HABITAT PREFERENCES AND STATUS OF THE MADEIRAN BUTTERFLY FAUNA

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With 5 tables and 2 figures

ABSTRACT. Line transect methods were used to record the butterfly species present in a variety of habitats on Madeira in March and April 1983. The main aim was to provide a basis for future comparative work. Correlations of species with habitat type are produced and the results used in conjunction with past records for a discussion of the status of certain species. Particular attention is paid to the effects of recent immigrants and the taxon cycle on the endemic species and subspecies.

RESUMO. Foram utilizados diversos percursos para assinalar espécies de borboletas numa variedade de habitats na Madeira, em Março de 1983. O principal objectivo do trabalho foi o de fornecer uma base para um trabalho comparativo futuro. Foram determinadas correlações de espécies com tipos de habitats e os resultados utilizados, em conjunção com anteriores, para uma discussão do estado de certas espécies. Foi prestada particular atenção aos efeitos de imigrantes recentes e ao ciclo dos táxones nas espécies e subespécies endémicas.

INTRODUCTION

Madeira has fourteen resident species of butterflies, three are endemic subspecies: Large White; Brimstone and Southern Grayling and one, the Madeiran Speckled Wood is a full endemic species. The majority of Madeira's butterflies are widespread, originating from mainland Europe; one exception is a subspecies of the Indian Red Admiral which is also found on the Canaries (Higgins & Riley, 1980). Three species are recent acquisitions to the fauna. The Small White, first recorded from Madeira in 1971 became widespread and abundant in 1974 (Wolf, 1975). The Speckled Wood, a single specimen of which was taken in 1976, became common the following year (Higgins, 1977) and the Monarch which has increased

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in abundance in the last few years is now known to breed (Maul pers. comm.). Several other species: Pale Clouded Yellow; Queen of Spain Fritillary and Diaden are vagrants.

In the past the endemics were perhaps more widespread and abundant than they are today. A decline in status may be attributed to the success enjoyed by recent colonizers and/or destruction and change of habitats through agricultural practices and land use.

Once densely wooded, Madeira now has natural forests of Laurel species (eg. *Laurus azorica, Ocotea foetens*) and Tree Heather *(Erica aborea*) which cover only 16% of the land surface and are largely restricted to the inaccessible valleys to the north. Cultivation and habitation account for 31% of land use, pasture for livestock 30% and managed forests, mainly of pine (*Pinus pinaster*) with some mimosa (*Acacia* spp.) and Eucalyptus *(Eucalyptus globulus),* a further 23% (Ingelög & Bråkenhielm, 1974). The natural vegetation is very vulnerable; many forest fires are caused deliberately to clear ground for agricultural purposes and to create pasture for grazing (Bramwell *et al.,* 1982).

A series of line transects through the various habitat types was conducted with the aim of obtaining information on the distribution of the various species, the status and relative abundance of the endemics and the recent colonists. Respective habitat preferences were established with a commitment to conservation and management for endangered species and threatened habitats.

METHODS

Between 27th March and 12th April 1983, two observers walking down the gradient made eleven transects of varying length through different habitats (Figure 1).

All sightings of butterflies and birds were recorded. The bird data have been analysed seperately where the same methods were applied (Jones *et al.* in prep.). The recordings were made in five minute blocks during which various habitat features were assessed on a 0 to 4 scale, these were: amount of Housing; Agiculture; Laurel; Tree Heather; Pine; *Eucalyptus;* Mimosa and Pasture. The scientific names of the butterflies appear in Appendix 1.

Precise locations of each transect and other information such as time, altitude and weather conditions are presented in Table 1. Transect 7 did not produce any butterflies and it is therefore excluded from the analysis. Mean habitat scores for each transect are shown in Table 2. It was impossible to measure the distance walked in most cases as the 1 : 50,000 maps of the island do not record the recently finished tracks and roads we often used.

Species seen on each transect are expressed as total number and mean number per five minute count. Totals greater than one were tested

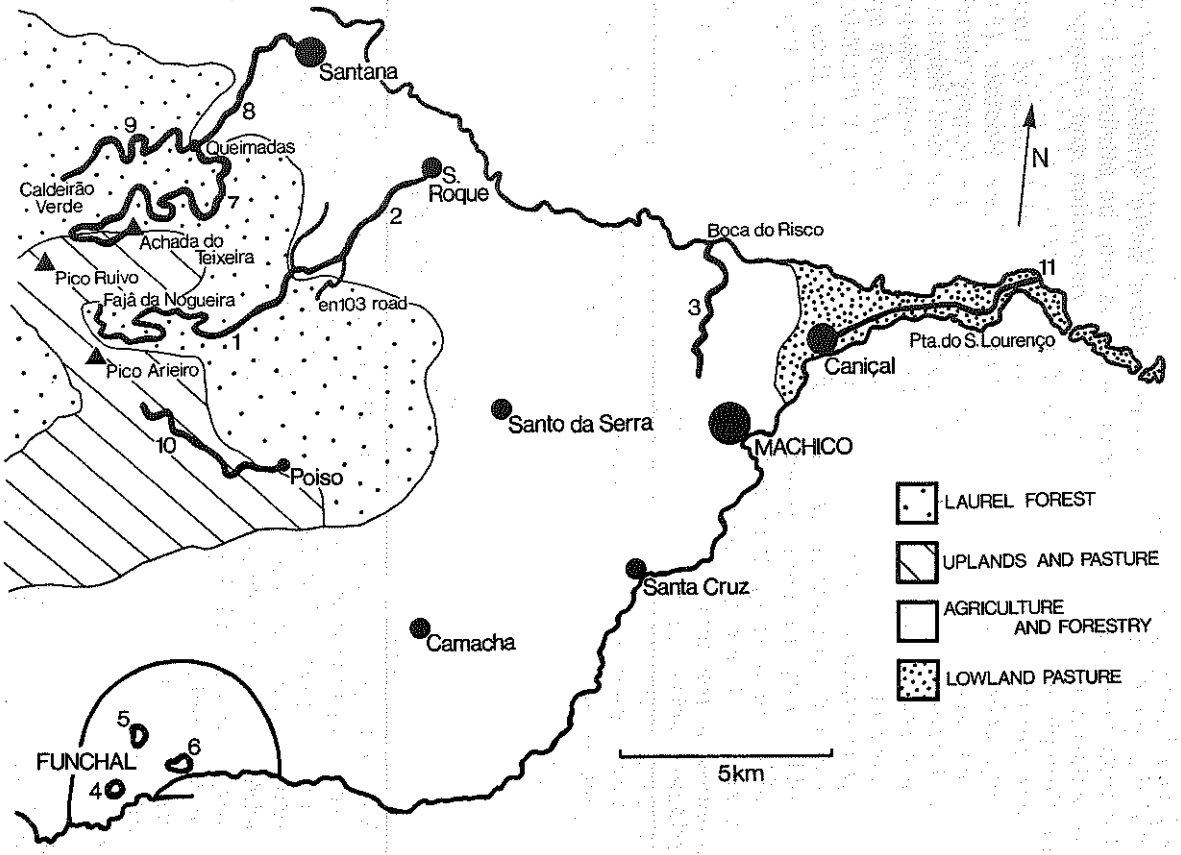

Fig. 1. – Map of the eastern half of Madeira showing transects and major habitat types.

TABLE 1

LOCATION AND DESCRIPTION OF TRANSECTS

Transect	Location	Initial Altitude	Final Altitude	Grid Reference	Weather	Time
1	Levada above Faja da Nogueira to the EN103 road (Faial to Funchal).	925m	410m	249214 to 254246	overcast	1500 to 1705
2	EN103 road towards Funchal, levada to Cedro Gordo, EN101 road at S. Roque do Faial.	400m	75m	254246 to 278272	overcast	1112 to 1332
3	Boca do Risco on the north coast, down Ribeiro Seco to the 101-3 road.	450m	125m	231338 to 258341	fine	1725 to 1840
4	Large private garden west of Funchal.	20m	20m	132197	sunny	1535 to 1555
5	Gardens of the Museu da Quinta das Cruzes, Funchal.	30m	30m	140208	sunny	1426 to 1436
6	Central gardens, Avenida Arriaga, Funchal.	10m	10m	137211	overcast	1242 to 1257
7	Peak of Achada do Teixeira, by road, via Pico das Pedras forest park to Queimadas.	1590m	875m	267202 to 287216	fine rain	1040 to 1245
8	Queimadas, by road to EN101 road at Santana.	875m	375m	287216 to	overcast	1442 to 1557
9	Caldeirao Verde, by levada path to Queimadas.	880m	875m	287216 to 311237	fine	1340 to 1500
10	Casa do Arieiro (below summit of Pico Arieiro) by road to crossroads at Poiso.	1580m	1425m	208232 to 219206	sunny	1425 to 1540
11	Canical, by path and road, along Ponta de S. Lourenco to cliff overlooking I. do Guincho.	10m	50m	229373 to 245415	sunny	1315 to 1610

Grid references and altitudes from "Arquipelago da Madeira", scale 1:50,000, published by Instituto Geografico e Cadastral, 1971

for their deviation from a Poisson distribution with the X^2 values and the probabilities given in Table 3.

Spearman Rank Correlation Coefficients were calculated to measure the association in each five minute recording between the habitat variables and the numbers of each species (Table 4). Correlations between habitat variables and the Shannon-Weaver diversity index H', (Shannon & Weaver, 1949) are given in Table 5. An extra variable in both tables «Habitat Diversity», is a somewhat contrived one produced by giving a

TABLE 2

MEAN "HABITAT TYPE" SCORES FOR EACH TRANSECT

	Transect										
Habitat	1 n=25	2 n=28	3 n=15	4 n=4	5 n=2	6 n=3	7 n=25	8 n=15	9 n=16	10 n=15	11 n=35
A	0.08	1.43	1.00	4.00	4.00	4.00	0.12	1.07	0.06	0.07	0.43
B	0.56	1.64	1.67	2.00	1.00	0.00	0.24	1.40	0.06	0.07	0.34
C	3.48	0.86	0.60	0.00	0.00	0.00	1.48	0.40	3.94	0.33	0.00
D	2.48	1.00	1.07	0.00	0.00	0.00	2.68	0.40	2.00	0.80	0.00
E	0.12	1.25	0.67	0.00	0.00	0.00	0.72	0.87	0.00	0.20	0.00
F	0.00	0.04	0.53	0.00	0.00	0.00	0.28	1.40	0.00	0.00	0.00
G	0.48	0.79	0.80	0.00	0.00	0.00	0.28	0.27	0.00	0.00	0.00
H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.13	3.66

A=housing; B=agriculture; C=Laurel; D=Heather; E=Pine; F=Eucalyptus; G=Mimosa; H=pasture; n=number of five minute recording sessions.

five minute period a score of one if it has one of the habitat types represented, two if it has two of the types represented and so on to give a range of one to eight.

Finally the distributions of the commonest two species, (the Speckled Woods) are shown as their total occurrence within each transect (Figure 2).

RESULTS

All nine species recorded during the transects were resident. It was impossible to determine whether the Red Admirals were *Vanessa atalanta* or *Vanessa indica vulcania* as the few individuals recorded were not observed at close quarters; it is probable however that they were examples of the latter, which is reputed to be the more abundant species on Madeira (Swash & Askew, 1982) .

Resident butterflies that were not seen include the subspecies of the Southern Grayling, the Tree Grayling and the Small Copper. Graylings fly from June to September but the Small Copper flies from February and March and also later in two more broods (Higgins & Riley, 1980). The

latter is a species we would have expected to encounter, although it is noted to be only locally common (Swash & Askew, 1982). Monarch butterflies were seen in Funchal on two occasions but not during the transects in this locality.

From our transects the habitats which are the most diverse are those of Housing, Agriculture and Pine in that order (Table 5). Associated with housing and agriculture are many introduced plants and shrubs and also fruit trees and agricultural produce which might be expected to attract a wide variety of species.

Correlations for species with various habitat types produces some interesting associations. Without exception, each species has its highest correlation with one of the habitat variables other than Habitat Mixture (Table 4).

The endemics, Large White, Brimstone and Madeiran Speckled

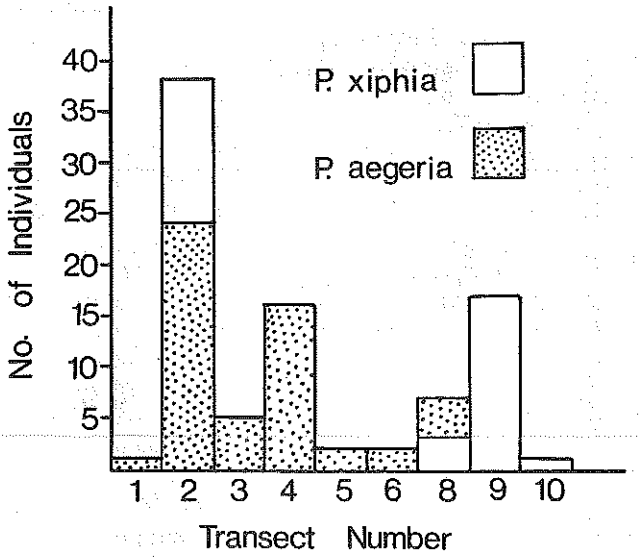

Fig. 2. – Total numbers of the two Speckled Wood species on each transect.

Wood, are the only species that are positively correlated with the indigenous vegetation of Laurel and Tree Heather. The Madeiran Speckled Wood is more highly correlated with the variable Pine only secondarily associated with Laurel and Tree Heather whereas the Large White and Brimstone are exclusively correlated with the latter two habitat types.

Examples of the Large White and Brimstone were seen on Transect 8 (Table 3) which had the highest mean score for Laurel (Table 2) but neither species was observed on Transect 1 which also scored high for Laurel and encompasses a locality where both species have previously been recorded (Swash & Askew, 1982).

TABLE 3

NUMBERS OF BUTTERFLY SPECIES SEEN ON EACH TRANSECT EXSPRESSED AS SUM, MEAN AND THE CHI-SQUARED VALUE AND ITS PROBABILITY OF DEVIATION FROM A POISSON DISTRIBUTION

Species		Transect Number 1 n=25	2 n=28	3 n=15	4 n=5	5 n=2	6 n=3	8 n=15	9 n=16	10 n=15	11 n=35
Speck. Wood n=57	χ	1	24	5	16	2	2	7			
	$\bar{\chi}$	0.04	0.86	0.33	3.20	1.00	0.66	0.46			
	χ^2	-	35.00	25.92	3.57	1.40	3.46	22.29			
	P			*							
M. Sp. Wood n=59	χ		38					3	17	1	
	$\bar{\chi}$		1.35					0.20	1.06	0.06	
	χ^2		29.76					39.20	16.68	-	
	P							***			
Small White n=18	χ		5	1	5					1	6
	$\bar{\chi}$		0.18	0.07	1.00					0.07	0.17
	χ^2		82.80	-	4.00					-	75.80
	P		***	-							
Large White n=2	χ								2		
	$\bar{\chi}$								0.13		
	χ^2								60.00		
	P								***		
Red Admiral n=4	χ		2		1					1	
	$\bar{\chi}$		0.07		0.20					0.07	
	χ^2		99.10		-					-	
	P		***								
Cl. Yellow n=23	χ		2					2			19
	$\bar{\chi}$		0.07					0.13			0.53
	χ^2		99.10					36.90			53.36
	P		***					**			**
Paint. Lady n=7	χ										7
	$\bar{\chi}$										0.20
	χ^2										14.18
	P										*
Brimstone n=3	χ									3	
	$\bar{\chi}$									0.19	
	χ^2									32.20	
	P									**	
Long-t. Blue n=10	χ		4	3	2						1
	$\bar{\chi}$		0.14	0.20	0.40						0.03
	χ^2		67.30	39.24	8.90						-
	P		***	***							

*=significant at the 0.05 level, ** at the 0.01 level and *** at the 0.001 level
n=number of five minute recording sessions.

Only one individual was observed throughout Transect 1 however, probably as a result of the inclement weather on the day of recording, which was cool and overcast after a heavy downpour during the early hours of the morning.

Previous records for the Large White come from several localities, mainly to the northeast: Pico Arieiro, (Oehmig, 1977) Santo da Serra, (Martin, 1941) Porto da Cruz, Fajã da Nogueira (Swash & Askew, 1982), Ribeiro Frio (Martin, 1941; Oehmig, 1977; Swash & Askew, 1982), Monte (Worms, 1964) and Aguas Mansas, (Oehmig, 1977) also westwards at Rabaçal, Caramujo and Chão das Feiteiras (Gardner & Classey, 1960). This species is more often associated with a higher altitude and perhaps a Laurel habitat but has also been observed in southern coastal areas: Santa Cruz and Funchal (Swash & Askew, 1982) and Oehmig (1977) considers this species to be widespread on the island, only being absent from Ponta de São Lourenço.

Sightings and localities for the Brimstone are poorly documented. Baker (1891) remarks that this species is common whilst Gardner and Classey (1960) suggest it is scarce and restricted to the northern part of the island. Oehmig (1977) associated it with Laurel Forest but it was only frequent at Ribeiro Frio. Swash and Askew (1982) saw several specimens at Fajã do Cedro Gordo; Fajã da Nogueira and Ribeiro Frio and consider the species to have declined to an uncommon and local status.

The evidence suggests that the Large White is not as rare and is perhaps more widespread than the Brimstone. If a Laurel habitat is important for these species then it might be expected that their declined status may be a consequence of the diminishing habitat rather than any pressure from recent additions to the fauna such as the Small White. The transect data for birds (Jones et al. in prep.) found the endemic Long-toed Pigeon *(Columba trocaz)* to be similarily rare and exclusively associated with a Laurel habitat.

Red Admiral, Speckled Wood and Small White are species that are all positively correlated with the variable Housing (Table 4).

The Small White sucessfully colonized Madeira in 1974 and became common in all the coastal locations from Funchal to Ribeira Brava and northwards to Serra d'Agua and was also abundant near Monte, Queimadas, Curral das Freiras and Pico Arieiro (Wolf, 1975). However, Swash and Askew (1982) found this species to be restricted to the coastal areas. This observation in conjunction with the transect data suggest that the species is no longer as widespread as it was initially and it tends now to be associated with lower elevations where housing and agriculture predominate and where one might typically expect to find this species.

The two Speckled Woods differ from each other with regard to their respective highest habitat correlations (Housing for *Pararge aegeria* and Pine for *Pararge xiphia*) (Table 4); both however are positively correlated with the same habitat variables to a greater or lesser extent. The Spearman

TABLE 4

SPEARMAN RANK CORRELATION COEFFICIENTS OF HABITAT SCORES (FROM TABLE 2) WITH NUMBERS OF EACH SPECIES PRESENT IN EACH FIVE MINUTE COUNT (FROM TABLE 3)

Species	Housing	Agricult.	Laurel	Tree Heather	Pine	Eucalypt.	Mimosa	Pasture	Habitat Diversity
Speckled Wood	+0.395***	+0.339***	-0.197*	-0.179*	+0.301***	+0.086	+0.289***	-0.301***	+0.269***
Mad. Sp. Wood	+0.171*	+0.145	+0.226**	+0.169*	+0.364***	-0.068	+0.162*	-0.297***	+0.334***
Small White	+0.284***	+0.220**	-0.246**	-0.272***	-0.014	-0.107	-0.016	+0.051	-0.031
Large White	-0.063	-0.076	+0.125	+0.084	-0.052	-0.027	-0.054	-0.052	-0.022
Red Admiral	+0.206**	+0.173*	-0.141	-0.116	+0.155	-0.055	+0.064	-0.045	+0.086
Cloud. Yellow	-0.033	-0.063	-0.294***	-0.317***	-0.142	-0.115	-0.382***	+0.382***	-0.295***
Painted Lady	-0.107	-0.145	-0.174*	-0.202*	-0.130	-0.068	-0.134	+0.330***	-0.253**
Brimstone	-0.109	-0.134	+0.218**	+0.146	-0.091	-0.048	-0.094	-0.091	-0.039
Lg.-tailed bl.	+0.117	+0.207*	-0.044	-0.072	+0.202*	+0.100	+0.214**	-0.082	+0.177*

*=significant at the 0.05 level, ** at the 0.01 level, and *** at the 0.001 level. The highest correlation for each species is underlined.

Rank correlation coefficient is significantly positive between the two species ($n = 159$, $r = 0.178$, $P = 0.025$) implying that they do tend to occur together.

The abundance of these speceis on each of the Transects (Figure 2) show that *P. aegeria* tends to occur exclusively on those transects at lower elevations; at higher altitudes (Transects 9 and 10) *P. xiphia* is prominent whereas both occur together on Transect 2 and Transect 8.

Prior to the establishment of *P. aegeria* on Madeira *P. xiphia* seems to have been more widespread than it is today. Baker (1891) claimed that *P. xiphia* was one of the commonest species, particularly at intermediate

TABLE 5

SPEARMAN RANK CORRELATION COEFFICIENTS OF HABITAT TYPES WITH DIVERSITY (H') OF BUTTERFLY SPECIES SEEN IN EACH FIVE MINUTE COUNT.

Habitat Type	Diversity(H')
Housing	+0.303***
Agriculture	+0.249**
Laurel	-0.177*
Tree Heather	-0.206**
Pine	+0.208**
Eucalyptus	-0.120
Mimosa	+0.125
Pasture	-0.063
Habitat mixture	+0.107

*=significant at the 0.05 level, ** at the 0.01 level and *** at the 0.001 level.

altitudes. It was also regarded as common in Funchal and Machico on the south coast (Cockerell, 1923) and in the city gardens of Funchal and allotments to the west of the city and at Palheiro east of Funchal (Worms, 1964). Figure 2 shows that *P. xiphia* does not occur at lower elevations and this was noted too by Oehmig (1977) who recorded this species from 500 to 1000 m and Swash and Askew (1982) who found this species predominantly at intermediate elevations such as, Ribeiro Frio and Fajã da Nogueira.

Clouded Yellow and Painted Lady are two species that are associated with the habitat variable Pasture and are negatively correlated with

all the other habitat types (Table 4). However neither species was seen on Transect 10, which also scored high for Pasture (Table 2). The Clouded Yellow always seems to have been abundant on Madeira especially at the lower altitudes and particularly on the south coast. It has been recorded from Palheiro Ferreiro, Pico da Ponta Cruz (Gardner & Classey, 1960) and abudantly in Funchal (Worms, 1964). Swash and Askew (1982) described this species as common in open areas from sea level up to 1300m and especially abundant on the Ponta de São Lourenço, from which most of the transect records come (Table 3). The Painted Lady was similarly observed from this locality but was not common (Table 3).

The Ponta de São Lourenço and the south coast generally tend to be warmer and drier than the mountainous interior and north coast, which may account for the fact that some species are preferentially associated with a pasture habitat where the climate is more equable.

The distribution of a species within a transect may be expected to be related more or less closely to the distribution of the resources it is reliant upon. On Transect 2, where both species of Speckled Wood occur in large numbers, they are randomly distributed, whereas *P. aegeria* on Transect 3 deviates from a random distribution, ($P =< 0.05$) and the same is true of *P. xiphia* on Transect 8 ($P = 0.001$) (Table 3). The standard deviations of the habitat variables with which the two species are most highly correlated (Pine and Housing) also have different distributions within Transects 2, 3 and 8:

Transect 2, Pine, $S = 0.44$, $\overline{x} = 1.25$;
Transect 8, Pine, $S = 0.9$, $\overline{x} = 0.87$;
Transect 2, Housing, $S = 0.57$, $\overline{x} = 1.43$ and
Transect 3, Housing, $S = 1.25$, $\overline{x} = 1$

The habitat variables Pine and Housing tend to be more evenly apportioned on Transect 2 than either Housing on Transect 3 or Pine on Transect 8. This could account for the random distribution of the two species on Transect 2 and the tendency for species to be aggregated where their prefered habitat type is similarly distributed.

The Small White, a species most highly associated with housing is significantly aggregated on Transect 2 and not so on Transect 4 (Table 3), where the variable Housing scored a maximum for each five minute count of that transect and so was evenly distributed. This lends support to the idea that selected habitat variables do bear some real relationship to the distribution and behaviour of species and may be considered useful criteria upon which to base an objective assessment of the fauna.

DISCUSSION

The advantage of transect methods (as opposed to casual recordings) is that they provide an objective and easily repeated means of

assessing both relative abundance and habitat preferences. Pollard (1977, 1982) developed transect methods as a means of assessing the habitat needs and for monitoring the effects of management of habitats on butterflies and also as an alternative to mark recapture for estimating abundance. Pollard calculated abundance by summing the means of each species count for every week of the recording period (April to September) with separate indexes calculated for each generation and for autumn and spring flights for over wintering species.

Thomas (1983), expanding on Pollard's ideas, took account of the flight area of species in determining the route taken for the transect which zig-zagged through these flight areas. Counts were made within a predetermined width and within an imaginary box of 5m length in front of the observer. It was possible to calculate a population index from the density of adults, the length of the transect and the flight areas which were found to agree closely estimates obtained from whole day counts made at comparable reference sites.

A thorough survey incorporating some of the above criteria could prove especially useful for providing detailed information regarding the ecology and requirements of the Madeiran butterflies.

The restricted range and apparent rarity of the Large White and Brimstone and the indications that suggest *P. xiphia* is no longer as widespread as it was prior to the establishment of *P. aegeria* may be attributed to the theoretical events of the taxon cycle (Wilson, 1961). Ricklefs and Cox (1972) recognised four stages of the cycle which were based on the geographical distribution and the degree of subspeciation exhibited by birds within an archipelago. The initial stages are those where species recently invading an archipelago are widespread and show little or no subspeciation on different islands culminating in a stage where species are endemic to single islands. They argue that successful new immigrants have a distinct competitive advantage over species that have been on an island for a long time as potential predators, disease and parasites have had little exposure to the newcomer. The cycle is driven by the combination of counteradaptation from the island biota and competitive pressure from new immigrants reducing the competitive ability of the earlier colonists. As new, competitively superior immigrants arrive on an island they tend to push older immigrants into progressively fewer habitats and reduce their population densities (Ricklefs & Cox, 1978). The subsequent destruction of habitats in which species become confined may lead to the extinction of the endemic species. It is necessary therefore to identify the requirements of endangered species and to provide a certain number of refuges to maintain viable populations.

The variables Housing, Agriculture and Pine are the habitats which tend to support the highest diversity of species. However, Laurel and Tree Heather and areas of pasture land such as the peninsula of São Lourenço with fewer species are important as they provide unique habitat

types and support a different set of species. The peninsula of São Lourenço is threatened, mainly from the encroachment of tourism along the south coast and the effects of erosion through excessive grazing by cattle.

For the remaining Laurel forests it is necessary to identify at least the best areas where the greatest densities of species associated with this kind of habitat may be found. The conservation and management of such areas may then favour the survival of an already small fauna where the relative proportion (31%) of endemism is great.

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APPENDIX 1

ENDEMIC SPECIES & SUBSPECIES	VERNACULAR NAMES
Pieris brassicae wollastoni Butler	Large White
Gonepteryx cleopatra maderensis Felder	Brimstone
Hipparchia aristaeus maderensis Baker	Southern Grayling
Pararge xiphia Fabricius	Madeiran Speckled Wood

NON-ENDEMIC SPECIES

Artogeia rapae L.	Small White
Colias crocea Geoffroy	Clouded Yellow
Lycaena phlaeas L.	Small Copper
Lampides boeticus L.	Long-tailed blue
Vanessa atalanta L.	Red Admiral
Vanessa indica vulcania Godart	Indian Red Admiral
Vanessa cardui L.	Painted Lady
Pararge aegeria L.	Spekled Wood
Neohipparchia statilinus Hufnagel	Tree Grayling
Danaus plexippus L.	Monarch

VAGRANT SPECIES

Colias hyale L.	Pale Clouded Yellow
Hypolimnas misippus Cramer	Diaden
Issoria lathonia L.	Queen of Spain Fritillary