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Proc.V.Congr.Eur.Lepid., Budapest 7-10.IV.1986
Nota lepid. Supplement No. 3 : 29-42 ; 30.IV.1992 ISSN 0342-7536

The importance of riparian forests in the conservation of butterflies in Central Spain

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Summary

Mediterranean ecosystems suffer severe drought stress during the summer months. Riparian forests, however, escape such water deficits and may act as temporary reserves for butterflies. Over a period of 6 months, Rhopalocera were sampled in 14 plots (7 in alluvial forests and 7 in adjacent areas) at different altitudes in the neighbourhood of the river Guadarrama, in central Spain. Results showed that well preserved riparian forests were frequented by greater numbers of butterfly species and individuals than adjacent areas. Species diversity was also higher. Correspondence analysis of faunal data showed that the main factors affecting butterfly distribution were the presence of riparian forest and altitude. The results suggest that the conservation of many butterflies is dependent upon the preservation of riparian ecosystems, as some species find their summer habitats along river banks.

Introduction

One of the peculiarities of Mediterranean ecosystems is the severe drought stress that plant communities suffer in the hot, dry summer months. Mediterranean forests are mainly comprised of evergreen shrubs or trees that have developed efficient mechanisms of water economy so enabling them to survive the dry season (Cody & Mooney, 1978). Grasslands are composed, basically, of thermophytic species, which spend the summer months as seeds thereby avoiding dehydration. Another characteristic typical of Mediterranean climates is the irregularity of rainfall and the marked variation in total precipitation from year to year. Series of two, three or five dry years are not uncommon and drought one year may aggravate the low rainfall of the next, creating severe water stress.

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Thus water may be regarded as a scarce and unpredictable resource in these ecosystems and it is not surprising that Mediterranean species display a wide variety of adaptations to prevent dehydration. Butterflies show both ethological and ecological adaptations to water stress, perhaps the most common being that of congregating in areas with moist conditions during the summer months. The vegetation surrounding permanent or temporal water courses does not suffer drought. The presence of running water or the proximity of the water table along river banks therefore favours the development of a riparian forest with a characteristic flora and fauna, which differs from that of surrounding areas. The sedimentary processes related to a river's geomorphological action create terraces with deep, fertile soils which present favourable conditions for the growth of freatophytes (elms, willows,ash, etc.) and intensive agriculture. Nowadays, most river margins in the Mediterranean region are under irrigation agriculture.

Alluvial forests are of some importance for conservation purposes for the following reasons :

— Although their total extension is not excessive, their branching spatial distribution means that few points within a territory fall far from a brook or river, thus providing well extended refuge areas for many species (birds, insects, amphibians, mammals) which may hunt or eat elsewhere (Galiano, Sterling & Viejo, 1985).
— Alluvial forests possess a specific fauna and flora (Odum, 1978 ; Johnson & Carothers, 1982) and act as migration routes for those animals or as suitable habitats for plant species associated with moist environments.
— They are relatively independent for their minimum water supply from the irregularities of precipitation, as they are functionally connected to the underground water system. This regulates the water current and maintains a certain amount of moisture in the river, brook or aquifer, even during unfavourable climatic conditions.
— The microclimatic conditions of riparian forests (lower mean temperature, greater moisture, lower light intensity and high evapo-transpiration during spring and summer months) retard the phenological development of the plant species present, providing flowers, fruit and green biomass in a period in which the surrounding ecosystems appear to be in a very low productive stage.
— The microclimate of river margins offers excellent conditions to prevent dehydration for the insect populations that live there either occasionally or permanently.

These circumstances are particulary relevant in areas with a Mediterranean climate. Riparian forests are the only ecosystems that have favourable environmental conditions for organisms unable to withstand high temperatures or strong water deficits in the Mediterranean lowlands. Rhopalocera are no exception. Many butterflies find their host plants in the woodlands of green oak (*Quercus ilex* L.) or in Mediterranean shrublands, where their larvae develop satisfactorily. However their imagines may present very different

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ecological requirements and are frequently forced to feed from flowers that appear elsewhere or to look for water or protection from dehydration in moist conditions such as those existing in riparian forests (Viejo, 1983). If this habitat disappears the whole survival strategy of many species may be severely disrupted. Thus the destruction of riparian forests not only affects those butterflies which rely exclusively on such habitats but also those species which pass part of their life cycle there.

The present study evaluates the conservation value of riparian forests for butterflies in a chosen Mediterranean area, considering in particular, the number and diversity of the species present and comparing these parameters with those of neighbouring ecosystems.

Materials and methods

The study area chosen was the basin of the river Guadarrama, located in a mountainous area close to Madrid in central Spain. The river has a roughly North-South orientation, descending from the upper peaks of the Sierra to the lower sedimentary area. Sierra de Guadarrama is a granitic upheaval eroded by fluvial action. In the upper zones, between 900 and 2200 m altitude, the lithology is mainly granitic with small local sedimentary areas where sand has accumulated. The middle zones, where Madrid is located, present Tertiary arkosic sediments several hundred meters deep and the base of the system (600 to 700 m altitude) is formed mainly by clay deposits and fine sands which are suitable for agriculture.

The lithological N-S gradient is superimposed upon a climatic gradient characterized by higher mean rainfall and lower mean temperatures as altitude increases. Both the natural vegetation and land-use follow the predominant climatic and geological patterns. The highlands of Sierra present extensive mature pine plantations of *Pinus sylvestris* and, below 1000 m, deciduous forests of the oak *Quercus pyrenaica*. This area has a marked sylvicultural and livestock raising character. An evergreen forest of green oaks (*Quercus ilex*) appears on the arkosic pediment of the Sierra and is cleared to allow the development of natural grasslands or cereal crops. These fields are progressively more abundant southwards, where agriculture becomes the dominant landscape feature.

This study centred on the alluvial forests along the margins of the river Guadarrama which crosses the whole geological, climatic and vegetational gradient.

Sampling

The strong interrelation between vegetation and other biotic components of the ecosystem made an inventory of the main vegetational features necessary in order to facilitate interpretation of faunal data. This is of particular

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importance in the case of Rhopalocera species, as the absence of some host plants may be responsible for the disappearance of highly specialized butterflies. However, as the main purpose of the study was neither to evaluate the trophic dependence of Lepidoptera, nor to elaborate full catalogues of the different points studied, the vegetation study was restricted to ligneous communities.

Seven sampling sites were randomly chosen along the Guadarrama or subsidiary courses, with altitudes ranging from 585 to 1485 m above sea level. The purpose of the investigation was to study the differences in butterfly communities between the riparian forest and neighbouring ecosystems and therefore all sampling was carried out in two sites, one on the river bank and the other in the surrounding area, at a minimum distance of 500 m from water's edge.

A reliable number of sampling plots were placed along the river margins and their neighbouring areas and species data recorded. Information was also gathered concerning the degree of human pressure, the general state of the vegetation and structural complexity both in and outside the alluvial forest. Vegetation data were not fully treated and the main characteristics of the sampled areas are listed in Tab. 1.

Butterflies were sampled between April and September in 1984. In each station butterflies were collected in monthly visits of an hour, 30 minutes spent within the riparian forest and 30 minutes in the surrounding area. After identification, specimens were released with a mark on the abdomen to avoid recounting, except those that were taken to the laboratory to solve identification problems. There was no recapture of specimens between different sampling areas or from one month to another.

Analysis of butterfly data

The strategy of information analysis of butterfly data was oriented towards the evaluation of the conservation potential of alluvial forests in comparison to adjacent areas. The first point under investigation was whether alluvial forests presented significant differences with regards to neighbouring areas in the numbers of specimens sampled or the number of species found. Mean numbers of individuals and species in each site were compared with Student's t-test, confronting data obtained in and outside the alluvial forest. Secondly, a correspondence analysis (Cordier, 1965 ; Benzecri, 1970) of all the information was undertaken and, lastly, diversity was analysed using Shannon-Weaver's index of diversity.

In all cases the information registered in different months was summed to form an information matrix of 14 plots (2 for each site, one in the alluvial forest and one outside) × 59 species found.

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Table 1

Characteristics of the sample sites

SITE	GENERAL CHARACTERISTICS	RIPARIAN VEGETATION	ADJACENT AREA
1	Mountain brook. Stony river bed. "Ranker" soils. Granite pediment. Steep slopes. Altitude 1.480 m.	No proper gallery forest. Riparian vegetation : Rubo-ulmifolii rosetum corymbiferae-cytisetosum-scoparii. Some phanerophytes present : *Taxus baccata, Ilex aquifolium, Sorbus aria, Salix atrocinerea.*	Natural pinewood of *Pinus sylvestris*. Shrubs of *Genista florida, G. cinerea, Adenocarpus hispanicus, Erica arborea, Juniperus communis, Galium rotundifolium, Pteridium aquilinum, Cytisus purgans*. Good herbacecus cover. Little grazing. Recreation zone.
2	Mountain brook, 1.5 m wide on granite pediment. Width gallery forest 10 m. Steep slopes. Altitude 1.100 m.	Dense riparian vegetation. Complex vertical structure. *Salix atrocinerea. Rubus ulmifolius, Prunus spinosa, Crataegus monogyna, Lonicera etrusca, Rosa corymbifera, R. ponzinii, R. micrantha*, etc.	Shrubs with son *Quercus pyrenaica* trees and *Cytisus scoparia, Cistus laurifolia* and *C. ladanifer*, some ruderal communities with *Santolina rosmarinifolia, Eryngium vulgaris, Echium vulgare, Urtica dioica, Malva sylvestris.* Well developed grasslands.
3	Polluted waters. Dense gallery forest (15-30 m wide). River bed 2 m wide. Granitic pediment. Gentle slope. Altitude 940 m.	Complex vertical structure. Dense riparian forest with *Salix atrocinerea, Populus nigra, Sambucus nigra, Rubus ulmifolius, Lonicera etrusca, Fraxinus angustifolia*, etc. Pruned ash trees.	Open woodland of *Quercus ilex*. Grasslands well exploited by livestock.
4	Degraded gallery forest. River bed 2 m wide. Granitic pediment. Gentle slope. Altitude 860 m.	Dense vegetation, similar to site 3, but more degraded.	Open woodland of *Quercus ilex* altered by human influence.
5	River bed 2 m wide. Sandy substrate. Altitude 610 m.	Main tree species present : *Salix atrocinerea, Salix alba, Rubus ulmifolius, Crataegus monogyna, Rosa corymbifera, Lonicera periclymenum, Scirpus holoschoenus, Sambucus nigra, Populus nigra, Quercus ilex, Quercus faginea*	Degraded *Quercus ilex* forest with *Populus nigra, Fraxinus angustifolia, Santolina rosmarinifolia, Cistus ladanifer, Rosa canina, Retama sphaerocarpa, Osiris alba.*
6	River bed 2-4 m wide. Sandy substrate. Altitude 590 m.	Wide gallery forest with complex vertical structure. Main species present : *Salix salvifolia, S. purpurea, S. alba, S. triandra, Scirpus holoschoenus, Ulmus minor, Crataegus monogyna, Lonicera etrusca, Sambucus nigra.*	Cleared forest of *Quercus ilex* with Mediterranean thermophytic grasslands heavily pastured by livestock.
7	Brook under strong human control. River bed 2 m wide. Planted *Ulmus sp.* and *Populus nigra* with regular exploitation. Sandy-silty substrate. Altitude 585 m.	Degraded gallery forest. Most vegetation planted : *Populus nigra, Ulmus minor, Hedera helix, Salix babilonica, S. triandra*. Herbaceous layer nearly absent.	Remnants of degraded woodland of *Quercus ilex*. Agricultural land (mainly olive groves and cereal fields).

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Results and discussion

Degree of vegetation conservation

One of the best indicators of the degree of conservation of an ecosystem is the grade of vegetation preservation. Therefore the vegetation samples taken were used to evaluate the degree of human influence in the seven sites studied, both in and outside the alluvial forest. In general it can be assumed that a change is produced towards the pioneer stages of ecological succession. This process may favour the presence of the host plants of pioneer, non-specialized butterflies and increase the risk of erosion of the river banks and nutrient leaching (Tamm, 1975).

Sustained forestry or agriculture are ways to artificially create an involution in the ecosystem. Taking into account that the preservation of a system in natural conditions will produce a mature ecosystem, the riparian forests showing the highest degree of conservation were those that presented high biomass (with old trees, high vegetation cover and complex vertical stratification) and low human pressure (such as grazing by cattle, building, river water pollution, tree felling or land excavation).

The classification of Sukopp (1971) of degree of preservation of ecological systems was the basis for the evaluation of stage of the sampled areas. Following this author, van der Maarel (1982) listed three main criteria to be taken into account :

— Degree of human influence on the biotic component of the ecosystems.
— Origin of the studied ecosystem (did it develop from a previously natural situation or from a more humanized one ?)
— Present stage of development (regarding ecological succession).

These three criteria help to distinguish six different categories : natural, quasi-natural, semi-natural, agricultural, semi-cultural and cultural. Tab. 2 summarizes the main conservation characteristics of the alluvial forests studied. Considering the high degree of anthropological pressure present in the study area, sites numbers 1, 2, 3 and 6 were regarded as natural or nearly natural, site 4 had an average degree of preservation (semi-natural, according to van der Maarel's classification) and sites 5 and 7 a low degree of conservation (agricultural and semi-cultural respectively).

Butterfly data

481 specimens were captured, belonging to 59 different species. The number of individuals and of species found in the 14 plots during the sampling are listed in Tab. 3.

Number of captures : 247 specimens were found in the alluvial forest and 234 in the neighbouring areas using the same sampling effort. Although in 5 of the 7 sites sampled the same or a higher number of individuals were

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Table 2

The main conservation characteristics of the alluvial forests studied

Site	Category	Description
1.	Natural	— no changes in the substrate — no structural or floristic change in vegetation — loss of native species 0 and gain in neophyte species 0 — natural origin — advanced stage of succession
2.	Nearly natural	— little change in the substrate — no structural changes in vegetation — most species spontaneous — loss of native species 1% — gain in neophyte species 5%
3.	Nearly natural	— the same as site 2
4.	Semi natural	— superficial changes in the substrate — changes in the dominance of the biological types — most species spontaneous — loss of native species 1% — gain in neophyte species 5%
5.	Agricultural	— moderate change in the substrate — changes in vegetation structure — planted population of *Populus nigra* L — 70% species spontaneous — loss of native species 1% — gain in neophyte species 5-12% — intermediate stage of succession
6.	Nearly natural	— the same as sites 2 and 3
7.	Semi-cultural	— drastic change in the substrate — strong change in vegetation structure, trees often absent — few spontaneous species — loss of native species 6% — gain in neophyte species 13-20%

Table 3

Number of species, number of individuals, diversity and conservation degree of each sampling site. In brackets, number of species occurring *only* inside or *only* outside the riparian forest

Site	Number of species inside	Number of species outside	Number of individuals inside	Number of individuals outside	Diversity inside	Diversity outside	Dif. Div. $\triangle H$	Conserv. degree
1	21 (11)	14 (4)	40	27	3.98	3.47	0.51	Highe
2	22 (14)	11 (3)	45	25	4.10	2.98	1.12	High
3	22 (15)	14 (7)	42	33	4.25	3.34	0.91	High
4	18 (10)	16 (8)	30	45	3.80	3.74	0.06	Medium
5	10 (1)	20 (11)	25	43	2.93	3.88	-0.95	Low
6	17 (10)	13 (6)	39	35	3.88	3.31	0.57	High
7	6 (4)	12 (10)	26	26	1.66	3.24	-1.58	Low
Total	53 (18)	41 (6)	247	234	—	—	—	—
Average	16.57	14.29	35.29	33.29	3.51	3.42	0.09	—

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found inside the alluvial forests, the results cannot be considered conclusive as the comparison by Student's t-test of mean captures inside and outside the riparian forest are not significant at a 95% confidence level. However it must be noted that the 3 cases in which the same or lower numbers of individuals were found in the riparian forest compared with adjacent areas correspond to sites of least preserved riparian forests.

Number of species : Inside the alluvial forest 53 species were found in the 7 plots and 42 species in the neighbouring areas. In 5 of the 7 sites the number of species found in the riparian forest was higher than outside. The two sites in which the number of species was lower in the riparian forest correspond to plots 5 and 7, again those presenting the lowest degree of conservation of riverside vegetation (classified as "agricultural" and "semi-cultural" in VAN DER MAAREL's classification). However, the mean number of species inside/ outside the riparian forest were not significantly different at a 95% confidence level using Student's t-test due to the inclusion of degraded riparian forest data in the comparison.

It is interesting to note that, out of the 53 species captured in the phreatophytic vegetation, 18 were exclusive to that vegetation, whilst only 6 out of the 41 butterfly species found in adjacent areas did not enter the riparian forest. This means that 30% of the total number of species sampled were never restricted to the river borders and only 10% were never found in those areas, which may be interpreted as higher specificity in habitat requirements of a good proportion of the butterflies appearing along river banks. A possible biological explanation of these data is that during the summer months the riparian forest acts as a temporary refuge for species which normally live outside, but also possess a characteristic fauna of Rhopalocera which never abandon the moist conditions typical of river margin ecosystems. This may explain why nearly a third of the species observed were found only in the riparian forest.

Multivariate analysis of faunal data : The information matrix of 59 species × 14 sampling plots was reduced to a matrix of 43 species × 14 plots, discarding those species that only occurred in either one or the other of the two sites. This matrix was analysed using correspondence analysis, the variance absorption of the first two axes being 20.05% (for the first axis) and 16.35 (for the second one). Fig. 1 shows the projection of sampling plots and species on the axis formed by the first two axes of the analysis. Full names of the species are listed in Tab. 4. Fig. 2, a reduction of Fig. 1 leaving only the projection of sampling plots, helped interpret results. All plots sampled within the riparian forest lie lower in axis I than their conterparts in neighbouring areas.

This axis I might, basically, be related to fauna with a marked hygrophilous character by Mediterranean standards. Some of the species presenting high negative scores for axis I (*Pieris napi, Pararge aegeria, Heodes tityrus* or *Heodes alciphron*) are known to be associated with moist environments or to favour host plants (elm, willow, ash, *Lonicera*) growing in riparian forests,

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Table 4

List of species recorded with abbreviations used in Fig. 1

	PIERIDAE	PAP	*Pandoriana pandora*
		FAN	*Fabriciana niobe*
APC	*Aporia crataegi*	FAA	*Fabriciana adippe*
PIB	*Pieris brassicae*	ISL	*Issoria lathonia*
PIN	*Pieris napi*	—	*Melitaea trivia*
PIR	*Pieris rapae*	—	*Melitaea phoebe*
EUC	*Euchloe ausonia*	—	*Melitaea cinxia*
ANC	*Anthocharis cardamines*	EUA	*Eyphydryas aurinia*
COC	*Colias croceus*	LIA	*Limenitis reducta*
GOR	*Gonepteryx rhanni*		
—	*Gonypteryx cleopatra*		LYCAENIDAE
	SATYRIDAE	LYP	*Lycaena phlaeas*
		—	*Heodes virgaureae*
BRC	*Brintesia circe*	HET	*Heodes tityrus*
HIS	*Hipparchia statilinus*	HEA	*Heodes alciphron*
—	*Erebia meolans*	QUQ	*Quercusia quercus*
MEL	*Melanargia lachesis*	LAR	*Laeosopis roboris*
MAJ	*Maniola jurtina*	NOE	*Nordmannia esculi*
HYL	*Hyponephele lupinus*	—	*Syntarucus pirithous*
PYT	*Pyronia tithonus*	CEA	*Celastrina argiolus*
PYB	*Pyronia bathseba*	GLA	*Glaucopsyche alexis*
PYC	*Pyronia cecilia*	GLM	*Glaucopyche melanops*
COP	*Coenonympha pamphilus*	ARC	*Aricia cramera*
—	*Coenonympha dorus*	POI	*Polyommatus icarus*
—	*Coenonympha arcania*		
PAA	*Pararge aegeria*		PAPILIONIDAE
—	*Lasiommata megera*		
LAM	*Lasiommata maera*	—	*Papilio machaon*
		IPP	*Iphiclides podalirius*
	NYMPHALIDAE		
			HESPERIIDAE
NYP	*Nymphalis polychloros*		
INI	*Inachis io*	—	*Pyrgus serratulae*
VAA	*Vanessa atalanta*	THA	*Thymelicus acteon*
VAC	*Vanessa cardui*	—	*Thymelicus lineolus*
—	*Aglais urticae*	—	*Thymelicus flavus*
PCA	*Polygonia c-album*	—	*Hesperia comma*

as is the case of *Limenitis reducta, Celastrina argiolus, Nymphalis polychloros, Polygonia c-album* or *Euphydryas aurinia* (Viejo, 1983). Other species with high negative scores on axis I are eurioic such as *Pieris brassicae* or avoid warm habitats such as *Gonepteryx rhamni.*

Axis II represents a biogeographical variation related to the altitudinal and climatic gradients present in Sierra de Guadarrama. This phenomenon is best observed in Fig. 3, where plots inside/outside the riparian forest were separated by bars. The correlation of altitude with axis I was -0.98 for the plots sampled outside the riparian forest and -0,85 for those inside.

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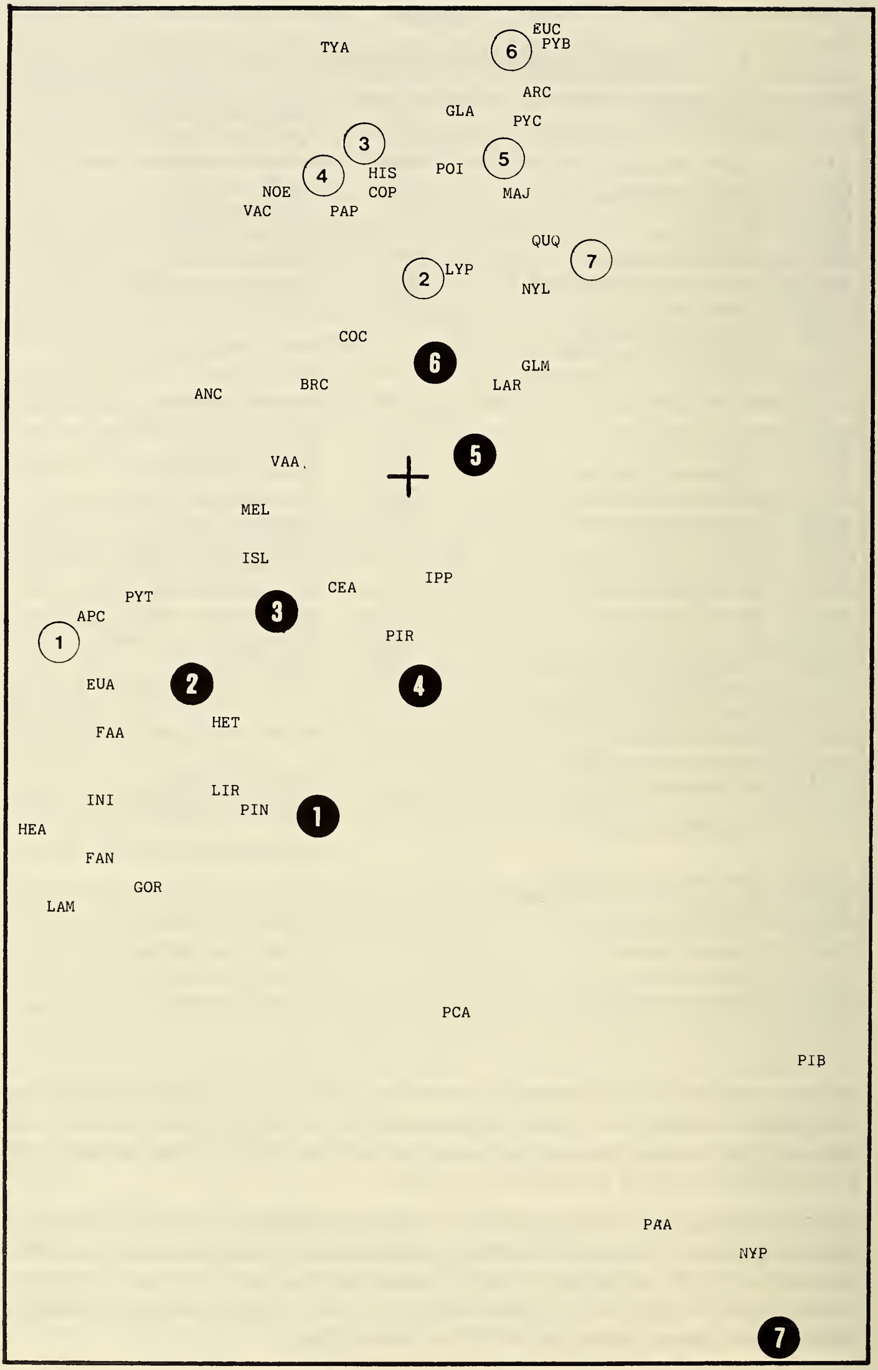

Fig. 1. Projection of plots and species on the plane formed by the two first axes of correspondence analysis. Black circles correspond to riparian forests, as in the other figures. The variance absorption was 20.05% for axis I and 16.35 for axis II.

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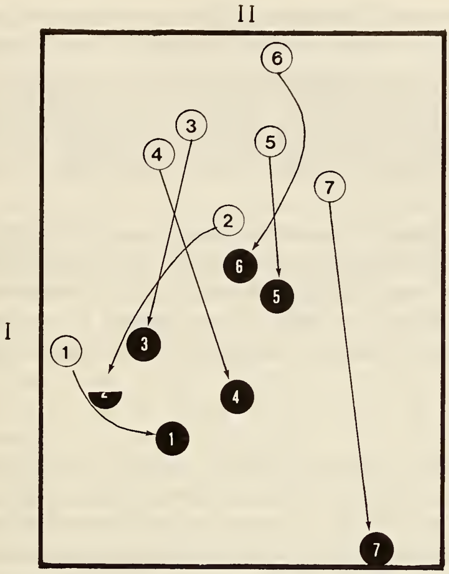

Fig. 2. Projection of plots on the plane formed by the two first axes of correspondence analysis. Neighbouring plots have been united by arrows.

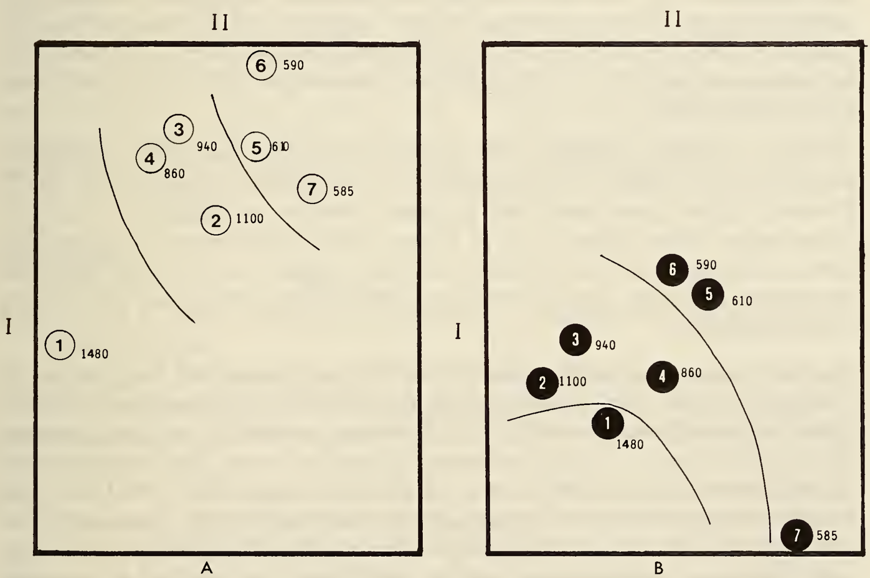

Fig. 3. Projection of plots sampled outside (A) and inside (B) riparian forests on the plane formed by the two first axes of correspondence analysis. Altitude are noted for each plot (in metres). Lines divide areas of differing altitude. Axis II is strongly correlated with altitude (A : r = -0.98 ; B : r = -0.85).

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It can be seen that the altitudinal gradient was clearer for plots outside the riparian forest, whilst those sampled along the river margin showed a less defined relation. This was interpreted in the sense that microclimatic conditions in the riparian forest presented similarities at different altitudes and so concealing the existing climatic gradient and produced a certain homogenization of their butterfly fauna. This biogeographical gradient is not distorted outside the river banks.

Axis I, basically related to moist habitats, was also slightly correlated with altitude, as the environmental conditions of the riparian forest (greater mean humidity and lower mean temperatures) are also typical of higher altitudes. There are species which can survive outside the forest along river margins in the highlands, but which are restricted to the riparian forest below certain altitudes, this being the only ecosystem where a fresh, moist environment can be found. Such is the case of *Pieris rapae* in the study area. Other species were closely linked to the altitudinal factor as expressed in Sierra de Guadarrama by occurring in different vegetational landscapes with well marked physical and floristic characteristics. Those species which presented high negative scores for axis II, such as *Heodes alciphron* or *Lasiommata maera*, are typical of mountain areas (in Mediterranean regions) or are related both to high altitudes and riparian forests, such as *Euphydryas aurinia, Fabriciana adippe, Fabriciana niobe* and *Limenitis reducta*.

Other species, such as *Pieris brassicae, Euchloe ausonia, Quercusia quercus, Maniola jurtina, Pararge aegeria, Pyronia bathseba* and *Pyronia cecilia*, with positive scores for axis II, are typically associated to lower altitudes. The biological reasons for this altitudinal distribution are well known and need not be emphasized.

Diversity: Species diversity can be regarded as an ecological parameter measuring the degree of organization of ecosystems (Margalef 1977). Diversity values have been used by many workers as indicators of a site's conservation value. Margules & Usher (1981), for instance, suggest that species diversity and the presence of rare species can be used as basic parameters to assess natural areas for conservation as they are accepted by most researchers.

Diversity values of butterfly species in the 14 plots sampled are listed in Tab. 3. Although mean diversity values in riparian forests ($H = 3.51$) were only slightly higher than in adjacent areas ($H = 3.42$), this was caused by averaging (perhaps objectionable from a strictly mathematical point of view) the diversity values of well preserved and poorly conserved riparian forests. When the three river margins with more intense human influence were discarded, riparian forests had a surprisingly high mean diversity value of 4.05. The difference in diversity ($\triangle H$) between a riparian forest and its surroundings is therefore an excellent measure of the conservation value of river margins. In the two least preserved riparian forests (sites 5 and 7), butterfly diversity was lower than in adjacent areas. In site 4 (mean conservation) diversity was similar in both plots and

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in the most highly preserved riparian forests, diversity was higher along the river margins (from 0.51 to 1.12 higher).

It seems clear that vegetation landscapes associated with rivers act as refuges for butterfly species during the summer months, particularly when well preserved. Not only typically hygrophilous species such as *Pieris napi, Pararge aegeria* or *Limenitis reducta* are found, or species whose host plants grow along river banks such as *Polygonia c-album* or *Nymphalis polychloros*, but also some migrating butterflies which normally live in the sclerophyllous Mediterranean shrubland but which are present in the riparian forest during the dry months of summer. Such is the case of *Pieris brassicae, Issoria lathonia* or *Iphiclides podalirius*. It is also possible that river margins act as mating sites for species which spend most of their time in other ecosystems.

Conclusions

Although the data collected are partial and a deeper study is needed to be able to establish definite conclusions, the results confirm the great value of riparian ecosystems for preservation of butterflies in Mediterranean areas. The fact that a third of species observed in the river Guadarrama study were only found within the riparian forest and that 90% of all species sampled were captured at least once in river margin areas is a clue to their conservation potential. However these ecosystems only act as butterfly refuges when their vegetation is adequately preserved. Riparian forests are very vulnerable to human impacts as they occupy small areas suitable for agricultural or recreational uses. They may play an important role in the survival of many butterfly species during the summer months and the biological reasons for their richness in species probably lies in their favourable microclimatic conditions, and in the presence of water and flowering plants in a period of the year when both resources are scarce in the surrounding Mediterranean chaparral.

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Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: Nota lepidopterologica

Jahr/Year: 1992

Band/Volume: Supp_3

Autor(en)/Author(s): Viejo Montesinos José Luis, Galiano E. F., Sterling A.

Artikel/Article: The importance of riparian forests in the conservation of butterflies in Central Spain 29-42