BUTTERFLY ECOLOGY AND CONSERVATION OF A SITE IN THE PRE-APENNINES OF PIEDMONT (NW ITALY)

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RÉSUMÉ. — *Écologie et conservation des papillons d'un site des pré-apennins du Piémont (nord-ouest de l'Italie).* — De 1999 à 2001 nous avons étudié la faune de papillons d'un site des pré-apennins du Piémont (Italie du NO). Soixante-huit espèces ont été observées et 16 autres ont été ajoutées à partir de travaux antérieurs. Au total la faune de la zone d'étude a des caractéristiques intermédiaires entre celles de l'Europe centrale et de la région Méditerranéenne: elle est composée d'espèces plus amplement distribuées et plus mobiles que le reste de la faune italienne. Les zones de jachères récentes et anciennes montrent un nombre d'espèces significativement plus grand que celui des aires boisées et cultivées, mais nous n'avons trouvé de différence significative ni pour les caractéristiques écologiques ni pour les surfaces des aires de distribution italienne entre les diverses associations d'espèces qui peuplent des environnements différents. Seules quelques espèces ont montré des préférences significatives pour un habitat particulier, et nous n'avons pas trouvé d'association d'espèces différente selon les habitats que nous avons étudiés. Les espèces qui ont disparu ou qui sont devenues plus rares dans la zone d'étude lors des 30 dernières années ont une aire de distribution italienne plus petite et une mobilité inférieure par rapport aux espèces qui ont survécu jusqu'en 1999-2001.

SUMMARY. — From 1999 to 2001 we studied the butterfly fauna of a site in the pre-Apennines of Piedmont (NW Italy). Sixty-eight species were observed, and another 16 were added from previously published works. On the whole, the fauna of the study area has intermediate characteristics between those of central Europe and the Mediterranean region, and is composed of species more wide-ranging in Italy and more mobile than the rest of the Italian fauna. Old and recent fallow habitats have significantly higher species richness than woods and cultivated areas, but we failed to find any clear difference, either in the ecological characteristics or in the Italian range-size, between the species assemblages inhabiting different habitats. Only a few species showed significant preferences for any single habitat type and different habitats were not occupied by different species assemblages. Species that disappeared or became rarer in the study area during the last 30 years had smaller Italian range-size and lower mobility than species still persisting in 1999-2001.

Butterflies are by far the best known among Insect groups. Detailed accounts of their biology in Europe have been published (Dennis, 1992), and the huge amount of distribution

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data has already been condensed into distribution atlases (e.g. Gonseth, 1987; Kurdna, 2002), whose quality and detail are comparable to those dealing with Vertebrates. The conservation status of European butterflies has also been assessed thoroughly by Van Swaay & Warren (1999), who found that at least 71 species (12% of total) are threatened on our continent, mostly because of habitat destruction or degradation. Even in Italy there is a good amount of ecological and distribution information (Balletto *et al.*, 1982; Balletto & Kurdna, 1985). However, when detailed analyses are attempted, the quality and completeness of the information available is often far from satisfactory. Distribution information on Italian butterflies has accumulated over many decades, and different authors have worked in areas of very different extension, over variable amount of time, and with different methodologies, thus making comparisons highly problematic. Particularly, very few accounts of the butterfly fauna of single, spatially circumscribed places, have been published, and this is a serious lack for studies involving species richness comparisons among different habitats. Moreover, as human activities are increasingly threatening European ecosystems, there is an urgent need of quantifying these impacts and acting against them. Monitoring changes of species richness over time and space in spatially circumscribed places could be a useful instrument to evaluate habitat degradation and to identify its causes.

In this paper we present the results of a multi-year survey of the local butterfly fauna of a site in north-western Italy. As this area was already surveyed in the past (Baldizzone, 1964, 1965, 1966, 1971), we also attempt to compare the changes in species richness that occurred in the area in the last three decades, and to find possible explanations for them.

STUDY AREA

This study was done in the pre-Apennines of south-east Piedmont, in the Z.R.C. (Zona di Ripopolamento e Cattura) “Brignano-Casasco”. It is a wildlife refuge area, characterized by a gentle relief, and located around the village of Casasco (44˚48’N 9˚00’E). It has a surface of 900 ha and altitudes between 250 and 450 m.

The climate is influenced by the vicinity of the Mediterranean Sea and can be classified within the sublittoranean rainfall regime (Cagnazzi *et al.*, 1998). There are rainfall maxima in autumn and spring, and minima in winter and summer. Total precipitation averages 847 mm, with one month of summer aridity in July (Cagnazzi & Marchisio, 1998). Yearly temperature averages 12.2˚C, with a minimum in January (1.4˚C) and a maximum in July (22.5˚C).

The study area is characterized by brown, calcareous soils (Regione Piemonte, 1979) and by a mosaic-like landscape, where small patches of several different habitats are intermixed. Cultivated areas (vineyards, orchards, alfalfa meadows and cereals) occupy approximately 50% of the area, woods 22%, while meadows and various seral stages of woodland regeneration account for 26%. The remaining 2% is occupied by barren soil and by buildings (Assessorato Tutela e Gestione Ambientale, unpublished data). Large expanses of monocultures are absent, and agriculture is practised at a relatively low-intensity level compared with lowland areas. Although agriculture is still the dominant activity, since the 1970s, the exploitation of the area progressively decreased and this led to the increase of woods and fallow.

Pastoralism was a common activity in the 1970s, but it has now almost disappeared. The few remaining cattle rarely graze outside their barns. Wild mammal species are also scarce, but Red Fox *Vulpes vulpes*, Roe Deer *Capreolus capreolus* and Wild Boar *Sus scrofa* occasionally frequent the area.

Observations were done in 41 sample sites within the study area. We recognized 5 different habitat types, which can be visualized as successive stages of decreasing human impact. CORINE codes (Devillers *et al*. 1991) allow a better characterization of the different habitat types.

Crops. (7 sample sites; CORINE codes 82.11 and 83.21). These include both annual (wheat, colza etc.) and perennial cultivation (vineyards and orchards). These habitats are characterized by heavy human impact, with regular input of fertilizers and pesticides.

Alfalfa meadows. (8 sample sites; CORINE code 81.1). This habitat is dominated by Alfalfa *Medicago sativa*, with low percentages of other herbs (*Poa trivialis*, *Trifolium pratense*, *Bromus sterilis*, *Plantago lanceolata*, *Rumex acetosa*). Alfalfa meadows are mown at monthly intervals between May and September, but there is no input of fertilizers and pesticides.

Recent fallow. (12 plots; CORINE code 34.32). This habitat can be classed within phytosociological alliance *Mesobromion*. In recent fallow, trees are absent and shrub cover is sparse or absent (average cover in the sample sites: 2.1 ± 3.3% S.D., range 0-10%), while herbs occupy 70% or more of the area (average 83.8 ± 11.9% S.D., range 70-100%). Herb species diversity is high and includes species such as *Bromus erectus, Brachypodium pinnatum, Dactylis glomerata*, *Avena fatua*, *Picris echioides*, *Erigeron annuus*, *Anthemis tinctoria*, *Gladiolus italicus*, *Helianthemum nummularium*, *Anthyllis vulneraria*, *Hippocrepis comosa, Vicia cracca*, *Astragalus* spp., *Hypericum perforatum*, *Potentilla* spp. Orchids such as *Ophrys fuciflora* and *Orchis purpurea* are also widespread. Recent fallow habitats are usually mown once per year in late September.

Old fallow. (10 plots; CORINE code 31.8D73) This habitat is transitional between recent fallow and wood. Tree cover is 20% or less (average 10.5 ± 7.6% S.D., range 0-20%), while shrubs occupy 30% or more of the area (average

44.0 ± 15.8% S.D., range 30-80%). Common shrubs include *Spartium junceum*, *Prunus spinosa*, *Crataegus monogyna*, *Cornus sanguinea*, *Rhamnus catharticus*. Herbs are the same as in recent fallow. Exact time of fallowing in these habitats is not precisely known, but based on the age of trees and shrubs, we estimated it to about 10-20 years.

Woods. (4 plots; CORINE code 41.73) These habitats can be classed within phytosociological alliance *Quercion pubescenti-petreae* and have 70% or more cover in the tree stratum (average 75.0 ± 5.8% S.D., range 70-80%) shrub cover is on average 47.5 ± 12.6% (range 30-60%). Woods are dominated by Downy Oak *Quercus pubescens*. In the shrub layer *Lonicera caprifolium*, *Corylus avellana*, *Cotinus coggyria, Crataegus monogyna* and saplings of *Ulmus minor* are common; herbs include *Brachypodium pinnatum*, *Primula vulgaris*, *Fragaria vesca* and *Carex flacca*. Coppicing and timber extraction are not practised in these habitats within the study area.

MATERIAL AND METHODS

The area was studied intensively from May 1999 to September 2000. Other visits in 2001 allowed observation of a few more species. During the intensive survey 41 sample sites (see Study Area) were selected and visited several times. Altogether 153 sampling sessions were done during the intensive survey phase (woods: 13 sessions; old fallow: 36; recent fallow: 50; alfalfa meadows: 32; crops: 22). In each session one of the 41 sample sites was visited and butterflies were observed by one of us (LB) for 30 minutes. When necessary, individuals were captured and usually immediately released after recognition. Specimen collection was limited only to those species that could not be reliably recognized in the field.

Specimen determination was done by comparison with the drawings of Tolman (1997). Some identification was confirmed by examining male genital structure according to Higgins (1975). Taxonomy follows Balletto & Cassulo (1995).

The chorology of the species was synthetically described according to the generalized distribution patterns adopted by Vigna Taglianti *et al*. (1992). We determined the composition of the butterfly fauna of Italy and Piedmont (the political subdivision of Italy encompassing the study area) drawing from the information provided by Balletto & Cassulo (1995) and from a distributional database of the Italian butterflies (E. Balletto, unpublished data). Distribution patterns of the butterfly fauna of these two larger regions were then compared to that of the study area. As the survey area represents a subsample of Italy and Piedmont, in order to avoid data autocorrelation, only the species found in Italy and Piedmont, but not in the study area, were considered for the comparison with those found in the study area.

Balletto & Kurdna (1985) evaluated all the species of the Italian butterfly fauna and scored their characteristics according to 6 ecological factors (habitat and altitude selection, sunlight, ground-water, thermal preferences and mobility). These scores were slightly modified to arrange them in an ordinal scale (Table I), and substituted with their arithmetic mean when more than one score was given by Balletto & Kurdna (1985). We evaluated the Italian range-size of the species at the level of 10 × 10 km UTM squares, again extracting the information from the distributional database of Italian butterflies (E. Balletto, unpublished data). Finally, we used the scores and the distribution data to evaluate the general ecological features of the butterfly community of the study area and compare them with that of the rest of the Italian butterfly fauna.

TABLE I

A summary of the scores utilized for evaluating six ecological factors characterizing Italian butterflies (modified from Balletto & Kurdna, 1985)

Ecological factor	Score = 1	Score = 2	Score = 3	Score = 4	Score = 5	Score = 6
Habitat selection	Open, unvegetated	Open, herbaceous	Shrubland	Woodland	-	-
Altitude selection	Coasts	Lowlands	Lower montane	Upper montane	Subalpine	High altitudes
Sunlight preference	Sciophilous	Indifferent	Heliophilous	-	-	-
Thermal preferences	Thermophilous	Mesophilous	Psychrophilous	-	-	-
Ground-water preferences	Xerophilous	Mesophilous	Hygrophilous	-	-	-
Mobility	Stationary	Intermediate/ stationary	Intermediate	Intermediate/ migrant	Migrant	-

Habitat selection was evaluated at both species and community level. At the species level, we used χ^2 tests to find out if a species was collected more often than expected in one particular habitat. The expected distribution of records was set proportionally to the number of sampling sessions carried out in each habitat. At the community level, we tested if different habitat types were characterized by different species sets. The matrix of species by sites was ordinated by detrended correspondence analysis (DCA); rare species (< 5 observations) were excluded from this analysis as they can negatively affect the performance of multivariate ordination techniques (ter Braak, 1985). Thus, only 33 species (out of a total of 68 species observed in 1999-2001) and 38 sampling sites (out of the original 41) were ordinated. DCA can find the best representation of two simultaneous data sets (species × sites) with unimodal distribution along gradients (ter Braak, 1985) and thus seems suitable for the analysis of our data, since we found that abundance and diversity peaked in the intermediate stages (recent and old fallows) of vegetation succession. The scores of the 38 sample sites on the first four DCA axes were then compared with one-way ANOVA followed by LSD *post-hoc* tests in order to find if different habitats were occupied by different sets of butterfly species.

RESULTS

General remarks on the butterfly community

Sixty-eight butterfly species were collected in 1999-2001. Another 16 species were reported from the area in the 1960s and the early 1970s (Baldizzone, 1964, 1965, 1966, 1971), but were not observed in 1999-2001 (Table II).

Table II

Species list. Species marked with an asterisk were not collected in 1999-2001, but were recorded in the area in the past (Baldizzone 1964, 1965, 1966, 1971). The chorology of the species follows the names adopted by Vigna Taglianti et al. *(1992).*

Family	Species	Frequency of collection	Chorology
Hesperiidae	*Carcharodus alceae* (Esper, 1780)	2	Centroasiatic-European-Mediterranean
Hesperiidae	*Carcharodus flocciferus* (Zeller, 1847)	1	Centroasiatic-European
Hesperiidae	*Carcharodus lavatherae* (Esper, 1780)	1	European-Mediterranean
Hesperiidae	*Erynnis tages* (Linné, 1758)	9	Siberian-European
Hesperiidae	**Pyrgus armoricanus* (Oberthür, 1910)	-	European-Mediterranean
Hesperiidae	*Thymelicus acteon* (Rottemburg, 1775)	2	European-Mediterranean
Hesperiidae	*Hesperia comma* (Linné, 1758)	2	Holarctic
Hesperiidae	*Ochlodes venatus* (Bremer & Grey, 1853)	7	Asiatic-European
Papilionidae	*Papilio machaon* Linné, 1758	11	Holarctic
Papilionidae	*Iphiclides podalirius* (Linné, 1758)	18	Centroasiatic-European-Mediterranean
Pieridae	*Aporia crataegi* (Linné, 1758)	3	Asiatic-European
Pieridae	*Pieris brassicae* (Linné, 1758)	5	Asiatic-European
Pieridae	*Pieris edusa* (Fabricius, 1777)	5	Asiatic-European
Pieridae	*Pieris mannii* (Mayer, 1851)	2	S-European
Pieridae	*Pieris napi* (Linné, 1758)	6	European
Pieridae	*Pieris rapae* (Linné, 1758)	35	Asiatic-European
Pieridae	*Euchloe crameri* (Butler, 1869)	1	W-European
Pieridae	*Anthocharis cardamines* (Linné, 1758)	1	Asiatic-European
Pieridae	*Colias alfacariensis* Berger, 1948	19	European
Pieridae	*Colias crocea* (Geoffroy, 1785)	27	European
Pieridae	**Gonepteryx cleopatra* (Linné, 1767)	-	Mediterranean
Pieridae	*Gonepteryx rhamni* (Linné, 1758)	1	Centroasiatic-European
Pieridae	*Leptidea sinapis* (Linné, 1758)	15	Asiatic-European
Riodinidae	*Hamearis lucina* (Linné, 1758)	4	European
Lycaenidae	**Lycaena alciphron* (Rottemburg, 1775)	-	Centroasiatic-European
Lycaenidae	*Lycaena phlaeas* (Linné, 1761)	6	Holarctic
Lycaenidae	**Lycaena thersamon* (Esper, 1784)	-	Centroasiatic-European-Mediterranean
Lycaenidae	*Lycaena tityrus* (Poda, 1761)	6	Centroasiatic-European-Mediterranean
Lycaenidae	**Thecla betulae* (Linné, 1758)	-	Asiatic-European
Lycaenidae	**Thecla quercus* (Linné, 1758)	-	European-Mediterranean
Lycaenidae	*Satyrium ilicis* (Esper, 1779)	3	European
Lycaenidae	**Satyrium w-album* (Knoch, 1782)	-	Siberian-European
Lycaenidae	*Callophrys rubi* (Linné, 1758)	2	Asiatic-European
Lycaenidae	*Leptotes pirithous* (Linné, 1767)	2	Afrotropical-mediterranean
Lycaenidae	*Lampides boeticus* (Linné, 1767)	1	Cosmopolitan
Lycaenidae	*Cupido alcetas* (Hoffmannsegg, 1804)	8	Siberian-European
Lycaenidae	*Cupido minimus* (Fuessli, 1775)	1	Holarctic
Lycaenidae	*Cupido osiris* (Meigen, 1829)	1	Centroasiatic-European-Mediterranean
Lycaenidae	*Glaucopsyche alexis* (Poda, 1761)	5	Centroasiatic-European
Lycaenidae	*Maculinea arion* (Linné, 1758)	1	Siberian-European

TABLE II (continued)

Lycaenidae	**Iolana iolas* (Ochsenheimer, 1816)	-	S-European
Lycaenidae	*Plebejus argus* (Linné, 1758)	19	Siberian-European
Lycaenidae	*Lycaeides argyrognomon* (Bergsträsser, 1779)	18	Centro-European
Lycaenidae	*Aricia agestis* (Denis & Schiffermüller, 1775)	23	Asiatic-European
Lycaenidae	**Polyommatus amandus* (Schneider, 1792)	-	Asiatic-European
Lycaenidae	*Polyommatus bellargus* (Rottemburg, 1775)	4	European
Lycaenidae	**Polyommatus coridon* (Poda, 1761)	-	European
Lycaenidae	*Polyommatus daphnis* (Denis & Schiff., 1775)	1	S-European
Lycaenidae	**Polyommatus dorylas* (Denis & Schiff., 1775)	-	European
Lycaenidae	*Polyommatus escheri* (Hübner, 1823)	3	S-European
Lycaenidae	**Polyommatus hispanus* (Herrich-Sch., 1852)	-	W-European
Lycaenidae	*Polyommatus icarus* (Rottemburg, 1775)	68	Asiatic-European
Nymphalidae	*Nymphalis polychloros* (Linné, 1758)	1	Asiatic-European
Nymphalidae	*Inachis io* (Linné, 1758)	1	Asiatic-European
Nymphalidae	*Vanessa atalanta* (Linné, 1758)	7	Cosmopolitan
Nymphalidae	*Vanessa cardui* (Linné, 1758)	2	Cosmopolitan
Nymphalidae	*Aglais urticae* (Linné, 1758)	1	Asiatic-European
Nymphalidae	*Polygonia c-album* (Linné, 1758)	1	Asiatic-European
Nymphalidae	*Argynnis adippe* (Denis & Schiff., 1775)	2	Asiatic-European
Nymphalidae	*Argynnis paphia* (Linné, 1758)	10	Asiatic-European
Nymphalidae	*Issoria lathonia* (Linné, 1758)	1	Centroasiatic-european
Nymphalidae	**Brenthis hecate* (Denis & Schiff., 1775)	-	Centroasiatic-European-Mediterranean
Nymphalidae	*Brenthis daphne* (Denis & Schiff., 1775)	2	Siberian-European
Nymphalidae	*Boloria dia* (Linné, 1767)	4	Centroasiatic-European
Nymphalidae	**Melitaea aurelia* (Nickerl, 1850)	-	Centroasiatic-European-Mediterranean
Nymphalidae	*Melitaea cinxia* (Linné, 1758)	4	Centroasiatic-European
Nymphalidae	*Melitaea didyma* (Esper, 1779)	9	Centroasiatic-European
Nymphalidae	*Melitaea phoebe* (Goeze, 1779)	9	Centroasiatic-European-Mediterranean
Nymphalidae	*Apatura ilia* (Denis & Schiffermüller, 1775)	1	Asiatic-European
Nymphalidae	*Limenitis reducta* Staudinger, 1901	6	S-European
Satyridae	*Satyrus ferula* (Fabricius, 1793)	5	Centroasiatic-European-Mediterranean
Satyridae	**Minois dryas* (Scopoli, 1763)	-	Asiatic-European
Satyridae	*Kanetisa circe* (Fabricius, 1775)	28	Centroasiatic-European
Satyridae	**Arethusana arethusa* (Denis & Schiff.), 1775	-	Centroasiatic-European
Satyridae	*Hipparchia fagi* (Scopoli, 1763)	11	S-European
Satyridae	*Chazara briseis* (Linné, 1764)	1	Asiatic-European
Satyridae	*Melanargia galathea* (Linné, 1758)	28	European
Satyridae	*Maniola jurtina* (Linné, 1758)	38	European
Satyridae	*Pyronia tithonus* (Linné, 1771)	7	European-Mediterranean
Satyridae	*Coenonympha arcania* (Linné, 1761)	4	European
Satyridae	*Coenonympha pamphilus* (Linné, 1758)	26	Centroasiatic-European
Satyridae	*Pararge aegeria* (Linné, 1758)	2	European
Satyridae	*Lasiommata maera* (Linné, 1758)	5	Siberian-European
Satyridae	*Lasiommata megera* (Linné, 1767)	25	European

Compared with the rest of the Italian fauna (191 species), the study area has no species with montane (Alpine or Apennine) chorology, while these represent 21% of the other Italian species (χ^2 test, $P < 0.001$). On the contrary, the study area has significantly more species with Asiatic or Centroasiatic distribution (49% of the species against 15% in the remaining of the Italian fauna, χ^2 test, $P < 0.001$). Species whose range is centred on the Mediterranean account for a slightly higher percentage in the study area than in the rest of Italian fauna (19% against 16%), but this difference is not significant (χ^2 test, $P = 0.63$).

Compared with the 133 species that are found in Piedmont, but not in the study area, the study area has significantly less species with Siberian-European distribution (8% against 17%, χ^2 test, $P = 0.02$). Mediterranean species are more numerous in the study area than in the rest of Piedmont (19% against 13%), but this difference is not significant (χ^2 test, $P = 0.29$).

Table III shows that the butterflies of the study area differ significantly from those of the rest of Italy in their habitat and altitude choice, as well as in temperature and sunlight preferences. Moreover, they also have significantly higher mobility scores and are more widely distributed in Italy. This suggests that the butterflies of the study area are on the whole more thermophilous and prefer lower altitudes and more densely vegetated, shady habitats. Moreover, wide-ranging, highly mobile species, are commoner in the study area than in the rest of the Italian fauna. Similar results (not shown for brevity) were found when the study area was compared to that of the rest of Piedmont.

TABLE III

Average score on six ecological factors and extent of distribution in Italy (as evaluated by the number of 10 km UTM squares occupied by the species) in the butterflies of the study area (84 species) and the remaining part of the Italian fauna (191 species). Differences were looked for with Mann-Whitney test

	Mean value (study area)	Mean value (rest of Italy)	P
Habitat selection	2.80	2.54	0.02
Altitude selection	2.63	3.55	> 0.001
Sunlight preference	1.87	2.17	0.04
Thermal preferences	1.57	1.76	0.04
Ground-water preferences	1.71	1.74	1.00
Mobility	2.25	1.68	> 0.001
Distribution	298	78	> 0.001

HABITAT SELECTION

Figure 1 shows the variation across habitats in the mean number of species collected in a single sampling session. Species richness peaked in old and recent fallow, and was lowest in strongly human-affected habitats (alfalfa and crops). Woods were intermediate between the other habitats. The differences observed across habitats were statistically significant (Kruskal-Wallis test, $P < 0.01$). However, the species assemblages found in the five habitats did not differ either in the extent of the Italian range-size or in any of the six ecological factors (Kruskal-Wallis test, $P > 0.20$ in all comparisons). There were significant positive correlations between the extent of the Italian range of a species and both the frequency of collection and the number of habitats occupied in the study area (Fig. 2 & 3).

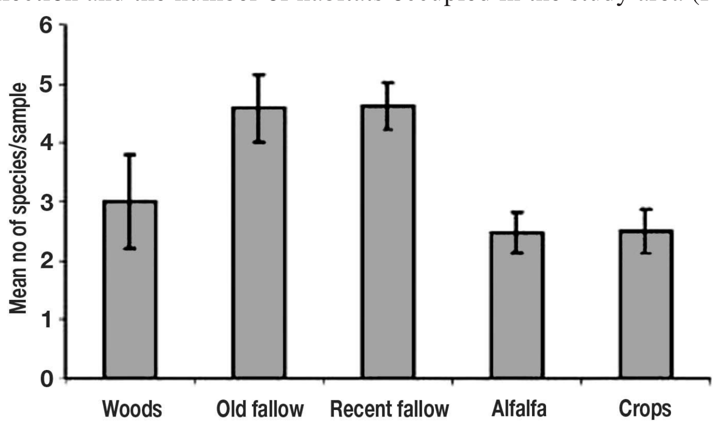

Figure 1. — Mean number of species/sample collected in the five habitats. Bars represent the mean number of species per sample session ± one standard error.

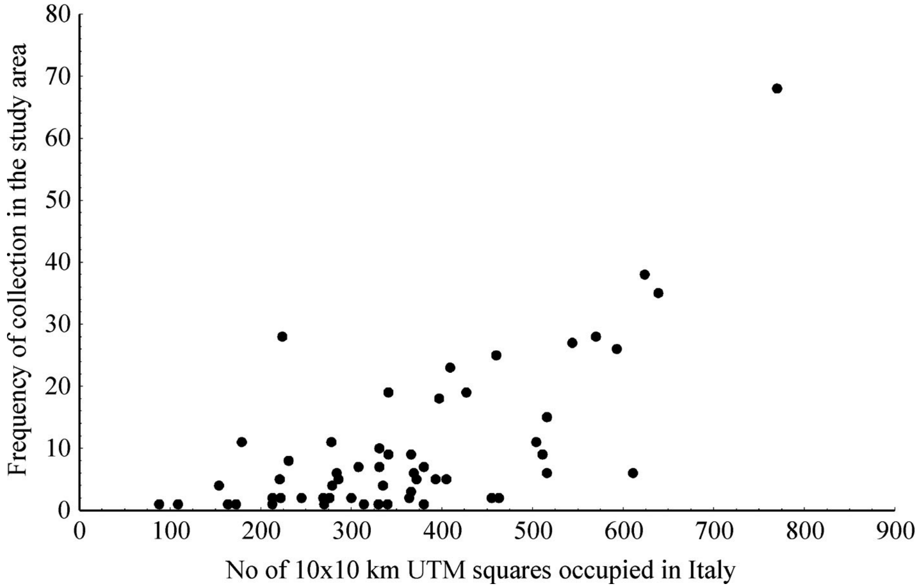

Figure 2. — The relationship between the range of a species in Italy and the number of times that species was collected in the study area. The two variables are significantly correlated (Spearman's rank correlation test, R = 0.59, P < 0.001).

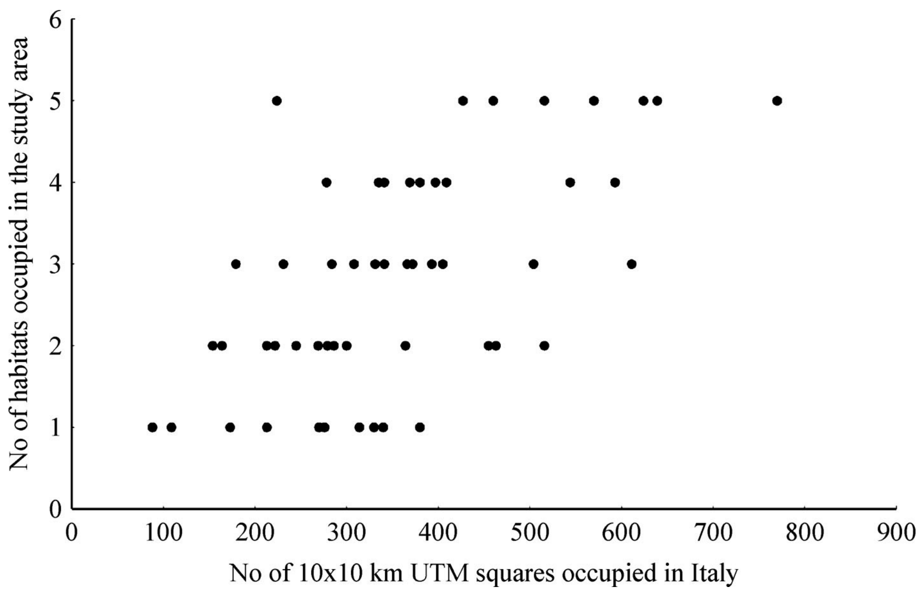

Figure 3. — The relationship between the range of a species in Italy and the number of habitats where that species was collected in the study area. The two variables are significantly correlated (Spearman's rank correlation test, R = 0.53, P < 0.001).

Fourteen species were observed in sufficient numbers to statistically check their distribution across habitats. Altogether, most species were slightly commoner than expected in old and recent fallow, and less frequent in woods and cultivation. However, the selection for different habitat types was not very marked, as only three species showed statistically significant preferences for one or more habitat (Table IV).

TABLE IV

Habitat selection at the species level; species collected more or less often than expected in an habitat are marked with + or – signs respectively. Differences were evaluated with χ^2 tests with 2 degrees of freedom (sample sizes in Table II). To attain sufficient sample sizes to perform the test, old and recent fallow as well as alfalfa meadows and crops were lumped together. Species showing significant habitat selection at the 0.05 level are in bold

Species	Woods	Fallow	Alfalfa, crops	P
Aricia agestis	+	+	-	0.13
Coenonympha pamphilus	**-**	**+**	**-**	**0.01**
Colias alfacariensis	-	+	-	0.13
Colias crocea	-	+	+	0.26
Iphiclides podalirius	-	+	-	0.11
Kanetisa circe	**-**	**+**	**-**	**0.04**
Lasiommata megera	-	+	-	0.39
Leptidea sinapis	+	+	-	0.19
Lycaeides argyrognomon	**-**	**+**	**-**	**0.001**
Maniola jurtina	-	+	-	0.06
Melanargia galathea	+	+	-	0.57
Pieris rapae	-	-	+	0.21
Plebejus argus	-	+	-	0.18
Polyommatus icarus	-	+	-	0.17

Altogether, the first four DCA axes accounted for 30.0% of the variability of the original data set (Axis: 11.6%; Axis 2: 7.9%; Axis 3: 6.1%; Axis 4: 4.4%). The low percentage of variability accounted for by DCA suggests that there was much superposition between the butterfly species sets inhabiting the different habitats. ANOVA (Table V) confirmed this hypothesis, as we only found significant differences on Axis 1, where crops appeared to be separated from all other habitats except woods. This suggests that the five habitat types were not characterized by markedly different species assemblages.

TABLE V

Results of one-way ANOVAs applied to the DCA scores of the five habitat types. When ANOVA resulted in significant differences (P < 0.05), these were further explored with LSD post-hoc tests: habitats marked with the same letters (a, b) are not significantly different from each other

	ANOVA		LSD tests				
DCA axes	$F_{4,33}$	P	Woods	Old fallow	Recent fallow	Alfalfa	Crops
1	4,28	0,0067	a, b	a	a	a	b
2	0,27	0,90					
3	1,96	0,12					
4	0,33	0,85					

CONSERVATION REMARKS

Six of the species observed (*Thymelicus acteon*, *Hamearis lucina*, *Glaucopsyche alexis*, *Maculinea arion*, *Lycaeides argyrognomon*, *Melitaea aurelia*) are threatened or near-threatened in Europe according to Van Swaay & Warren (1999).

The butterfly community of the study area decreased in richness and abundance in the last three decades. Bibliographic information (Baldizzone, 1964, 1965, 1966, 1971) suggests that at least three species were commoner in the 1960s and the early 1970s than they were in 1999-2001. Another 16 species were collected only in 1960s and 1970s but not refound during the present study. The larval host plants of all but two of these butterflies were still present in the study area in 1999-2001 (Table VI).

TABLE VI

A comparison of the abundance of some species in the study area between 1960s and 1999-2001. Larval host plant species are taken from Tolman (1997) and Verity (1940-1953); only plant species present in the study area are listed. Plant species marked by "!" were observed at least in one of the 41 sample sites, those followed by "?" were not observed in the sample sites in 1999-2001, although their presence in the area was reported in the past by Carrega & Silla (1995)

Species	Abundance (1960-70)	Abundance (1999-2001)	Larval host plant
Arethusana arethusa	common	not found	*Poaceae* spp.!
Brenthis hecate	rare	not found	*Filipendula ulmaria*?
Gonepteryx cleopatra	rare	not found	*Rhamnus* spp.!
Hamearis lucina	very common	rare	*Primula vulgaris*!
Iolana iolas	rare	not found	*Colutea arborescens*?
Lycaena alciphron	rare	not found	*Rumex acetosa*!
Lycaena thersamon	rare	not found	*Polygonum aviculare*!
Melitaea aurelia	fairly common	not found	*Plantago lanceolata*!
Minois dryas	very common	not found	*Poaceae* spp.!
Polyommatus amandus	common	not found	*Vicia cracca*! *Vicia tetrasperma*!
Polyommatus bellargus	very common	rare	*Hippocrepis comosa*!
Polyommatus coridon	fairly common	not found	*Hippocrepis comosa*!
Polyommatus dorylas	rare	not found	*Anthyllis vulneraria*!
Polyommatus escheri	very common	rare	*Astragalus* spp!
Polyommatus hispanus	very common	not found	*Hippocrepis comosa*!
Pyrgus armoricanus	rare	not found	*Potentilla reptans*! *Fragaria vesca*!
Satyrium w-album	rare	not found	*Ulmus* spp!
Thecla betulae	fairly common	not found	*Prunus spinosa*!
Thecla quercus	common	not found	*Quercus* spp!

The species listed in Table VI do not differ significantly from the rest of the local community in either their habitat, altitude, thermal, ground-water and sunlight preference scores (Mann-Whitney test, all $P > 0.10$). However, there were significant differences both in mobility and Italian range-size (Mann-Whitney test, $P = 0.04$ and $P < 0.001$ respectively): species that became uncommon or disappeared from the study area are less mobile and less widely distributed in Italy than those still persisting in 1999-2001.

DISCUSSION

As there are few published long term studies on the butterfly fauna of single, spatially circumscribed sites in Italy, it is very difficult to compare our results with other data. However, the 84 species of our study area seem to be a fairly high number compared with other places in Northern Italy (e.g. 66 species in Val Sessera (Raviglione *et al.*, 1994); 59 in the Baraggia Nature Reserve (Raviglione & Boggio, 2001); 65 in the Vauda Nature Reserve (L. Borghesio, unpublished data); 52 in the Ticino Nature Reserve (Balestrazzi, 1999)). Other authors found a higher number of species, but always in areas with a much larger surface and altitude range (125 species at Mt Avic Nature Reserve (Brockmann *et al.*, 1993); 124 at Monte Baldo (Wolfsberger, 1971)). On the whole, the scarcity of cold climate specialists (species with Siberian-European distribution) and the abundance of species typical of dry, steppic habitats (Asiatic or Centroasiatic distribution, La Greca, 1963) suggest that our study area is inhabited by a thermophilous fauna, with transitional characteristics between central-European and Mediterranean regions. Moreover, the fauna of Casasco is dominated by lowland species (as suggested by the absence of species with Alpine or Apennine distribution, and by the low mean altitude score), often selecting shaded habitats, such as woodland edges or shrubland.

The butterfly assemblage of Casasco has a higher proportion of wide ranging, highly mobile species compared with the rest of the Italian fauna. This might be a consequence of the selective extinction of some species, as we discuss later in greater detail. However, a similar pattern was found in Histeridae beetles in the same area (Borghesio *et al.*, 2002) and in the birds in an English wood by Gaston & Blackburn (2000). These authors suggested that in large regions, such as Italy, many species only occur in a small proportion of all possible sites. By chance alone, a local assemblage should contain a disproportionately higher fraction of widely ranging species, while the proportion of species with small ranges should progressively increase with area. More studies are needed on this subject to confirm the generality and the explanation of this pattern across a range of other taxa.

Species richness peaked in old and recent fallow habitats, and was lower both in woods and in highly man-modified habitats, such as cropland and alfalfa meadows. Changes in butterfly biodiversity along different stages of the vegetation succession have already been reported in several studies, although rarely have these taken into account the full range of stages from cultivation up to woodland regeneration. As a rule, low butterfly diversity has been found in cultivated, strongly man-modified areas (Erhardt & Thomas, 1991; Kitahara & Sei, 2001), and also in habitats with dense tree cover (Balletto *et al.*, 1982; Balletto & Kurdna, 1985; Warren, 1992). Our results confirm this pattern. However, we found very similar species richness in both old and recent fallow. This has not been the case in many other studies, which usually found higher species diversity in open grasslands (Erhardt, 1985; Erhardt & Thomas, 1991) than in shrub-dominated ("old fallow") habitats. Old fallow land is usually perceived as having a lower conservation value than more open habitats and has drastically decreased in many parts of Europe (Balmer & Erhardt, 2000). However, most studies on the effects of vegetation succession on insects have been done in central or northern Europe and their results do not seem to apply to the warmer southern part of the continent. Here, low temperatures are probably less limiting to insects' distribution, thus allowing many species to live in more densely vegetated and shadowy habitats. From a more general point of view, our results support the intermediate disturbance hypothesis (Connell, 1978), which states that a modest level of disturbance (i.e. human activity) confined to small patches of the total area can allow early successional species to persist, without eliminating more specialized species, resulting in higher diversity. Our findings have important management implications, as fallow is an intermediate stage in the vegetation development, and cannot be considered as a temporally stable habitat. This suggests that local biodiversity conservation depends on a continuing low-intensity level of human disturbance, which will avoid large areas being overgrown by dense woodland, at the same time avoiding transforming the entire landscape into low diversity monocultures.

Although there were significant differences in species richness across habitats, and some species were collected more frequently in fallow, we failed to find any significant difference either in any of the 6 ecological scores, or in the Italian range-size between the species assemblages inhabiting different habitats. Moreover, DCA failed to highlight any clear discontinuity across habitats, apart from the trivial separation between crops and the other habitats, due to the low species diversity of cultivated areas. Thus, different habitats were not occupied by markedly different butterfly communities. On the contrary, many species frequented more than one habitat type. Our results do not support the widespread opinion that butterflies are sensitive indicators of habitat change and that different habitat types are usually occupied by different species sets, which are also characterized by differences in their ecological characteristics, such as range size, mobility and voltinism (Balmer & Erhardt, 2000; Kocher & Williams, 2000; Kitahara & Sei, 2001; Swengel & Swengel, 2001). We suggest that our anomalous result is due to the landscape characteristics of our study site, where different habitats are fragmented into many small-sized patches. Butterflies are very mobile and can easily fly over several hundred meters, a much larger distance than the average size of the habitat patches in our study area. Small-range displacements could therefore have taken many individuals temporarily out of their preferred habitats and cancelled faunal differences between habitat types. Habitat patch size has already been found to influence the composition of the butterfly communities inhabiting otherwise similar habitats (Weibull *et al.*, 2000; Schneider & Fry, 2001), and this factor should be considered in studies aiming at describing the habitat selection of different butterfly species. Thus, in our study area, between-habitat differences where mainly due to differences in biodiversity levels (i.e., the number of species recorded), rather than to differences in community composition (i.e., the identity of the species recorded).

From the conservation point of view, we found that our study area held several endangered species (Van Swaay & Warren, 1999). This confirms the importance of Italy for butterfly conservation in Europe. However, our data also suggest that numerous species locally disappeared or strongly decreased during the last 30 years. Species that suffered most severely had lower mobility scores, as was found in other studies (Blair & Launer, 1997; Kitahara & Sei, 2001), and also had smaller Italian ranges. As we found that the Italian range-size was positively correlated with both capture frequency and the number of habitats where a species was collected, it seems that species that decreased or disappeared from our study area were mostly habitat-specialists with low population density. The disappearance of habitat specialists, in turn, could be one further reason for the lack of differences between the butterfly assemblages inhabiting different habitats. We believe that direct habitat destruction cannot be considered the primary cause for the disappearance of butterflies from our study area, since old and recent fallow, the richest butterfly habitats, are still abundant, and even increased in the last decades due to the abandonment of some cultivated areas. Moreover, the disappearance of these butterflies was probably not related to that of their host plants, since most (if not all) of these plants are still present in the area. Instead, the disappearance of several species of butterfly is probably related to changes in agricultural techniques, such as increased mechanization (which may affect biodiversity in crops and alfalfa habitats) and the increased use of chemicals (which may have wider, ecosystemic impacts).

In conclusion, our study is one of the first that has attempted to characterize the structure and ecological features of a local butterfly fauna in Italy. We were able to confirm that many patterns observed in northern Europe also held in our study area. However, our study area also has some features that distinguish its butterfly community from those of central and northern Europe (such as high species richness in old fallow and the scarce differences between species assemblages inhabiting different habitats). Further research is needed to confirm whether these features are also found elsewhere in Italy, but these factors should be taken into account in future studies.

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