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Cover

Detail of the under side of the hind-wing of Painted Lady, *Vanessa cardui* (photo: O. Massana)

Mediterranean Skipper, *Gegenes nostrodamus*, nectaring on Agnus castus, *Vitex agnus-castus* (photo: O. Massana)

Editorial

Are there more species of Butterfly in Europe than we think?

This new edition of *Cynthia* – happily back to appearing annually – provides a summary of the highlights of the CBMS and BMSAnd monitoring programmes for the year 2014. Unfortunately, 2014 was yet another poor season, something that we are now getting used to and a reality that denotes an evident fall in population numbers in many butterfly species in Catalonia. The weekly monitoring data are helping to define increasingly well just what is behind these decreases in butterfly numbers — even though it is still very difficult to quantify the exact impact of each individual factor. In this edition of *Cynthia* we present a complete joint analysis of the Catalan butterfly and bird monitoring programmes that suggests that the loss of open spaces is one of the key factors behind the decline in biodiversity in Catalonia. Nonetheless, it is clear that other factors are at work and, for instance, the recent severe droughts may be having an accumulative effect that is preventing a recovery back to the population levels that existed when the CBMS got underway at the beginning of the 1990s.

We also take a look at a review of the taxonomic situation of Iberian butterflies that indicates that in the future there could be a number of surprises in the status of certain species. The use of molecular techniques is revealing the existence of far greater genetic diversity than that suggested by traditional morphological techniques. The DNA barcoding technique, for example, suggests that some European butterfly species are in fact complexes of a number of cryptic species. In some cases, this was already suspected (e.g. Heath Fritillary *Melitaea athalia* and False Grayling *Arethusana arethusa*) but in others it is much more unexpected (e.g. Spotted Fritillary *Melitaea didyma* and Essex Skipper *Thymelicus lineola*). Consult the original article for more information on particular species.

The section *The Butterfly* is devoted to the Lesser Purple Emperor *Apatura ilia*, one of the most spectacular butterflies in Catalonia and one of the few that is expanding its range. In recent years, it has become established in the city of Barcelona and numerous observations are now being made there.

Finally, the identification datasheets include the final part of the 'Dappled' white group (genera *Euchloe* and *Pontia*) and the second part of the difficult *Melitaea* sp. group of fritillaries.

The CBMS network

Current situation (2014) of the Butterfly Monitoring Scheme in Catalonia, Andorra and the Balearic Islands

During the 21st season of the CBMS and BMSAnd networks 73 stations were active, the highest number to date. Two new stations were incorporated and four others were re-activated. The three stations on the island of Menorca and six in Andorra continued to provide data. In all, 119.384 butterflies belonging to 166 species were counted.

During the 2014 season counts were carried out at 73 stations (Fig. 1), six more than in 2013, which raised the number of active stations in a single season to over 70 for the first ever time. This increase is as much due to the reactivation and restructuring of old stations where the butterfly walks had been abandoned (cases of Rabós, Sebes, Banyoles) as to the incorporation of two new stations (L'Escanyat, Betren).

The available annual data series are shown in Figure 2. Of the 129 stations that have provided data at one time or another, 44 (over a third) have provided data for ten or more years, and 15 have been active for 15 or more years. These data reflect the potential of the CBMS database as a tool for analysing in the mid-to-long-terms the tendencies operating in the biodiversity of our country.

New stations

L'Escanyat (CBMS-129, Vallès Oriental, 182 m). This circular itinerary stretches for 1,506 m around the outskirts of the city of Granollers. Although it runs through the domain of holm oak forests, intensive agricultural environments are in fact the most representative habitat. Its seven sections pass through a number of fields, along field edges and through relict patches of woodland. The butterfly fauna is thus fairly poor and is dominated by common generalist species such as Small *Pieris rapae* and Large *Pieris brassicae* Whites, Clouded Yellow *Colias crocea*, Mallow Skipper *Carcharodus alceae*, Common Blue *Polyommatus icarus*, Wall Brown *Lasiommata megera*, Meadow Brown *Maniola jurtina*, Common Swallowtail *Papilio machaon*, Small Copper *Lycaena phlaeas* and Long-tailed *Lampides boeticus* and Lang's Short-tailed *Leptotes pirithous* Blues. Geranium Bronze *Cacyreus marshalli* also appears, undoubtedly due to the proximity of the city of Granollers where this butterfly feeds on cultivated geranium plants. The presence of stands of natural vegetation also provides habitat for species such as both Southern *Pyronia cecilia* and Spanish *Pyronia bathseba* Gatekeepers, Iberian Marbled White *Melanargia lachesis* and Green Hairstreak *Callophrys rubi*. One of the most interesting species recorded on this itinerary is the Mediterranean Skipper *Gegenes nostrodamus*, a migratory species that is rare in Catalonia but which quite often in summer is detected in the Vallès plain. The counts are carried out voluntarily by A. Pascual.

Betren (CBMS-133, Val d'Aran, 991 m). This is the first CBMS to operate in the Val d'Aran. It is short (853 m in length with just seven sections) and runs around the village of Betren, very near the town of Vielha. Despite a certain degree of ruderalization due to the proximity of the built-up area, the moist cool climate guarantees the survival of patches of subalpine pastures and riparian woodland of great entomological interest. In total, 59 species were counted during the first counting season but more are bound to appear if the counts continue in future years. Some of the most interesting butterflies include montane species such as Small Tortoiseshell *Aglais urticae*, Apollo *Parnassius apollo*, Scarce *Lycaena virgaurea* and Sooty *Lycaena tityrus* Coppers, and Lesser Marbled Fritillary *Brenthis ino*, amongst others. It is worth highlighting the presence of the Large Blue *Maculinea arion*, a threatened species that appears in most catalogues of protected species. As well, this station has enabled us to add Marbled White *Melanargia galathea* to the list of CBMS species (this species is only found in the Val d'Aran in Catalonia) and new populations of two species that are rare on the CBMS itineraries, the Map Butterfly *Araschnia levana* and the Ringlet *Aphantopus hyperantus*. The counts are carried out voluntarily by Montse Bacardit.

Habitats represented

The main environments and plant communities represented in the 2014 counts are detailed in Table 1. The percentages corresponding

to the different environments have remained practically unchanged compared to previous years: lowland itineraries (holm-oak woodland, scrub and garrigue) account for 71% of the itineraries, mid-altitude upland itineraries (various types of deciduous and pine woodland) for 21% and, lastly, high-altitude Pyrenean stations (subalpine stage) for 8%. This proportion mirrors closely the proportion of land covered by these three environments in Catalonia as a whole (Fig. 1).

Species present

The list of species detected over the past 10 years is given in Table 2. In 2014, 166 species were recorded, a figure that is almost five points above the annual average of recorded species for the period 2006–2013, i.e. since the incorporation of the BMSAnd into the network (161.1 species) (Fig. 3). This rise in the total number of species is due to the large number of stations that took part in the counts in 2014, which include the happily re-activated Gerri de la Sal station, the most diverse of all.

Despite the increase in the number of species recorded, there was only one new species for the network, the Marbled White *Melanargia galathea*, a Satyrid with a limited distribution that replaces the Iberian Marbled White *M. lachesis* in the Val d'Aran. The incorporation of the Betren station in the Val d'Aran has boosted the number of species recorded on the CBMS transects and, if this and other stations from the same area can be maintained, other new species such as Scarce Swallowtail *Iphiclides podalirius*, Black Hairstreak *Satyrium pruni*, Northern Wall Brown *Lasiommata petropolitana* and Chequered Skipper *Carterocephalus palaemon* that are only found in the Val d'Aran in Catalonia, may soon also become CBMS species.

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For references, see the original Catalan version.

Table 1. Environments and plant communities present in the CBMS in 2014, with the number of stations in which they appear. See ref. 1 for the classification of the vegetation zones and plant communities.

Table 2. Butterfly species recorded in the CBMS network over the last 10 years (2005–2014). The number of stations at which a species has been recorded is indicated (out of a possible total of 54 in 2005, 64 in 2006, 70 in 2007 and 2008, 65 in 2009, 69 in 2010, 67 in 2011, 66 in 2012 and 67 in 2013 and 73 in 2014). Taxonomy based on ref. 2.

Fig. 1. Geographical situation of all the stations that have participated in the CBMS network (1994–2014), with their official number and name. Also shown are the generally accepted boundaries of the biogeographical regions present in Catalonia.[1]

Fig. 2. Distribution of the annual series available for the stations that have participated in the CBMS and BMSAnd networks since their beginnings. Data from the stations at La Rubina and Vilaüt, which were active in 1988 and 1989, respectively, before the official launch of the CBMS are included.

Fig. 3. Number of butterfly species detected each year in the CBMS network.

Photographs:

The addition of the station of Betren has enabled us to add the Marbled White *Melanargia galathea* (a species only found in the Val d'Aran in Catalonia) to the list of CBMS species (photo: J. Jubany).

Mediterranean habitat in the new station of L'Escanyat. Stone Pine *Pinus pinea*, Agave *Agave americana* and Giant Cane *Arundo donax* are present on the hedges of some sections (photo: A. Arrizabalaga).

The CBMS – 21 years
Summary of the 2014 season

The 2014 season was once again a year of very low butterfly counts at the vast majority of CBMS sites and turned out to be the second poorest-ever season after that of 2012. Despite the lack of any prolonged hot spells or summer drought, overall 2014 was a warm year due to the very mild winter. Of the very few species that flew in good numbers, it is worth highlighting Lang's Short-tailed Blue and the African Tiger, the latter of which was extraordinarily abundant in the Ebro Delta at the end of summer and at the beginning of autumn. Nevertheless, it was not a particularly good year for the other migratory species, nor for the species that are habitually common (certain Satyrinae and Lycaenidae).

Weather and butterfly counts

The year 2014 was generally hot (the exception being the northeast of Catalonia, Pyrenees and pre-Pyrenees, where temperatures were around the average) and rainy over much of the country (see www.meteocat.com). Compared to other years, 2014 was one of the hottest (after 2009, 2006 and 2003), above all in central coastal areas and inland from the southern coast. However, the high average temperatures were not caused by a hot summer but, rather, by the lack of cold snaps in winter. In fact, officially there were no heat waves in 2014 and the most significant positive anomalies in temperature occurred in October and November, once the CBMS season had finished.

The winter of 2013–2014 was extremely mild. December was warm and dry, a situation that continued into January and February. This warm dry weather lasted for most of spring and into June, coinciding with the first half of the CBMS season. By contrast, July and August over much of Catalonia (above all, in the Pyrenees) were cool and rainy or even very rainy (with the exception of coastal and precoastal areas). Rain continued to fall in many areas throughout September, albeit with high temperatures that broke average temperature records in certain parts of the country. Overall, the second half of the counting season coincided with a relatively wet summer characterized by cool temperatures and a succession of generalized periods of heavy rain in July–September.

In 2014, an average of 4.15 counts were lost per station (Fig. 1a), an almost identical figure to the previous year (4.21). Both these figures are higher than the average for the period 2000–2014 (3.51 counts per station) and reflect the abundant rainfall that fell in spring 2013 and summer 2014. In particular, the frequent rain and storms in August 2014 hindered counts at many stations. As a whole, there were especially critical periods of heavy rain in the last week of May and the third week of August, which were the year's most abundant for many parts of the Pyrenees (Fig. 1b).

Changes in abundances: general considerations

The 2014 season was in general a poor one for Catalan butterflies and was the second worst of the 21 seasons with comparable data (Fig. 2), the worst ever being 2012. Of the 66 commonest CBMS species, two had their worst-ever years in 2014 (Southern White Admiral *Limenitis reducta* and Western Marbled White *Melanargia occitanica*) and a further nine their second worst-ever year. Just a single species (Lang's Short-tailed Blue *Leptotes pirithous*) reached its best ever numbers.

Such low butterfly numbers meant that, compared to the previous season, at all stations declines in the number of butterflies recorded during the season were obvious ($P < 0.001$). By contrast, the number of species detected per station did not change significantly ($P = 0.802$). The values for the 66 stations with comparable data for 2014 and 2013 were as follows: 46.92 ± 17.03 species/itinerary in 2014 vs. 47.11 ± 17.13 species/itinerary in 2013, and 1,658.3 ± 1,227.9 individuals/itinerary in 2014 vs. 2,120.4 ± 1,501.8 individuals/itinerary in 2013.

The accumulated CBMS data reflects a worrying and continued decline in Catalan butterfly populations, shown clearly in Figure 2. Specifically, from the mid-2000s onwards, the populations of most species began to fall below the levels that they had maintained up to that point. Although a fuller rigorous analysis is still needed, the droughts and extreme summer temperatures in 2005 and 2007 may have caused this pattern, which was further exaggerated by the drought of 2012. Yet, in 2014 it was a different situation – a very rainy summer – that seems to have had extremely negative effects on the butterfly populations in many upland areas.

Changes in abundance: fluctuations in populations

The counts for the most abundant species in 2014 are given in Table 1, along with their rank in comparison with 2013. The total counts reveal important declines in the numbers of hitherto common species such as Spanish Gatekeeper, which fell from its position as the commonest species in 2013 – over 11,000 ex. counted throughout the CBMS network – to sixth position, with fewer than 7000 butterflies counted. Even species that have maintained their positions such as the Meadow Brown *Maniola jurtina* and the Gatekeeper *Pyronia tithonus* have decreased seriously in number. Finally, it is worth noting that for the second year in succession the False Ilex Hairstreak *Satyrium esculi* in 2014 was in ninth position – despite in the past often being the commonest species in Catalonia – and has declined in number considerably over the past two counting seasons.

The annual indices of the 86 commonest species recorded in the CBMS network in 2014 compared with the average values from 1994 to 2013, together with the regional trend, are given in Table 2. Around 40% of species have uncertain trends, probably due to marked interannual fluctuations or to a lack of sufficient monitored populations. However, the fact that only 15% of the species whose populations show clear tendencies have increased in number whilst 42% have fallen, is of great concern. Only 33% of species can be regarded as having stable populations. A new methodology to analyse population trends not only confirms this general negative trend in butterfly numbers but also magnify it (Melero, Stefanescu & Pino, in prep.). Thus, it is clear that the patterns revealed by the CBMS data are both accurate and highly worrying.

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For references, see the original Catalan version.

Table 1. Sum of the annual indices and ranking of the commonest 20 species in the CBMS network in 2014 relative to the corresponding figures for the 2013 season.

Table 2. Annual indices of the 86 commonest species recorded in the CBMS network in 2014 (based on an arbitrary value of 1 for 1994) compared with the average values from 1994 to 2013. The regional trend for each species as given by TRIM software is also included.

Fig. 1. (a) Coverage of the counts at the different CBMS stations in 2014 and (b) the distribution of the lost counts during the official 30 weeks of the recording season (1 March–26 September).

Fig. 2. Ranking of the CBMS seasons in terms of the general abundance of the 66 commonest species in the CBMS network. The best year to date was 2002 and the worst 2012. Calculations were carried out using the methodology described in Greatorex-Davies & Roy (2001); annual indices were calculated using the TRIM software.

Drawing 1. In 2014 the Southern White Admiral *Limenitis reducta* reached its lowest-ever level since the CBMS began. This species is currently displaying a significant negative tendency that cannot be explained simply by the effects of habitat (i.e. it is a forest species and the forest cover in Catalonia has increased in recent years). It is highly likely that this fall in its numbers is related above all to the negative effects of climate on its summer generations (drawing: M. Franch).

Drawing 2. Lang's Short-tailed Blue *Leptotes pirithous* was particularly common in 2014, possibly due to the lack of any cold spells in winter and an unusually high overwintering survival that reinforced the migrant population (drawing: M. Franch).

Habitat management and conservation
How the abandonment of open spaces affects biodiversity in Catalonia: evidence from butterfly and bird monitoring programmes

This article details the results of a study using data from butterfly (CBMS) and bird (SOCC) monitoring programmes to create an indicator for the effects of land abandonment on biodiversity in Catalonia. Over the past two decades forest cover has increased in the analysed monitoring stations, which has had clear repercussions on the communities of both birds and butterflies. Other studies, both at general and local scales, suggest that this phenomenon can be extrapolated to the Mediterranean region as a whole.

Recent changes in the landscape pose one of the greatest current threats to biodiversity. In many areas of our planet, the destruction of forests and their conversion into agricultural and built-up land is the main cause of species extinctions.[1] Nevertheless, over large areas of Europe it is precisely the opposite process – the abandonment of fields and pastureland and subsequent encroachment of forests – that is the most worrying factor at work.[2-3] This process is leading to an increase in forest cover and is particularly notable in the Mediterranean region.[4]

The past decade saw the development of numerous indicators that faithfully measure how biodiversity is changing in relation to global change.[5-7] Amongst terrestrial systems, butterflies and birds have become the most used bioindicator groups due to their sensitivity to environmental change and their appeal to the public in general.[8-9] The existence of simple methodologies that generate scientifically robust results has engendered the spread of wide-ranging volunteer monitoring programmes, which enable biodiversity patterns to be examined at large spatial and temporal scales. This is the case of Catalonia, which boasts highly successful butterfly (CBMS) and bird (SOCC) monitoring programmes. These programmes' results enable us to study how the disappearance of open areas is affecting these two animal groups and to evaluate to what extent this phenomenon is having wide, across-the-board repercussions on the biodiversity of Catalonia.

This study was conducted within the framework proposed by Herrando *et al.* (2014) (ref. 10) and has two main objectives:

1. Determine the environmental preferences of birds and butterflies along an ecological gradient running from open spaces to forests and then test whether population tendencies in a species can be forecasted according to its position on that gradient.

2. Use multi-specific indicators to evaluate whether the communities of these two taxonomic groups are being affected in general throughout Catalonia by the above mentioned forest encroachment.

To carry out this analysis, data were used from 174 SOCC itineraries (2002–2013) and 74 CBMS stations (1994–2013), all of which are situated in areas dominated by natural or semi-natural vegetation (data from itineraries in agricultural or urban areas were discarded) (Fig. 1). The full methodology has recently been published[11] and here we present a summary of its main conclusions.

Habitat preferences of birds and butterflies along the open space-forest gradient

Birds and butterflies differ in terms of the spatial scale in which their most important biological processes take place.12 Thus, the habitat preference analyses were carried out using data from different spatial scales for each group: for butterflies the scale was represented by the sections of the itineraries that are categorized by the vegetation present in a 5-m-wide buffer zone along the transect; for birds, the itineraries are classified according to the Catalan Habitat Map 1999–2000 (www.ub.edu/geoveg/en/mapes.php) with a 100-m-wide buffer along the whole census route. The CORINE habitat cover categories were simplified and classified either as 'open habitat' or 'closed habitat' but were adapted to the ecological requirements of both taxa. After a number of trials aimed at assigning a similar number of species to each of the two categories, the following thresholds were established: for butterflies an open habitat was defined as a habitat dominated by vegetation with a maximum height of 60 cm; for birds, the vegetation in an open habitat could reach a height of 150 cm.

These criteria were applied to each section of the chosen butterfly itineraries and to the whole bird census routes in order to evaluate the relative percentage of open and closed habitats. To quantify the preference of a species along the open-closed habitat gradient, Generalized Linear Models (GLM) were used that took the average abundance of a species on an itinerary (birds) or a section (butterflies) as the dependent variable, and the proportion 'closed/(open + closed)' as the independent variable. Only species that gave significant results were selected ($P < 0.05$): 65 species of butterfly (48 with negative correlations and 17 with positive correlations with forests) and 66 species of birds (44 with negative correlations and 22 with positive correlations with forests) (Table 1).

The following step was to test whether the habitat preference of a species along this gradient enables us to forecast the tendency in operation in its populations. These trends were calculated using the software TRIM (excluding rare species and species present in fewer than 10 itineraries). The association between habitat preference and population tendency was analysed using linear regression models in which preference was the predictor and tendency the response variable.

We found in both groups a significant positive correlation between population tendency and the estimated habitat preference (butterflies 1994–2013: $F_{1,63} = 5.33$, $P = 0.024$; birds 2002–2013: $F_{1,64}=4.17$; $P = 0.045$) (Fig. 2). The positive correlations indicate that the species that are most tied to forests have undergone the most positive population trends, the opposite being true for the species that are most associated with open areas. Nevertheless, values are highly dispersed and so the association with the type of habitat only explains a relatively small part of the variance in the data for butterflies and, above all, birds.

Design of an indicator for the impact of forest encroachment on biodiversity

Land-cover maps from 1993 and 2009 (www.creaf.uab.es/mcsc/) were used to calculate the change in the proportion of forest and open space cover on the analysed itineraries. The 16-year period between these two maps coincides to a large extent with the time period covered by the monitoring programmes used in this study. The original land-use categories were reclassified as either 'open habitats' (grassland and scrub) or 'closed habitats' (open or closed

forests) and for each period the percentage of forest cover as a proportion of all the natural and semi-natural habitat in a 1-km buffer zone around the station was calculated. Then, an ANOVA with repeated measures was used to test whether significant changes had occurred in the proportion of forest cover between these two years.

Two multi-specific indices, one for butterflies and another for birds, were calculated for the impact of forest encroachment. These indicators were generated following Gregory *et al.* (2009) (ref. 6), and compare population tendencies in species that are significantly and positively (+) associated with closed habitats along the studied gradient, and in species significantly and negatively (-) associated with closed habitats. The indicators take an initial value of 100 for the first year of the study and so values over 100 indicate that the forest species in the community have increased in relation to the species that prefer open spaces, the opposite being true for values under 100.

Results of the indicators

Between 1993 and 2009 a significant increase of 4% in the proportion 'closed/(open + closed)' was recorded at the stations included in this analysis ($F_{1,236}$=5.43, P = 0.021); no differences were found between the analyses for the CBMS and for the SOCC.

Changes in landscape were reflected by a greater number of positive trends in the groups of species that prefer closed habitats than in the group that prefer open habitats in both butterflies and birds (Figs 3a and 4a). Moreover, these trends continued unchanged throughout the study period and have led to ever-greater divergence between the two groups of species. Thus, a progressive change has occurred in bird and butterfly communities, which are becoming increasingly dominated by forest species (Figs. 3b and 4b).

Interpretation of the results

Although butterflies and birds are two of the most popular bioindicators in terrestrial ecosystems, the divergent results that are sometimes thrown up when the patterns of diversity in these two groups are compared suggest that the environmental variables that affect them are different or – at least – act at different spatial and/or temporal scales.[13-14] Nevertheless, the results of the present study reveal a remarkable similarity in the response of these two groups to forest encroachment. If we consider butterflies as surrogates of many other less well-known insect groups, and birds as surrogates of other vertebrate groups, we can conclude that the increase in forest cover in Catalonia is negatively affecting an important segment of the country's biodiversity. Changes in landscape are leading to rapid changes in community structures, which are increasingly becoming dominated by forest species. It is important to note that the magnitude of the changes in land use (increase in forest cover) at the study sites is fully comparable with the changes that occurred throughout Catalonia during the same period of time; thus, it is legitimate to extrapolate conclusions for the country as a whole from our results. Likewise, our analysis vindicates the results of both general and specific case studies[15-16] by other authors in the Mediterranean region, a finding that indicates that this phenomenon is having a generalized and important impact on the wildlife of this region.

Obviously, it would be of great interest to broaden this study to include other taxonomic groups. The problem, however, is the lack of data gathered at similar scales to that generated by the CBMS and SOCC. An option for testing whether other groups are being affected in the same way could be to work at smaller scales with data generated by long-term research stations such as those of the LTER for other taxonomic groups. The existence of large-scale monitoring projects such as the CBMS and SOCC should be seen as a unique opportunity for developing robust indicators that can provide an excellent vision of the changes that are occurring within the biodiversity of our country.

It is important to appreciate that the indicators that we have described here neither assess the changes that have occurred in the total number of species present in Catalonia nor whether these changes are of conservation concern. These indicators simply reveal comparative tendencies in species associated with open and closed habitats. The repercussions of these changes on species abundance should, for example, now be studied in greater detail on the basis of an analysis of the data from each station. Come what may, in the case of butterflies the situation is clear: these changes have led to a generalized loss of biodiversity since most butterfly species are markedly thermophilous and require a large amount of sunlight in which to develop their life cycles.

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For references, see the original Catalan version.

Table 1. Habitat preferences for butterflies and birds along an ecological gradient running from open to closed spaces. The positive estimates correspond to preferences for closed habitats (forests) and the negative estimates to open habitats (grassland). Only the significant GLM models are shown.

Fig. 1. Itineraries with 75% or more natural or semi-natural habitats (grassland, scrub, forests) used in this study. In all, 174 SOCC itineraries and 74 CBMS itineraries were taken into account.

Fig. 2. Relationship between the estimates of habitat preference along the open-closed gradient in the studied bird and butterfly species. The population tendencies correspond to the period 1994–2013 for butterflies and 2002–2013 for birds.

Fig. 3. Multispecific indicators of the impact of the abandonment of open areas on butterfly communities. (a) The indicator distinguishes between the groups of species that prefer open and closed habitats; (b) the final indicator is calculated as the ratio between the values of the two groups. The significant increase over time indicates that the species with preference for closed habitats have been favoured by landscape changes more than those with preference for open habitats.

Fig. 4. Multispecific indicators of the impact of the abandonment of open areas on bird communities. (a) and (b) as in Fig. 3.

The station

The butterflies of Sant Feliu de Pallerols, La Garrotxa Volcanic Zone Natural Park

The Sant Feliu de Pallerols station has provided data for the CBMS network since 2010. Like the other station in this natural park (Can Jordà), Sant Feliu boasts a great variety of species, despite being at an altitude of just 518 m a.s.l.: from Mediterranean species like the Provence Hairstreak *Tomares ballus*, to Central European species like the Map Butterfly *Araschnia levana*. This itinerary passes through a wide range of natural environments.

The transect

CBMS station 115 is located in La Garrotxa Volcanic Zone Natural Park in the municipality of Sant Feliu de Pallerols. Specifically, it passes through the NE-SW-running Vallac valley, and lies 6 km from the Can Jordà station, situated just the other side of the Serra del Corb mountain ridge.

This itinerary, which measures1,570 m and is divided into 12 sections with an average length of 130 m, runs through a wide variety of natural environments. The first three sections follow a track and pass through, successively, thick holm oak *Quercus ilex* woodland, arable land (in recent years sown with alfalfa *Medicago sativa* and oilseed rape *Brassica napus*), and alongside the gully that gives the valley its name, which is lined by a strip of riparian woodland populated with elms *Ulmus minor* and black poplars *Populus nigra*. Section 4 boasts productive rough margins with bramble *Rubus ulmifolius* patches along the field edges. From here, the itinerary heads into holm-oak woodland (section 5) and then enters into pastures that stand on an area of volcanic soils. Sections 6, 7, 8 and 9 constitute a small mosaic of meadows that are regularly mown and have thus maintained their structures as hay meadows. Section 10 once again follows a line of riparian woodland. Section 11 differs importantly since it is south facing and is clearly Mediterranean in nature; it passes over open areas of sedimentary rock where thyme *Thymus vulgaris* and a number of strawberry-trees *Arbutus unedo* grow. Finally, section 12 consists of a path between cultivated fields (alfalfa or oilseed rape) and Mediterranean holm-oak woodland.

The butterflies

During the six years of monitoring, 22,892 of butterflies belonging to 92species have been counted. The annual averages in 2010–2015 were 3,800 individuals (243.01 ind./100 metres)and 70.2 species.

Annually, there are three peaks in abundance. The first occurs in April with the appearance of spring species such as Orange-tip *Anthocharis cardamines* and both Green *Callophrys rubi* and Chapman's Green *Callophrys avis* Hairstreaks, along with the first generations of Short-tailed *Cupido argiades* and Provençal Short-tailed *C. alcetas* Blues and the Map Butterfly *Araschnia levana*. The second and far more obvious peak in both species and individuals comes in the second half of June and first half of July, which is when the most abundant species such as Meadow Brown *Maniola jurtina*, Pearly Heath *Coenonympha arcania*, Clouded Yellow *Colias crocea* and Holly Blue *Celastrina argiolus* fly. The third peak takes place in August: the number of butterflies on the wing is still high and Violet Fritillary *Boloria dia,* Clouded Yellow, Common Blue *Polyommatus icarus* and Silver-washed Fritillary *Argynnis paphia* are all among the most abundant species.

The Meadow Brown is the commonest species – annual indices of 1,425 in 2010 and 1,187 in 2011– and is far more abundant than the second commonest, the Gatekeeper *Pyronia tithonus*. However, in the past four years the number of Meadow Browns has fallen greatly to just 400 annually. However, a longer data series is required before deciding whether 2010 and 2011 were exceptionally good years for the species or whether it is truly undergoing a decline.

It is still too early to evaluate on either an individual or overall level the stability of the populations of the species present at this station. This becomes clear if we look at the number of butterflies counted each year: in 2010 and 2011 numbers were much higher than in the following years and 2015 was the year to date with fewest butterflies counted. Although this would seem to suggest a decline in butterfly numbers, we still need a longer data series to be able to confirm any negative tendency. There has also been a decline in the number of species recorded annually: a maximum of 74 were counted in 2011, but only 65 (five points below the average) were detected in 2015. In the case of species, a longer series is essential as 18% of species observed are irregular in appearance and have only been observed in one or two of the six years of monitoring. Of these occasional species, some are of interest due to their scarcity in either La Garrotxa or Catalonia, or as protected species: Chapman's Green Hairstreak, Tufted Marbled Skipper *Carcharodus flocciferus*, Small *Cupido minimus,* Turquoise *Polyommatus dorylas* and Large *Maculinea arion* Blues, Dappled White *Euchloe crameri*, Provence, Spanish Purple *Laeosopis roboris* and White-letter *Satyrium w-album* Hairstreaks, Lesser Spotted Fritillary *Melitaea trivia*, Bath White *Pontia daplidice* and Spanish Festoon *Zerynthia rumina*.

Protected species and habitat management

The year 2010 was excellent for most CBMS stations and Sant Feliu de Pallerols was no exception. The species richness in that initial year of counting suggested that this station would have a great variety of butterfly species, as the 92 species observed in six years of monitoring demonstrate. One of the habitats that ensures such a high density of species is the meadows that are even today still mown for their hay. Every year I let the owner of these meadows (two of the sections pass through the middle of them) know the number of species and butterflies counted, and show him some photographs. In fact, in summer, above all, I often find him working to repair the holes dug by the wild boar or mowing, and he is always keen to know how the season is progressing — all the more since I told him that a species protected in Europe, the Large Blue, flies in his fields and that it is used as an indicator of habitat quality! In 2015 he asked a pertinent question: will we have to protect these fields? And, if so, will that mean he can't use them as before? My answer was clear: if up to now his activities have given rise to so many species, there is probably very little we can do to improve the management of these meadows. Habitat maintenance and/or improvement do not always mean avoiding human interference. However, the day that the techniques used to work these pastures over the last 40 years are abandoned will perhaps be the time to start thinking of a fresh management strategy.

Beth Cobo

Photo. One of the meadows in the transect that are traditionally managed and harbour a very rich butterfly community (photo: B. Cobo).

Aerial photo. The CBMS transect at Sant Feliu de Pallerols. It is 1,570 m long and has 12 sections with an average length of 130 m.

Fig. 1. Average abundance (average of the annual indices during the period 2010-2015) of the 15 commonest butterflies at the Sant Feliu de Pallerols station.

Bibliographical review

Dinca, V., Montagud, S., Talavera, G., Hernández-Roldán, J., Munguira, M.L., García-Barros, E., Hebert, P.D.N., Vila, R. 2015. **DNA barcode reference library for Iberian butterflies enables a continental-scale preview of potential cryptic diversity.** ***Scientific Reports*** **5: 12395. DOI: 10.1038/srep12395**

DNA barcodes of Iberian butterfly species enabled a continental-scale preview of potential cryptic diversity

European butterflies are arguably the most intensively studied invertebrates, being targeted by monitoring schemes, comprising numerous models for research and representing a flagship group for insect conservation efforts. Nevertheless, large-scale studies (that combine comprehensive taxon and geographic coverage) aiming to assess their genetic diversity have remained scarce, particularly so in the Mediterranean region, despite its high species richness and endemicity.

A recent study published in the journal Scientific Reports performed a high resolution survey of mitochondrial genetic diversity for all the butterfly species occurring in the Iberian Peninsula, including mainland Spain, Portugal, Andorra and the Balearic Islands. The authors employed DNA barcoding (a method that uses a short, standardized region from the genome of an organism to identify it as belonging to a particular species; for animals, this region is the cytochrome c oxidase subunit 1 - COI) to assemble a comprehensive DNA barcode library for all Iberian butterfly species: 3502 DNA barcodes for 228 species, sampled across various parts of the region (Fig. 1). Once established, this library creates a reliable system for the DNA-based identification of specimens regardless of life stage or condition. It has been found that over 93% of the butterfly species occurring in Iberia can be unambiguously identified based on DNA barcodes, while the vast majority of the remaining cases could be identified up to species pair levels (several of which have debated taxonomic status).

As a second step, the authors merged the Iberian data with all other publicly available DNA barcodes of European butterflies available in the Barcode of Life Datasystems (BOLD) (www.boldsystems.org), generating a dataset of 5782 DNA sequences for 299 species (ca. 60% of the European butterfly fauna).In this case, 84.6% of the species could be reliably identified using DNA barcodes; although notably lower than for Iberia alone, this percentage is arguably still high enough for numerous applications, such as the documentation of food webs or of host-parasitoid interactions.

The same extended dataset also provided an overview of variability in the mitochondrial genome which could highlight potential cases of cryptic species that can subsequently be investigated in more detail, using additional markers (e.g. nuclear DNA, morphology, ecology etc). Large datasets are also suitable for automated approaches of species delimitation that estimate species boundaries based on DNA data. Such a method is the Generalized Mixed Yule-Coalescent Model (GMYC) that combines phylogenetic and population genetic theories to define statistically significant clusters of specimens and provides probabilities for the delimitations as a measure of robustness. Thus, the clusters recovered by the GMYC analyses can be regarded as evolutionary significant units (ESU) that facilitate more objective research and nature conservations decisions.

Using the GMYC model and comparing its results with the current taxonomy (as reflected by Fauna Europaea, http://www.fauna-eu.org/), the authors found that 27.7% (83 species) of the 299 species analyzed include from two to four ESU, suggesting that the European butterfly fauna, despite having been intensively studied for over 200 years, might still harbour unexpectedly high levels of cryptic biodiversity. It should however be stressed that the ESU recovered by the GMYC should be regarded as genetically diverged lineages that reflect various evolutionary processes (each with its own research value) and only in some cases represent potential cryptic species - the status of the latter can be clarified only through additional, more detailed, studies. As a matter of fact, diverse and often complex patterns have been detected, some including the lumping of currently accepted species, others splitting, and several involving both lumping and splitting. Among the 83 species involving multiple ESU, 14 represented particularly promising cases involving potential cryptic species, because the ESU displayed high levels (at least 2.5%) of intraspecific gene-

tic divergence (Table 1). Although some likely reflect intraspecific variability (e.g. *Pyrgus cinarae*), others have already been suspected of comprising cryptic species, such as *Arethusana arethusa* (due to taxon *boabdil*), or *Melitaea athalia* (due to taxon *celadussa*). Interestingly, even in such cases the results sometimes did not fully match the "traditional" views on taxa and/or their distribution.

To facilitate the vizualization and interpretation of spatial genetic patterns, the species split into multiple ESU were also mapped (an example for *Thymelicus sylvestris* is available in Fig. 2) and, together with comments on the patterns detected, have been provided in the supplementary material of the study.

Although the DNA barcodes were able to highlight a considerable number of patterns requiring further attention, the authors also showed that some cases are likely to be overlooked by a single marker approach. This shortcoming was exemplified with *Iphiclides podalirius*, where the individuality of *feisthamelii* (a taxon with debated status), could not be detected in Iberia by the COI gene due to an apparently fixed mitochondrial DNA introgression from *podalirius* into *feisthamelii*.

All the cases detected (involving both lumping and splitting) suggest that much research is still needed even for one of the best studied invertebrate groups such as European butterflies. Given the global accelerated loss of biodiversity, DNA barcoding combined with automated methods for species delineation represents a powerful approach that can provide an overview of genetic patterns across wide areas. Such information can then be used for further research, but also for more efficient conservation measures.

Vlad Dinca

Table 1. Fourteen species were split into multiple GMYC entities with a minimum genetic distance of at least 2.5%.The sympatry/allopatry relationship among conspecific entities is shown based on a 50-km distance threshold. If a species was split in more than two entities, the data presented refer to the entity that was genetically most distant to the others.

Fig. 1. Map of the Iberian Peninsula (Spain, Portugal and Andorra) displaying the sites from where specimens were sampled and successfully barcoded. The map was generated based on a relief map from Natural Earth.

Fig. 2. Geographic distribution of the four ESU recovered by the GMYC model for *Thymelicussylvestris*. Two areas of sympatry have been detected (southern Spain and Romania).

The butterfly

The Lesser Purple Emperor *Apatura ilia*, an increasingly common denizen of the riparian woodland of Catalonia

The sight of a male Lesser Purple Emperor gliding through the treetops of its riverside territory, or a flash of purple as it opens and closes its wings whilst taking moisture from wet sand, are two of the most gratifying of all experiences for butterfly lovers. Happily, such sights are becoming progressively more common as the Lesser Purple Emperor expands its range in Catalonia due probably to the increase in the amount of riparian woodland and, above all, the number of poplars and willows.

Geographical distribution and situation in the CBMS

The Lesser Purple Emperor flies throughout the Palearctic region, from southern Europe, temperate Asia and as far as northeast China.[1] In Europe, the southern limit of its range lies in the north of the Iberian Peninsula, the south of France, the Po valley and the Apennines, whilst to the east it is found as far as the Balkan Peninsula. In the past decade, global warming has allowed it to undergo a clear expansion northwards into several parts of Scandinavia, Estonia and the Russian Federation.[2] It occupies the northern third of the Iberian Peninsula, from Galicia and northwest Portugal to the Catalan coast.[3] Its range in Catalonia has been well studied:[4] there are numerous populations throughout the northern half of the country in the Pyrenees (including the south and centre of Andorra), the pre-Pyrenees, the mountains of the Serralada Transversal, the far east of the Depressió Central and the northern half of the Serralada Prelitoral, Depressió Prelitoral and Serralada Litoral. The most southerly known sites are in the city of Barcelona and in the nearby county of Vallès Occidental, where this emperor has become established in recent years as part of the southward expansion of its range.[5] Its altitudinal range is broad and it is found from sea level to 1,650 m a.s.l. in the Pyrenees but becomes much scarcer above 1300 m a.s.l. (ref. 4).

In the CBMS and BMSAnd networks, the species has appeared to date in 39 butterfly walks, with the highest counts from stations in and around El Montseny, the Serralada Transversal (county of La Garrotxa) and the province of Girona; albeit in somewhat lower numbers, it also appears in the stations around Sant Llorenç del Munt and in the pre-Pyrenees. On the other hand, within the boundaries of its range it is absent from the Empordà plain and, apparently, from the stations along the Llobregat valley.

Habitats and food plants

The Lesser Purple Emperor is closely tied to riparian woodland, the most important habitat for its food plants. It is thus logical that Stefanescu & Dantart (2001) found in their review of the species that most of the records of this species are from woodland associated with watercourses. Due to its ability to travel distances, the species is often recorded at sites that are some way from rivers, although in general it is a species that clearly shies away from dry environments.

The females lay their eggs on trees of the Salicaceae family such as willows (*Salix* spp.) and poplars (*Populus* spp.)[1,6-7] that are characteristic of fluvial habitats. Specific records of egg-laying are few and far between for Catalonia since, given the nature of the woodland this emperor inhabits, it is difficult to observe females in the act of laying eggs or to find its caterpillars. Nevertheless, the use of black (*Populus nigra*) and white (*P. alba*) poplars, as well as aspen (*P. tremula*) and grey willow (*Salix cinerea*) has been confirmed.[8] In the literature there are also reports of egg-laying on alders (*Alnus glutinosa*) in Provence in France,[9] a food plant that has never been confirmed in any other population.

Females select branches in the crown of tall trees or saplings that grow at the forest edge. Eggs are laid on the upper side of a leaf with no apparent preference for any particular orientation within the tree.

Biological and phenological cycles

The Lesser Purple Emperor in Catalonia is a bivoltine species that has a first generation in June-July followed by a second in August-September. This pattern changes slightly depending on the geographical location of the population (Fig. 2): in Mediterranean habitats butterflies appear earlier, from mid-May onwards, and there is a second population peak in mid-August (Fig. 2a); by contrast, in more central-European-type upland habitats the first generation peaks in July and the second at the end of August/beginning of September (Fig. 2b). In addition, in Mediterranean environments the second generation tends to be more abundant, whilst in upland areas the opposite is true, which suggests that, in the latter type of habitat, the second generations are partial and some individuals develop as univoltines.

The egg (Photograph (a)), which hatches after around one week (depending on the temperature), is initially pale green but within a few hours of being laid a beige-coloured ring appears near its top. At birth, the caterpillar first eats the egg's chorion and then heads for the tip of the leaf, where it weaves a silk cocoon in which to rest when it is not feeding. About 7–10 days later, it moults into its second instar and acquires the green colour that will not then change during the rest of its growth. Two brownish horns appear on its head (Photograph (d)), behind which two yellowish lines extend as far as the first thoracic segments (Photograph (b)). At rest, the caterpillar is perfectly camouflaged as its horns merge with the outline of the leaf and the yellow lines with the leaf's veins.

In the caterpillars that hibernate (i.e. all those of the second generation plus those of the first generation that do not originate a second generation), the third instar stops eating, turns dark brown and chooses a resting place on the tree's bark, where it will remain motionless and well camouflaged until the fresh leaves appear the following spring. When it starts to feed again, it turns green once more and continues to moult through two further instars (Photograph (c)). Pupation takes place on the tree trunk, on the back of a leaf or amongst the tree's branches and results in a perfectly camouflaged pale-green chrysalis (Photograph (e)). Then, almost two weeks later, the adult butterfly finally emerges (Photograph (f)).

Adult behaviour

Unlike the majority of Catalan butterflies, the Lesser Purple Emperor does not take nectar from flowers;[10] rather, it is attracted to ripe or even rotten fruit. First-generation butterflies have been observed in Catalonia drinking from cherries, loquats and the fruits of the white mulberry, whilst those of the second generation have been recorded on apples, figs, peaches and grapes. Observations of these butterflies feeding on aphid honeydew on trees such as grey willow or on the sap of cork oaks (*Quercus suber*) are also commonplace.[4] The lure of ripe fruit and other substances with high sugar concentrations is also habitual in certain phylogenetically close tropical species and for centuries collectors have taken advantage of this habit to set traps for this much sought-after species.

As well, it is also common in the morning to see males and occasionally even females taking moisture from wet soil or mud. It is not clear whether they are simply drinking water or whether they are searching for elements such as sodium and nitrogen that are dissolved in the water.[11] The fact that this species occasionally feeds on excrements – and even dead toads[12] – would seem to suggest that these sources of nitrogen are an important part of their diet.

A common characteristic of both the Lesser and the Common Purple Emperor *Apatura iris* (much scarcer in Catalonia, but also present in the north of the country) is the strong territorial behaviour that males display in the afternoon[4,13] They choose a vantage point where they await the arrival of a female with whom they can mate (Photograph (g)). This stationary vigilance is broken by reconnaissance flights that demarcate the butterfly's territory around the chosen tree. If the territory holder detects another male, the result is a series of acrobatic aerial persecutions that are similar to those performed by other Nymphalidae.[14] Interactions with other species of butterfly that enter into the territory are also frequent, although in these cases the flights last for much less time. A study carried out in El Baix Montseny noted that an isolated lime tree growing next to a field was used in a number of consecutive years by Lesser Purple Emperors, and that certain males are faithful to a particular site and establish their territory there for a number of days.[4] The setting up of territories in trees in riparian woodland alongside rivers is also a regular occurrence.

Population trends

The Lesser Purple Emperor has been recorded from almost 100 UTM 10x10 km quadrants in Catalonia. Most records are fairly recent, i.e. from the past two decades, and thus indicate that the species has healthy populations in the northern half of the country.

The review by Stefanescu & Dantart (2001) only detected one negative tendency — the disappearance of the populations of this butterfly known from around Barcelona at the end of the nineteenth and beginning of the twentieth centuries. Nevertheless, since this review was published, a series of observations in the past five years reveal that this species has in fact recolonized Barcelona.[5] These new records suggest that the species is undergoing a southward expansion and today the city is at the southernmost edge of the species' known distribution in Catalonia.

Furthermore, CBMS data indicates that the populations of this emperor have increased in recent years.[15] This increase has been notable at stations such as Can Vilar and Can Jordà, even despite the difficulties in detecting this species due to its propensity for remaining high up in the tree-tops (Fig. 3). Curiously, the other purple emperor present in Catalonia, the Common Purple Emperor, is also on the increase and in recent years it has gone from being only known in the Val d'Aran and a few sites in El Pallars Sobirà to being regularly observed in Andorra and the eastern Pyrenees and pre-Pyrenees, and southwards along the valley of the river Noguera Pallaresa[16]

The increase in forest cover in Catalonia may be the main reason behind the increases in these two species' populations since both are closely tied to forests and, above all, riparian woodland. Over the past two decades all Catalonia habitats with an abundance of willows and poplars have spread, as the comparative habitat map of Catalonia reveals (Fig. 4). Thus, this appearance of new habitat for these species may well be the key to the establishment of fresh populations of these emperors and the general increase in their numbers. Nonetheless, the increase in the populations of the Lesser Purple Emperor in other European countries cannot be compared with the situation in Catalonia since, as mentioned above, in northern Europe these positive population trends have occurred above all due to climatic change.[2]

Constantí Stefanescu

For references, see the original Catalan version.

[2] Despite a few observations of the Lesser Purple Emperor in Estonia in 1937–1959, this species disappeared as a result of a series of cold winters and was not recorded again until 1995. Since that year, it has colonized the whole country in just 10 years and its populations are now considered to be stable (T. Tammaru, com. pers.). An expansive process has also occurred in recent years in Finland where, coinciding with two abnormally hot summers, the first observations of the species were made in 2002 and in 2010–2011. The populations of this emperor then increased suddenly and it has now established itself there in a number of new sites. Despite the regression due to the wet summer of 2015, this species is now well established in Finland (M. Kuussaari, com. pers.). The first confirmed record from Sweden is from 2011, since when the species has expanded along the country's east coast, albeit without as yet establishing any stable populations. The situation is similar in Denmark, from where there were numerous observations in 2015 (N. Ryrholm & L. Pettersson, com. pers.).

[5] The first recent observations in Barcelona are from July 2010. J. M. Sesma noted up five butterflies in Passeig Valldaura and thereafter reported the existence of a good colony in the area of Meridiana-Can Dragó- Passeig Valldaura-Parc de la Guineueta. Other new records from the city are from Poble Nou, Vall d'Hebron, El Fòrum and Naves de Tolosa (see Ornitho.cat).

[8] New observations not included in the review by Stefanescu & Dantart (2001) include those of a female egg-laying on a poplar *Populus nigra* sapling on 25 May 2011 at Olzinelles (M. Miralles, com. pers.) and two females egg-laying on the leaves of white poplars *Populus alba* in the last week of July 2014 in Santa Susanna (El Montseny), very close to the CBMS-11 butterfly walk (C. Stefanescu, obs. pers).

[10] Exceptionally, we observed a male taking nectar for a long time from the flower of a buddleia *Buddleia davidii* on 9 March 2007 in Sant Pere de Vilamajor.

[12] Observations of emperors attracted by a dead toad (J. Ylla, com. pers.), and by dog excrement and a manure heap (C. Stefanescu, obs. pers.).

[15] The tendency in the period 1994–2014 calculated with the TRIM software is moderately positive. Likewise, the tendency calculated with a method (Y. Melero, C. Stefanescu, J. Pino, in prep.) using Bayesian statistics that takes into account the species' detectability is also significantly positive. This type of analysis shows that the Lesser Purple Emperor is the butterfly that has undergone the sixth most important increase in Catalonia over the last 20 years (out of a total of 64 species analysed).

Fig. 1. Relative abundance (expressed as the values of the annual index/100 m) of the Lesser Purple Emperor *Apatura ilia* at different CBMS stations (1994-2014).

Fig. 2. Phenology of the Lesser Purple Emperor in the CBMS network: (a) Mediterranean habitats, 28 stations, 1994–2014, n = 300 individuals; (b) Central European upland habitats, 12 stations, 1994–2014, n = 240 individuals.

Fig. 3. Fluctuations in the populations of the Lesser Purple Emperor in the CBMS network in 1994–2014, calculated with the TRIM software. The tendency during the study period was one of a slight increase.

Fig. 4. Comparison of the surface area occupied by the vegetation communities with significant presence of poplars *Populus* and willows *Salix* (codes: 44b-f and 44h-j in the habitats manual of Catalonia) according to the mapping analyses carried out in 1998– 2003 and 2008–2012. The red colour represents where these two communities have spread in the time between the two periods considered (45.84% of the overall cover of these two communities). Source: Moisès Guardiola.

Photograph 1. Mud-puddling in search of salts and minerals dissolved in water is a common behaviour in males of the Lesser Purple Emperor. In this picture, a male of the yellow form *margheritae* in the transect of the valley of Riudemeia, in Argentona (photo: J. Corbera).

Photograph 2. Two Lesser Purple Emperors feeding on mature loquats in Sant Pere de Vilamajor, in July 2007 (photo: C. Stefanescu)

Photographs. (a) Egg on a white poplar leaf, **(b)** second-instar larva on a grey willow leaf, **(c)** fifth-instar larva, **(d)** detail of the cephalic capsule, **(e)** pupa with the adult near to emerge, **(f)** recently emerged adult, and **(g)** perching male (photos: J. Jubany).

Identification

How to separate the species of the genera *Euchloe* and *Pontia* (2)

The second group of these species should cause no identification problems and also includes two species, Green-striped White *Euchloe belemia* and Greenish Black-tip *E. bazae*, that have only ever been observed in Catalonia a few times. The other two, Bath White *Pontia daplidice* and Peak White *P. callidice*, have very different altitudinal ranges and habitats but may occasionally coincide given that the former disperses and migrates freely. However, it can be confused in spring with Western Dappled White *E. crameri*.

The Bath White is very common and can be found throughout almost all of Catalonia. It appears on virtually every CBMS itinerary and reaches its greatest densities in dry open envi-

ronments, above all in lowland areas. In the Pyrenees and pre-Pyrenees in alpine grassland, along ridge-tops and on screes it is easier to find Peak White,[1] which has only been observed once in the CBMS, at Campllong. The other two species are very rare in Catalonia. Greenish Black-tip was discovered in 1994 on the hills around Granja d'Escarp[2] but has never appeared in the counts from the two nearby CBMS stations. It prefers continental steppe-like habitats and as an Iberian endemic species is regarded as vulnerable.[3] The Green Striped-White, on the other hand, has been recorded just twice from the Serra de Collserola, once on the Torre Negra itinerary.[4,5] It is common on rough fallow ground in the south of the Iberian Peninsula and North Africa.[3] The Bath White is polyvoltine between March and October but is commonest at the end of summer. In many parts of Catalonia it cannot survive the winter and its populations depend on the arrival of migrants from the south. Its caterpillars feed on a variety of Brassicaceae and Resedaceae species. The Peak White flies in a single generation between June and mid-August and its larvae feed on plants from the genera *Cardamine*, *Erysimum* and *Reseda.* Finally, Greenish Black-tip is also univoltine and flies in March and April. Its caterpillars feed on garden rocket *Eruca vesicaria*, *Boleum asperum* and corn mignonette *Reseda phyteuma.* The Green-striped White has two overlapping spring generations (February–April and April–June) and feeds on various Brassicaceae species.

Jordi Dantart

For references, see the original Catalan version.

Drawings

BATH WHITE
Upperside: white; black wingtip and discal mark on fore-wing; females with more black suffusion.
Underside: fore- and hind-wingtips grey-green with white spots; black discal mark fore-wing.
Marked with line:
sub-rectangular mark on wingtips; white spots on veins that reach wing margins; wider discal mark, more black shading on margin; white post-discal mark in shape of a bird in flight; round mark in the middle of the cell.

PEAK WHITE
Upperside: white; marked sexual dimorphism in the extent of the black marks on all four wings.
Underside: fore- and hind-wingtips grey-green or yellowish; hind-wing with white, arrow-shaped post-discal marks.
Marked with line:
wingtips with black extending along margins and veins; more black on outer margin; tear-shaped white marks, darker in female; arrow-shaped marks are transparent; white arrowhead-shaped marks.

GREENISH BLACK-TIP
Upperside: sulphur-yellow; black wingtip and discal mark on fore-wing.
Underside: fore-wing yellow with greenish tip; hind-wing greenish with white discal mark.

GREEN-STRIPED WHITE
Upperside: white; black tip and discal mark on fore-wing; hind-wing with underside patterning visible through wing.
Underside: fore- and hind-wingtips with white, zebra-like patterning. Fore-wing with black discal mark.
Marked with line:
greenish wingtip with white lines; white zebra-like patterning on green background.

All four species are reasonably easy to separate. Most confusion occurs in spring between Bath and Western Dappled Whites (see Cynthia 12). To separate these species it is important to note the mark on the wingtip on the fore-wing, and the green coloration and the shape of the white marks on the underside of the hind-wing. Both these species are common in dry agricultural land, although when one becomes abundant the other is scarce: Western Dappled White is abundant in spring while Bath White is commonest at the end of summer when the former species is no longer on the wing. Peak White is found on summits in the Pyrenees, where males quarter their territories at high speed. The white arrow-shaped marks on both the upper- and undersides of the hind-wings are distinctive. Greenish Black-tip (originally known as *Elphinstonia charlonia*) is immediately identified by its unmistakeable sulphurous yellow colour. The Green-striped White can resemble the similar Western Dappled White due to its rapid flight but is separable from this latter species by the white zebra-like patterning on the underside of the hind-wings.

Identification

How to separate the species of the genera *Melitaea* (2)

Glanville *Melitaea cinxia* and False Heath *M. diamina* Fritillaries are two typical species of this genus. The former, common in upland pastures and widespread in Catalonia, is easily separated by the submarginal black spots on the hind-wings, while the latter, although relatively common in high mountain areas, is generally much scarcer in the rest of Catalonia. Despite its dark coloration, it can be confused with the complex group consisting of Provençal *M. deione*, Heath *M. athalia* and Meadow *M. parthenoides* Fritillaries. Both Glanville and False Heath Fritillaries have just a few food plants, where their larvae live gregariously in silken nests that are usually quite easy to locate.

The Glanville Fritillary lives in upland areas throughout most of Catalonia and is common in the Pyrenees but becomes much more localized in the south in the province of Tarragona. It is also found in small populations near the coast in the northern half of Catalonia (e.g. the Aiguamolls de l'Empordà and Lake Sils) and in arid areas in the counties of El Segrià and Ribera d'Ebre. It has been recorded from almost 50% of CBMS and BMSAnd stations.[1] It is common in open areas, typically flying in xeric pastures with short sward. Its food plant is narrow leaf plantain *Plantago lanceolata*, although it may occasionally lay its eggs on spiked speedwell *Veronica* spicata.[1] Despite being much more localized, the False Heath Fritillary is not uncommon in the Pyrenees and pre-Pyrenees, above all in the subalpine stage, where it flies between 500 and 2,000 m. Outside of the Pyrenees it maintains relict populations in the higher parts of El Montseny and Els Ports de Tortosa and Beseit, where it displays notable genetic differences.[2] It lives in clearings in humid woodland and near rivers and streams where its food plant, valerian *Valeriana officinalis*, grows.[3] The Glanville Fritillary is univoltine, flying in a long generation between April and July; the exception are its populations in the L'Alta Garrotxa and L'Alt Empordà, which are bivoltine.[1] Caterpillars hibernate gregariously in a nest at the base of the food plant and feed conspicuously once they awake in spring. The False Heath Fritillary is also univoltine and flies in May–July

Constantí Stefanescu

For references, see the original Catalan version.

Drawings

GLANVILLE FRITILLARY
Upperside: golden orange; females larger and darker; black submarginal spots of variable size on hindwing.
Underside: whitish background with two orange bands bordered with black marks; submarginal black marks within the orange spots.
Marked with line
obvious black submarginal spots; whitish apex with submarginal black marks

FALSE HEATH FRITILLARY
Upperside: darker than other *Melitaea*, above all on hind-wing.
Underside: yellowish background colour; submarginal band with blackish orange spots.
Marked with line
well-marked marginal and submarginal orange spots; anal angle less rounded than in other *Melitaea*; submarginal orange spots near the costa are darker.

The Glanville Fritillary is easily separated by the black spots in the orange submarginal band on its hind-wing, which are visible on both the upper- and undersides. Males are golden orange and are less reddish than other members of this genus. The tips to the fore-wings are less pointed in males than in females, which are darker and often have noticeably larger black spots in the orange submarginal band. The False Heath Fritillary is the darkest *Melitaea* to fly in Catalonia, although the Catalan subspecies *vernetensis* is somewhat less dark than the nominal subspecies that flies in central and northern Europe. Its hind-wing has a characteristic angular shape. The underside is yellowish with a submarginal band enclosing distinctive blackish orange marks near the costa. Nevertheless, this species is rather variable and can be confused easily, above all with the Heath Fritillary *M. athalia*. To avoid confusion, the male genitalia can be examined in the field with a magnifying glass without having to kill the butterfly. The valves of the male genitalia of the False Heath Fritillary are deeply forked and have two divergent prongs (like a fishtail).

Ajuntament Granollers
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