Cover
Detail of the upperside of Provence Chalk-hill Blue Polyommatus fulgens (photo: A. Miquel).
Small White Pieris rapae on barley spike (photo: J.C. Vicente Aranz).

Editorial
Cynthia celebrates its tenth edition
This edition of Cynthia, the annual review of the CBMS network, is, ten years to see the light of day. Over the past 10 years, Cynthia has consolidated its position as an attractive, rigorous work that provides a wealth of information – not only for CBMS collaborators, but also for others interested in this wonderful group of insects – regarding progress in the study of the ecology and conservation of butterflies in Catalonia, Andorra and the Balearic Islands. From the outset, we have tried to establish a balance between purely descriptive information relating to the workings of the CBMS and articles with pedagogical content or that discuss advances in the study of Catalan butterflies. Of the more educational content, to date we have published identification sheets for 59 species (almost a third of all butterflies in Catalonia) and articles summarizing knowledge of the ecology of a further 11 species. Data from the CBMS network has been essential in this task of providing new information about these species.

In this tenth edition, we shine the spotlight on the Swallowtail Papilio machaon, one of the most spectacular of all our butterflies. This species appears in practically all the CBMS itineraries, even those in the Balearic Islands and in high mountain areas, and as such, it is one of the most familiar of all Catalan butterflies. Nevertheless, we hope that all will learn something about its biology and ecology through this article and thus be able to view this wonderful species through different eyes. As well, in this edition you will find all the habitual sections that we have maintained over the past 10 years. We would like to thank all of those who have provided us with the photographs and drawings that accompany the texts, an essential part of Cynthia and one that guarantees an attractive design that cannot fail to increase interest in the world of the butterflies.

Finally, we are pleased to be able to announce in these difficult times the consolidation of the CBMS project thanks to the signing of a four-year agreement between the Museu de Granollers – Ciències Naturals and the Catalan Government. This agreement will ensure that there will be sufficient funding to continue the efficient running of the CBMS and that all the data collected will be analyzed rigorously in order to extract as much relevant information as possible.

Current situation (2010) of the Butterfly Monitoring Scheme in Catalonia, Andorra and the Balearic Islands
In all, 69 stations provided complete data during the 17th CBMS season. Four new stations were incorporated into the scheme, while at a further four stations preliminary but regular counts were undertaken. The majority of the stations in the BMSAnd network and on Menorca and Eivissa continued to function. In total, 142,426 butterflies belonging to 164 species were counted in 2010.

During the 2010 season counts at 69 stations provided sufficient data to calculate the annual indexes of the species found (fig. 1). As well, preliminary counts have continued at Llobra (Solsonès, 830 m), Planes de Son (Pallars Sobirà, 1,540 m) – these two stations will form part of the network from 2011 onwards – and Moisà (Bages, 700 m), while a new count was begun at Meandre de Castellbell (Bages, 150 m).

The available annual series are shown in figure 2. There are currently 47 stations for which datasets of eight or more years are available. The Cortalet station is the oldest in the network (dataset going back 22 years) and a further five stations have already provided data continuously for 17 years. These figures give some idea of the ability of the CBMS database to detect population trends operating at mid- and long-term.

New transects
Sils (La Selva, 66 m). This butterfly walk takes place in and around L Estany de Sils, a lake whose basin has largely been drained, and as such this hygrophilous community is well represented (Magnuscarion grassland communities and hay meadows). Nevertheless, the itinerary is quite diverse and includes areas of pasture, meadows, scrub and poplar and holm-oak woodland and, as a result, the butterfly community is also fairly diverse despite being located in a lowland area. Counts have revealed the presence of butterflies that are scarce outside of upland areas – Glanville Fritillary Melanargia glauca, Violet Fritillary Boloria dia and Black-veined White Aporia crataegi – and a remarkable population of Spanish Festoon Zerynthia rumina in an area of acid substrate, as well as occasional sightings of Lesser Purple Emperor Apatura ilia and Mediterranean Skipper Hesperia c. nunnus. Part of the walk passes through land that is managed by a stewardship agreement with the association Acció natura; counts are carried out by Antoni Mariné, a member of this association.

El Brull (Osona, 832 m). This itinerary was started as a substitute for the Viladrau walk that was outside the limits of the Montseny Natural Park. This new itinerary runs through more Mediterranean habitats, dominated by holm oaks, although there are still plenty of pasture and grassland that ensure that the diversity of butterfly species is very high. Given that the substrate of the itinerary is calcareous, this area holds one of the richest butterfly assemblages in the whole of the Montseny. The Lycæinae are particularly well represented and include interesting species such as Small Blue Capido minimus, Catalan Furry Blue Polyommatus fulgens, Mazarine Blue P. remiarius, Chapman’s Blue P. thoroides and Escher’s Blue P. ciceri, as well as many members of the genus Melissa and other species that are scarce in the CBMS network as a whole. The counts are carried out by Arnau Amat.

Vacarrises (Valle Occidental, 325 m). This walk passes through woodland near the town of Vacarrises that is dominated by scattered holm oaks and pines. Although the butterfly communities are rather poor, there is still a large number of Marsh Fritillaries Speyeria aurinia, and populations of rare species such as Provence Hairy Merus bellalis and Dingy Skipper Eueides toges. The counts are carried out by José Manuel Serra.

Sant Feliu de Pallerols (La Garrotxa, 430 m). This new itinerary is situated on a south-facing slope in La Garrotxa Volcanic Zone Natural Park in an area of pasture and holm and downy oak woodland. It is very rich in butterflies as the around 70 species of butterflies counted in the first season testify. Both Lycæinae and Nymphalidae are abundant, and there are good populations of species that have generally more northerly distributions in Catalonia such as Provençal Short-tailed Cupido daceta and Short-tailed C. arigades Blues, Sloe Hairstreak Satyrion acis, Turquoise Polyommatus dorylas and Chalkhill Blue P. cordun Blues, Map Butterfly Araschnia levana and White Admiral Limenitis camilla, although more southerly species such as Provence Hairy Merus bellalis, Two-tailed Pasha Chanares jasius, Striped Grayling Hipparchia sara and Spanish Gatekeeper Pyronia bähmi also appear. The counts are carried out by Beth Cobol.

The counts for 2009, 2008 and 2007 were compared to 2009, there were four more active stations in 2010 and the total number of active transects now approaches the 70 stations that were walked in 2007 and 2008. In 2010 walks were discontinued at four sites: El Remolar, Olivella, Pesons and Viladrau. The transect at Olivella alternates annually with those of Vallgrassa and Olesa de Bonesvalls, while the station of Viladrau has been replaced by that of El Brull (see above). At both El Remolar and Pesons the walks have been discontinued due to a problem of staffing in these two protected area. The loss of data from Pesons is very unfortunate since this walk was the highest in the whole network and was very representative of alpine environments in Andorra. On the other hand, the stations at Olesa de Bonesvalls, La Granja d’Excarr and L'Aigubarrèg (the latter two in El Segrià) were all reactivated in 2010.

Habitats represented
The main environments and plant communities represented in the 2010 counts are detailed in table 1. The predominance of the Mediterranean environments – above all the various different types of holm oak woodland (54 of itineraries) – continues, although the number of upland montane habitats represented now stands at 13 itineraries (20% of total). Subalpine habitats are still poorly represented, a situation that has been worsened by the loss of the
The list of butterflies detected in 2010 and in previous years can be found in table 2. In all, 164 species were detected in 2010, four more than in the previous year and 26.5 more than the average for the period 1994-2009 (fig. 3). Two new species for the CBMS were recorded in 2010: Portuguese Dappled White *Euchloe brassicae*, also known from Madeira and the Canary Islands, and *Glaucopsyche* *leuconoe*. Both could have been overlooked in previous years in the same or other walls given their resemblance to other commoner species (i.e. Dappled White *Euchloe caerulea* and Brown Argus *Aricia agestis*).

**Seventeenth year of the CBMS Summary of the 2010 season**

After three poor years, 2010 was a somewhat better season for Catalan butterflies as many species made a modest but marked recovery. Annual totals for False Ilex Hairstripe *Satyrium esculi* were the highest since monitoring began and, once again, this hairstreak was the commonest butterfly in the Catalan Sahara. Counts of Nettle Tree Butterfly *Libythea celithers* were also the highest ever as the positive tendency showed by this species over the last decade continued. Species and the majority of browns were commoner than the year before, possibly as a result of the abundant winter and spring rainfall during the previous two years. On the other hand, it was a poor season for migratory species and others such as Two-tailed Pasha *Charaxes jasius* (whose totals were the lowest since 1994) that are particularly affected by frost and cold winters.

**Weather and butterfly counts**

In sharp contrast to the exceptionally warm year 2009, 2010 was one of the coldest years of the last two decades in Catalonia (see www.meteocat.com). Heavy frosts occurred over much of the country in winter and the number of days with sub-zero temperatures was similar to that of 2005, one of the coldest winters in recent years. Most serious was the heavy snowfall that affected much of central and northeast Catalonia on March 8, right at the beginning of the CBMS season, which was followed by a number of very icy nights. In fact, much of the 2010 season was marked by cold wet weather, although April and May were on average the warmest months of the year (fig. 1a). As a result, August was more or less average with just a couple of days of intense heat (26 and 27). Although overall 2010 was a fairly good year, rainfall was quite irregular and some areas had below-average annual figures (e.g. the far west of Catalonia and the comarques of Baix Ebre and Montsià), while others such as the northern coastline and the basin of the river Llobregat recorded rainfall figures that were well above average annual totals. In all, an average of 3.2 cm was lost per station in 2010, surprisingly fewer than in 2009 given the generally poor population situation (fig. 1a). The most critical periods were the second week of March (affected by the exceptional snowfall over much of the northern half of the country), the first fortnight of May (very wet and windy conditions in Catalonia) and the last week in September (when rain swept over much of the country) (fig. 1b).

**Changes in abundances: general considerations**

Compared to 2009, neither the number of species nor the number of individuals counted changed to any great extent in 2010. In terms of species richness, the average number of species and their standard deviations calculated for the 61 stations that provided comparable data were 47.6 ± 17.9 species per station in 2010, as opposed to 47.1 ± 19.9 in 2009 (Student Test for paired samples, t = 0.71, P = 0.48). Average abundances were 2132.8 ± 2073.4 individuals per station in 2010, as opposed to 2212.7 ± 1953.5 in 2009 (t = 0.90, P = 0.37). Overall, however, the populations of a number of species did increase slightly in relation to 2009, as is revealed by the species ranking for the season calculated using the annual indices of the 66 commonest species (fig. 2). This graphic shows that for a certain extent Catalan butterfly populations recovered in 2010 after the lowest-ever figures of the three previous years, caused possibly by the extreme drought in 2008-2009. Even so, recent population figures are still lower than those recorded at the beginning of the 1990s (fig. 2).

**Changes in abundances: fluctuations in populations**

Of the commonest species in 2010, both Nettle-tree Butterfly *Libythea celithers* and False Ilex Hairstripe *Satyrium esculi* reached their highest annual indices since monitoring began in 1994. The case of the Nettle-tree Butterfly is especially remarkable since this positive trend is merely a continuation of the steady increase in this butterfly’s numbers over the past decade that could be related to more frequent favourable winter conditions that ensure greater survival chance and hence surfer adults. It is also possible that the increase in the use of the southern nettle tree (*Celtis australis*) as an ornamental plant is favouring the breeding success of this species, ever commoner in Catalonia. The False Ilex Hairstripe is another species that in the previous two years benefited from the generous late winter and spring rainfall, and for the second consecutive year it was one of the country’s commonest butterflies (table 1). These rains also favoured the majority of browns, which were clearly commoner in 2010 than in 2009 (table 1 and 2). Of note are the highest ever annual figures for Meadow Brown *Maniola jurtina* and the health of the country’s populations of Great Banded Grayling *Brizania circus*, whose numbers have been steadily and significantly increasing since the study period began.

As was to be expected, the season’s generally low temperatures gave rise to low numbers of African migrants. The clearest examples are those of Painted Lady *Cynthia cardui* and Plain Tiger *Danaus chrysippus*, which were scarce everywhere and no exceptional migrations such as in previous years were noted. For example, the Painted Lady appeared sporadically in the Ebro delta at the end of the season, despite having been one of the commonest species in 2009. Likewise, Barth White *Pontia daplidice*, Clouded Yellow *Colias crocea* and Large White *Pieris brassicae* and Small White *P. papae*, as well as the Lycaenidae Lang’s Short-tailed Blue *Leptosia pirithous* and Long-tailed Blue *Lampides boeticus*, were all rarer in 2010. The negative tendency in the Long-tailed Blue in Catalonia continued and its 2010 counts were the lowest ever for the species. The combination of a number of factors could have led to this situation: important mortality amongst over-wintering larvae due to the severe frosts, few adults migrating arriving in spring, and poor breeding success of these migrants in what was a cool summer. The impact of these recent winters could also explain the serious drop in numbers of Two-tailed Pasha *Charaxes jasius*, whose annual index in 2010 was the lowest since counts began. This species’ larvae hibernate as adults (e.g. Camberwell Beauty *Nymphalis antiopa*), which do not hibernate fully in winter and as such they are very vulnerable to cold snaps, as has been shown in previous years. On the other hand, low winter temperatures do not seem to have affected species that hibernate as adults (e.g. Camberwell Beauty *Nymphalis antiopa*, Large Tortoiseshell *N. polychloros*, Peacock *Inachis io*, Small Tortoiseshell *Aglais urticae*, Comma *Polygonia c-album*, Brimstone *Gonepteryx rhamni* and Chequered Blue *Scotinotis ornis*, Black-eyed Blue *Glaucopsyche melanargia*, Spanish Fritillary *Zerynthia rumina*, Orange-tip *Anthocharis cardamines* and Moorish Orange-tip *A. euphrosynoides*) was noted in 2010, a welcome trend after the serious declines in these species recorded in previous years characterized by prolonged spring droughts.

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analyses are conducted at regional and continental scale, although both habitat diversity and human influence (e.g. landscape degradation) have been identified in some cases as of equal importance.\textsuperscript{13} At smaller scales, landscape structure plays an important role since in the way in which the landscape is managed and the degrees of specialization of trophic resources and both larvae and adults are also fundamental factors to be taken into account.\textsuperscript{14}

Patterns of species richness, nevertheless, can be complicated by other sources of variations. For example, in butterflies both geographical region and species ecology are determinant. In the Palaearctic, for example, a latitudinal gradient in the importance of climatic factors exists; whilst temperatures and number of sunshine hours are key at high latitudes, water availability is determinant at lower and hotter latitudes.\textsuperscript{15} On the other hand, a recent study in Great Britain suggests that climatic variables are more determinant in species that behave as habitat generalists, whilst the richness and distribution of trophic resources for larvae are more important in habitat-specialist species.\textsuperscript{16}

These relationships are relevant to conservation biology since they enable us to predict tendencies in butterfly diversity with greater certainty under a scenario of global change. This ability is also relevant at a more general level, given that butterflies can be regarded as an indicator group for many other insect groups for which far less information exists, but which constitute a significant part of the most numerical part of terrestrial ecosystems.\textsuperscript{3} For a number of different reasons these considerations seem to be particularly important in the case of the Mediterranean area: (1) the Mediterranean represents the limits of distribution for many species that are likely to be seriously affected by climatic change; (2) within a European context the Mediterranean harbours exceptional levels of biodiversity; and (3) very little is known about the biology and distribution of most terrestrial insects (except for butterflies and a few other smaller groups).

In this article we summarize the results of a study exploring these questions that is entirely based on data from the CBMS.\textsuperscript{17} Its main aim was to model Catalan butterfly diversity by taking into account simultaneously a large number of factors relating to landscape structure and human impact that operate at different geographical and climatic scales. As well, different ecological groups were considered based on the degree of species specialization.

Methodology

The analysis is based on data obtained between 1994 and 2007 at 82 CBMS stations of Catalonia and two in Andorra. The altitudinal range of the stations (0–1,930 m) is broad enough to have obtained data for a total of 169 species (85% of all Catalan butterfly species). For each station the average annual species richness (number of species detected annually) was calculated.

The analyses were performed on all species simultaneously and also on different ecological groups. First of all, groups were separated according to the degree of food-plant specialization of their larvac (monophagous, oligophagous or polyphagous). Monophagous species were those that only feed on plants belonging to one genus, oligophagous species feed on a variety of plants, but all belonging to the same family, while polyphagous species feed on plants of a number of different families. Then, the degree of specialization of adult habitat-use was considered and four groups were defined (IEH1 to IEH4, from more to less specialization) based on a specialization index used in previous studies.\textsuperscript{18} Finally, species were separated into four categories on the basis of their dispersive abilities: 1) species that live in metapopulations with little exchange between populations; 2) species that live in metapopulations with a lot of exchange between populations; 3) species that live in open populations but with no seasonal migrations; 4) seasonal migrants. A correspondence analysis was used as the basis for the examination of how these variables are interrelated between Catalan butterflies. The results indicate that there is a clear correspondence between dispersion strategy 1–4, monophagous species at small specialization classes IEH1 and IEH2. As a whole, a close correspondence was also found between the classes and the degree of specialization (both in terms of trophic resources and habitat use) and greater dispersive ability. Thus, we can talk in broad terms of specialist butterflies (monophagous species restricted to few habitats and with poor dispersive ability) and generalist butterflies (oligophagous, present in many habitats and with moderate-to-high dispersive abilities)

Ten predictor environmental variables separated into four main groups were used in the analysis:

1) Climatic variables: for each station the average annual temperature, the average annual rainfall and an aridity index was calculated using data from the Catalan Digital Climatic Atlas.

2) Geographical variables: the average longitude and latitude were calculated for each station.

3) Resource variables: within each transect the amount of trophic resources available for larvae and habitat for adults was estimated. The availability of trophic resources was calculated indirectly as the number of plant communities of interest with characteristics of each transect, and the availability of habitat as the percentage of grassland and similar open areas in each itinerary (based on the fact that the majority of European butterflies (88%) fly in open areas, and that a large percentage (57%) of these species are specialists).\textsuperscript{19} The proportion of open areas in each itinerary was calculated using a GIS at two different scales: within 5 km of the transect route and within a buffer zone of 5 km around the central point of the itinerary.

4) Landscape structure and human impact: the landscape structure for each transect was characterized using a GIS and 1:25 000 maps of Catalonia based on colour aerial photographs taken in 1993. The percentage of land occupied by woodland, scrub, agricultural land, bare land and built-up areas was calculated in a radius of 5 km around each itinerary. This information was then subjected to a principal components analysis to obtain a single measurement that would place each itinerary along a few easily interpretable landscape axes. Finally, the main axis was used as a gradient of landscape intensification, running from highly humanized areas dominated by agricultural areas and man-made infrastructures (negative values) to more natural zones where woodland and scrubland predominate (positive values). Given that axis 1 was found to be strongly co-related to aridity, before the analysis residues relating to these variables were extracted in order to work with an independent landscape variable.

The modelling was performed in two stages. First, the bi-variant relationships between species richness and the predictor variables were explored using linear and quadratic models. Then, different types of multiple regression models were applied using a maximum of four variables simultaneously and correcting for the auto-correlation of the data whenever necessary.

Factors conditioning butterfly species

Butterfly species-richness is clearly related to some of the predictors in the simple models using just two variables (fig. 1): species-richness increases linearly as rainfall increases, while there is a rapid fall in richness as aridity increases. The relationship is quadratic with temperature: species richness increases with temperature within the lowest range of this variable (e.g. in high mountain areas), but beyond a threshold at around 10°C, increases in temperature have a negative effect on richness. Finally, landscape structure also influences species richness, with fewer species found in the most intensively agriculturally used areas.

Multi-variant models that take into account simultaneously a number of different factors explain a large part of the variance (r$^2$ = 0.56-0.71), thereby empowering this type of model with excellent predicti-
ve powers. The combination of these factors mirrors the clear altitudinal gradient in species richness, and predicts the richness of species in montane areas (fig. 2). At these more moderate altitudes temperature is not a limiting factor and both the degree of aridity and the intensification of habitat change are low, all of which enhances species richness.

When results are analysed in terms of ecological groups a number of interesting patterns emerge (table 1). Firstly, the general quadratic relationship with temperature is repeated, although with two exceptions: the species with the greatest habitat special- 

Table 1. Multiple regression models for butterfly species richness. The significant values are: * P < 0.05, ** P < 0.01, *** P < 0.001. See text for more details.

CBMS sites

The CBMS in the Olzinelles valley (Sant Celoni)

In 2006 as part of the presentation by the technical department of the Montnegre i El Corredor Natural Park of the project Improvement in the hydrological and other natural resources in the Olzinelles valley, a CBMS walk was set up at Can Valls d’Olzinelles. The aim of this itinerary was to detect whether the proposals made by his project would have any effects on local butterfly populations.

The transect

This transect is walked in the heart of the Olzinelles valley in the western part of the Montnegre massif in the mountains of La Serralada Litoral. The waters of this lush and relatively humid valley drain northwards into the river Tordera. On the shady north-
facing slopes stand mixed forests of holm and downy oak, while on the sunnier south-facing slopes the forest consists of cork oak and pines. The bottom of the valley is humid and gallery woodland of alders and poplars lines the main watercourses. Other trees here include wild cherry, hazel and the occasional sweet chestnut. Most of the former fields and pastures have been planted with poplars, although in recent years some have been cut down in an attempt to promote a return to arable farming. The butterfly walk began in 2006 in an area in which the Natural Park planned to implement important habitat changes in many of the walk’s sections. The clearing of the first five sections that run along a footpath through mixed woodland was proposed to create a firebreak (i.e. removal of biomass and the creation of vertical and horizontal discontinuities in the forest mass). Sections 6 and 7 in mixed woodland and poplar plantations were to be transformed into crop- and pastureland, respectively. Section 8 runs along a shady path through cork oak and poplar woodland and leads on to section 9, which passes through a former poplar plantation (but with many poplar stumps still present), which was by 2006 had become smothered by bushes. Sections 10 and 11 run along roads and tracks, the former through holm oak woodland and the latter marked by a dense wood of poplars and fields. Section 12 consists of a path through a humid poplar plantation, while section 13 passes through a cereal field belonging to the farm of Can Olzinelles.

However, the changes that have taken place between 2006 and 2011 were not as expected: sections 1–6 have been cleared; in 2011 for the first time cereals were sown in section 9, and the line of poplars in section 11 were clear cut in 2011. It is worth remarking that the walk passes by La Pega, one of the best-loved spots in the area around the Monje de Sant Celoni. Here there are two trees, 1,500 years old, one dating back to the ninth and tenth centuries and L’Alzina de Pega (the Pega holm oak), probably the tallest holm oak in Catalonia (over 35 m tall). As well, the walk passes by a pond, La Bassa de l’Aranyal, which is surrounded by a number of enormous plane trees.

The butterflies
In all, 55 species of butterfly have been recorded at Olzinelles, with an annual average of 37.8 species. In the period 2006–2010, 4,035 butterflies were counted, with 36 species of 87 butterflies and a density of 40.2 butterflies/100 m. In general, species at home in humid forests predominate and there are well constituted populations of species such as Pieris rapae, Gonepteryx rhamni, Pieris napi, Polyommatus cervi, and Celastrina argiolus. The presence of many nettle trees explains the existence of a strong population of Nettle-tree Butterflies, and females are often seen in spring laying their eggs on the fresh buds of this tree.

Even rarer species include White-letter Hairstreak and Small White Pieris rapae, Large White P. brassicae, Common Blue Polyommatus icarus and Small Copper Lycaena phlaeas) and these species, as is commented below, have benefited from the degradation of the open areas of the transect that have been restored. A number of other, generally rarer species also appear on this butterfly walk: Camberwell Beauty Necidephora nigrolutea, Large Tortoiseshell N. polychloros, Lesser Purple Emperor Apatura ilia and Nettle-tree Butterfly Libythea celia. The first three are all tied to the riparian woodland with willows and poplars that thrives in the valley bottom (eg-layering by Lesser Purple Emperor on poplar leaves has been recorded). The presence of many nettle trees explains the existence of a strong population of Nettle-tree Butterflies, and females are often seen in spring laying their eggs on the fresh buds of this tree.

Review
The African ‘Common Blue’ Polyommatus icarus, a new butterfly species for Europe
I n a recent article published in Molecular Ecology we describe the evolutionary history of one of Europe’s commonest butterflies, the Common Blue Polyommatus icarus. Recently, it has been found that this species is replaced in North Africa by Polyommatus celina, a very similar species that is regarded only as a subspecies of P. icarus and which should be referred to as the ‘African Common Blue’. We used molecular techniques (mitochondrial and nuclear DNA analysis) and geometric morphometrics to reconstruct the evolutionary history of this pair of species. Whereas traditional linear morphometrics only measure distances, modern geometric techniques enable us to compare forms and shapes naturally. In particular, we compared the male genitalia and studied the patterns on the underside of the wings. The results were surprising. First of all, we have shown that these two species of blues are not sister species, despite their very similar appearances. In fact, in terms of its evolution P. icarus is closer to species such as Eros Blue Polyommatus eros. Never- theless, the ‘African’ and ‘European’ Common Blues are very hard to separate in the field: the former has somewhat broader black margins on the upper wings, and often has a line of black spots on the upper margin of the hindwing, although examples of P. icarus with these characteristics are found. The genitalia of the two species are also very similar and we have been unable to detect a geographical barrier or a totally completely reliable way of separating these two species is by DNA sequencing and as such P. celina represents a good example of a cryptic species. As a result of new genetic and morphometric studies, the true extent of the planet’s so-called ‘cryptic biodiversity’, much of which has to date gone unnoticed, is being shown to be much more sizeable than was once thought. This is of great importance if we are to discover just how many species exist and has serious implications for management and conservation.

We have also discovered that P. celina has a much broader distribution than was previously thought, in fact flies in continental Europe. The African Common Blue replaces its European counterpart in many areas in southern Iberia, as well as on the Balearic and Canary Islands and on Sardinia and Sicily. It is interesting to note that these two species do not seem to be able to live sympatrically on these islands and that southern Iberia represents a point of contact between these two taxa. One hypothesis that would explain this distribution is that neither species is able to detect the other and that their hybrids are unfer- tile; thus if one of these blues mates with the other, the offspring will not produce fertile eggs. We have also identified three strongly diverged lineages of P. celina: one in North Africa, the Canary Islands and southern Iberia; a second only on Sicily; and a third in the Balearic Islands. We infer that the evolutionary history of this species began in North Africa, from where around 800 000 years ago it colonized the Balearic Islands and Sicily. Subsequently, three lineages have evolved independently and only re- latively recently have African butterflies colonized Andalusia, and have Balearic butterflies reached Sar- dinia. Thus, the lineage of P. celina on the Balearic Islands is only shared with Sardinia. The biogeographical history of P. icarus is equally complex. Numerous migratory waves originating in central Europe have occurred over the last two mi- llion years; nevertheless, the oldest lineages are all but extinct and we have only identified them in the extreme south of this species’ distribution in areas in which more recent lineages from the north have not become established. This is the case of the ‘European’ Common Blues on Crete and a relic population at over 2,000 m on Pico Veleta in the Sierra Nevada, which is currently surrounded by populations of P. celina. Despite their abundance, these two species have rich biogeographic histories, full of changes mar- ked by the colonization of islands and mountain ranges, and their ongoing present adaptation to climate change and then onward movements, during which time one species evicts the other without the two species ever learning to co-exist. Undoubtedly, much still remains to be learnt about the distribution and evo-
One of the most common and most spectacular of our butterflies is the Swallowtail *Papilio machaon*. Although it flies in many different habitats, the best place to find it is on hilltops and ridges, where large numbers of males congregate to await the arrival of hilltopping that are also extremely eye-catching and easy to spot on their foodplants, which include fennel, wild carrot and rue.

Geographical distribution and situation in the CBMS

The Swallowtail *Papilio machaon* is common in the Palaearctic region, where it is well distributed throughout Europe, Northwest Africa, the Middle East and much of temperate Asia. It is also found in North America, while in the Iberian Peninsula it is has been recorded from all the Spanish provinces, Portugal and Andorra, as well as even the smallest of the Balearic islands. i

In Catalonia and Andorra its altitudinal range is large and it is regularly observed from sea-level right up to the tops of alpine peaks. It is one of the most widely distributed species in the CBMS network and appears in the counts of almost every transect, including all three Moroccan sites and on Ibiza (fig. 1). Nevertheless, its population densities are distorted by its behaviour as a ‘hilltopper’, which is a male *Swallowtails* congregate on hilltops and ridge, the highest *Swallowtails* populations in the CBMS network correspond to walks with these type of relief features. This is the case in six out seven transects in which the species appears at densities of over 200/100 m, and the name of some of these transects is self-explanatory: Turo de Can Tiri, Turo d’en Fumet, Turó de l’Home (turo = hill). Other than in a few isolated cases, the highest densities of this species are recorded from coastal sites such as the delta of the river Ebro and Llobregat, possibly because these areas are staging posts for migrants from southern Europe and the Mediterranean Sea. At the opposite end of the scale, in the high mountain transects individual *Swallowtails* are only occasionally recorded.

Habitats and foodplants

The Swallowtail is an oligophagous species able to use a large number of different foodplants belonging to the Umbelliferae and Rutaceae families. Nevertheless, *Swallowtails* do have a clear preference for the plants they lay their eggs on, which in general coincides with the preferences of the caterpillars. There is also great variability amongst females: some are strict specialists and only lay on the best food plants, while others are more generalists and accept suboptimum plants. In Catalonia, the species’ favourite food plants are wild fennel *Foeniculum vulgare*, wild carrot *Daucus carota* and common rue *Ruta graveolens*. More rarely, eggs and caterpillars have been found on *Prunus spinosa* and *Ruta graveolens* and even parsley *Petroselinum crispum* growing in gardens.

In terms of habitat, the Swallowtail is one of the most generalist species in Catalonia. It has appeared in all the different habitats represented in the CBMS and according to its habitat specialization index it is one of the 10 most generalist species in the CBMS network. Maximum densities are recorded in the most humid areas such as groves of tree crops, extensive herbaceous croplands and rual areas. It is also one of the butterflies that is most often found in parks and gardens, even in the centre of large cities such as Barcelona.

Natural history and phenology

The Swallowtail is polybiontine and during the season an indeterminate number of highly overlapping generations appear (possibly as many as four or five depending on the site and the year). The first generation emerges at the end of winter or beginning of spring from pupae that have overwintered, and in lowland areas it is not rare to see the first *Swallowtails* of the season on the wing during sunny spells at the end of February. Spring emergence is marked for this species and butterflies of the first generation are smaller and darker. Subsequently, the summer generations follow on without interruption from the end of spring until mid-autumn.

The biological cycle of the species is completed in around two months, although this will depend on the temperatures at which the immature phases have to develop. The egg is bright yellow, spherical (1.4 mm in diameter), smooth and with no external features. After 1–2 weeks the larva – black with a white saddle – hatches; it is often claimed that this initial colour stage is secondary, following local selection, and that this pigmentation is thus confuses potential predators. In later stages the larva’s characteristic three-part colouration emerges: green background colour, a series of black strips and spots on each segment, and three pairs of orange spots that interrupt the black stripes. Nevertheless, environmental conditions during growth affect the larva’s colouring: when the photoperiod is long in spring, the larva grows more rapidly and is green or brown, the larva’s colouring: when the photoperiod is long in spring, the larva grows more rapidly and is green, while in summer, when the photoperiod is short, the larva turns brown, the larva’s colouring: when the photoperiod is long in spring, the larva grows more rapidly and is green, while in summer, when the photoperiod is short, the larva turns brown. The pupal stage is usually spent in the vegetation (fig. 3b). When a male mates with a female they fly around her, sometimes in a circular motion. This mating flight and when she stops on a branch or leaf, the female lays her eggs close to the male and leads to a certain degree of proterandry, whereby females emerge slightly earlier than the males. A characteristic trait of this species’ mating behaviour is known as ‘hilltopping’, whereby males select hills, ridges or any other prominent relief feature as ‘meeting points’ for finding females (fig. 3a). They establish territories that they defend from other males. *Swallowtails* or from other species, which have similar behaviour (e.g. the Scarce *Swallowtail* *Papilio dardanus*). Males pursue each other in long acrobatic flights as one tries to expel another from its territory. This ‘hilltopping’ is likely to continue for up to six-seven hours, starting at the beginning of the morning and continuing until the beginning of the afternoon. Reconnaissance flights and aerial displays alternate with periods of perching on prominent vantage points on bushes, plant stems or even on the ground. The marking of butterflies on a hill in El Maresme has shown that a high percentage of males (around 50%) establish territories and defend it throughout the day. This study has also revealed that only a very small proportion of males (less than 10%) return to the same hill – up to a maximum of around seven days – on consecutive days. As an alternative to hilltopping, males try to mate with females at strategic sites for nectaring such as large butterfly *Buddleia davidii* bushes or fields of alfalfa *Medicago sativa* in flower.

Nonetheless, observations of actual mating are scarce. Males fly closely behind females in an undulating flight and when she stops on a branch or leaf, the male does the same and mating begins. On the three occasions we have been able to record such behaviour in the field the larger female was on top as the male hung head down, sometimes holding the vegetation (fig. 5a), and mates for the first time or when he has not mated for three days or more, copulation lasts for an hour; however, if he mates on consecutive days the second attempt lasts almost ten times as long. Sexual dimorphism in the *Swallowtail* implies longer development time for females, as has been reported in related species, and leads to a certain degree of protandry, whereby males emerge slightly earlier than the females. Thus, the males’ first mating attempts in which they invest greater resources (by transferring a larger spermatophore) are likely to take place with virgin females, of greater reproductive value.

Another characteristic of the mating behaviour of the *Swallowtail* is the males’ habit of mudpuddling (photo f). In some sites in the pre-Pyrenean spectacular concentrations of *Swallowtails* of a dozen or more males occur, mixed in with a number of Scarce *Swallowtails*. The males extract minerals – above all sodium, lacking in most plants – from the mud, which is accumulated in the mudpuds that are transferred to the females during mating. Sodium is a critical element in the production of the egg and is thus needed by adult females. Females lay their eggs close to one on their chosen food plant (fig. 3c). They have a wonderful ability to localize even the most isolated of these plants, for example, fennel plants growing in urban parks in the cities of Barcelona or Granollers or, remarkably, at
plant of common rue growing on the balcony of a fifth-floor flat in the middle of Barcelona (A. Baure, com. pers.).

Natural enemies
In their first stages the larvae of the Swallowtail are predated by a number of carnivorous invertebrates that include spiders (fig. 6) and Hemiptera (true bugs).47 A typical defence mechanism used by many swallowtail butterflies against invertebrate predators is the osmeterium, an orange-coloured extensible organ located on the caterpillar’s thorax that gives off a pungent smell.48,49 Rather than the osmeterium, which has no or little effect, the caterpillar’s most effective defence against insectivore birds is its aposematic colouration, which warns of its toxic qualities.20-22 As we see, it is this scheme colour also provides a certain degree of camouflage at long-distance; thus a combination of cryptic (cryptic colouration) and aposematism reinforces the larva’s defence against predators that locate their prey visually.5

In the case of the pupae (which are not rejected by birds)48 their main defence is their cryptic colouration: they can be green or brown in tune with the background colour of the site in which they have chosen to pupate (photo e). Experiments have shown that this coincidence of coloration and background helps reduce losses to predation and so increases survival rates.47 Adult Swallowtails, on the other hand, have been seen to be captured in flight on a number of occasions by Buteo buteo merops-apatertus.

The Swallowtail is also attacked by a variety of parasites, of which the most regular are two specialized species, a tachinid (Diptera: Buquetia nuica) and an ichneumon (Hymenoptera: Trogus lapidator), which attack the larvae (although the latter’s offspring emerge from the butterfly’s pupa), and two generalists, the ichneumons Pimpla rufipes and a chalcidid (Hymenoptera: Peromis papuaria) that attack the pupae.42

Population trends
Although it rarely occurs in great densities, the Swallowtail is one of the most common and most widespread of all our butterflies. Population densities are usually low, a factor that theoretically could have led to the development of huddling behaviour as an effective mechanism for mate-finding.50 Despite its relative abundance, Swallowtail populations in Catalonia declined slightly but significantly in the period 1994–2010 (fig. 5). It is too early to say whether this apparent regression will be confirmed by data from the coming years, or whether these oscillations will even themselves out around the initial value of the data set. Theoretically, the Swallowtail will not be affected that much by the despread of all our butterflies. Population densities of the Swallowtail is one of the commonest and most widespread species of butterfly in Spain (D. Horvath, pers. obs.).

The general dynamics of the species in the country. The Swallowtail will not be affected that much by the despread of all our butterflies. Population densities of the Swallowtail is one of the commonest and most widespread species of butterfly in Spain (D. Horvath, pers. obs.).


C. Stefanescu (pers. obs.).


20 The cost of being aposematic. An experimental study of predation on larvae of Papilio machaon by the great frit Paros major. Oikos, 36: 267-272.


Fig. 1. Relative abundance (expressed as the values of the annual index/100 m) of the Swallowtail Papilio machaon in different CBMS sites (1994–2010).

Fig. 2. Phenology of Papilio machaon at different CBMS sites. (a) The beach of La Tancada in the Ebro delta in the period 2002-2010 (n = 522 butterflies); (b) El Turó d’en Fumet in La Serra de Collserola in the period 1996-2010 (n = 525 butterflies); (c) in all CBMS stations located at over 1,000 m; data from the period 1994-2010 for 14 stations in the mountains of La Serradala Preiador and the Pyrenees (n = 357 butterflies).

Fig. 3. Prominent relief features are excellent places to see Swallowtails hilltopping. (a) El Turó del Vent is the best place to see this species and the scarce Swallowtail Jizldesades podrusius in Els Aiguamolls de la Llarga Natural Park; (b) mating pair El Turó d’Onofre Arna in El Maresme; (c) Female egg-laying on Ruta graveolens (photos: a, C. Stefanescu; b, J. Corbera; c, J. Oliveras).

Fig. 4. A crab spider preying upon a third instar larva on fennel (photo: A. Miquel).

Fig. 5. Population fluctuations in Papilio machaon in the stations of the CBMS network in the period 1994–2010 calculated with the programme TRIM. A significant, moderately negative tendency has occurred during this period.

Photos. (a) Two eggs and one first-instar larva on fennel; (b) third-instar larva, and (c) fifth-instar larva; (d) melanic larva in the fifth instar; (e) green and brown overwintering pupae; (f) two males mud-puddling (photos: a and c, E. Stefanescu; b, J. Jubyang; d, J.M. Sesma; e, C.C. Vicente; f, J. Clavell).
Here we look at two pairs of confusing species: Pyrenean Brassy Ringlet E. rondouii vs. Common Brassy Ringlet E. cassioidea arvernensis and Dewy Ringlet E. pandrose vs. False Dewy Ringlet E. sthenyo, typically found in subalpine and alpine habitats, although the former pair are sometimes reported from lower altitudes.

O f these species, the only two that have been de- tected in the CBMS-RMSAnd network are E. rondouii (once considered to be a subspecies of Sie- rra Nevada Brassy Ringlet E. hispania, an endemic species to the Sierra Nevada) and Common Brassy Ringlet E. c. arvernensis, which in theory should not fly together at the same time. The former flies at 1,600–2,500 m in the eastern Pyrenees (from El Ripollès to La Serra del Cadí), the Pallars and La Vall d’Aran, but seems to be absent from the north of La Cerdanya and Andorra, while the latter flies at 1,800–2,900 m from La Cerdanya to El Pallars, but seems to be absent from La Vall d’Aran. Neither do E. pandrose and E. sthenyo fly together, although both are found at over 2,000 m. The former is found in El Ripollès, La Cerdanya and Andorra, and the latter in La Vall d’Aran; El Pallars Sobirà represents the frontier between the two species. All four species live in subalpine and alpine pastures and on grassy slopes between screes. All are univoltine. The two dewy ringlets fly earlier, from the second week of June to the beginning of August: E. rondouii flies in July and August and E. c. arvernensis from July to September. E. pandrose and E. sthenyo have biennial cycles, and the other two annual cycles. The food plants of E. sthenyo are unknown;1 E. pandrose feeds on Festuca, Poa and Sesleria; E. rondouii on Festuca ovina and E. c. arvernensis on Nardus stricta.1

Identification

How to separate the species of the genus Hipparchia (1)

Two of the commonest butterflies on the wing in Mediterranean environments in mid-summer are Tree Hipparchia sallustiana and Striped F. fidia Greywings, while in more upland areas the Grayling H. selemes can also be abundant. At first sight, all three are easy to confuse, but there are morphological clues that enable them to be separated relatively quickly.

The Tree Greyling is well-distributed throughout Catalonia from sea-level to the base of the subalp- ine mountains. It is commonest in areas of the moun- tains of La Serralada Litoral and pre-Pyrenees, mainly in scrub and open woodland. The Striped Greyling, a butterfly of arid environments with little vegetation cover, also occupies much of Catalonia, but avoids humid woodland in the northern half of the coun- try and the Pyrenees (although it is present in some of the sunnier Pyrenean valleys). The Greyling can become very ab undant to quite high altitudes in open upland areas, above all on and around rocky outcrops, but is only occasionally found in lowland areas. All three are found in the lowest parts of An- dorra and have, exceptionally, been recorded in the Balearic islands, although it seems that currently the re- are no stable populations on these islands. All are univoltine: Tree and Striped Greyling fly from July to September, while the Greyling appears in May-June and flies until September-October, with a peak in Au- gust. Males of the three species are territorial. Their larval food on grasses belonging to the genera Arrhe- natueme, Brachypodium, Festuca, Koeleria, Nardus and Stipa (see ref. 2–3 for more details of the biology).

Constanti Stefanescu


Drawings

TREE GRAYLING

Underside (general): dark brown-grey colouration, with paler areas in the post-discal area in females

Underside (general): uniform grey with at most a dark central line

Stripped Greyling

Underside (general): dark brown, almost grey

Underside (general): contrasting white and black lines on a uniform grey background

Drawings

PYRENEAN BRASSY RINGLET

Marked with line: Short, rusty-brown, poorly defined post-discal band Two small apical eye-spots with small white pupils; series of three black eye-spots with rounded rusty- coloured centres

DEWY RINGLET

Underside (general): reddish brown; fore-wing with rusty-coloured post-discal band and series of blind black eye-spots

Underside (general): fore-wing rusty brown with series of black eye-spots; hind-wing marbled grey with discal band outlined with sinuous transversal lines

FALSE DEWY RINGLET

Underside (general): rusty brown; fore-wing with post-discal band with blind black eye-spots

Underside (general): fore-wing rusty brown with blind black eye-spots; hind-wing marbled grey; transversal lines less obvious

Marked with line: Less apparent post-discal band; series of black spots near outer margin; uniform marbled grey background without conspicuous lines

Recent studies4,5 seem to conclude that the Pyrenean Brassy Ringlet E. rondouii is endemic to the Pyrenees and is different from the Sierra Nevada Brassy Ringlet E. hispania. On the other hand, it is not as clear that arvernensis should be thought of as a good species and so as a matter of prudence we here treat it as a subspecies of E. cassioidea. These two brassy ringlets tend to be common where they are found and are easy to confuse. E. rondouii has a dark brown ground colour without metallic reflections, a broad orange post-discal band, two large apical eye-spots with white pupils that fuse into a single spot, and the underside of the hind-wings grey with a yellowy sheen. To separate Dewy from False Dewy Ringlet the most consistent cri- terium is the series of black post-discal spots, further from the outer margin in the latter than the latter.

Grayling

Underside (general): brown, with orange post- discal markings that merge to form a continuous band on the hind-wing

Underside (general): orange tones on fore-wing; grey hind-wing with white patches of varying size

Marked with line: Velvety sex-brand; large orange areas; irregular dark line marking a sharp angle in the middle of the wing

These three species can be separated from the other Iberian species of the genus Hipparchia by the lack of any broad post-discal band on the upper-wing. Of the three, the Greyling is the only with conspicuous orange colouration on the underside (especially the hind-wing), and also has a large orange patch on the underside of the hind-wing. Striped and Tree Greylings are very similar above, but can be separated by studying the underside: whilst the Tree Greyling is more or less uniform grey (sometimes with a certain white suffusion), Striped Greyling has a black zigzag post-discal stripe and another shorter stripe in the discal area. In general, Striped Greyling prefers drier hotter areas than Tree Greyling, but both species can appear in the same areas. The Greyling is mainly found in upland areas (but is very rare in the mountains of La Serralada Litoral).