sampled/site (sd)		H'		E	
	2002	2003	2002	2003	2002	2003	2002	2003
High	29	34	257.67 (140.43)	409.67 (245.67)	2.70	2.50	0.8	0.71
Intermediate	28	32	260.0 (51.16)	242.33 (79.12)	2.43	2.28	0.73	0.66
Low	32	36	252.33 (212.27)	287.33 (331.67)	2.63	2.46	0.76	0.69

Table 5. Diversity indices calculated on the Plant Typologies in 2002 and 2003 seasons. The numbers express the sum of the sampling dates.

Plant Typology	Total No. of species sampled		Mean no. of individuals sampled/site (sd)		H'		E	
	2002	2003	2002	2003	2002	2003	2002	2003
Hedgerow and weed community	29	36	196.0 (108.75)	271.0 (266.34)	2.64	2.62	0.79	0.73
Hedgerow	26	28	198.0 (98.8)	161.0 (72.13)	2.33	2.32	0.72	0.70
Weed margins	29	31	382.0 (101.49)	507.0 (171.56)	2.46	2.22	0.73	0.65

sampling sites did not influence significantly the butterfly diversity (table 3).

Comparing the Lepidoptera diversity among the "Plant Typologies", the following results can be evinced: i) the higher number of species and biodiversity indeces were registered in "Hedgerow + weed" sites and also the most rare species were sampled within this typology; ii) weed margins showed the higher frequency of catches (mean number of individual sampled per 30 minutes), probably for the rich flowering weed community within this typology; iii) hedgerow typology (linear corridor with a very scarce weed community) showed the lowest number of species sampled and individuals collected, in particular for 2003 season (tables 3, 4 and 5).

Cardinal orientation seems to influence the Lepidoptera diversity and frequency of catches. In general, from an analysis of the species collected and frequencies of catches, North-South exposure of the transept showed more suitable conditions for Lepidoptera fauna. For example maa11 (East-West exposure) site, characterised by low insolation level, showed the lowest number of species sampled and the lowest diversity indices; similar conclusions can be evinced for ma3 site characterised by the same cardinal orientation. For these reasons insolation, that is influenced by the exposure of the hedgerow, could affect Lepidoptera diversity as found also by Fabbri and Scaravelli (2002) in a similar study carried out in Northern Italy. These consideratiosn are to be considered only preliminary, because form this study it is not possible to carry out a detailed analysis of this factor.

Ordination of the sites according to the Lepidoptera fauna was carried out by Correspondence Analysis (CA), performed on the relative abundances of Lepidoptera collected in all the sites in the whole study (2002 and 2003). This multivariate analysis did not cluster in a coherent way the butterflies data according to the landscape complexity (figure 3) but grouped the

Lepidoptera fauna according the plant typology. For example the sites within "Weed margin" typology were grouped together in the right part of the plot, while the other six sites characterised by hedgerows ("H" and "H+w" plant typologies) formed a distinct group. This analysis gives an ordination of sites and Lepidoptera species at the same time and it can be used to correlate the species to the sites (Pielou, 1984; Manly, 1994). For example species 23 [*Plebejus argus* (L.)] was strong correlated to me5 site, the species 33 [*Melitaea didyma* (Esper)] to site me4, the species 8 (*Iphiclides podalirius* (L.), a rare species with very low relative abundances), 5 [*Thymelicus lineolus* (Ochsenheimer)] and 19 [*Leptotes pirithous* (L.)] were correlated to site maa14. Some butterflies are extreme outlier on the y axis (i.e. species 31, 33, 9) but CA is known to be sensitive to rare species and for these species the ordination in these cases can be unclear.

The most abundant species collected (*P. icarus*, *C. pamphilus* and *P. rapae*) are characterised by a wide host range, including common plant species that are abundant in rural landscapes. In a similar study Fabbri and Scaravelli (2002) sampled butterfly fauna inhabiting the hedgerows of biological farms in Northern Italy, recording a total of 21 species; in this research butterflies were watched and identified at sight, or captured for identification and released alive. These authors found that farms with lowest values of Lepidoptera diversity presented the hedgerow and the bordering fields subject to deep disturbances, like repeated mowings, higher chemical input from neighbouring crops and unfavourable cardinal orientation.

Some species sampled in the research (marked with an asterisk, table 2) are to be considered rare in rural landscapes of Emilia-Romagna region (Marini, 1981 and 1998; Fiumi and Camporesi, 1998; Chiavetta, 1998 and 2000; Govi and Fiumi, 1998), because of the habitat destruction and the high impact of landscape management, including non-crop areas. Also *Pieris edusa* (F.) is not common in rural agroecosystems (Fiumi and Camporesi, 1988; Merighi, 2000; Fabbri and Scaravelli, 2002). *I. podalirius* is linked to shrubs and tree within hedgerow. Other species linked to the hedgerow (Fiumi and Camporesi, 1991) like *Aporia crataegi* (L.), *Nymphalis antiopa* (L.), *N. polychloros* (L.) and *Limenitis reducta* Staudinger, were not found in our study.

In a study carried out in 10 arable sites in Cambridgeshire (UK) a total of 22 butterfly species were recorded and, with the exception of one rare species, they were most abundant in the green lanes in comparison with other types of linear features (Croxton *et al.*, 2004). In the mentioned study species richness of butterflies was positively associated with species richness of the plants and with the number of larval foodplants of the recorded

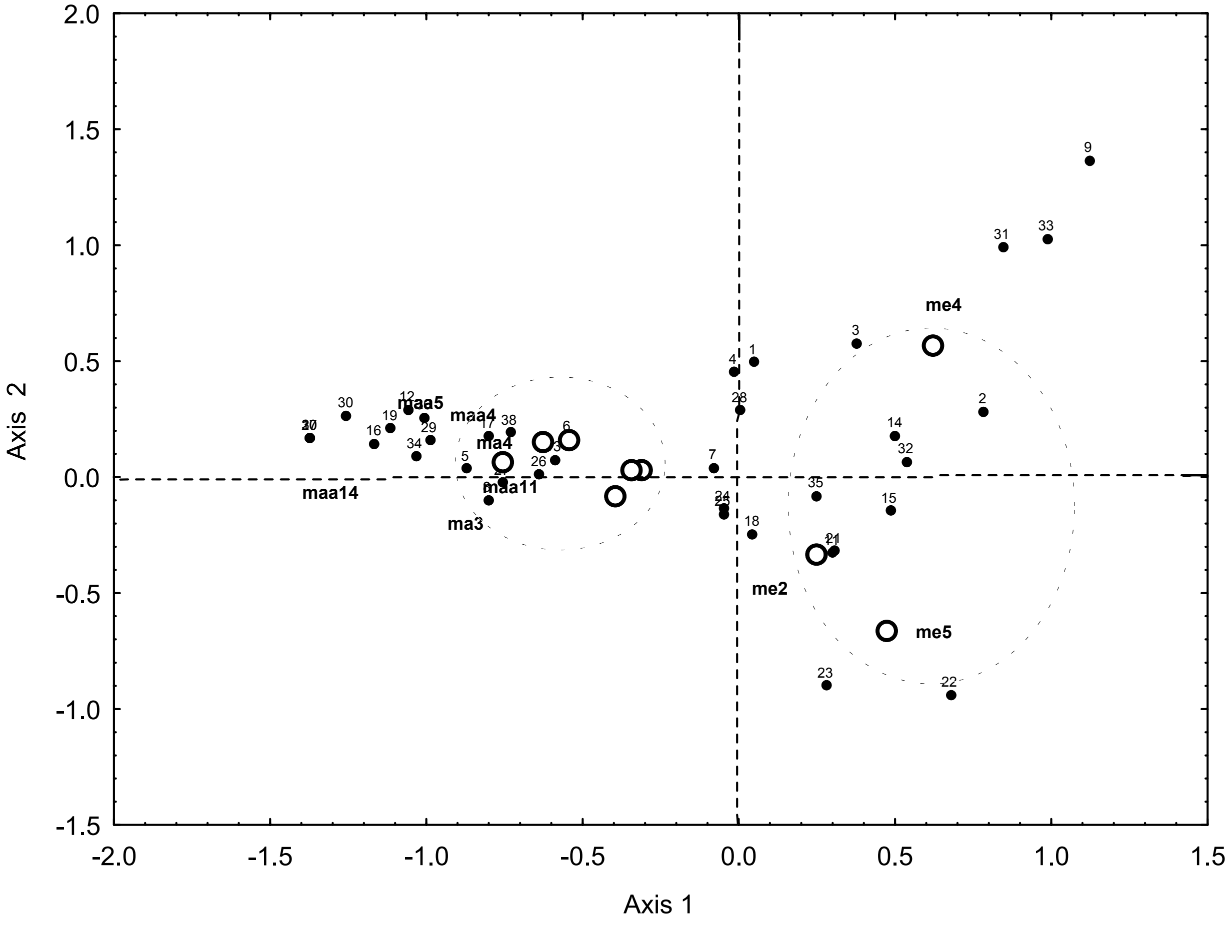

Figure 3. Ordination of sites and Lepidoptera species by Correspondence analysis. Open circles indicate the sites; black points indicate the butterfly species.

butterflies. A number of reasons may be put forward to account for the preference shown by butterflies for the green lanes, including the greater diversity of plant species, the greater abundance of larval foodplants, the more sheltered conditions and the greater structural variety within the green lane environment. The results of the mentioned paper are comparable with our study because the green lanes of the UK study show great affinity with our "hedgerow and weeds" plant typology. The environmental conditions within green lanes are likely to be more stable than the conditions out-side with reduced air movement between double hedgerows and subsequently reduced evapotranspiration leading to the higher moisture levels (Croxton *et al*., 2004). It was shown that the height/width ratio of green lanes also play a role in affecting the diversity of butterflies utilising the habitat (Sparks *et al*., 1999).

Linear features have been recognised as providing a wide range of function for a variety of wildlife, including butterflies (Dover *et al*., 1999; Sparks *et al*., 1999; Croxton *et al*., 2004). They act as linkages between habitats, roost ad shelter sites, providing defying resources and increase the diversity of the areas in which occur (Croxton *et al*., 2004). In our study the richness of butterflies was strongly affected by the micro-habitat of the sites and in a lesser extent by the structural complexity around the sites.

Lepidoptera diversity could be also affected by the management of the adjacent crops and a qualitative analysis of the main disturbance factors was carried out. Among these factors we can list: chemical sprays on the crops, soil tillage of the areas close to hedgerows and field margins, destroying of the shrubs during the management of field margins and irrigation channels and cutting of the grass within field borders during the flowering, that is considered on of the higher disturbance factors for Lepidoptera fauna.

In our research handnet sampling was carried out, using the catch and release method. Collection of adults was employed only in the cases of uncertain adult identification. This methodology showed to be practical and suitable for studies within rural landscape, also for the low ecological impact. On the other hand this sampling is not considered a quantitative method and it can be applied only for a relative comparison among the frequencies of catches of the sites, to calculate relative abundances of the species collected, and in general for a faunistic analysis of butterflies. Other sampling methods like Malaise traps and light traps can be used to sample Lepidoptera community but probably these methods are more suitable for natural environments like natural parks (Dapporto and Strumia, 2002) or forests (Huemer and Triberti, 2004).

Conclusions

Our data show that the micro-habitat within a site, including vegetation diversity, significantly affects the Lepidoptera richness. Also cardinal orientation of the transept, affecting the insolation intensity, could affect the Lepidoptera diversity and frequency catches but this conclusion is only preliminary. In the present study the Lepidoptera richness was strongly influenced by the plant typology (point diversity) and not by the landscape complexity. In general "weed margins" typology showed the highest number of sampled individuals (frequency of catches) in comparison with the other typologies, for the predominance of many flowers suitable for adult food. Weed diversity offers to butterflies host plant for the development of larval stages and a number of flowers that are the food of adults. The higher number of Lepidoptera species, including rare species for Emilia-Romagna region rural landscapes, were sampled in the "hedgerow and weed" typology and in the "weed margin" plant typology, the last being characterised by abundant plant communities on the borders of field or irrigation channels. Only few species [for example *I. podalirius* or *Apatura ilia* (Denis et Schiffermüller)] are linked to the shrubs or trees within the hedgerows within hedgerows.

In conclusion butterflies in our environmental conditions seem to be poorly effective as landscape bioindicators (or large-scale indicators), for their biological and ecological characteristics, including the high mobility of adults and the strong dependence from the micro-habitat. Plant typology of the micro-habitat greatly influenced the richness of butterflies and showed to be very important for their conservation, including rare species. The value of the ecological compensation areas (including green lanes and weed margins) is especially important as they may be the only semi-natural habitats left in many rural areas. The architecture of the hedgerow (or in general of linear features) could be an important factor for the nemoral species. Management of ecological compensation areas is crucial for Lepidoptera conservation, including conservation of rare species. Some interventions for the protection of Lepidoptera fauna can be suggested, including improving of the floral diversity surrounding field, the promotion of low impact cutting of ecological compensation areas mainly during the flowering of the weeds and avoiding, when possible, chemical control of weeds at field borders (Fabbri and Scaravelli, 2002).

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