

THE EFFECTS OF ELEVATION ON THE BUTTERFLY COMMUNITIES OF A MEDITERRANEAN MOUNTAIN, SIERRA DE JAVALAMBRE, CENTRAL SPAIN

J. F. SANCHEZ-RODRIGUEZ AND A. BAZ

Departamento de Biología Animal, Universidad de Alcalá de Henares,
28871-Alcalá de Henares, Madrid, Spain

ABSTRACT. This paper examines altitudinal changes in butterfly communities in the Sierra de Javalambre of central Spain. From May to September 1991 we sampled the butterfly fauna every 15 days at 10 stations located between 1100 and 2000 m. We obtained a total of 2,123 individuals of 101 different butterfly species. Abundance and species richness were highest at low elevations and declined with increasing altitude, while the converse held for habitat breadth. The chorological index was highest at low elevations. Changes in the butterfly communities along the altitudinal gradient of the Sierra de Javalambre are caused by harshness of environmental conditions, changes in the vegetation, and presumably, resource impoverishment. High elevations do not seem to 'select' for a endemic fauna of butterflies. The communities in the lowest places are composed of rare and localized species, while high elevation communities are less original in faunistic composition since they are composed of euryecious and widespread species in this area.

Additional key words: altitudinal changes, habitat breadth, resource poverty, species richness.

Analyses of altitudinal changes in diversity, abundance, and species composition of biotas can provide important information on such phenomena as those aspects of the environment limiting the distribution of organisms, factors influencing the structure of communities, and biogeographical patterns. These problems have been investigated by ecologists for the past 40 years. Several studies (Hagvar 1976, Claridge & Singh Rao 1978, Hebert 1980, Ichijo et al. 1982) have concluded that a decrease in species richness with elevation is typical of many groups of animals, including insects, with the exception of bees (Gauld 1987) and tropical psocids (Turner & Broadhead 1974). At least four causes have been suggested for this decrease: reduced habitat area at high elevations, reduced resource diversity, increasingly unfavorable environments, and/or reduced primary productivity at higher altitudes (Lawton et al. 1987). In addition to these, other processes (competition, predation, evolutionary time, etc.) also may influence species richness (Lawton et al. 1987).

Other studies (Janzen 1973, Janzen et al. 1976), however, have concluded that species richness peaks at middle elevations, rather than at low ones. Many distinct processes have been proposed to explain mid-elevational peaks: disturbances caused by human activities in low elevations (Wolda 1987), increasingly unfavorable environments at both high and low altitudes (Gagne 1979, Randall 1982), and even the sam-

pling regimes (short-term vs. long term sampling regimes) (Wolda 1987, McCoy 1990).

The purpose of this paper is to present the results of a study of changes in the structure of butterfly communities along an altitudinal gradient in a Mediterranean mountain. There is a dearth of such studies in these latitudes (see Claridge & Singhrao 1978).

MATERIALS AND METHODS

The study was conducted in the Sierra de Javalambre, Sistema Ibérico, Teruel province, central-eastern Spain (Fig. 1). The Sierra consists largely of carbonated Jurassic rocks. The climate is typical of mediterranean mountains, with a wide daily and seasonal variation in temperature, with hot summers and cold winters. Rainfall is low and seasonal, varying annually from 400 to over 500 mm. These mountains thus provide a remarkable opportunity for the study of altitudinal distributions and zonation of organisms.

The lower slopes are heavily cultivated with various fruits and vegetables. Elsewhere, forests dominated by holm oak (*Quercus rotundifolia* Lam.) (Fagaceae) and Spanish juniper (*Juniperus thurifera* Linnaeus) (Cupressaceae), and their successional stages dominate the landscape. At about 1300 m the forest is dominated by lusitanian oak (*Quercus faginea* Lam.) (Fagaceae), extremely perturbed and replaced in many cases by bushes of *Ligustrum vulgare* Linnaeus (Oleaceae), *Prunus spinosa* Linnaeus (Rosaceae), *Berberis vulgaris* Linnaeus (Berberidaceae) and *Rosa canina* Linnaeus (Rosaceae).

Spanish juniper and black pine (*Pinus nigra* Arnold) (Pinaceae) form mixed forests at 1400–1600 m, dominated by seminatural black pines. This forest is replaced above 1600 m by Scot pine forests (*Pinus sylvestris* Linnaeus) (Pinaceae). Just below the summit, at about 2000 m, there is a meadow with *Erodium celtibericum* Pau (Geraniaceae). A general account of the natural vegetation of the area is given by Peinado and Martinez-Parras (1985, 1987) (also see Fig. 2).

METHODS

The study was conducted along an altitudinal transect between the village of Camarena de la Sierra and the peak of the highest mountain (Javalambre, 2020 m). Ten stations separated by intervals of approximately 100 m of elevation (from 1100 to 2000 m) were established in the above described habitats.

Every two weeks from May to September 1991 we sampled the butterfly fauna at these 10 stations. Samples were taken on sunny days between 1000 and 1600 h. The sampling scheme was based in sampling subunits (40 min) of collecting effort per site per sample. We obtained

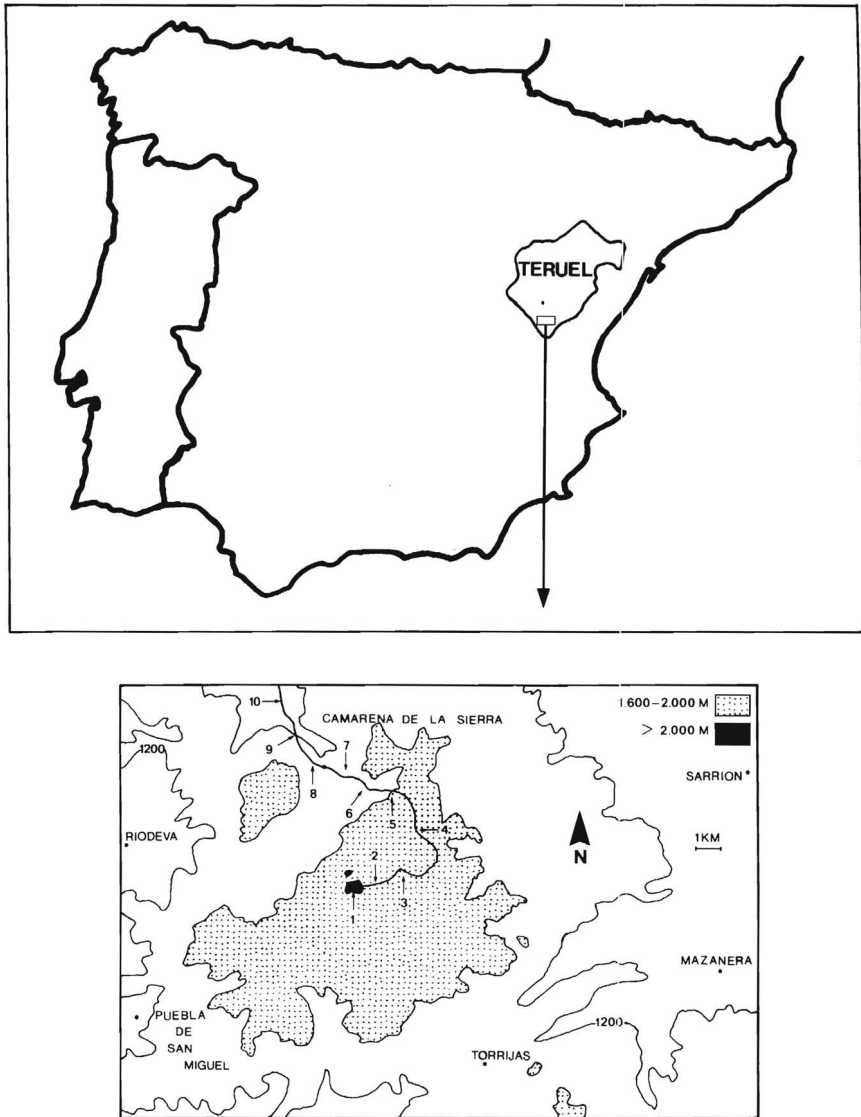


FIG. 1. Map showing the study area. Transect with the numbers of sampling sites are also represented.

a total of 2,123 individuals of 101 different species (Appendix A). From these data, the following variables were calculated:

- Number of species (**S**) equals the total number of species recorded on each site.
- Abundance (**Ab**) equals the total number of individuals.

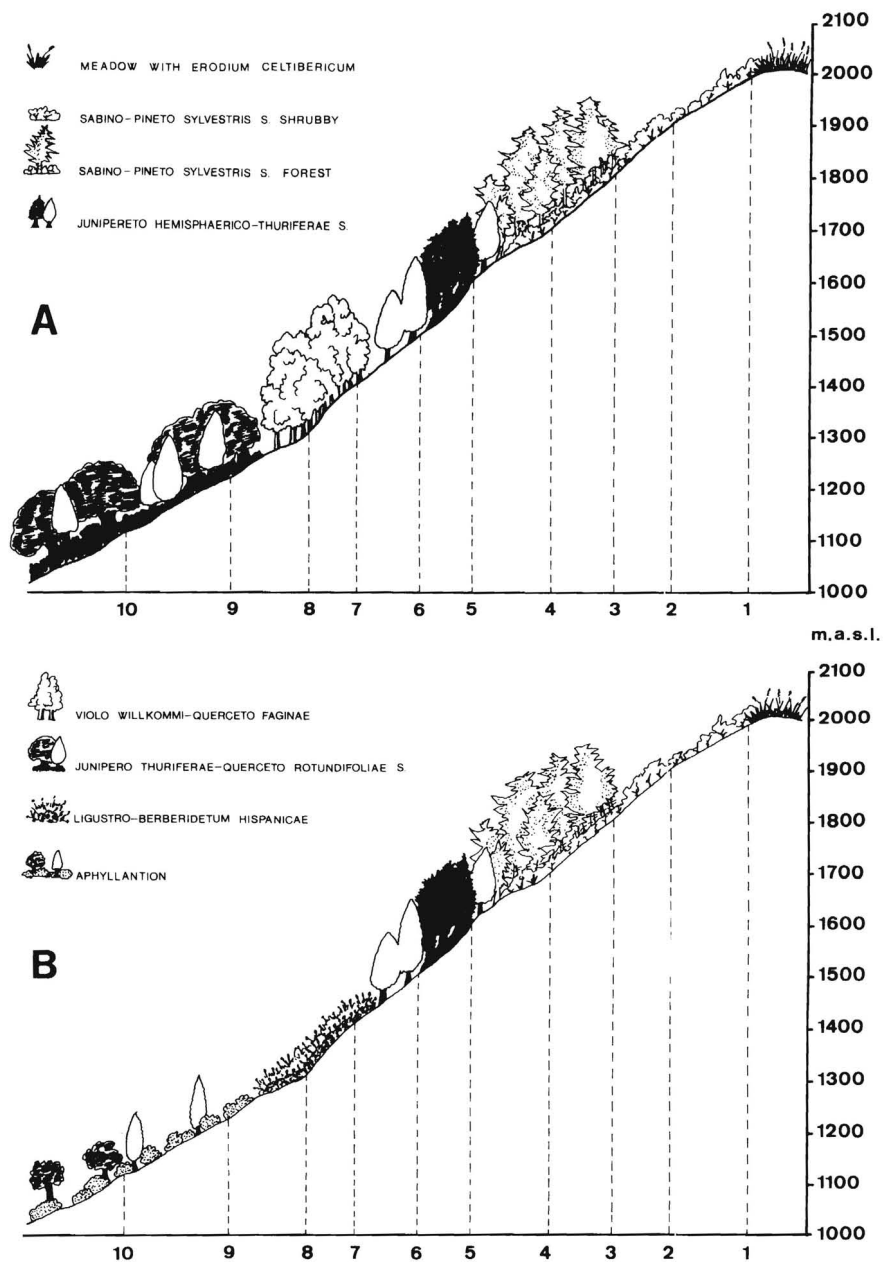


FIG. 2. Schematic representation of both potential (A) and present (B) vegetation along the elevational transect. Numbers 1-10 refer to sampling sites, number 1 being at the highest elevation.

TABLE 1. Values of the 7 variables used in the characterization of butterfly communities on each sampling site, number 1 being at the highest elevation.

	1	2	3	4	5	6	7	8	9	10
S	26	37	47	39	38	58	54	52	45	48
AB	135	158	200	212	173	253	258	258	230	246
D	0.49	0.32	0.35	0.17	0.21	0.16	0.17	0.19	0.26	0.28
H'	3.41	4.29	5.18	4.75	4.61	5.23	5.20	5.05	4.57	4.53
J'	0.72	0.82	0.93	0.89	0.87	0.89	0.90	0.88	0.83	0.81
CI	6.61	6.54	6.76	6.76	7.15	7.24	7.09	6.73	7.20	6.83
HB	4.75	4.54	4.35	4.62	4.65	4.05	4.06	4.02	4.24	3.94

—Dominance (**D**) was obtained from the McNaughton & Wolff's index (1970), expressed as $D=Y_{1,2}/Y$, where $Y_{1,2}$ is the sum of individuals of the two most abundant species, while Y is the total number of individuals.

—Diversity (**H'**) was obtained from the Shannon & Weaver's index (1963), expressed as $H' = -\sum p_i \log_2 p_i$, where p_i is the proportion of the i th species in the total sample

—Equitability (**J'**) expressed as: $J' = H'/H'_{\max}$.

—Mean chorological index (**CI**). Calculated for each site by means of the chorological index of each species (data from Kudrna 1986). As Kudrna pointed out, the chorological index allows an evaluation of the biogeographic arrangement of all European butterfly species from a conservation point of view, as well as an evaluation and comparison of habitats (localities) based solely upon the composition of their butterfly fauna. The values of **CI** result from the sum of the numerical values of *range size*, *range composition* and *range affinity* ("sensu" Kudrna 1986). Values for range size vary from 1 (species widespread across Europe) to 5 (species confined to small areas, such as islands, mountain ranges, or single sites in Europe). Range composition evaluates the continuity of the distribution; in other words, the ability of individuals of one population to reach other populations. It ranges from 1 (continuous, or nearly so, distribution over most of the European range of the species) to 5 (widely isolated single populations, small groups of populations, and small stocks of very restricted range). Lastly, range affinity synthesizes the relationship between the species' European distribution and its world range as a supplementary indicator of the relative importance of these populations for the overall survival of the species. Its value ranges from 1 (extra-European species as defined by Kudrna 1986) to 4 (species endemic to Europe). Thus, the chorological index varies from 4 (most widespread species) to 14 (endemic European species restricted to very small territories).

—Mean habitat breadth (**HB**). Obtained from the habitat breadth of each species after Simpson's (1949) formula, expressed as $HB = 1/\sum p_i^2$, where p_i is the proportion of individuals on each site.

The values of all these variables are summarized in Table 1.

RESULTS

Table 2 shows the results of the regression analysis between altitude and variables of community structure. Significant negative relationships were found between altitude and both species number and abundance (i.e., species number and abundance decrease with altitude), whereas mean habitat breadth increased with elevation (Fig. 3). However, no correlations between altitude and dominance, species diversity or equitability were found. This is due to the fact that number of species (species

TABLE 2. Results of the regression analysis between altitude and the 7 variables considered. CI* represent results of the regression after the localities 8 and 10 were removed (see text for explanations).

	S	AB	D	H'	J'	HB	CI	CI*
<i>r</i>	-0.66	-0.82	0.48	-0.44	-0.20	0.81	-0.53	-0.88
<i>R</i> ²	42.82	68.46	23.9	19.5	34.24	66.0	29.12	—
<i>P</i>	0.03*	0.003*	0.15	0.20	0.56	0.004*	0.10	0.005*

* *P* < 0.05. *R*² = Coefficient of determination (in %).

richness) and equitability (evenness in abundance) are the two components defining *H'*. Diversity increases as species are added, as well as when the species abundances are evenly distributed. In diverse situations, single species do not dominate; in contrast, where one or two species are much more abundant than the rest, there is low diversity (see Price 1984). Thus, the absence of a relationship between elevation and equitability is the result of the absence of a relationship between elevation and butterfly species diversity as expressed by *H'*.

As regards the mean chorological index, no significant relationships were found when all 10 sampling sites were included in the analysis. However, when localities 8 and 10 (both located close to human-perturbed habitats) were removed from the analysis, a highly significant negative relationship between elevation and mean chorological index was found (Fig. 4).

To evaluate the effect of the resource impoverishment (i.e., decrease in the abundance of suitable host plants) on the variation in species numbers along the gradient, we proceeded as follows. We assigned each butterfly species to one of four groups based on their larval host plants: 1) plants of the class Dillenidae (families Brassicaceae, Resedaceae, Primulaceae, Malvaceae); 2) plants of the class Rosidae (families Rosaceae, Fabaceae, Rutaceae, Umbelliferae); 3) plants of the class Asteridae (families Caprifoliaceae, Valerianaceae, Dipsacaceae, Boraginaceae, Lamiaceae, Escrofulariaceae); and 4) plants of the class Lillidae (family Poaceae) (Appendix B). Figure 5 shows that in the lowest elevations the percentages of the four different butterfly groups are close to those expected (high values of equitability), while at the highest altitudes some groups are proportionally better represented than expected (low values of equitability).

DISCUSSION

Studies on the distribution of insects along elevational gradients have yielded differing results (see McCoy 1990 for a review). Recent long-term sampling studies have concluded that previously identified mid-

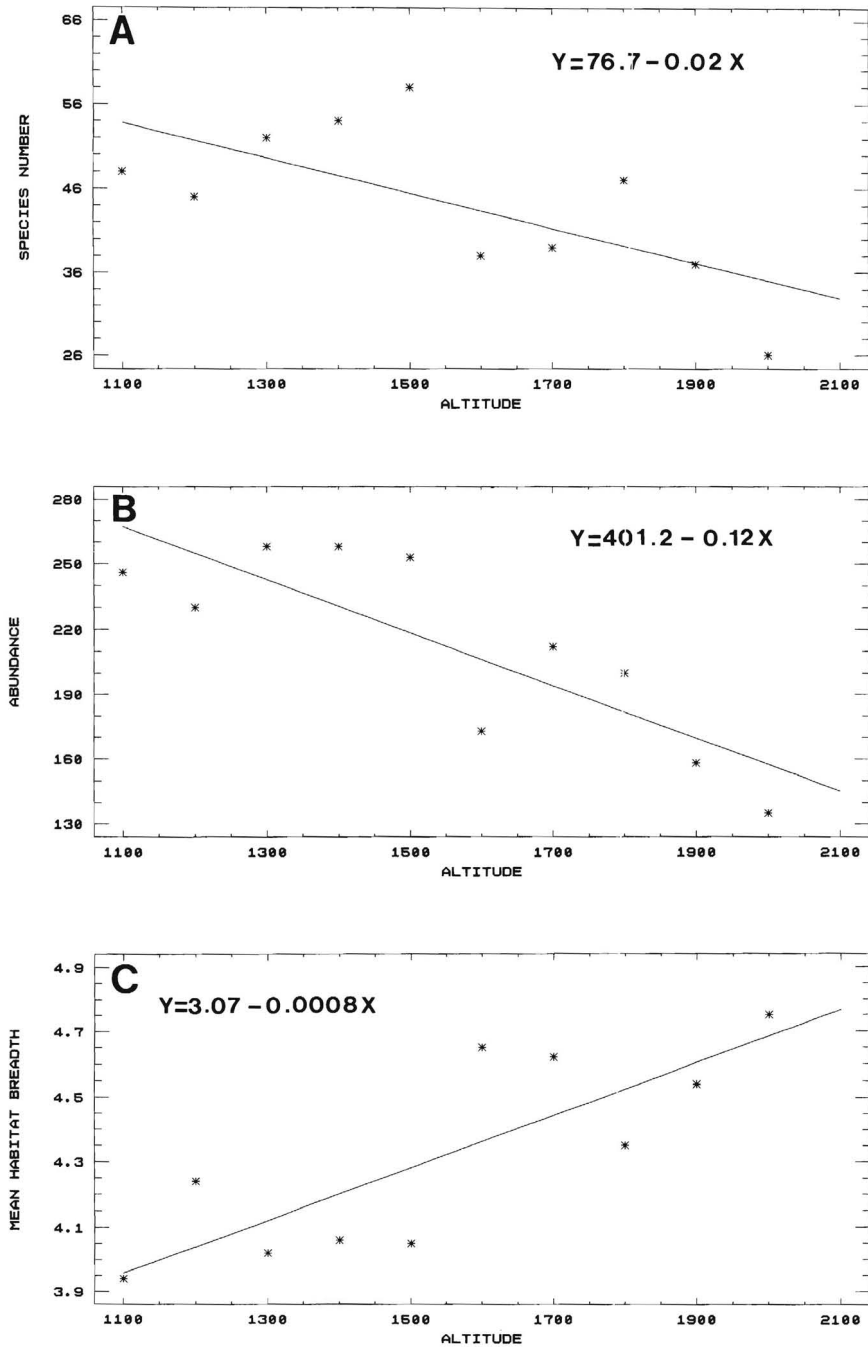


FIG. 3. Relationships between altitude and species number (A), abundance (B), and mean habitat breadth (C).

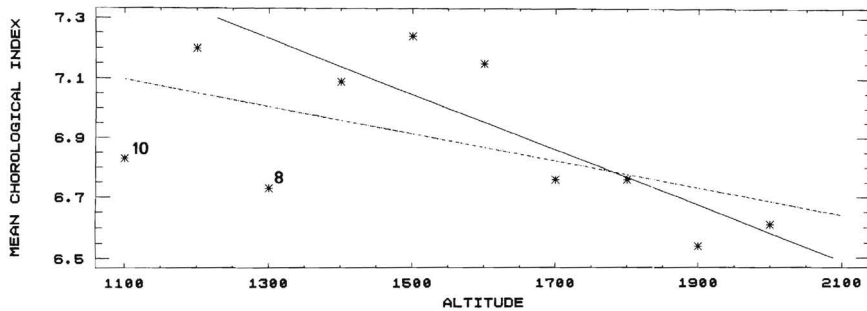


FIG. 4. Relationships between altitude and the mean chorological index. Dashed line obtained from all 10 sampling sites. Bold line obtained after sampling sites 8 and 10 were removed (see text for explanations).

elevational peaks in species richness may have resulted from the short-term sampling regimes that were employed (Wolda 1987). However, mid-elevational peaks have been documented for organisms that should be less affected by factors such as sampling regime and disturbance, for example, birds of the Páramos (Vuilleumier & Ewert 1978, Terborgh 1977).

Our data indicate that both richness and abundance of butterflies decrease with altitude, although the greatest number of species was found at 1500 m. This may be interpreted as a result of the interaction of two different variables—habitat and disturbance. The lowest places of Javalambre have been human-managed historically for agricultural uses, thus the climax vegetation has been replaced by its seral stages, which support lower butterfly species richness (Baz 1986). On the other hand, habitats at mid-elevations are deciduous woodlands (*Quercus faginea*) that contain the richest butterfly faunas, at least in the Iberian peninsula (Baz 1987, Viejo et al. 1989). If the habitat at lower elevations were in a natural stage, one would expect to find more butterfly species there. The continuous decrease in the number of species with increasing elevation may be caused by the harshness of environmental conditions and area reduction, but also as a consequence of a reduction in resource diversity (Lawton et al. 1987). In the absence of more detailed inventories of plant species, Fig. 5 may serve as an example to illustrate this point, showing that at the highest elevations a trophic group of species dominates community composition (ca. 55% of all species).

An interesting pattern found in this work is an extension of Rapoport's latitudinal rule to altitude (i.e., the tendency for latitudinal ranges to become smaller with decreasing latitude [Rapoport 1982, Stevens 1989]) which has been reviewed recently by Stevens (1992). Mean habitat

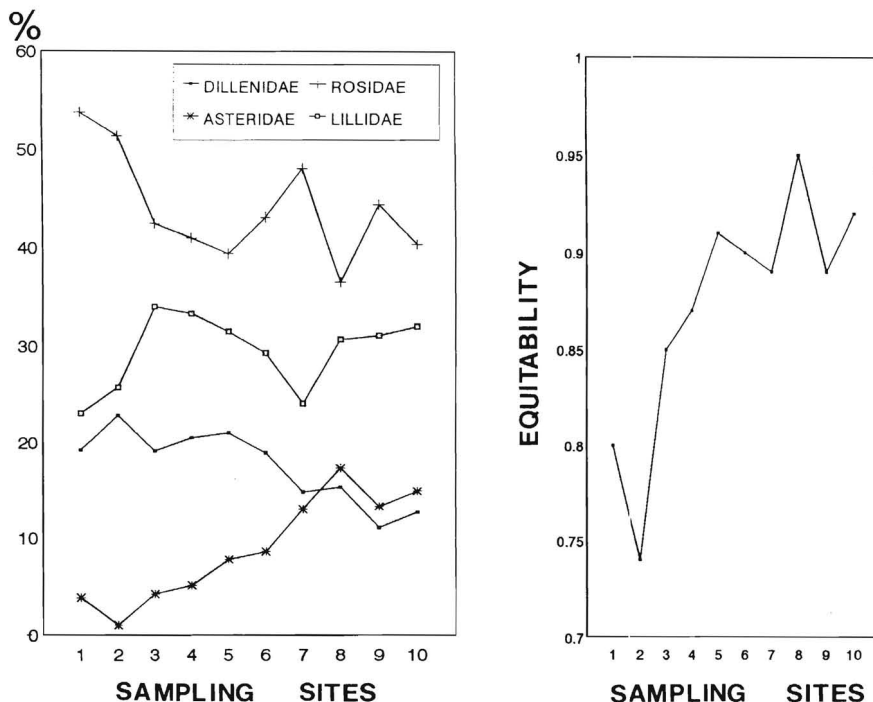


FIG. 5. Altitudinal changes in the relative importance of the 4 butterfly groups in relation to their caterpillar host plants. The altitudinal changes of equitability of the butterfly assemblage are also represented. Sampling site number 1 is at the highest elevation.

breadth increases with altitude (Fig. 3), hence the butterfly communities are composed primarily of common and euryecious species in the highest elevations (see Baz 1987 and Thomas & Mallorie 1985a who found the same pattern in other Mediterranean mountains). Stevens (1989) indicates that the latitudinal Rapoport's rule arises as a result of the narrowing range of climatic conditions the individuals experience with decreasing latitude. Since non-migratory individuals must be physiologically or behaviorally capable of tolerating the full range of conditions the seasonal changes impose on them, natural selection has favored broad tolerances at high latitudes. The consequence is that species from high latitudes have large latitudinal ranges because each individual of the species must have broad climatic tolerances just to survive at any latitude location.

At the other extreme, the breadth of climatic conditions each individual of a tropical species experiences is so narrow that there is no penalty for possessing narrow climatic tolerances. As Stevens (1992)

pointed out, if this explanation for Rapoport's latitudinal rule is correct, a pattern conforming to the altitudinal Rapoport's rule should be found, since the breadth of climatic conditions experienced by mountain residents does increase with increasing elevation. Certainly, our data support this idea.

Lastly, an interesting pattern in relation to the value of mountains for conservation purposes has been observed. Figure 5 shows that after man-managed localities (i.e., 8 and 10) are eliminated from the analyses, an inverse correlation between the mean chorological index and altitude exists, so that communities in the piedmont are composed of more rare or localized species (in a European context) than those at the highest elevations which probably is due to the peculiarities of basal habitats (Baz 1987, Thomas & Mallorie 1985b). In Iberia, mountains chains have acted as corridors for butterfly species of predominantly European origin (Martin & Gurrea 1990), and have facilitated the expansion in range of many European species. As a consequence, low altitudes seem to have inhibited dispersal of banal European butterflies (Martin & Gurrea 1990) and nowadays harbor a more original Mediterranean butterfly fauna. However, more detailed studies in undisturbed habitats within altitudinal ranges 8 and 10 of our study are necessary to prove this hypothesis.

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APPENDIX A. List of the 101 butterfly species recorded, with their distribution along the elevational gradient. Values of habitat breadth and the chorological index for each species are also included.

	1	2	3	4	5	6	7	8	9	10	Total	CI	HB
Papilionidae													
<i>Iphiclide feisthamelii</i> (Duponchel, 1832)		1			2	1	4	2	1		11	8	4.48
<i>Papilio machaon</i> Linnaeus, 1758						2	1			1	4	5	2.66
<i>Parnassius apollo</i> (Linnaeus, 1758)	14	15	22	11	10	4					76	8	5.05
Pieridae													
<i>Anthocharis cardamines</i> (Linnaeus, 1758)						4					4	5	1
<i>Anthocharis euphenoides</i> (Staudinger, 1869)		1	1	5	10	6	10	5	2		40	10	5.47
<i>Aporia crataegi</i> (Linnaeus, 1758)	1	3	14	20	15	22	21	16	9	3	124	5	7.31
<i>Colias alfacariensis</i> (Berger, 1948)	1	1	2		2	1	4	7	11	3	32	7	4.97
<i>Colias crocea</i> (Geoffroy, 1785)	3	1	2	9	4	4	8	5	19	19	74	6	5.83
<i>Euchloe ausonia</i> (Hübner, 1804)					1						1	10	1
<i>Gonepteryx cleopatra</i> (Linnaeus, 1767)			1	3	2	1	4		2	1	14	7	5.44
<i>Gonepteryx rhamni</i> (Linnaeus, 1758)				2	2						4	4	2
<i>Leptidea sinapis</i> (Linnaeus, 1758)		1						2	3	1	7	5	3.26
<i>Pieris brassicae</i> (Linnaeus, 1758)										1	1	4	1
<i>Pieris daphidice</i> (Linnaeus, 1758)				5	3	2	3	11	15	6	45	5	4.72
<i>Pieris rapae</i> (Linnaeus, 1758)			1	7	2	2	6	11	7	13	49	4	5.54
Lycaenidae													
<i>Aricia allous</i> (Geyer, 1837)		3	8	1		6	5	1	1	1	26	8	4.89
<i>Aricia cramera</i> (Eschscholtz, 1821)			6		3	6	2		2	2	21	9	4.79
<i>Callophrys rubi</i> (Linnaeus, 1758)						1		1			2	4	2
<i>Celastrina argiolus</i> (Linnaeus, 1758)				1						2	3	4	1.8
<i>Cupido osiris</i> (Meigen, 1829)							1		1		2	9	2
<i>Cyaniris semiargus</i> (Rottemburg, 1775)						1	1	2			4	5	2.66
<i>Glaucopsyche alexis</i> (Poda, 1761)	1					1	8	2	10	2	25	7	3.57
<i>Glaucopsyche melanops</i> (Boisduval, 1828)						1			2		3	10	1.8
<i>Lampides boeticus</i> (Linnaeus, 1767)			1							2	3	6	1.8
<i>Lycaeides idas</i> (Linnaeus, 1761)	2	5	2	1		3	2	2			17	5	5.66
<i>Lycaena alciphon</i> (Rottemburg, 1775)	2	4	1		1	7		3			18	7	4.15

APPENDIX A. Continued.

	1	2	3	4	5	6	7	8	9	10	Total	CI	HB
<i>Lycaena phlaeas</i> (Linnaeus, 1761)			1							1	2	4	2
<i>Nordmannia acaciae</i> (Fabricius, 1787)				1	1	2		2	1		7	7	4.45
<i>Nordmannia spini</i> (Denis & Schiffermüller, 1775)			2	1							3	6	1.8
<i>Plebejus argus</i> (Linnaeus, 1758)		1	5		7	7	5	1			26	5	4.5
<i>Plebejus pylaon</i> (Fischer, 1832)							2			1	6	9	2.57
<i>Polyommatus amandus</i> (Schneider, 1791)							1	1			2	7	2
<i>Polyommatus bellargus</i> (Rottemburg, 1775)	1	5	1	4	1	3	7	3	17	3	45	6	4.45
<i>Polyommatus damon</i> (Denis & Schiffermüller, 1775)	1	2	2								5	8	2.77
<i>Polyommatus dorylas</i> (Denis & Schiffermüller, 1775)		1	5	4	1	4			3		18	9	4.76
<i>Polyommatus fabressei</i> Oberthür, 1910						3	2				5	14	1.92
<i>Polyommatus hispana</i> (Herrichschäffer, 1852)			1			1	10	8	6	10	36	11	4.29
<i>Polyommatus icarus</i> (Rottemburg, 1775)	1	5	1	5	5	18	13	31	43	33	155	4	5.37
<i>Polyommatus nivescens</i> (Keferstein, 1851)						3					3	12	1
<i>Polyommatus ripartii</i> (Freyer, 1830)							3				3	11	1
<i>Polyommatus thersites</i> (Cantener, 1834)	1					2					3	8	1.8
<i>Pseudophilotes panoptes</i> (Hübner, 1818)						3	6	7	1	1	18	14	3.37
<i>Scolitantides orion</i> (Pallas, 1771)						2					2	8	1
<i>Syntarucus piriethous</i> (Linnaeus, 1767)							3	1	3	1	8	6	3.2
Libytheidae													
<i>Libythea celtis</i> (Laicharting, 1782)							1				1	8	1
Satyridae													
<i>Arethusana arethusa</i> (Denis & Schiffermüller, 1775)		2		2				4	3		11	8	3.66
<i>Chazara briseis</i> (Linnaeus, 1764)					1	1					2	8	2
<i>Coenonympha arcania</i> (Linnaeus, 1761)				3		1					4	6	1.6
<i>Coenonympha dorus</i> (Esper, 1782)					1	1				2	4	9	2.66
<i>Erebia epistygne</i> (Hübner, 1819)	8		1	2	1						12	13	2.05
<i>Erebia triaria</i> (De Prunner, 1798)	3	4	12	7	16	6					48	11	4.51
<i>Erebia zapateri</i> Oberthür, 1875			1	3		3					7	14	2.57
<i>Hipparchia fidia</i> (Linnaeus, 1767)								1	2	2	5	9	2.77
<i>Hipparchia hermione</i> (Linnaeus, 1764)			9	9	7	6		2		1	34	8	4.58
<i>Hipparchia semele</i> (Linnaeus, 1758)	53	34	29	15	22	16	11	4	3	2	189	9	5.03

APPENDIX A. Continued.

	1	2	3	4	5	6	7	8	9	10	Total	CI	HB
<i>Hipparchia statilinus</i> (Hufnagel, 1766)			1	4	3	5	4	4	1	1	23	8	6.22
<i>Hyponephele lupina</i> (Costa, 1836)			1		1		1	2	2	2	9	9	5.4
<i>Hyponephele lycaon</i> Muschamps, 1915	3	6	12	13	2	14	2	4			56	7	5.48
<i>Kanetisa circe</i> (Fabricius, 1775)		1	1			1	1	2	3	7	16	9	3.87
<i>Lasiommata megera</i> (Linnaeus, 1767)	1	3	4	8	11	4	4	7	1	3	46	4	7
<i>Maniola jurtina</i> (Linnaeus, 1758)							1	10	6	20	37	4	2.54
<i>Melanargia ines</i> (Hoffmannsegg, 1804)										1	1	10	1
<i>Melanargia lachesis</i> (Hübner, 1790)		1	11	18	10	20	24	19	17	37	157	10	6.96
<i>Melanargia russiae</i> (Esper, 1784)	1	2	2			1	2				8	9	4.57
<i>Pararge aegeria</i> (Linnaeus, 1758)			1	1		4			1		7	4	2.57
<i>Pyronia bathseba</i> (Fabricius, 1793)						1	1	6	2	1	11	9	2.81
<i>Pyronia cecilia</i> (Vallantin, 1894)									1	3	4	9	1.6
<i>Pyronia tithonus</i> (Linnaeus, 1771)							11	2	2	6	21	7	2.67
<i>Satyrus actaea</i> (Esper, 1780)			1	1	3	2					7	8	3.26
Nymphalidae													
<i>Aglais urticae</i> (Linnaeus, 1758)		1	1	3							5	4	2.27
<i>Argynnis adippe</i> (Denis & Schiffermüller, 1775)	5	17	10	11	5	10	8	10	5	12	93	5	8.71
<i>Argynnis aglaja</i> (Linnaeus, 1758)	5	3		1		1	7	2	1	3	23	5	5.34
<i>Argynnis niobe</i> (Linnaeus, 1758)		1	4								7	5	2.33
<i>Argynnis pandora</i> (Denis & Schiffermüller, 1775)				1		1					2	8	2
<i>Argynnis paphia</i> (Linnaeus, 1758)					2	4	4				10	5	2.77
<i>Brenthis hecate</i> (Denis & Schiffermüller, 1775)										1	1	8	1
<i>Euphidryas aurinia</i> (Rottemburg, 1775)								2	1		3	8	1.8
<i>Euphidryas desfontainii</i> (Godart, 1819)						6	6				12	10	2
<i>Issoria lathonia</i> (Linnaeus, 1758)	1	2	1	9	5	8	2	2			34	4	4.89
<i>Limenitis reducta</i> (Staudinger, 1901)						1		1		1	3	8	3
<i>Melitaea athalia</i> (Rottemburg, 1775)						3	8	12			23	5	2.43
<i>Melitaea cinxia</i> (Linnaeus, 1758)					1		6	1	8	18	34	5	2.71
<i>Melitaea deione</i> (Geyer, 1832)						1		1		1	3	10	3
<i>Melitaea didyma</i> (Esper, 1779)								2	1		3	7	4.26
<i>Melitaea parthenoides</i> (Keferstein, 1851)							1				1	10	1

APPENDIX A. Continued.

	1	2	3	4	5	6	7	8	9	10	Total	CI	HB
<i>Melitaea phoebe</i> (Denis & Schiffermüller, 1775)				1		3	3	5		4	16	7	4.26
<i>Vanessa cardui</i> (Linnaeus, 1758)	13	2	2		3		1			2	23	4	2.76
Hesperiidae													
<i>Carcharodus alceae</i> (Esper, 1780)								1			1	5	1
<i>Carcharodus boeticus</i> (Rambur, 1839)								1	1		2	8	2
<i>Erynnis tages</i> (Linnaeus, 1758)								3			3	4	1
<i>Hesperia comma</i> (Linnaeus, 1758)	5	6	5	3	3	3	1	1	3	1	30	5	7.25
<i>Pyrgus alveus</i> (Hübner, 1803)		3	1								4	5	1.6
<i>Pyrgus armoricanus</i> (Oberthür, 1910)			1	2				1	2	2	8	5	4.57
<i>Pyrgus carthami</i> (Hübner, 1819)	4	2	3	1		1					11	4	3.9
<i>Pyrgus cirsii</i> (Rambur, 1839)	1	2		12		5	3	2	1	1	27	8	3.94
<i>Pyrgus onopordi</i> (Rambur, 1839)								1			1	8	1
<i>Pyrgus serratulae</i> (Rambur, 1839)	2	16	3			2					23	6	1.93
<i>Spialia sertorius</i> (Hoffmannsegg, 1804)	1	1	2	3	1	1	1	11	3		24	5	3.89
<i>Syrichthus proto</i> (Ochsenheimer, 1816)									1		1	7	1
<i>Thymelicus acteon</i> (Rottemburg, 1775)							1			3	4	4	1.6
<i>Thymelicus flavus</i> (Brünnich, 1763)		2	1				8	4			15	4	2.64

APPENDIX B. Butterfly species included in each group of caterpillar host plant. Sources from Takhtajan (1980), Gomez-Bustillo and Fernandez-Rubio (1974) and Higgins and Riley (1980).

Dillenidae	Rosidae	Asteridae	Lillidae
<i>A. cardamines</i>	<i>I. feisthamelii</i>	<i>P. panoptes</i>	<i>P. hispana</i>
<i>A. euphenoides</i>	<i>P. machaon</i>	<i>A. urticae</i>	<i>A. arethusa</i>
<i>E. ausonia</i>	<i>P. apollo</i>	<i>E. aurinia</i>	<i>C. briseis</i>
<i>P. brassicae</i>	<i>A. crataegi</i>	<i>E. desfontainii</i>	<i>C. arcania</i>
<i>P. rapae</i>	<i>C. alfacariensis</i>	<i>L. reducta</i>	<i>C. dorus</i>
<i>P. daphidice</i>	<i>C. crocea</i>	<i>M. cinxia</i>	<i>E. epistygne</i>
<i>L. alciphon</i>	<i>G. cleopatra</i>	<i>M. didyma</i>	<i>E. triaria</i>
<i>L. phaleas</i>	<i>G. rhamni</i>	<i>M. parthenoides</i>	<i>E. zapateri</i>
<i>A. adippe</i>	<i>L. sinapis</i>	<i>M. deione</i>	<i>H. fidia</i>
<i>A. aglaja</i>	<i>A. allous</i>	<i>M. athalia</i>	<i>H. hermione</i>
<i>A. niobe</i>	<i>A. cramera</i>	<i>M. phoebe</i>	<i>H. semele</i>
<i>A. pandora</i>	<i>C. rubi</i>	<i>V. cardui</i>	<i>H. statilinus</i>
<i>A. paphia</i>	<i>C. argiolus</i>	<i>C. boeticus</i>	<i>H. lupina</i>
<i>I. lathonia</i>	<i>C. ostris</i>	<i>S. proto</i>	<i>H. lycaon</i>
<i>C. alceae</i>	<i>C. semiargus</i>		<i>K. circe</i>
<i>P. alveus</i>	<i>G. alexis</i>		<i>L. megera</i>
<i>P. carthami</i>	<i>G. melanops</i>		<i>M. jurtina</i>
	<i>L. boeticus</i>		<i>M. ines</i>
	<i>L. idas</i>		<i>M. lachesis</i>
	<i>N. acaciae</i>		<i>M. russtae</i>
	<i>N. spini</i>		<i>P. aegeria</i>
	<i>P. argus</i>		<i>P. bathseba</i>
	<i>P. pylaon</i>		<i>P. cecilia</i>
	<i>P. amandus</i>		<i>P. tithonus</i>
	<i>P. bellargus</i>		<i>S. actaeae</i>
	<i>P. damon</i>		<i>P. onopordi</i>
	<i>P. dorylas</i>		<i>T. acteon</i>
	<i>P. fabressei</i>		<i>T. flavus</i>
	<i>P. icarus</i>		
	<i>P. nivescens</i>		
	<i>P. ripartii</i>		
	<i>P. thersites</i>		
	<i>S. orion</i>		
	<i>S. pirithous</i>		
	<i>L. celtis</i>		
	<i>B. hecate</i>		
	<i>E. tages</i>		
	<i>H. comma</i>		
	<i>P. armoricanus</i>		
	<i>P. cirsii</i>		
	<i>P. serratulae</i>		
	<i>S. sertorius</i>		