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Butterfly diversity and rarity within selected habitats of western Andalusia (Spain) (Lepidoptera : Papilionoidea and Hesperioidea)

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Summary

A study was made of the butterfly fauna associated with six habitat types in eight localities of western Andalusia (Spain). Four assessment methods identified kermes oak wood and evergreen oak forest as the habitats supporting the greatest diversity and rarity of butterflies and skippers both at local and regional scale. Results suggest an important influence of woody plants, by means of microclimate effects, on butterfly communities. A comparison of the assessment methods, reveals that the Shannon-Weaver index (H′) is a poor discriminant of diversity in this study, and that richness and rarity are sufficient and better measures for site conservation assessment.

Résumé

Les auteurs ont étudié la faune des lépidoptères diurnes sur six types de biotopes dans huit localités d'Andalousie occidentale (Espagne). Quatre méthodes d'évaluation ont permis d'identifier les bois de chênes kermès et la forêt de chênes à feuilles persistantes comme les biotopes abritant la plus grande diversité de Diurnes et d'Hespérides, ainsi que les plus rares, tant sur le plan local que régional. Ces résultats font penser que les lieux boisés exercent une forte influence sur les communautés de Diurnes du fait de leurs effets sur le microclimat. En comparant les méthodes d'évaluation, on découvre que l'Index Shannon-Weaver (H′) a peu de valeur pour distinguer la biodiversité dans la présente étude, et que la richesse de la faune et la rareté de ses espèces sont suffisantes et plus efficaces pour apprécier l'importance de la conservation des sites.

Introduction

Habitat loss is considered to be by far the most significant threat to insect conservation, with agricultural management as the major contributor. As agriculture continues to expand, natural lands become more and more fragmented, increasing the need to integrate regional land use and conservation strategies (Van Hook, 1994).

Insects, and especially butterflies, are receiving much attention because of their potential as indicator species of landscape structure and ecological changes (Ferrín & Martín-Cano, 1994 ; Kitahara & Fujii, 1994 ; Daily & Ehrlich, 1995). Surveys and monitoring have been successfully used for habitat assessment, having direct management implications for land acquisition and reserve planning (Cheverton & Thomas, 1985 ; Munguira & Thomas, 1992 ; Wood & Samways, 1992 ; Pollard & Yates, 1993).

This paper deals with the diversity and rarity of the butterfly fauna in several habitats within the Mediterranean ecosystem of western Andalusia, an area which has been little investigated entomologically.

Materials and methods

Study area, sites and sampling

The study was carried out during five months, between 5 March and 21 July, 1994, with the exception of the second half of April and first half of May, due to bad weather. Eight sites were surveyed in the Penibetic mountains, approximately 100 km south-east of Seville (western Andalusia, Spain), in a mosaic landscape of agriculture, settlements and seminatural areas (Fig. 1). This part of our province has a typically Mediterranean climate that changes from the dry to the wet type with increasing altitude, here from 100 to 1100 m. The substrate is mainly calcareous (see also Molina & Palma, 1992 ; 1994).

According to Rivas-Martínez (1987), potential vegetation belongs to the evergreen oak forest (*Quercus rotundifolia* Lam.). There is no natural forest today, and the actual vegetation comprises a mosaic of scrub types, successional stages, and climax remnants together with crops, mainly olive groves, cereal and sunflower fields.

Butterflies and skippers were sampled by conducting fixed transect walks, mostly 200 to 400 m in length, recording the number of individuals of each species seen within 2.5 m either side of and 5 m in front of the recorder (Pollard, 1977 ; Descimon & Napolitano, 1991 ; Pollard and Yates, 1993). Population density for each transect is calculated as the number of individuals seen within the 5 m square per hundred meters of transect walk (an area of 500 m^2) (Cheverton & Thomas, 1985), and the values obtained used in calculations of diversity. A total number of 48 samples evenly distributed among all sites were studied.

Fig. 1. Location of the Penibetic mountains within the province of Seville. UTM zone 30S. Numbers indicate the sampling sites used in this study. Black dots indicate sites visited since 1989 and used for calculations of species distribution within the study area (see also Molina & Palma, 1994 ; 1995).

Local transects were divided into sections which coincide with changes in the nature of the vegetation (Pollard, 1977). Six distinct vegetation types, as an approximation to habitats, were subjectively distinguished, mainly according to the structure of dominant plant species (see Table 1) :

(I) Evergreen oak forest is dominated by *Quercus rotundifolia* (Lam.) growing in association with *Olea europaea* L. and *Ceratonia siliqua* L. ; plants such as *Pistacea lentiscus* L., *Daphne gnidium* L. or *Smilax aspera* L. are also characteristic. They appear mainly on limestone substrate. Clear-cut undergrowth is usual as a result of forestry and grazing ('dehesa' landscape). Intensively managed evergreen oak forests usually have the shrub layer dominated by *Cistus* spp.

(II) Kermes oak wood occurs naturally in the Penibetic mountains on steeper, stony slopes, impoverished soils and sunny sites. *Quercus coccifera* L. is dominant together with *Asparagus albus* L., *Rhamnus oleoides* L., and *Crataegus monogyna* Jacq. ; *Aristolochia baetica* L. is also characteristic.

Open scrub occurs mainly as a result of grazing or as a consequence of abandoned cropping. Sites have characteristically dry and bare ground from late spring to autumn ; there are some shrub species, climax remnants or early successional ones.

(III) Thyme grassland occurs on sunny and calcareous sites as the penultimate or last retrograde successional stage in the natural vegetation series. Species of *Fabaceae, Asteraceae* and *Lamiaceae*, especially *Thymus* spp. are dominant. There are few grasses and herbs (Rivas-Goday & Rivas-Martínez, 1969).

(IV) Broom scrub is dominated by *Retama sphaerocarpa* (L.) Boiss. in association with grasses and some herbs of small size which form a short turf.

(V) Grasslands are structurally simplified habitats, the result of the complete elimination of woody plants, usually by fire or extensive grazing. Grasses and thistles are characteristic in the late spring and summer, giving a similar physiognomy to that of broom scrub.

(VI) We have also considered road verges as a distinct habitat. Herbs and weeds here are most diverse, resulting from the introduction of many annual and biannual nitrophilous species. Examples of the climactic plant species are usually also present.

Data analysis

Four measures for the quantity and/or quality of Rhopalocera species were used to compare habitats : (a) species richness, i.e. the total number of species present, irrespective of their rarity ; (b) the Shannon-Weaver diversity index (H′) (Southwood, 1978) ; (c) the proportion

Table 1

Some characteristic habitats in the study area.

Habitat type	*No. of sites*	*Formation type (Southwood, 1978)*	*Local characteristics*	*Approximate plant sociological type*
Evergreen oak forest	4	Woodland Trees dominant	Hunting and forestry. Grazing, mainly cows. Every three years crops of cereal or sunflower	*Paeonio-Quercetum rotundifoliae* Riv.Mtnez., 1964 transitional to *Smilaci-Quercetum rotundifoliae* Barber, Quezel & Riv.Mtnez., 1981
Kermes oak wood	3	Scrub dominant plants not exceeding shrub layer height, usually not over 7.6 m	Hunting. Occasional grazing. No more than 3-4 m in height	*Asparago-Rhamnetum oleoidis* Riv.God., 1959 *em* Riv.Mtnez., 1975
Thyme grassland	2	Field dominant plants coincide with field layer, usually not more than 2 m high	None. Near olive groves. Vegetation seldom reaches more than 1 m in height. Bare ground	*Teucrio-Corydothimetum baeticum* Riv.God. & Riv.Mtnez., 1969
Broom scrub	3	Scrub	Grazing for 5-8 month/year, few cattle, mainly goats	*Saturejo-Corydothimion* Riv.God. & Riv.Mtnez., 1968. Similar to *Genisteto-Retametum*
Grassland	3	Open-ground dominant plants not usually more than 15 cm in height	Grazing with few cattle, mainly goats and sheeps	*Thero-Brachypodion* (Br.-Bl., 1925) Riv.Mtnez., 1977 *Astragalo-Poeion bulbosae* Riv.God. & Ladero, 1970
Road verge	4	Field/open-ground	None. Occasional grazing. Nitrophilous plant communities.	*Brometalia rubenti-tectori* Riv.Mtnez. & Izco, 1977. *Scolymo-Onopordetalia nervosi* Br.-Bl. & O.Bolós. 1957 *corr* Riv.Mtnez., 1975

of species that are locally rare (LRS) ; and (d) the species rarity factor (SRF), an index ignoring common species and weighted towards those rarest in Seville province as a whole.

The latter two measures were calculated as follows : (c) species of restricted distribution in the study area, locally rare species (LRS), were defined as those recorded to date in fewer than 50 % of the total number of UTM squares (10 km^2) prospected (Molina & Palma, 1994, and some unpublished data). The proportion of locally rare species was expressed as the ratio of the number of these species to the total number of species on a site.

The relative rarity of the species selected in (c) was quantified by assigning each a score reflecting its distribution for UTM squares in Seville province following the octave method proposed by Dony & Denholm, 1985) :

No. of UTM (100 km^2) squares with species present	1	2-3	4-7	8-15	16-31	>31
Score	6	5	4	3	2	1

Some unpublished data on geographical ranges taken from Molina & Palma (1995) were used as a source of distribution data. Summation of the scores for each locally rare species (c) gave (d) the SRF, the fourth measure used to assess habitats (see also Dony & Denholm, 1985).

Correlation among the assessment measures was carried out using the Spearman rank correlation coefficient (r_S) (Southwood, 1978).

Results

A grand total of 1403 individuals of 47 species were registered during this study. Details of recorded species are included in Molina & Palma (1994 ; 1995 ; Table 2). The total number of species in the habitats ranged from 20 to 33, with a mean of 26 species. Tables 3 and 4 summarise the results obtained with the four assessment methods applied at each locality and habitat type.

The greatest number of species and diversity were found in evergreen oak forest and in kermes oak wood. Minimum species richness and diversity were obtained both locally and as mean values in broom scrub, grassland and along road verges.

Table 2

List of species under study. Names follow mainly those contained in Higgins (1975), and Gómez-Bustillo & Arroyo-Varela (1981, 1984) with some modifications in the arrangement of families (Ackery, 1984).

Hesperiidae
Spialia sertorius (Hoffmansegg, 1804)
Syrichtus proto (Ochsenheimer, 1808)
Carcharodus alceae (Esper, 1780)
Carcharodus boeticus (Rambur, 1839)
Thymelicus acteon (Rottemburg, 1775)
Thymelicus flavus (Brünnich, 1763)
Lycaenidae
Lycaena phlaeas (Linnaeus, 1761)
Quercusia quercus (Linnaeus, 1758)
Satyrium esculi (Hübner, 1804)
Satyrium spini (Denis & Schiffermüller, 1775)
Tomares ballus (Fabricius, 1787)
Cupido lorquinii (Herrich-Schäffer, 1847)
Pseudophilotes abencerragus (Pierret, 1837)
Glaucopsyche melanops (Boisduval, 1828)
Aricia cramera (Eschscholtz, 1821)
Lysandra albicans (Herrich-Schäffer, 1851)
Lysandra bellargus (Rottemburg, 1775)
Polyommatus icarus (Rottemburg, 1775)
Nymphalidae
Vanessa atalanta (Fabricius, 1807)
Vanessa cardui (Linnaeus, 1758)
Melitaea aetherie (Hübner, 1826)
Euphydryas aurinia (Rottemburg, 1775)
Hipparchia statilinus (Hufnagel, 1766)
Hipparchia fidia (Linnaeus, 1767)
Melanargia occitanica (Esper, 1793)
Melanargia ines (Hoffmansegg, 1804)
Maniola jurtina (Linnaeus, 1758)
Hyponephele lupinus (Costa, 1836)
Pyronia bathseba (Fabricius, 1793)
Pyronia cecilia (Vallantin, 1894)
Coenonympha pamphilus (Linnaeus, 1758)
Coenonympha dorus (Esper, 1782)
Pararge aegeria (Linnaeus, 1758)
Lasiommata megera (Linnaeus, 1767)
Pieridae
Aporia crataegi (Linnaeus, 1758)
Pieris brassicae (Linnaeus, 1758)
Pieris rapae (Linnaeus, 1758)
Pontia daplidice (Linnaeus, 1758)
Euchloe ausonia (Hübner, 1804)
Euchloe tagis (Hübner, 1804)
Euchloe belemia (Esper, 1799)
Anthocharis belia (Linnaeus, 1767)
Colias crocea (Geoffroy in Fourcroy, 1785)
Gonepteryx cleopatra (Linnaeus, 1767)
Papilionidae
Papilio machaon Linnaeus, 1758
Iphiclides podalirius (Linnaeus, 1758)
Zerynthia rumina (Linnaeus, 1758)

Table 3

Species richness (S), Shannon-Weaver diversity (H'), locally rare species (LRS) and (proportion), and species rarity factor (SRF) at habitats and sampling sites. Spearman rank correlation values (r_s). Critical value $n = 19$, $p < 0.05$, 2 tails = 0.454) : $r_{s(S/H')} = 0.796$; $r_{s(S/LRS)} = 0.581$; $r_{s(S/SRF)} = 0.567$; $r_{s(H'/LRS)} = 0.476$; $r_{s(H'/SRF)} = 0.435$; $r_{s(LRS/SRF)} = 0.987$).

Site number and name		*S*	*H'*	*LRS*	*SRF*	*Habitat type*
1	Sierra Vaquera	17	2.15	5 (0.24)	20	Evergreen oak forest.
		11	1.61	3 (0.27)	14	Broom scrub. *Pinus* spp. afforestation (2-3 years old).
2	Mte. Becerrero	25	2.93	4 (0.24)	17	Kermes oak wood. Some *Quercus* spp. trees.
		11	2.13	0 (0.00)	0	Grassland. Abandoned crop.
		9	1.89	1 (0.11)	4	Road verge.
3	Pte. Lopera	16	1.96	0 (0.00)	0	Grassland. Grazing.
		11	2.21	2 (0.18)	6	Road verge.
4	Mte. Aguila	17	2.49	4 (0.29)	14	Kermes oak wood.
		17	2.18	5 (0.29)	19	Thyme grassland.
		15	2.48	1 (0.07)	5	Road verge.
5	Mte. Terril	18	2.59	2 (0.28)	7	Evergreen oak forest.
		15	2.29	6 (0.20)	22	Kermes oak wood.
		10	2.14	0 (0.00)	0	Grassland. Grazing.
6	La Gomera	16	2.11	3 (0.13)	12	Managed Evergreen oak forest. *Cistus* spp. undergrowth.
		7	1.72	1 (0.14)	4	Broom scrub. A lot of bare ground.
7	Fte. La Roya	23	2.65	3 (0.13)	8	Evergreen oak forest. Clear-cut undergrowth.
		18	2.31	4 (0.22)	16	Thyme grassland.
8	Barrancos Blancos	21	2.63	3 (0.14)	9	Broom scrub. Some climactic plant species remnants.
		11	2.12	0 (0.00)	0	Road verge.

Fifteen regional rare species have been found in the sampled habitats, 20% of those occurring in Seville province. Six are very rare, occupying 3 or less UTM 100 km² squares, and 21 are locally rare within the study area (Molina & Palma, 1995).

The mean number of LRS was 6, among 1/3 and 1/4 of the species in each habitat (Tables 3,4). Kermes oak wood has the greatest mean of LRS. In the evergreen oak forest the proportion of LRS has a mean value of 1/5. The species rarity factor (SRF) was also greater

Table 4

Mean values and (coefficient of variation) of abundance (*Ab*), species richness (*S*), Shannon-Weaver diversity index (*H'*), locally rare species (*LRS*), and species rarity factor (*SRF*) in the six habitat types. *n* = sites visited.

Habitat	*n*	*Ab*	*S*	*H'*	*LRS*	*SRF*
Evergreen oak forest	4	224.5 (27.59)	18.50 (14.54)	2.38 (10.35)	3.25 (38.72)	12.75 (50.29)
Kermes oak wood	3	169.3 (39.25)	19.00 (22.74)	2.57 (12.74)	4.67 (24.74)	17.67 (22.88)
Thyme grassland	2	216.5 (17.78)	17.50 (2.85)	2.25 (4.09)	4.50 (15.71)	17.50 (12.12)
Broom scrub	3	178.3 (52.00)	13.00 (45.23)	1.99 (28.18)	2.33 (49.49)	9.00 (55.55)
Grassland	3	185.3 (37.68)	12.30 (21.30)	2.08 (4.87)	0.00 (0.00)	0.00 (0.00)
Road verge	4	183.5 (32.48)	11.50 (18.86)	2.18 (11.21)	1.00 (81.65)	3.75 (70.13)

both locally and as a mean value in kermes oak wood and in evergreen oak forest (Tables 3, 4).

During this study none of the rare species occurred in all habitats (Table 5), though they tended to be biased to evergreen oak forest and woods. Nymphalidae and Lycaenidae are the families with the greatest number of locally rare species. The latter includes the more habitat-restricted species and has the greater mean rarity score (see Table 5).

Some successional stages contain very rare species, which increase the values of both LRS and SRF (Table 4). This result is in agreement with that obtained by Thomas & Mallorie (1985) for the Moroccan butterflies.

Discussion

The richness and diversity pattern obtained within the study area is similar to that described from other agricultural areas in the Iberian Peninsula, although there are some changes in species composition and smaller H′ diversity values (Sanchez & Viejo, 1986 ; Viejo, 1986 ; Baz, 1986). A possible explanation is the expansion of cereal crops and olive groves as monocultures in the region. On a regional scale, a mosaic of various biotope patches provides a high degree of habitat heterogeneity that may enhance species richness and rare species survival

Table 5

Distribution of locally rare species among habitat types.
I = Evergreen oak forest, *II* = Kermes oak wood, *III* = Thyme grassland,
IV = Broom scrub, *V* = grassland, and *VI* = road verge.

	Presence (+) in the habitats						*Occurrence in Seville province*	
Species	*I*	*II*	*III*	*IV*	*V*	*VI*	*No. of UTM squares*	*Rarity score*
Carcharodus. alceae					P	+	8	3
Carcharodus boeticus	+	+	+			+	5	4
Quercusia quercus	+						5	4
Satyrium spini	+	+	+				5	4
Tomares ballus	+	P					5	4
Cupido lorquinii	+	+					2	5
Glaucopsyche melanops				+			18	2
Lysandra albicans			+				2	5
Lysandra bellargus			+				8	3
Vanessa atalanta	+	+	+	+			16	2
Melitaea aetherie				+			2	5
Euphydryas aurinia	+			+*			6	4
Hipparchia statilinus	+	+	+				10	3
Hipparchia fidia		+	+			+	2	5
Melanargia occitanica		+			P		3	5
Hyponephele lupinus	+						8	3
Coenonympha dorus	+	+	+	+			7	4
Pararge aegeria						+	10	3
Aporia crataegi		P		+*			3	5
Anthocharis belia	+	P					7	4
Iphiclides podalirius		+					18	2

* one sole individual, near a well-conserved evergreen oak forest.
P = present, but not recorded during the sampling period included in this study, and not considered in calculations.

(Duelli *et al.*, 1990), whereas homogeneity within our study area should produce quite the reverse.

Local butterfly richness and diversity have been correlated with plant species richness and habitat complexity by several authors (Erhardt, 1985a,b ; Thomas & Mallorie, 1985 ; Baz, op. cit. ; Spitzer *et al.*, 1987 ; Leps & Spitzer, 1990). In this study evergreen oak forest and kermes oak wood have the greatest values for both richness and diversity ; this is perhaps to be expected, since these habitats have suffered least human disturbance, thereby conserving many of the plant species of the potential climax vegetation of the region (Rivas-Martínez, 1987).

Within habitats, diversity of woody plants has been considered as an indicator of the diversity of food resources for insects (Lawton, 1983) ;

but also trees, shrubs and climbers are most important components of habitat complexity and heterogeneity, providing varying types of microhabitats which would be differentially suitable for species in space and time (Thomas, 1984 ; Spitzer *et al.*, 1987 ; Munguira & Thomas, 1992 ; Wood & Samways, 1992).

In our Mediterranean ecosystem, climate makes many sites unsuitable for butterflies because of the annual late spring and summer drought from mid-June until autumnal rains. During this time, open habitats, such as low scrub, grassland, and bare ground are the most unsuitable, whereas shaded habitats act as refuges for butterfly species (Viejo *et al.*, 1992). Woody plants provide shade, protection from desiccation by wind, lower midday temperatures, and other microhabitat modifications, including floristic composition (Montoya-Oliver, 1982 ; Montoya-Oliver & Mesón-García, 1982).

Many open habitats have been mainly caused, and are used by cattle. Grazing by sheep and goats should reduce diversity and floristic composition of plant communities, especially shrubs (Van Hook, 1994), particularly affecting the rarest butterflies in the study area.

Field data support the important influence of woody plants on communities (compare Tables 1, 2 and 3), but as no objective measurements were made of the vegetation diversity or structure in the habitats, this needs further research. However, this should explain both mean abundance and local rarity values obtained for kermes oak woods, since these habitats have the best floristic and structural conservation. This is mainly owing to their occupying marginal land of low agricultural value and their management as hunting reserves. Positive effects of shrubs on butterfly communities have been recently reported by Arechavaleta *et al.* (1994) and Ferrín & Martín-Cano (1994).

The Penibetic Mountains give shelter to many regionally uncommon or rare species of butterflies (Molina & Palma, 1995). In this study these species are generally associated with the better conserved sites and vegetation types. The presence in some successional habitats of very rare species. (e.g. *Lysandra albicans* (Herrich-Schäffer, 1851) and *Lysandra bellargus* (Rottemburg, 1775) in thyme grassland, or *Melitaea aetherie* (Hübner, 1826) in broom scrub) may be explained by the existence of specific ecological requirements for the larval stages (Thomas, 1984).

Rarity patterns and index values obtained also suggest actual differences among habitats, even when these are very close to each other, and support a sedentary character for rare butterflies (Erhardt, 1985a,b).

High values of species diversity are often an important, if not a unique, criterion when selecting sites for conservation (Margules & Usher, 1981). In this study, diversity values were very similar among habitats and did not represent a good discriminant measure. Only the H′ index was well associated with species richness, whereas there was little or no correlation with rarity values (Table 3). Relative similarity in diversity values among habitats may be due to influx of species from adjacent habitats during late spring and summer, which could vary from year to year, depending on the weather.

Conclusions

All assessment methods using butterfly communities as indicators, identified kermes oak wood (*Q. coccifera*) as the least disturbed and most interesting habitat in the study area for nature conservation.

There is indirect evidence that within habitats the presence of woody plants act as microclimate modifiers during the hottest period of the flight season. Together with the intensity of human influence upon vegetation, which decreases diversity, these seem to be the determining factors of butterfly species richness, diversity and rarity in the study area.

Butterfly conservation policy must focus on kermes oak woods if characteristic Mediterranean communities are to be preserved, whereas attempts to conserve individual species must involve a study of their specific habitat requirements within the succession. When assessing sites, species richness, together with an evaluation of the faunal quality, would be a better discriminant than diversity index values.

References

Ackery, P. R., 1984. Systematic and faunistic studies on butterflies. *In* Vane-Wright, R. I. & Ackery, P. R. (Eds) : The Biology of Butterflies. *Symp. R. Ent. Soc.* 11 : 9-21. Academic Press, London.

Arechavaleta, M., Oromi, P. & Zurita, N., 1994. Preferencias ambientales de los lepidopteros diurnos del Parque Nacional de Garajonay (La Gomera). (Papilionoidea, Lepidoptera). *In* VI Congreso Ibérico de entomología. Madrid, 26-30 septiembre 1994. Resúmen C-3.

Baz, A., 1986. Las mariposas de la comarca madrileña del río Henares, I : Influencia de la vegetación sobre la composición y estructura de sus comunidades. *Misc. Zool.* 10 : 189-198.

Cheverton, M. R. & Thomas, C. D., 1985. Land use and conservation in Panama : A study of butterfly density and species diversity. *Proc. 3rd. Congr. eur. Lepid., Cambridge*, 1982 : 30-45.

DAILY, G. C. & EHRLICH, P. R., 1995. Preservation of biodiversity in small rainforest patches : rapid evaluations using butterfly trapping. *Biodiversity & Conservation* 4 : 35-55.

DESCIMON, H. & NAPOLITANO, M., 1990 (1991). L'étude quantitative des populations des Papillons (Lepidoptera). *Alexanor* 16 (7) : 413-426.

DONY, J. G. & DENHOLM, I., 1985. Some quantitative methods of assessing the conservation value of ecologically similar sites. *J. Appl. Ecol.* 22 : 229-238.

DUELLI, P., STUDER, M., MARCHAND, I. & JAKOB, S., 1990. Population movements of Arthropods between natural and cultivated areas. *Biol. Conserv.* 54 : 193-207.

ERHARDT, A., 1985a. Lepidoptera fauna in cultivated and abandoned grassland in the Subalpine region of Central Switzerland. *Proc. 3rd Congr. eur. Lepid., Cambridge*, 1982 : 63-73.

ERHARDT, A., 1985b. Diurnal Lepidoptera : Sensitive indicators of cultivated and abandoned grassland. *J. Appl. Ecol.* 22 : 849-861.

FERRÍN, J. M. & MARTÍN-CANO, J., 1994. Impacto de las repoblaciones forestales sobre las poblaciones de mariposas (Papilionoidea). *In* VI Congreso Ibérico de entomología. Madrid, 26-30 septiembre 1994. Resúmen C-17.

GÓMEZ-BUSTILLO, M. R. & ARROYO-VARELA, M., 1981. Catálogo sistemático de los Lepidópteros ibéricos. 498 pp. INIA, MAPA, Madrid.

GÓMEZ-BUSTILLO, M. R. & ARROYO-VARELA, M., 1984. Apéndice al catálogo sistemático de los Lepidópteros ibéricos (vol. I) Macrolepidoptera (1981) (1982-1984). *SHILAP Revta. lepid.* 12 (48) : 1-83.

HIGGINS, L. G., 1975. The classification of European butterflies. 320 pp. Collins, London.

KITAHARA, M. & FUJII, K., 1994. Biodiversity and community structure of temperate butterfly species within a gradient of human disturbance : An analysis based on the concept of generalist vs. specialist strategies. *Res. popul. Ecol.* 36 (2) : 187-199.

LAWTON, J. A., 1983. Plant architecture and the diversity of phytophagous insects. *A. Rev. Ent.* 28 : 23-29.

LEPS, J. & SPITZER, K., 1990. Ecological determinants of butterflies communities (Lepidoptera, Papilionoidea) in the Tam Dao Mountains, Vietnam. *Acta ent. bohemoslovaca.* 87 : 182-194.

MARGULES, C. & USHER, M. B., 1981. Criteria used in assessing wildlife conservation potential : A review. *Biol. Conserv.* 21 : 79-109.

MOLINA, J. M. & PALMA, J. M., 1992. Mariposas de las Sierras Subbéticas de Sevilla. (Lepidoptera : Papilionoidea et Hesperioidea). *Bolm. Soc. port. Ent. Supl.* 3 (2) : 563-572.

MOLINA, J. M. & PALMA, J. M., 1994. Distribución, abundancia y adiciones a la fauna de mariposas de las Sierras Subbéticas de Sevilla. (Lepidoptera, Rhopalocera). *SHILAP Revta. lepid.* 22 (86) : 101-108.

MOLINA, J. M. & PALMA, J. M., 1995. Analisis corológico de la fauna de mariposas de Sevilla. (Insecta : Lepidoptera : Hesperioidea et Papilionoidea). *In* Comité Editorial : Avances en Entomología Ibérica. pp. 229-240.

Museo Nacional de Ciencias Naturales (CSIC), y Universidad Autónoma de Madrid, Madrid.

Montoya-Oliver, J. M., 1982. Efectos del arbolado de las dehesas sobre los factores ecológicos que actúan a nivel del sotobosque. *An. INIA / Ser. Forestal* / N.5 : 61-85.

Montoya-Oliver, J. M. & Mesón-García, M. L., 1982. Intensidad y efectos de la influencia del arbolado de las dehesas sobre la fenología y composición específica del sotobosque. *An. INIA / Ser. Forestal* / N.5 : 43-59.

Munguira, M. L. & Thomas, J. A., 1992. Use of road verges by butterfly and burnet populations, and the effect of roads on adult dispersal and mortality. *J. Appl. Ecol.* 29 : 316-329.

Pollard, E., 1977. A method for assessing changes in the abundance of butterflies. *Biol. Conserv.* 12 : 115-134.

Pollard, E. & Yates, T. J., 1993. Monitoring butterflies for ecology and conservation. 274 pp. Chapman & Hall, London.

Rivas-Goday, S. & Rivas-Martínez, 1969. Matorrales y tomillares de la Península Ibérica comprendidos en la Clase Ononido-Rosmarinetea Br.-Bl., 1947. *Anal. Inst. Bot. Cavanilles* 31 (2) : 205-259.

Rivas-Martínez, S., 1987. Memoria del Mapa de las Series de Vegetación de España. 268 pp. MAPA. ICONA, Madrid.

Sánchez, B. & Viejo, J. L., 1986. Las mariposas del norte de la provincia de Ciudad Real. (Lepidoptera : Papilionoidea et Hesperioidea). *In* Actas VIII Jornadas AeE, Sevilla. Octubre 1986 : 936-945.

Southwood, T. R. E., 1978. Ecological methods, with particular reference to the study of insects populations. 524 pp. 2d. Ed. Chapman & Hall, London.

Spitzer, K., Leps, J. & Soldan, T., 1987. Butterflies communities and habitat of seminatural savanna in Southern Vietnam (Papilionoidea, Lepidoptera). *Acta ent. bohemoslovac.* 84 : 200-208.

Thomas, C. D. & Mallorie, H. C., 1985. Rarity, species richness and conservation : Butterflies of the Atlas Mountains in Morocco. *Biol. Conserv.* 33 : 95-117.

Thomas, J. A., 1984. The conservation of butterflies in temperate countries : past efforts and lessons for the future. *In* Vane-Wright, R. I. & Ackery, P. R. (Eds) : The Biology of Butterflies. *Symp. R. Ent. Soc.* 11 : 333-353. Academic Press, London.

Van Hook, T., 1994. The conservation challenge in Agriculture and the role of entomologist. *Florida Entomologist* 77 (1) : 42-73.

Viejo, J. L., 1986. Diversity and species richness of butterflies and skippers in Central Spain habitats. *J. Res. Lepid.* 24 (4) : 364-371.

Viejo, J. L., Galiano, E. F. & Sterling, A., 1992. The importance of riparian forest in the conservation of butterflies in Central Spain. *Nota lepid. Suppl.* 3 : 29-42.

Wood, P. A. & Samways, M. J., 1992. Landscape element pattern and continuity of butterfly flight path in an ecologically landscaped botanic garden, Natal, South Africa. *Biol. Conserv.* 58 : 149-166.