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Seasonal patterns in butterfly abundance and species diversity in five characteristic habitats in Sites of Community Importance in Sicily (Italy)

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Abstract

Sicily (Italy) is one of the richest European regions in animal biodiversity. Butterflies offer good opportunities for studies on biodiversity, population and community ecology. Many species are strictly seasonal, preferring only a particular set of habitats. Five typical Mediterranean habitats: olive grove (conducted following organic farm management), mixed wood, ampelodesmos prairie (with dominance of *Ampelodesmos mauritanicus*), Mediterranean shrub and shrub at the coastal areas, were monitored for diversity and seasonal patterns in butterfly communities for 2 years. All habitats were inside protected areas indicated as Sites of Community Importance. Butterfly species richness was highest in ampelodesmos prairie and in olive grove. *Pieris brassicae*, *Lasiommata megera*, *Maniola jurtina*, *Pararge aegeria* have been reported in all habitats, although with different abundance whilst other species were observed only in one particular habitat. *Melanargia pherusa*, endemic species, and *Hipparchia statilinus*, listed in the IUCN Red List, respectively as “Least Concern” and “Near Threatened”, were observed in the ampelodesmos prairie. The morphotype *Coenonympha pamphilus* f. *lyllus* was reported in olive grove and ampelodesmos prairie. The majority of species showed abundance peaks in June and July, however many species showed a longer flight period than reported in literature with detection of specimens until November or December. The analysis of the similarity of communities among habitats shows a similarity between ampelodesmos prairie and olive grove and between Mediterranean shrub and Mediterranean shrub at the coastal areas, while the butterfly community in mixed wood is substantially different. The results of several diversity indexes suggest that ampelodesmos prairie has an important ecological role, as it supports butterfly abundance and species diversity.

Key words: butterflies, biodiversity indices, conservation, habitat type, *Ampelodesmos mauritanicus*.

Introduction

Biodiversity is generally considered an important intrinsic and extrinsic value to be preserved (CBD, 1992), however to translate this into protection goals still represents an open issue, as this is not clearly outlined in many legislative frameworks and it is under consideration in Europe (Nienstedt *et al*., 2012). In fact, the effective implementation of the post-2010 biodiversity framework at the national level is still an unsolved issue (MATTM, 2010). Collection of baseline data on animal biodiversity is relevant for environmental risk assessment and risk management but it is still far from being achieved (CBD, 2013).

Several studies have suggested that butterflies are key taxa for biodiversity monitoring because they reflect changes of climatic conditions (Beaumont and Hughes, 2002) as well as seasonal and other ecological changes (Kunte, 1997) and they are good indicators in terms of anthropogenic disturbance and habitat quality (Bergman *et al*., 2008; Bonebrake *et al*., 2010). Butterflies can also be used as an indicator taxon for restoration assessment (Lomov *et al*., 2006; EEA, 2007; 2010). In comparison with central and northern European countries, Italy is a very species-rich country (Balletto *et al*., 2010). Species that are considered threatened at the European level and occur in Italy are found mostly in wetlands, forests, rocky areas and shrub lands. These ecosystems require particular attention in order to ensure the habitats of these sensitive species are maintained (IUCN, 2013).

IUCN (2013) provides an overview of the conservation status of species in Italy based on the results of all European Red Lists completed to date and it does not provide the status of the species in the country, however there are no a specific national and sub-national Red Lists for butterflies (IUCN Comitato Italiano, 2014).

One of the most important aspects of any conservation strategy is the identification of high-value sites on the basis of their biodiversity content (Margules and Pressey, 2000) but for Mediterranean countries, information on the distribution of many species is often incomplete and data are lacking for many regions (Ramos *et al*., 2001). Moreover Dapporto *et al*. (2012) confirm that Mediterranean islands host butterfly populations that are distinct from those on the nearest mainland and highlight the importance of studying butterflies biodiversity in these areas.

Sicily is considered a hot-spot of abundance of rare species for different taxa (Balletto *et al*., 2010), and it is also known to have a rich butterfly fauna including endemic and rare species (Sabella and Sparacio, 2004; Dapporto and Dennis, 2008). A specific study conducted by Girardello *et al*. (2009) confirmed the presence in Sicily of several species of conservation concern. This Mediterranean region is also an important area for migrating butterflies. For example *Danaus chrysippus* (L.) (Lepidoptera Nymphalidae) is a wide-ranging migrant species that from the North African coastal regions has colonized parts of the south coast of Spain, Corsica, Sardinia, Italy, Malta and Greece (Pisciotta *et al*., 2008). However, when studies were carried out at lower latitudes, such as in Mediterranean mountains, a reduction of species distributions was observed (Wilson *et al*., 2005; EEA, 2013). On the basis of strict biogeographical techniques an impoverishment in butterfly diversity was predicted for western Mediterranean's largest islands including Sicily (Dapporto and Dennis, 2009). Despite numerous studies on the Sicilian insect fauna (Falci *et al*., 1995; Romano, 2006; Fiumi *et al*., 2007; Infusino, 2008; Bella and Fibiger, 2009), studies regarding the biodiversity and the biology of butterflies in Sicilian habitats are still scant (Infusino *et al*., 2010; Dapporto and Dennis, 2008) and little quantitative information is available. However Girardello *et al*. (2009) highlighted again the relevance of Sicilian environments (among others) for many butterfly species of conservation concern. Considering the Sicilian climate, the differences in the habitat and the ongoing global climate change a specific determination of flight periods of butterflies represents an important piece of knowledge for monitoring biodiversity changes and to support risk management activities (EFSA Panel on Genetically Modified Organisms, 2010). Several studies have demonstrated how butterfly populations of a number of species have declined in many parts of Europe in relation to direct habitat modifications (van Swaay *et al*., 2006; Girardello *et al*., 2009; EEA, 2013), thus it is essential for conservation purposes to know the most suitable habitats for butterflies and their actual status.

The main goals of this study are: 1) produce a first faunal list of diurnal butterflies in two SCIs (ITA020023 "Raffo Rosso, Monte Cuccio e Vallone Sagana" and ITA020006 "Capo Gallo") in Sicily for which no specific information for this guild was available, 2) correlate butterfly biodiversity to the different habitats present within protected areas and 3) compare the recorded flight periods of the most common species with information already available in the scientific literature. In this study we present the results of a biennial survey of species composition of butterfly communities in five Sicilian typical habitats. Based on these data, biodiversity indexes were estimated and butterfly seasonal variations described.

Materials and methods

Study areas

The surveys were carried out in the Sites of Community Importance (SCI) of the province of Palermo (Italy) ITA020023 named "Raffo Rosso, Monte Cuccio e Vallone Sagana" (38°7'27"N 13°13'55"E) and "Capo Gallo" ITA020006 (38°12'30"N 13°17'28"E) (figure 1).

"Raffo Rosso, Monte Cuccio e Vallone Sagana" covers an area of 6089 hectares. The existing vegetation (Natura2000, 2013a; 2013b) is described as follows:

- *Oleo-Euphorbio dendroidis sigmetum*, on ledges and drier ridges (south side);
- *Rhamno-Querco ilicis sigmetum pistacietoso terebinti*, *Pistacio-Querco ilicis sigmetum* and *Aceri campestri-Querco ilicis sigmetum*, all pioneer species on rocky limestone substrates;
- *Oleo-Querco virgilianae sigmetum* on deep soils and evolved.

The SCI "Capo Gallo" covers an area of 547 hectares and includes a coastal biotope of considerable interest. It is a protected area often indicated as one of the most successful examples of enhancing the biodiversity of the coastal areas of Sicily. The existing vegetation is mainly described as follows:

- *Pistacio-Chamaeropo humilis sigmetum*, along the sides sub-coastal;
- *Rhamno-Querco ilicis sigmetum pistacietoso terebinthi*, on detrital slopes;
- *Oleo-Euphorbio dendroidis sigmetum*, on ledges and drier ridges (south side);
- *Pistacio-Querco ilicis sigmetum*, at the top of the plateau.

Lepidoptera sampling

For sampling of diurnal Lepidoptera adults, 5 sites were selected, 4 in the protected area "Raffo Rosso, Monte Cuccio e Vallone Sagana" and 1 site in the Nature Reserve of "Capo Gallo". The five sites were representatives of five different habitats: 1) olive grove (OG) managed under organic farming regime (no direct fertilisation or pesticide used, low grazing by horses was allowed), 2) mixed woods (MW), 3) Mediterranean prairie with dominance of *Ampelodesmos mauritanicus* (Poiret) Durand et Schinz generally called ampelodesmos prairie (AP), 4) Mediterranean shrub (MS) in the SCI "Raffo Rosso, Monte Cuccio e Vallone Sagana" and 5) Mediterranean shrub at the coastal areas (MSC) in the SCI "Capo Gallo" (figure 1). The characteristics of each habitat are summarized in table 1. The 4 habitats of "Raffo Rosso, Monte Cuccio e Vallone Sagana" were sampled every 2 weeks from June 2010 to March 2012, in the case of "Capo Gallo" sampling was conducted every week from July 2010 to March 2012. For each habitat 4 linear transects of 50 meters length, were marked for diurnal Lepidoptera surveys; the total survey time for each habitat was about 30 minutes. The choice

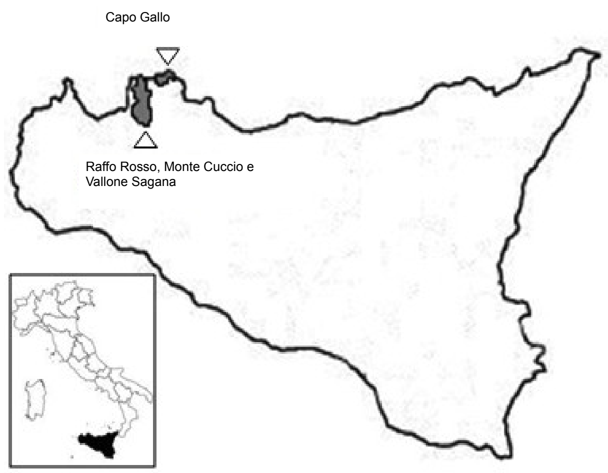

Figure 1. Geographical locations of the SCI of the province of Palermo (Italy) ITA020023 named "Raffo Rosso, Monte Cuccio e Vallone Sagana" and ITA020006 named "Capo Gallo".

Table 1. Description and characterization of the 5 habitats: olive grove (OG); mixed wood (MW); ampelodesmos prairie (AP); Mediterranean shrub (MS); Mediterranean shrub at the coastal areas (MSC).

Habitat	Position	Name	m a.s.l.	Type habitat	Major botanical species
OG	38°05'22"N 13°15'06"E	San Martino delle Scale	551	typical Mediterranean crop	*Olea europea*, and typical of the Mediterranean vegetation
MW	38°09'06"N 13°25'28"E	Portella Renne	539	mostly sclerophyllous shrub	typical of the Mediterranean vegetation
AP	38°08'15"N 13°23'83"E	Portella Renne	735	herbaceous xerophytes	*Ampelodesmos mauritanicus*
MS	38°08'44"N 13°24'70"E	San Martino	700	mostly sclerophyllous shrubs	*Quercus ilex*, *Quercus suber*, *Arbutus unedo*, *Juniperus* sp., *Ceratonia siliqua*
MSC	38°21'29"N 13°29'16"E	Capo Gallo	20	mostly shrubs	*Pistacia lentiscus*, *Erica arborea*, *Euphorbia dendroides*, *Laurus nobilis*, *Rosmarinus officinalis*, *Capparis spinosa*

of four 50 meters long transect rather than the classical 200 m long transect was due to the geomorphological and floristic characteristics of the sites. The transects were geo-referenced on a Garmin GPSMAP 60CSx.

Observations were done between 9:00 and 13:00 h during good weather period (no heavy rain or strong winds). Temperature, relative humidity, intensity of sunlight and wind (using Beaufort's scale) were recorded. When transect walking was performed, the cloud cover never exceeded 20%, temperature ranged between 15 and 33 °C and wind was weak or absent (1-2 on Beaufort's scale). Butterflies were counted up to a distance of 5 m from the observer.

Lepidoptera were identified at species level by visual recognition, but in doubtful cases, specimens were net-captured for identification and released into the environment immediately after capture. 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 its low ecological impact.

The nomenclature used in the check-list of European Butterflies (van Swaay *et al*., 2010a) and in IUCN (2014) was followed. All data collected were included in a database to analyze occurrence patterns for each species.

Data analysis

The number of butterfly species (S), the number of individuals for each species (N), α- and β-diversity indexes were calculated. The α-diversity was calculated from various indices including the Shannon-Wiener diversity index (H) (Shannon, 1948) that measures the species diversity within the community of an ecosystem (Sagar and Sharma, 2012), Pielou's equitability index (J) which consider the distribution of individuals within the various species that make up a community, Margalef index (d) that provides a measure of species richness, and Simpson index (D) that gives the species dominance. As the D index increases, the diversity decreases and for this reason we also calculated the form 1-D. In addition, as a measure of α-diversity the Hill index ($N\infty$), which expresses the role that the most represented specie plays in structuring the community, was calculated. Indices were calculated at the species level, the subspecies/morphotypes were not considered in the calculation of the diversity indices.

The Bray-Curtis index was calculated to measure the β-diversity and quantify the similarity of species composition between habitat types.

In order to identify a quantitative estimate of the interdependence between species assemblages and sampled habitats, an ordination of the sites according to the abundance of adult butterflies (2010-2012) was carried out by Correspondence Analysis (CA, according to Greenacre, 2010), The results are represented on a plane whose axes are the first two components that best explain the overall variance of the samples.

All these indexes were calculated using Past® software, version 2.15 (Hammer *et al*., 2001) available at http://folk.uio.no/ohammer/past/ (accessed on May 18, 2012).

Results

Species presence and flight periods

A total of 33 species of diurnal Lepidoptera belonging to 5 families were recorded in the five different habitats. The list of butterflies and their relative abundance is presented in table 2.

Out of 5 families recorded, Nymphalidae was the most common with 13 species identified (40% of total) followed by Pieridae and Lycaenidae with 7 species each, the lowest number of species was observed in the families Hesperiidae and Papilionidae. Even if the Nymphalidae represent the family with the highest number of species observed in the area, Pieridae represented the family with the highest number of individuals recorded (47%), followed by Lycaenidae and Nymphalidae (25% respectively). The lowest number of individuals was observed for the family Hesperiidae and Papilionidae (2% and 1%). *Pieris brassicae* (L.), *Lasiommata megera* (L.), *Maniola jurtina* (L.), *Pararge aegeria* (L.) were found in all five habitats; at the contrary, some species were observed only in a particular habitat. For example

Table 2. List of species and percentage of abundance of diurnal Lepidoptera species found for each of the 5 habitats.

Family	Species	OG	MW	AP	MS	MSC
Pieridae	*Anthocharis cardamines* (L.)	1	-	-	2	-
	Aporia crataegi (L.)	-	-	-	2	-
	Colias crocea (Geoffroy)	6	-	12	17	2
	Colias crocea f. *helice* (Hubner)[1]	x	-	x	x	-
	Gonepteryx cleopatra (L.)	2	-	1	6	6
	Pieris brassicae (L.)	31	29	13	19	34
	Pieris rapae (L.)	13	-	3	2	10
	Pontia edusa (F.)	-	-	1	-	x
Nymphalidae	*Coenonympha pamphilus* (L.)	1	-	5	-	1
	Coenonympha pamphilus f. *lyllus* (Esper)[1]	x	-	x	-	-
	Hipparchia cf. *semele* (L.)[2]	1	-	6	2	-
	Hipparchia statilinus (Hufnagel)	-	-	1	-	-
	Lasiommata megera (L.)	6	10	9	8	4
	Limenitis reducta Staudinger	x	-	-	1	-
	Maniola jurtina (L.)	7	5	4	5	4
	Melanargia galathea (L.)	-	-	1	2	-
	Melanargia pherusa (Boisduval)	-	-	2	-	-
	Melitaea athalia (Rottemburg)	-	-	1	-	-
	Pararge aegeria (L.)	2	53	2	2	2
	Pyronia cecilia (Vallantin)	3	-	7	1	1
	Vanessa atalanta (L.)	1	3	1	-	3
	Vanessa cardui (L.)	1	-	2	1	2
Lycaenidae	*Aricia agestis* (Denis et Schiffermuller)	3	-	5	9	-
	Celastrina argiolus (L.)	x	-	1	-	2
	Lampides boeticus (L.)	1	-	3	9	4
	Leptotes pirithous (L.)	-	-	1	1	19
	Lycaena phlaeas (L.)	2	-	3	2	1
	Plebejus argus (L.)	2	-	3	6	-
	Polyommatus celina (Austaut)	15	-	11	4	2
Hesperiidae	*Carcharodus alceae* (Esper)	2	-	1	-	-
	Hesperia comma (L.)	x	-	-	1	x
	Ochlodes sylvanus (Esper)	x	-	1	-	-
	Thymelicus sylvestris (Poda)	-	-	-	1	1
Papilionidae	*Iphiclides podalirius* (L.)	x	-	2	-	-
	Papilio machaon L.	x	-	4	-	1

[1]shows the morphotypes; [2]*H. semele* is very similar in this area of Sicily to the endemic species *Hipparchia blachieri* (Fruhstorfer) according to male genitalia; x = species and morphotypes with abundance less than 1%.

Melanargia pherusa (Boisduval), *Melitaea athalia* (Rottemburg) and *Hipparchia statilinus* (Hufnagel) were present only in AP, while *Aporia crataegi* (L.) was observed exclusively in MS. It is important to notice that the Sicilian endemic species *M. pherusa*, listed in the IUCN Red List (van Swaay *et al*., 2010a; 2010b) was observed during sampling activities in AP in 2001 (May and July) while in September 2010 we observed *H. statilinus*, listed in IUCN (2014) as "Near Threatened".

In addition to the species recorded, we report also the collection of the following morphotypes (table 2): *Colias crocea* f. *helice* (Hubner) that was 5-10% of total population confirming what estimated by Tolman and Lewington (2009) and *Coenonympha pamphilus* f. *lyllus* (Esper). In some recent scientific works appears the hypothesis that this last form is indeed a separate species of *C. pamphilus* (e.g. Wiemers, 2007). During the winter sampling an individual of *Acherontia atropos* (L.) (Lepidoptera Sphingidae) was also found. During the two years of sampling we also found the following species: *Chiasmia clathrata* (L.) (Lepidoptera Geometridae) in April, *Zygaena filipendulae* (L.) (Lepidoptera Zygaenidae) from April to June and from October to November, *Amata* (*Syntomis*) *phegea* (L.) (Lepidoptera Arctiidae) in May and *Utetheisa pulchella* (L.) (Lepidoptera Arctiidae) in October.

Almost 75% of our observations coincide with data reported in the literature. Other species showing a longer flight period compared with reports in the scientific literature are: *C. pamphilus*, *Hipparchia semele* (L.), *M. pherusa*, *P. cecilia*, *Celastrina argiolus* (L.), *Leptotes pirithous* (L.), *Vanessa atalanta* (L.), *Papilio machaon* L. (figure 2).

Some species were observed for longer periods in some habitats, e.g. in MSC, where some butterflies were recorded even during winter months (figure 2). Another interesting feature clearly highlighted by the consultation of the data base concerns the existence of a standstill period during the summer (figure 2) for several species such as *H. semele*, *M. jurtina*, *P. machaon*,

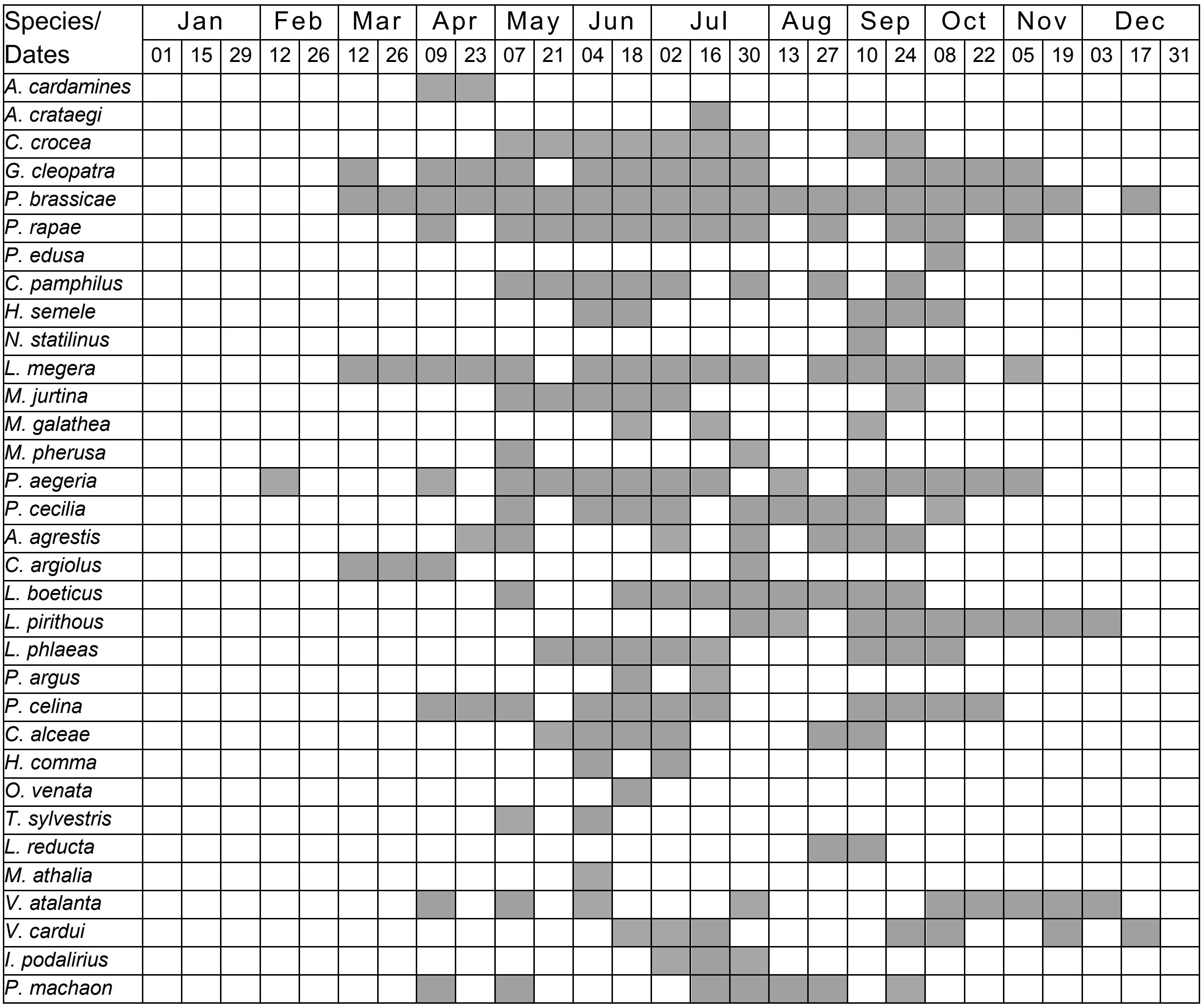

Figure 2. Overview of butterflies presence over time, as recorded during the study period. Observations from the 2 years were pooled to derive flight periods.

Vanessa cardui L. and *V. atalanta*. Also the day-flying moth *Z. filipendulae* was quite abundant during the sampling period.

The use of the database (e.g. figure 3) enabled to compare the flight range of the species collected with existing information in the scientific literature or specialized web sites. However for 9 of the 33 species listed above, the records are too sporadic to make such a comparison. Our data indicate for example that *Gonepteryx cleopatra* (L.) might have in this area a flight period longer than it was recorded in other areas of Southern Italy (Santorsola *et al*., 2012) due to a prolonged activity in autumn. Figure 3 is an example based on flight period of C. *crocea* that allows to explore another important feature of the database combining flight period and habitats.

Diversity indices

Abundance and biodiversity calculated over the entire sampling period

The diversity of butterfly communities in the five habitats for the entire period are presented in table 3. It shows that AP is the richest habitat (28 species) followed by OG (25 species), MS (22 species), MSC (20 species) and MW (5 species). In total, 1203 individuals were observed and identified. The largest number was observed in OG (453 individuals, 38% of total), followed by MSC (327 individuals, 27% of total), while in AP and in MS almost the same number of individuals was observed (195 individuals in AP and 190 individuals in MS, 16% of total respectively), a very low number of individuals was registered in MW (38 individuals, 3% of total). The non-preference for this habitat has been noted for several butterfly species (e.g. *C. crocea* figure 3).

The values of Pielou's index indicates that there is an equal distribution of the species in all the 5 habitats, and even with the high value of the index recorded in the AP it is not possible to identify a dominant species. In AP also the Shannon index value was the highest. MW and OG are the habitats presenting the lowest values of Pielou index but MW has the highest value of Simpson index, showing a situation of strong dominance of few species. MW was also the habitat with the lowest Shannon's index value and then with less biodiversity of butterflies. The low value of the Hill index (N∞) found in

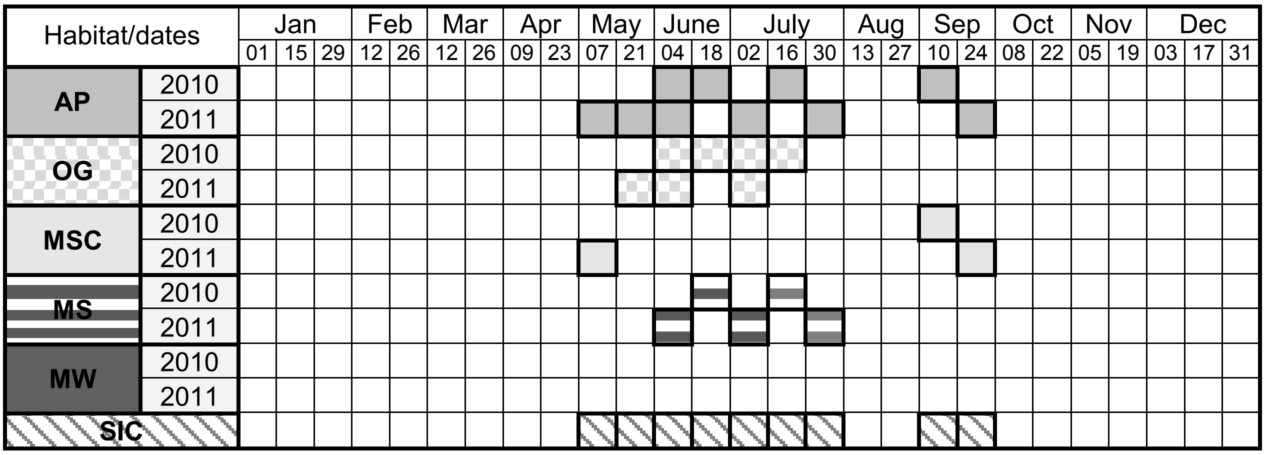

Figure 3. Flight periods of *Colias crocea* during the study period in each of the 5 habitats.

Table 3. Diversity indices for butterfly communities in five different habitat types.

Habitat	Species number (S)	Individual number (N)	Shannon (H)	Pielou (J)	Simpson (D)	Simpson (1-D)	Margalef (d)	Hill (N∞)
OG	25	453	2.36	0.73	0.15	0.85	3.92	3.21
MW	5	38	1.18	0.73	0.37	0.62	1.10	1.90
AP	28	195	2.87	0.86	0.07	0.93	5.12	7.50
MS	22	190	2.57	0.83	0.10	0.90	4.00	5.28
MSC	20	327	2.22	0.74	0.18	0.82	3.28	2.92

the MW, can indicate that the most representative species of this habitat have in fact a dominant role in structuring the community. This suggests that only a few species show sciaphilous habits. Margalef index presents a high value in AP and low in MW thus indicating possible differences in species richness among habitats.

Seasonal variation of biodiversity

Seasonal variation of the diversity indices is shown in figure 4 and 5. The number of species (S) (figure 4a) varied over the season in all habitats. The maximum value of S was recorded in June 2010 in OG, followed in the same month and year from AP. This is confirmed also by the values of the Shannon index (H) (figure 4b) which appear, however, higher in AP than in OG. MW is the habitat with the least number of species and also individuals throughout the year (figure 4a) and with shorter flight season. Margalef's index (figure 4c) shows the highest value in June 2010 (AP) and July 2011 (OG). As regards equitability (figure 5b), butterfly communities remain well-structured even if MSC presents greater fluctuations, however it is the only habitat where butterflies were recorded until November (figure 4a, 4b). MW also presents the less structured butterfly communities (figure 5a, 5c) and with the lower diversity of species (figure 4b). The lower biodiversity found in this habitat is confirmed by the high values of Simpson dominance index (D) (figure 5b). D maximum was also recorded in AP (November 2010 and March 2011) and in MS (March 2011 and October 2011) while OG has always presented the lowest values of this index.

Table 4. Bray-Curtis index of similarity for butterfly communities in the 5 different habitats.

Butterfly community	OG	MW	AP	MS	MSC
OG	1				
MW	0.43	1			
AP	0.94	0.42	1		
MS	0.88	0.46	0.86	1	
MSC	0.89	0.48	0.88	0.90	1

Similarity

The calculation of the Bray-Curtis index (table 4) indicates that the butterfly communities in OG were similar in species composition to the butterfly communities in AP, while the butterfly community in MW was different from all other communities (less than 50% of similarity).

Correspondence analysis (CA)

Two of the first axes explained more than 60 % of the variance, and indicated the main gradients which shape butterfly communities among different environments (figure 6). In fact, the first axis of the CA of the butterfly assemblage explained 37.08% of the variation and the second axis the 30.76%. The first through the fourth eigenvalues are 0.29, 0.24, 0.13 and 0.10 respectively. 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. For example *P. aegeria* was strongly correlated to the habitat MW and *L. pirithous* to MSC, to which also *C. argiolus* and *T. sylvestris* were associated. *M. pherusa* was linked mainly with AP.

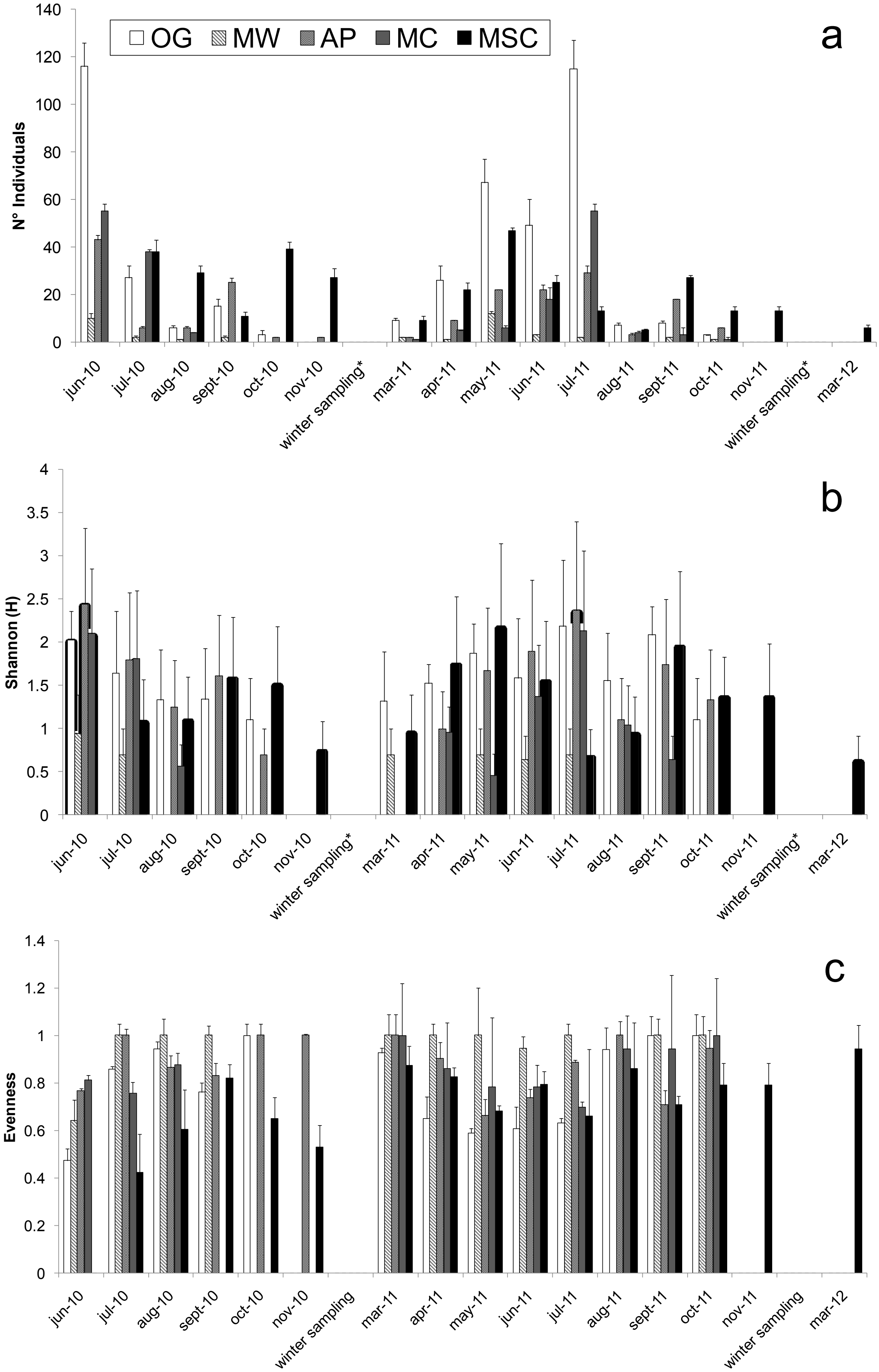

Figure 4. Graphical representation of monthly trends of average number of individuals (a) and diversity indices (b = Shannon; c = Eveness) during the sampling period for the 5 different habitat types. Data on Y axes synthesize average values of four transects per data. *Though during the winter sampling more butterflies were collected, these data were not considered in the calculation of indices.

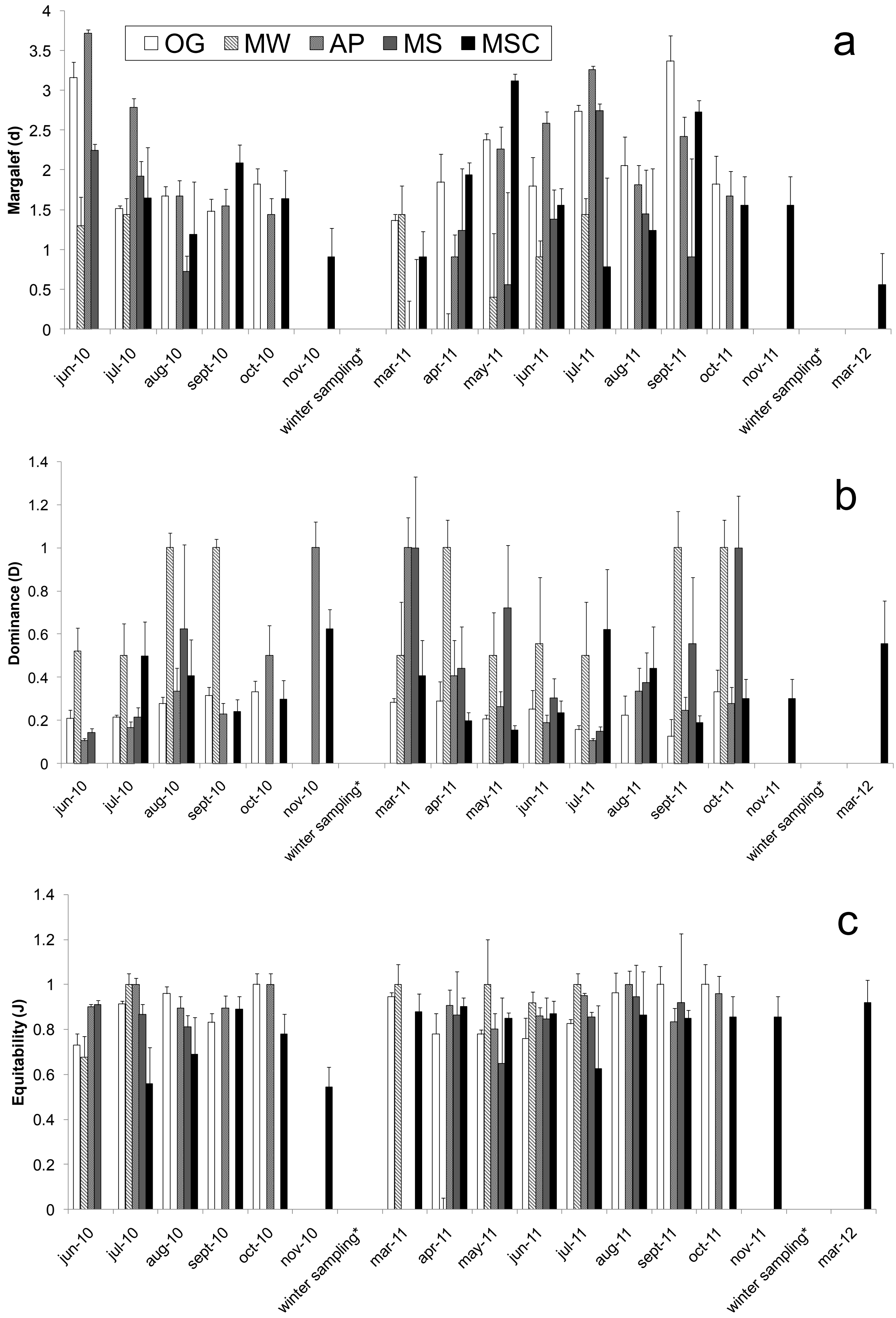

Figure 5. Graphical representation of monthly trends of diversity indices (a = Margalef; b = Dominance; c = Equitability) during the sampling period for the 5 different habitat types. Data on Y axes synthesize average values of four transects per data. *Though during the winter sampling more butterflies were collected, these data were not considered in the calculation of indices.

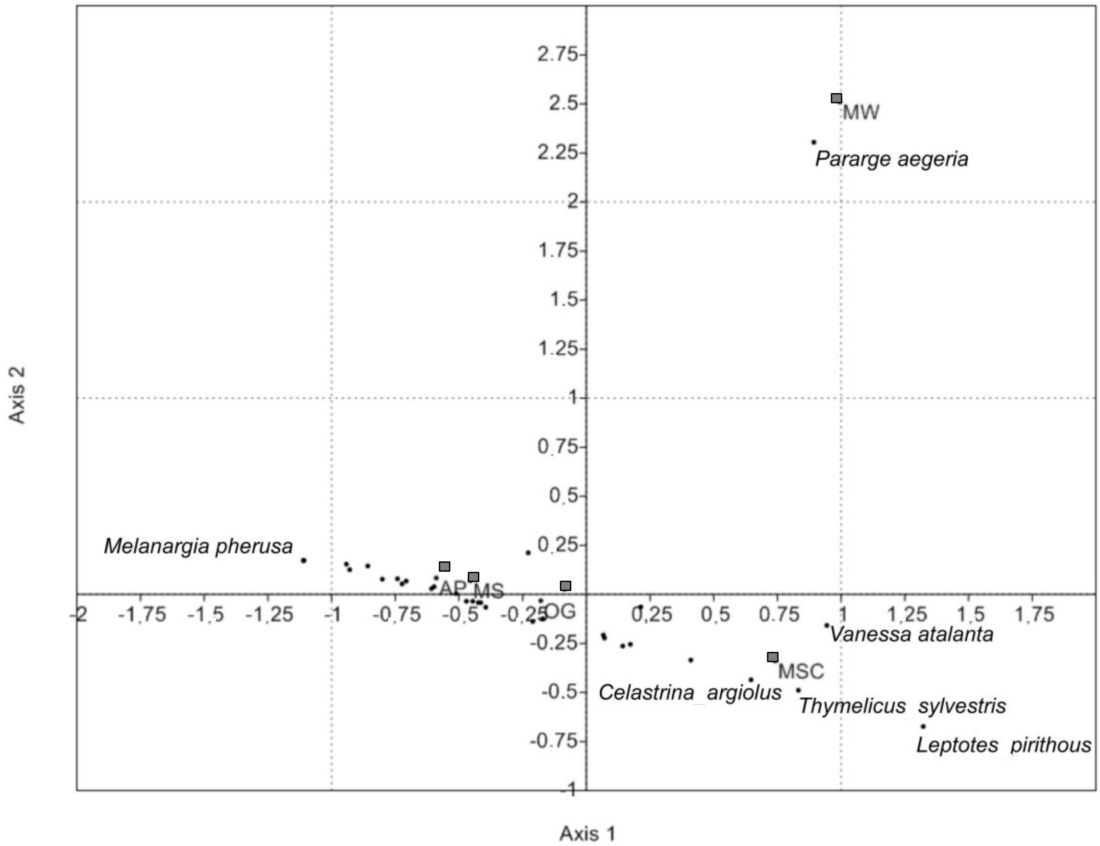

Figure 6. Ordination of sites and Lepidoptera species by Correspondence analysis. Grey squares indicate the sites, black points indicate the butterfly species. For sake of clarity, only the name of the most significant are reported.

Discussions and conclusion

Extensive and exemplary butterfly monitoring programs in Europe have been vital sources for documenting the effects of habitat, landscape, human activities and even climate change on biodiversity (Boriani *et al*., 2005; Dover and Settele, 2009; Bonebrake *et al*., 2010; van Swaay *et al*., 2010a; EEA, 2013). Butterfly monitoring programs have primarily focused on the value of this group as indicators of habitat diversity, but they can also be fruitfully used to document changes in butterfly communities through time and space (Beaumont and Hughes, 2002; Hoyle and James, 2005; D'Aniello *et al*., 2011). A wide range of factors threaten important natural habitats for butterflies, and the future preservation of many endangered species will depend on the conservation of their habitats (Boriani *et al*., 2005; van Swaay *et al*., 2006). Italy hosts 60% of all butterfly species in Europe and 4% of them are considered threatened at the European level, however there is no a national or Sicilian red list of butterflies species, and the data are based on the European Red List (IUCN, 2013).

The value of the biodiversity indices recorded in this study were generally high (except for MW) and comparable with the highest value recorded in similar studies (Robinson *et al*., 2012).

We calculated the estimated biodiversity and its seasonal variation and compared these data with the existing scientific literature, however not many data are available for the Mediterranean area (e.g. Feest and Spanos, 2009; Salomone *et al*., 2010; D'Aniello *et al*., 2011). The results we obtained show a high biodiversity recorded in all the analyzed sites except for MW. In particular, the estimate of species diversity highlights the potential relevance of the habitat "ampelodesmos prairie" in the conservation of butterflies communities. In fact, the values of Shannon's index show that AP and OG are the most biodiverse habitats. The biodiversity indices calculated for AP are even higher than the ones for OG, and the latter are comparable with the ones recorded in semi-natural grasslands located within the SCI "Monti di Lauro" (Avellino, Italy) where grasslands were subjected to moderate grazing (D'Aniello *et al*., 2011). The results of this study then confirm that grasslands are the most suitable environment for many butterflies that in grasslands profit from a large weed diversity that offers to butterflies host plant for the development of larvae and a diversity of flowers that constitute suitable food sources for the adults. Moreover the data can be useful for monitoring and conservation programs. In addition the database, by giving detailed information on the flight period in different season and in each of the observed habitat, can represent an important tool to be used in specific protection actions to estimate the potential exposure to environmental stressors (e.g. exposure to pesticides).

MW is the habitat with the lower index values and therefore with less biodiversity of butterflies. This is a quite common feature of many butterfly monitoring, since most day-flying species generally show heliophilus/xerophilus habits. However, it is interesting to highlight the preference of the aptly named Speckled Wood (*P. aegeria*) for this latter habitat; confirming that this species fly in partially shaded woodland. Lang's Short-tailed Blue (*L. pirithous*), is primarily a species common in savannah, but due to its migratory behaviour it could be seen in other habitats. During this survey, the species was linked to the MSC and was recorded from July to December.

Margalef's index has allowed to evaluate and compare possible differences in species richness between the 5 habitats during the sampling period. These values are probably influenced by the presence of food resources for larvae and adults, the exposure of the site to the wind (e.g. in the MSC) and the penumbra. This last factor is likely to be the cause of the low number of species and the Margalef's low index value found in the MW. In addition, the results of Bray-Curtis similarity index indicate that AP and OG share a large similarity of butterfly species. MW and AP show the lower value of the index and thus are represented by relatively different species, a result probably driven by the different type of vegetation. The results obtained highlight how the AP is an habitat worth to be protected in these SCIs because it is the richest in butterfly's biodiversity, supports the largest number of species and is the best structured, as can be argued by the value of biodiversity indices calculated. Also OG, run under a traditional low input regime, constitute a good reservoir of biodiversity in this area of Sicily. It is well known that some human activity has negative impacts on butterflies (White and Kerr, 2007), but in some cases it created agricultural and woodland management systems, such as hay meadows and coppicing, that may favour many butterfly species which could become extinct in some European countries if such practices were discontinued (Dover and Settele, 2009). From the faunal list presented in table 2, it can be noted the presence of *M. pherusa*, a species also listed in the 2010 IUCN Red List of Threatened Species, though it is considered as of Least Concern since it has not been declining by more than 25% in the last ten years and its population size is probably larger than 10,000 adults (van Swaay *et al*., 2010a). Our surveys however detected only three individuals of this species during the sampling period which might indicate the existence of tiny populations in the area. There remains some controversy regarding the taxon *pherusa*. Usually it is considered a subspecies/morphotype of *Melanargia occitanica* (Esper) (Nazari *et al*., 2010) but sometimes it has been considered a species in itself on the grounds of subtle differences between the early stages. The exact taxonomic identification was beyond the scope of this study, in which a separate specific status for this taxon (Villa *et al*., 2009; van Swaay *et al*., 2010b) was adopted.

The present study represents the first survey of butterfly diversity in two protected areas in Sicily, therefore, it is not possible to compare the diversity of the butterflies recorded in these areas with historical data bases, that are mainly organized in check lists without any quantitative information. Data from this survey could also constitute the baseline information on the diversity of butterflies for setting future conservation plans. In Italy, agricultural activities constitute the major land use in many protected areas; therefore, the possible impact of cultivation practices in these areas on animal biodiversity needs to be assessed in the light of the specific protection goals of these areas. While acknowledging the possible underestimation in terms of species diversity in our survey, based on the data collected it is possible to carry out an initial characterization of the 5 habitats in preparation of environmental risk assessments for SCIs using the composition of the Lepidoptera communities as an important assessment endpoint. Therefore, the selection of focal species for environmental risk assessment can effectively be initiated by considering estimated abundance and protection status of the species described here. Given the importance of selected habitats for butterfly conservation, the information collected in the present study will hopefully constitute an incentive for planning *ad hoc* conservation actions for protected areas of the Sicilian Region.

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