CBMS
Catalan Butterfly Monitoring Scheme

cynthia

Bulletin of the Catalan Butterfly Monitoring Scheme 2012/2013 - no. 12

Cover

Detail of the fore wing of Small Copper, *Lycaena phlaeas* (photo: Albert Miquel).

Small white, *Pieris rapae*, about to visit a flower (photo: Antoni Carvajal).

Editorial

Two *Cynthia* in one

After a long period without a *Cynthia*, we are pleased to be able to publish this longer edition that corresponds to the 2012 and the 2013 seasons. Inside, you will find details of the new stations that have become active over the past two years, as well as a summary of how the butterfly populations in Catalonia have fluctuated during these two years. The year 2012 was the poorest butterfly year, i.e. the fewest butterflies were counted, since the CBMS project began: exceptionally, almost 20% of species had their worst-ever year, a fact that is very possibly related to the severe summer drought that Catalonia suffered that year. In 2013, butterfly populations recovered somewhat but were still far from matching the numbers that characterized the first years of the project.

The weather alone cannot explain the severe fall in butterfly numbers in 2013 and we should also look to the fragmentation and loss of preferred butterfly habitats. The effect of these phenomena has been analysed recently using data from the CBMS and it has become clear that numerous factors influence the colonization and extinction rates of our commonest butterflies. This analysis reveals how the landscape has become impermeable and makes it difficult to butterflies to move from one area to another.

For the section 'The butterfly' we have chosen the Speckled Wood *Pararge aegeria*, a species that appears in practically all the CBMS stations – including those on the Balearic Islands, where it is particularly common – throughout the whole year. It is a woodland species and can often be seen exhibiting territorial behaviour in clearings and woodland edges. This behaviour has been – and still is – much studied by authors such as N.B. Davies and experimentally by research groups led by C. Wiklund and H. Van Dyck.

Finally, the identification section focuses on one of the traditionally most difficult groups: the fritillaries of the genus *Melitaea*. In this first part, we have concentrated on the Knapweed, Spotted and Lesser Spotted Fritillaries and in future editions we will look at the remaining species of this group. The other identification section tackles the common but often confusing group of the Dappled Whites vs. Bath White and female Orange-tip.

The CBMS network

Current situation (2012–2013) of the Butterfly Monitoring Scheme in Catalonia, Andorra and the Balearic Islands

During the 19th and 20th seasons, 66 and 67 stations, respectively, were active in the CBMS and BMSAnd networks. Six new stations were incorporated and two others were reactivated with modifications to their original routes. The three Menorcan stations continued to provide data and a new station was set up in Andorra. In 2012 101,758 butterflies were counted belonging to 158 species, whilst in 2013 the number of individuals and species were 143,586 and 161, respectively.

In all, during the 2012 and 2013 seasons counts were carried out at 72 stations (66 and 67, respectively; see figure 1 for the situation in 2013). As well, regular counts were made at two other sites (Dosrius in El Maresme and L'Escanyat in Granollers), and counts were resumed at Gerri de la Sal; in all three cases, it is hoped that these stations will provide complete data in the 2014 season. The two counts in La Val d'Aran continued, although the number of counting weeks was reduced.

The available annual series are shown in figure 2. Of the 123 stations that have provided data at one time or another, 41 (a third) have provided data for ten or more years, while five stations (El Cortalet, Darnius, Can Ferriol, Can Jordà and El Puig) have now been active for 20 or more years.

New transects

Can Tiril Nou (CBMS-119, Maresme, 173 m). This itinerary runs through a totally Mediterranean environment on an acid substrate. The wooded surface includes stands of umbrella pine *Pinus pinea* with fragments of Mediterranean oak woodland. The understorey includes numerous herbaceous plants, above all grasses such as *Brachypodium retusum* and *B. phoenicoides*. This itinerary coincides partially with itinerary 31, which was only active in 1998. The current itinerary is short (1,223 m) and consists of eight sections. Of the 38 species of butterfly detected to date, the most abundant are Mediterranean species such as Spanish Gatekeeper *Pyronia bathseba*, False Ilex Hairstreak *Satyrium esculi* and Green Hairstreak *Callophrys rubi*. Due to the presence of a small hillock in sections 5 and 6, there is an unusually high abundance of hill-topping species such as Wall Brown *Lasiommata megera*, Swallowtail *Papilio machaon*, Scarce Swallowtail *Iphiclides feisthamelii*, Western Dappled White *Euchloe crameri* and Long-tailed Blue *Lampides boeticus*. Of note are a number of good populations of more localised and sedentary species such as Provence Hairstreak *Tomares ballus* and Escher's Blue *Polyommatus escheri* (the latter linked to the here abundant Montpellier milkvetch *Astragalus monspeliensis*). Occasionally, Marsh Fritillary *Euphydryas aurinia*, Woodland Grayling *Hipparchia fagi* and Black-eyed Blue *Glaucopsyche melanops* have been detected. The counts are carried out voluntarily by Carles Tobella.

Viladecans (CBMS-120, Baix Llobregat, 117 m). This itinerary is situated close to the non-active itineraries of Sant Boi and Sant Ramon in a very humanized part of the Barcelona coastal strip. The first section runs through the built-up area of the town of Viladecans and then passes through a number of habitats to the north of the town occupied by a variety of herbaceous and shrub habitats, with shade provided by a few pines. The vegetation consists of various different phases of succession towards a climax Mediterranean vegetation. The butterfly fauna is clearly dominated by Mediterranean and thermophile species such as Spanish *Pyronia bathseba* and Southern *P. cecilia* Gatekeepers, Wall Brown *Lasiommata megera* and False Ilex Hairstreak *Satyrium esculi*. There are also a number of generalist species such as Small White *Pieris rapae*, Clouded Yellow *Colias crocea*, Common Blue *Polyommatus icarus*, Small Copper *Lycaena phlaeas* and Long-tailed Blue *Lampides boeticus*. The abundance of Geranium Bronze *Cacyreus marshalli*, logically, is a result of the urban nature of the first section. There are also a number of more localized species such as Marsh Fritillary *Euphydryas aurinia* and Great Banded *Brintesia circe*, Tree *Hipparchia statilinus* and Striped *H. fidia* Graylings, which appear in low numbers, as well as a few even less common species including Dusky Heath *Coenonympha dorus*, Grayling *Hipparchia semele*, Moroccan Orange-tip *Anthocharis euphenoides* and Spotted Fritillary *Melitaea didyma* that possibly disperse from nearby colonies. The counts are funded by Viladecans Town Council as a means of evaluating the work done in the area after the recent forest fires. The counts are carried out by Guillem Pascual.

El Remolar Nou (CBMS-121, Baix Llobregat, 1 m). A substantial part of this itinerary coincides with the original Remolar itinerary. As it reaches the sea, the itinerary passes through lines of vegetation running parallel to the sea: pinewoods, dune slacks and sand dunes. As well, it runs alongside the lagoon of El Remolar and also crosses areas of ruderal vegetation and Mediterranean grasslands. The new sections correspond essentially to *Brachypodium phoenicoides* and other types of grassland, as well as the remains of the area's riparian woodland, often with an importance presence of allochthonous plant species. The butterfly fauna is dominated by generalist species including Small White *Pieris rapae*, Common Blue *Polyommatus icarus*, Clouded Yellow *Colias crocea*, Bath White *Pontia daplidice*, Swallowtail *Papilio machaon* and Painted Lady *Cynthia cardui*. Nevertheless, populations of more ecologically demanding species still persist in the area; thus, counts here also include Gatekeeper *Pyronia tithonus* (surprisingly, as this is a typical species of mid-altitude mountains), Southern Gatekeeper *P. cecilia*, Large Skipper *Ochlodes venata* and Green-veined White *Pieris napi* (abundant and closely tied to wetland habitats). However, the most interesting butterfly from a conservation point of view is probably the Mediterranean Skipper *Gegenes nostrodamus*, which here flies in a stable population that was detected by the station's original itinerary. This station is also highly valuable from the point of view of monitoring the migrations of the Plain Tiger *Danaus chrysippus*. Despite not being detected in 2013, data from previous years show that this species regularly establishes breeding colonies in the Remolar area that are dependent on the allochthonous milkweed *Gomphocarpus fruticosus*. The counts are carried out by Guillem Pascual and are funded by Delta del Llobregat protected area.

Puig Graciós (CBMS-122, Vallès Oriental, 644 m). This itinerary runs through an area of the Cingles del Bertí that was seriously affected by the great forest fire of 1994. Thus, although mature woodland is almost totally absent, shrub- and scrublands are well represented and the data that are obtained are highly interesting from a point of view of documenting the evolution of butterfly communities in the aftermath of a forest fire. Although much of the itinerary corresponds to areas of sub-Mediterranean vegetation, topographical variations and changing orientations (i.e. north-facing vs. south-facing slopes) mean that the pure Mediterranean vegetation alternates with more sub-Mediterranean habitats. The butterfly fauna is moderately diverse and is dominated by thermophile and Mediterranean species such as Wall Brown *Lasiommata megera*, False Ilex Hairstreak *Satyrium esculi*, Spanish Gatekeeper *Pyronia bathseba*, Provence Chalkhill Blue *Polyommatus hispana*, Two-tailed Pasha *Charaxes jasius*, Cleopatra *Gonepteryx cleopatra* and Southern White Admiral *Limenitis reducta*, along with an abundance of more central European species including Gatekeeper *Pyronia tithonus* and Pearly Heath *Coenonympha arcania*. Due to their localized character, the most interesting species are Osiris *Cupido osiris*, Small *C. minimus*, Escher's *Polyommatus escheri*, Chapman's *P. thersites* and Silver-studded *Plebejus argus* Blues. The counts are funded by the Granollers Natural History Museum and were carried out in 2012 by Maria Guixé and Elisabeth Martínez, and in 2013 by Antoni Arrizabalaga.

Moià (CBMS-123, Bages, 745 m). This station is dominated by sub-Mediterranean vegetation including downy oak *Quercus pubescens* woodland and Blue aphyllanthes *Aphyllanthes monspeliensis* grassland. The number of different habitats is relatively diverse – woodland, pastures, scrub and croplands – and, given that this is mid-altitude calcareous habitat, the diversity of butterfly species is truly exceptional: in just two years 91 species have been detected and it is likely that in future years this number will continue to grow. There are important populations of Satyrinae such as the different Gatekeepers *Pyronia* spp., Iberian Marbled White *Melanargia lachesis* and Meadow Brown *Maniola jurtina*, as well as a large number of Nymphalinae and Lycaenidae. Just some of the well-established populations at the site include the Lycaenidae Adonis *Polyommatus bellargus*, Chapman's *P. thersites*, Catalan Furry *P. fulgens*, Meleager's *P. daphnis*, Amanda *P. amandus*, Mazarine *P. semiargus*, Osiris *Cupido osiris*, Small *C. minimus*, Provençal short-tailed *C. alcetas* and Short-tailed *C. argiades* Blues, and Brown Hairstreak *Thecla betulae*; the Nymphalidae Dark Green *Argynnis aglaja*, High Brown *A. adippe* and Marsh *Euphydryas aurinia* Fritillaries, and a number of different *Melitaea* spp. fritillaries; and, finally, amongst the Satyrinae, False *Arethusana arethusa* and Woodland *Hipparchia fagi* Graylings and Autumn Ringlet *Erebia neoridas*. The exceptionality of the site was confirmed with the observation of a Large Blue *Maculinea arion* in 2013; this protected species is very rare in Catalonia outside the main area of the Pyrenees. The counts are carried out voluntarily by Dolors Escalé.

Freginals (CBMS-124, Montsià, 165 m). This short (780 m) itinerary is situated between La Serra de Godall and Montsià and runs through a dry area of garrigue with dwarf fan palm *Chamaerops humilis* that suffers from severe summer drought. The butterfly diversity is low, as is normal for this type of environment, and only 26 species were detected during the first year of counts. Nevertheless, it is worth highlighting interesting species that are typical of southern Catalonia such as Spanish Festoon *Zerynthia rumina*, Blue-spot Hairstreak *Satyrium spini* and Sage Skipper *Muschampia proto*. Other typical Mediterranean species here include False Ilex Hairstreak *Satyrium esculi*, Dusky Heath *Coenonympha dorus*, Striped Grayling *Hipparchia fidia* and Two-tailed Pasha *Charaxes jasius*. The counts are carried out voluntarily by Oriol Hidalgo.

Turó del Carmel (CBMS-125, Barcelonès). This, the first strictly urban CBMS itinerary, runs through the park of El Turó del Carmel in Barcelona (except the first section in the Nou Barris quarter). This park has a few patches of Mediterranean vegetation (scrub and *Brachypodium phoenicoides* grassland), as well gardened areas. The number of butterflies is, logically, low due to the isolation of the area in the midst of a hostile urban area. To date, 21 species have been detected, most of which (e.g. Bath *Pontia daplidice,* Small *Pieris rapae* and Large *P. brassicae* Whites, Clouded Yellow *Colias crocea*, Cleopatra *Gonepteryx cleopatra*, Painted Lady *Cynthia cardui* and Red Admiral *Vanessa atalanta*) are highly mobile and generalist. Some species gather on top of the small hill and practice hill-topping – the case of the Swallowtail *Papilio machaon*, Scarce Swallowtail *Iphiclides feisthamelii*, Two-tailed Pasha *Charaxes jasius*, Long-tailed Blue *Lampides boeticus* and Wall Brown *Lasiommata megera*. The proximity of the hills of La Serra de Collserola explain the presence of isolated populations of Spanish *Pyronia bathseba* and Southern *P. cecilia* Gatekeepers, and, possibly, of Great Banded Grayling *Brintesia circe*. In the purely urban section the only regularly appearing species is the Geranium Bronze *Cacyreus marshalli*. The counts are carried out voluntarily by Rebeca Izquierdo and Javi Quesada.

Vall del Riu (CBMS-126). A new BMSAnd station situated in the parish of Canillo in northern Andorra. The itinerary runs through an area of humid subalpine meadows that host a very diverse and interesting butterfly fauna; during the first year, 54 species were detected, although it is certain that many more will appear in coming years. The most abundant species include typical Pyrenean species such as Autumn *Erebia neoridas* and Bright-eyed *E. oeme* Ringlets, Scarce Copper *Lycaena virgaurea*, Small Tortoiseshell *Aglais urticae* and Apollo *Parnassius apollo*. As in other similar damp meadow habitats in Andorra, Bog Fritillary *Boloria eunomia* is present. This itinerary also passes through a rocky area where rock stork's-bill *Erodium foetidum glandulosum* grows; this is the food plant of the Spanish Brown Argus *Aricia morronensis* and the itinerary is home to one of the most important populations of this butterfly in the whole of Andorra and Catalonia.[2] Thanks to the incorporation of this new itinerary, this Iberian endemic butterfly can now be added to the list of CBMS and BMSAnd species. Other well-represented species here in the Vall de Riu include the Hermit *Chazara briseis* and Turquoise Blue *Polyommatus dorylas*, two species that are poorly represented in the CBMS network. The counts are carried out voluntarily by Eric Sylvestre.

Gironella Nou (CBMS-127, Berguedà). The Gironella (active since 2000) had to be changed since in 2013 a number of pastures were fenced off to be grazed by cattle. Although the first sections coincide with the old itinerary, this station has had to be renamed and renumbered in order to be able to compare counts in successive years. Naturally, the species that are found are similar both in types and abundance.

The number of active stations in 2012–2013 has remained steady at around 65–70, within the range of the number of stations that stabilized around 2006. This fact is worthy of mention in a context of economic difficulties in which budget cutbacks have occurred in many protected areas. Thus, itineraries such as those at Montjoi (CBMS-64), Sadernes (CBMS-99) and part of the Garraf itineraries are no longer walked. Of note too is the fact that the Can

Liro itinerary (CBMS-10) became inactive in 2012 after 18 years of uninterrupted counts. However, this loss was partially compensated for by the resumption of counts on the Santa Susanna itinerary (CBMS-11), also in El Montseny, which is home to very diverse and interesting butterfly communities.

Habitats represented

The main environments and plant communities represented in the 2013 counts are detailed in Table 1. Lowland itineraries (holm-oak woodland, scrub and garrigue) account for 72% 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 7%.

Species present

The list of species detected over the past 10 years is given in Table 2. In 2012 and 2013, respectively, 158 and 161 species were recorded. These figures are close to the annual average of 161.1 species per year that has been recorded since the incorporation of the BMSAnd into the network in 2006, which guaranteed better quality data from the Pyrenees (fig. 3). In all, four new species were added to the CBMS database in 2012 and 2013: the Monarch *Danaus plexippus* and Great Sooty Satyr *Satyrus ferula* in 2012, and Rosy Grizzled Skipper *Pyrgus onopordi* and Spanish Brown Argus *Aricia morronensis* in 2013. Of these new species, perhaps the most surprising was the appearance of a Monarch on the Santa Susanna itinerary (CBMS-11) in El Montseny on 17 July 2012. This observation can be added to others of the same species in 2011 and 2012 in different parts of Catalonia and the Mediterranean. The spate of recent sightings of this species would seem to be related to its release during weddings by specialized companies, as reported in an exhaustive analysis by John *et al.* (ref. 3). On the other hand, the appearance of Rosy Grizzled Skipper in the scrub in the Margalef itinerary, confirmed by photographs, is another notable addition from the past two years. It is almost certain that this species has a stable population in the area (and possibly in other similar areas in southern and western Catalonia), which, due to the difficultly in separating the species of the genus *Pyrgus,* has gone unnoticed to date.

[1] Folch i Guillèn, R., 1981. *La vegetació dels Països Catalans*. Ketres Editora, Barcelona.

[2] Dantart, J. & Lockwood, M., 2002. "*Aricia morronensis* (Ribbe, 1910), un ropalòcer nou per a Catalunya i Andorra (Lepidoptera: Lycaenidae)." *Butll. Soc. Cat. Lep.*, 87: 25-34.

[3] John, E., Stefanescu, C., Honey, M.R., Crawford, M. & Taylor, D., 2014. "Ceremonial releases of *Danaus plexippus* (Linnaeus, 1758) (Lepidoptera: Nymphalidae, Danainae) in the Iberian Peninsula, the Balearic Islands and Cyprus: implications for biogeography, potential for colonisation and a provisional listing of Asclepiadoideae from these regions." *Entom. Gaz.*, in press.

[4] Karsholt, O. & Razowski, J., 1996. *The Lepidoptera of Europe. A Distributional Checklist.* Apollo Books, Stenstrup.

Table 1. Environments and plant communities present in the CBMS in 2013, 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 (2004–2013). The number of stations at which a species has been recorded is indicated (out of a possible total of 52 in 2004, 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). Taxonomy as per ref. 4.

Fig. 1. Geographical situation of all the stations that have participated in the CBMS network (1994–2013), 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, that 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:

Of all the additions in recent years to CBMS, it is worth to note the itinerary of Moià, due to its exceptional butterfly diversity. Thanks to the combination of a variety of grassland, shrubland, forest and crops, as well as its strategic geographical position, this site harbours a rich butterfly community of nearly 100 species, with several rarities like the Large Blue *Maculinea arion*, among others (photo: Dolores Escalé).

Colonies of the Spanish Brown Argus *Aricia morronensis*, a small Lycaenidae endemic to the Iberian Peninsula, were recently discovered in Andorra, El Solsonès and La Cerdanya. In La Vall del Riu there is a very important population of the species in the rocky areas that are home to its food plant, rock stork's-bill *Erodium foetidum glandulosum* (photo: Pep Monterde).

In 2012 the Monarch *Danaus plexippus* was observed in a number of places in Catalonia. In October, its caterpillars were found on the beach at Castelldefels (see photo) feeding on the milkweed *Gomphocarpus fruticosus*. It would seem that these larvae (some of which completed their cycle and produced adults that emerged in December) were the product of eggs laid by a female that had been bred in captivity and released by a company that organizes wedding celebrations (photo: J.M. Sesma)

The CBMS – 20 years

Summary of the 2012 and 2013 seasons

The year 2012 was the worst in the 20 years of the CBMS: 12 of the 66 commonest species reached historically low levels and none of these 66 reached all-time highs. The Satyrinae were probably the worst hit group, although the Scarce Swallowtail, Moroccan Orange-tip, Two-tailed Pasha, Glanville Fritillary and Mallow Skipper also suffered badly. The most likely causes were the heat waves that hit from June to August and the drought. Although there were signs of recovery in many species, overall 2013 was also a below-average year for butterfly abundance.

Weather and butterfly counts

In general, 2012 was a warm year with less marked extremes than 2011; however, July and, above all, August were notably hot (see www.meteocat.com). It was also a dry year throughout almost the whole of Catalonia, above all in the northeast, the western pre-Pyrenees, the Ebro delta and centre, as well as in central coastal and Pre-littoral areas; one of the exceptions was the county of Pallars Sobirà, which had an exceptionally wet year. Only November was wet throughout the whole of Catalonia, although precipitations in April were generous over much of the country. January, February, May, June, August and December were dry or very dry months everywhere.

Winter was marked by cold spells of Siberian air in the first fortnight of February that lasted for over two weeks and produced many frosty mornings; indeed, not since the mid-1960s had a cold snap persisted for so long. The hottest days of the year, with temperatures over 40ºC, occurred between mid-July and the end of August. The first heat wave, however, struck early on 25–30 June but was surpassed on 17–23 August by the year's hottest days with temperatures that soared and then persisted high for days throughout the whole of western Europe. Only July 2006 and August 2003 have ever had weeks quite as hot as those of summer 2012 in Catalonia. The combination of these heat waves and the lack of rain in summer gave rise to a severe drought that seriously affected both plants and butterflies.

Unlike 2012, weather-wise 2013 was a fairly average year, with no long cold or hot spells. It was reasonably wet – or even very wet – in parts of the country such as the western Pyrenees, eastern Catalonia and the Pre-littoral mountains. In terms of the seasons, early winter was warm or even very warm, with historically high temperatures over the Christmas period and during the first week of January, but was cold in February and generally dry or very dry (above all, in the northeast). Spring was remarkable for the quantity of rain that fell (a lot of snow in the Pyrenees) and was fairly cool: May 2013 was one of the coldest for 20 years or more, due more to constant cloud cover and rain rather than to any severe cold spells. Summer 2013 was very different from the previous year and there were no exceptionally hot periods at all. June continued cool, with a succession of cold fronts that brought frequent rain, albeit in little quantity. The weather was hot and dry in July, and in August temperatures and rainfall were close to average values for the period. Finally, autumn was warm throughout much of Catalonia, above all October and the first part of November, and was dry in September and October. However, the weather finally broke in November and rain fell generously everywhere.

In the years 2012 and 2013, respectively, 3.1 and 4.2 counts per station were lost (figs. 1a,b), respectively, below and above the average for the period 2000–2013 (3.46 counts per station). The greater number of lost counts in 2013 can be put down to the persistently uncertain weather in spring and at the beginning of summer that made it difficult to find good days for counting. This is well illustrated by figure 1d, in which the concentration of lost counts in the first half of the season is clear (up to week 16 in mid-June). In 2012, on the other hand, critical periods of bad weather were limited to a few weeks of generalized bad weather in April and May (fig. 1c).

Changes in abundances: general considerations

Both the number of species and the number of individuals counted were exceptional in the 2012 and 2013 seasons. Firstly, 2012 was very poor: on the 59 itineraries with comparable data from the previous year, 44.8 ± 16.7 species/itinerary (average ± standard deviation) were counted, a contrast to the respective figures in 2011 of 47.0 ± 17.6 species/itinerary (Student Test for paired samples, $t = 3.448$, $P < 0.001$). Differences in abundances were even more marked: 1532.9 ± 1160.7 individuals/itinerary in 2012 vs. 1975.7 ± 1433.2 individuals/itinerary in 2011 ($t = 5.275$, $P < 0.0001$).

Bearing in mind that the abundances of the majority of species in 2011 were already below average for the whole CBMS period, the fall in numbers in 2012 represents by far the worst-ever CBMS season since counts began in 1994 (fig. 2). More specifically, 12 of the 66 commonest species in the CBMS network (almost 20%, or almost one in five butterflies) reached their lowest-ever levels for the period 1994–2013 in 2012; likewise, no species in 2012 reached a new peak in numbers. It seems clear that the cause of this enormous fall in numbers was the cumulative effect of two hot dry years, as well as the coincidence in 2012 of an intense cold spell in February and four heat waves in the summer.

Fortunately, in 2013 a certain recovery was noted in many species: the number of species/itinerary registered a marginally significant increase compared to 2012 ($P = 0.065$), while the number of individuals/itinerary showed a very significant recovery ($P < 0.0001$). Specifically, the values for the 61 itineraries with comparable data for 2012 and 2013 were: 46.3 ± 17.3 species/itinerary in 2013 vs. 44.9 ± 16.3 species/itinerary in 2012; and 2170.4 ± 1532.5 individuals/itinerary in 2013 vs. 1558.3 ± 1141.1 individuals/itinerary in 2012. Even so, butterfly numbers in 2013 were in general well below the yearly averages recorded since 1994, as figure 2 shows.

Changes in abundance: fluctuations in populations

As commented above, in the poor 2012 season almost 20% of Catalan butterflies reached record lows for the period beginning in 1994. A good example is the Two-tailed Pasha *Charaxes jasius*, a species that is not resistant to intense winter cold[2] and was undoubtedly badly hit by the persistent cold weather in February 2013 (Table 1).

It is also worth mentioning the severe fall in numbers suffered by certain Satyrinae that are generally some of Catalonia's most abundant and widespread species. For example, the Speckled Wood *Pararge aegeria*, Iberian Marbled White *Melanargia lachesis*, Gatekeeper *Pyronia tithonus*, Southern Gatekeeper *P. cecilia*, Small Heath *Coenonympha pamphilus*, Tree *Hipparchia statilinus* and Striped *H. fidia* Graylings, and Meadow Brown *Maniola jurtina* had either their first, second or third worst-ever years since records began in 1994 (Table 1). Other species with a variety of ecological requirements and phenologies such as Scarce Swallowtail *Iphiclides feisthamelii*, Moroccan Orange-tip *Anthocharis euphenoides*, Berger's Clouded Yellow *Colias alfacariensis*, Green-underside Blue *Glaucopsyche alexis*, Glanville Fritillary *Melitaea cinxia* and Mallow Skipper *Carcharodus alceae* also registered historically important lows. This coincidence in low numbers in so many species is almost certainly related to the negative impact of the drought on the quality of larval food plants and the number of nectar sources for adults, two factors that typically result in significant increases in mortality rates.

On the other hand, 2012 was not so bad and was even moderately favourable for migratory species such as Long-tailed *Lampides boeticus* and Lang's Short-tailed *Leptotes pirithous* Blues, Bath White *Pontia daplidice*, Red Admiral *Vanessa atalanta* and, above all, Plain Tiger *Danaus chrysippus*. Exceptionally, the Plain Tiger migration was concentrated on the Aiguamolls de l'Empordà and was much less obvious in the Ebro delta and non-existent in the Llobregat delta, the two wetlands in which this species is most commonly observed. On the Mig de Dos Rius itinerary two Plain Tigers were counted at the end of June and beginning of July and then, with the emergence of the local generation in August, numbers increased spectacularly to total of 69 individuals at the end of the month. At La Tancada in the Ebro delta, a few Plain Tigers were counted in August and September.

Although the negative trends in many species were reversed in 2013, for a few species this year was even worse than 2012. This is the case of the Wood White *Leptidea sinapis*, Black-eyed Blue *Glaucopsyche melanops* and Small Heath *Coenonympha pamphilus*, three species whose numbers have fallen worryingly – and for unknown reasons – in Catalonia in recent decades. By contrast, 2013 saw historically high counts of the Nettle-tree Butterfly *Libythea celtis* and Banded Grayling *Brintesia circe*, two species that are expanding rapidly in Catalonia.

The commonest species in the CBMS network in 2013 are shown in Table 2, along with comparisons of their positions in 2011 and 2012. The total counts show clearly – with the extreme example of Tree Grayling – how the populations of many common butterflies have recovered. In addition, it is worth commenting on the position of the Silver-studded Blue *Plebeius argus* whose populations in L'Empordà increased dramatically to their highest-ever level over the past 25 years. Nevertheless, 2013 was a bad year for the False Ilex Hairstreak after two excellent years in which it was the commonest butterfly in the CBMS network.

[1] Greatorex-Davies, J.N. & Roy, D.B., 2001. *The Butterfly Monitoring Scheme. Report to recorders, 2000*. 76 pàg. Centre for Ecology and Hydrology, Natural Environment Research Council, Huntingdon.

[2] Stefanescu, C. & Planes, J., 2003. "Com afecta el rigor de l'hivern les poblacions catalanes de *Charaxes jasius*." *Butll. Soc. Cat. Lep.*, 91: 31-48.

Fig. 1. Coverage of the counts at the different CBMS stations in 2012 (a) and 2013 (b); distribution of the lost counts during the official 30 weeks of the recording seasons (1 March–26 September) in 2012 (c) and 2013 (d).

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 (closely followed by 1995) and the worst 2012. Calculations were carried out using the methodology described in Greatorex-Davies & Roy (2001); annual indices were calculated using the TRIM programme.

Table 1. Evolution of the annual indices of 86 species of butterflies from the CBMS network over the past 10 years (2004–2013), based on an arbitrary value of 1 for 1994. Annual indices were calculated using the TRIM programme.

Table 2. Sum of the annual indices and order of abundance of the commonest 20 species in the CBMS network in 2013 compared with the corresponding indices and abundances for the 2012 and 2011 seasons.

Drawing 1. Moroccan Orange-tip *Anthocharis euphenoides*, a typically Mediterranean butterfly and one of the first to appear every year, also had a historically bad year in 2012 (drawing: M. Franch).

Drawing 2. The cabbage butterfly, *Pieris brassicae*, was one of the most common species during the 2013 season, when it attained the third highest record since 1994. Particularly noteworthy were the numerous observations of northward migration during the second half of June, in different mountain areas (e.g. in the Pyrenees and Montseny). It is highly likely that these migrations relate to massive emergences from fields of canola, *Brassica napus*, a very common crop in recent years in central Catalonia and in the counties of Vallès (drawing: M. Franch).

Habitat management and conservation

How species ecology and landscape structure affect the colonization and extinction rates of Catalan butterflies

This article discusses the result of a study in which for the first time an estimation is made of the colonization and extinction rates of a group of Catalan butterflies present in the CBMS network. Multi-season occupancy models were used along with an analysis of the environmental variables that most affect the taxa under study. A greater surface area of suitable habitat for the species and the permeability of the landscape matrix that surrounds the itinerary are factors that clearly favour colonization by a species or reduce the risk of extinction. The topographical complexity of a landscape also plays a part and decreases the risk of extinction in more sedentary species. The best way to preserve butterfly-rich communities is to conserve large areas of favourable habitat, above all upland areas that act as refugia in epochs of extreme climate.

As a result of anthropic pressure, many plant and animal species today occupy suitable habitat patches that are separated by a matrix of more or less inhospitable modified landscape. When this occurs, the species in question form metapopulations, that is, a series of smaller populations occupy some of the available habitat patches that are connected via dispersive processes. The persistence of a metapopulation depends on the dynamic colonization and extinction processes in the suitable habitat patches in which the species can survive.[1] The understanding of the factors that affect these processes is thus currently one of most pressing tasks in conservation biology.

Butterflies often live in metapopulations in landscapes modified by human activities.[2] In general, it is believed that population dynamics are affected by the geometry of habitat patches (above all, by their size and degree of isolation); nevertheless, increasingly, it is thought that other factors related to patch quality and the nature of the landscape matrix separating the patches also play an important role.[3-5] Thus, various studies have emphasized the importance of the landscape that surrounds the patches.[6-8] Climatic fluctuations may also be important, as they will affect the availability of trophic resources and the behaviour of both larvae and adult butterflies.[9-10]

It is also evident that not all species respond in the same way to the different factors at work, a fact that hinders the identification of general traits that can be applied to a community as a whole. Despite this difficulty, it is clear that we must work at community level if we are to preserve a significant part of our biodiversity. This study aims to identify the key factors that explain the persistence of the greatest number of butterfly species in the Mediterranean environments sampled by the CBMS.[11] To this end, multi-season occupancy models were used to infer the occupation dynamics of the habitat patches taking into account the imperfect detectability of the species.[12] Specifically, both the colonization rates for all species in new habitat patches and the extinction rates for occupied patches were estimated, as well as how patches are affected by various environmental variables.

Methodology

The study was based on an analysis of data from 26 CBMS stations with data series of at least 10 years (Table 1) and 73 species with data from a minimum of 10 stations. The presence/absence data for each species at each station was used to estimate the colonization/extinction rates, which were then related to a series of landscape and climatic variables. Subsequently, we were able to grasp how two relevant ecological traits (degree of habitat specialization and dispersive capacity) affect colonization/extinction rates.

To simplify the analysis, the weekly counts were grouped into months so that the number of annual samples was reduced from 30 to 7. For each species, a final presence/absence matrix was generated with 26 rows (the number of stations) and 119 columns (the number of samples multiplied by the number of seasons),

The presence/absence data for each species were analysed using multi-season occupancy models,[13] which calculate changes in species occupancy over time and which in turn can be used to evaluate the importance of the processes that give rise to these changes. For the first time in the analysis of CBMS data, observer experience was taken into account in the detectability of the species. Observers were classified as belonging to one of three categories, ranging from beginners to observers with over three years of experience in the itinerary, and this variable was then included in calculations of species detectability. The details of the construction of the models and the modelling techniques are to be found in the work by Fernàndez-Chacón *et al.* (2013).[11]

Results

Colonization and extinction rates

Colonization rates are above all affected by a combination of landscape permeability and the amount of suitable habitat along the transect (74% of cases). Some models also indicate that the aridity index has a certain influence but to a much lesser extent than the other two variables.

Landscape permeability makes colonization easier for most species; likewise, the amount of suitable habitat will always have an effect on colonization (fig. 1). Thus, the stations with more suitable habitat that are surrounded by a permeable landscape are those that will be most often colonized by a greater number of species. The aridity index, however, has no such clear cut influence on colonization, although some studies have shown that drought periods force adults to disperse (due to a lack of resources) and will in fact favour the colonization of new habitats. Our data indicate that aridity increases colonization rates in some species, but decreases them in others.

Extinction rates are mainly influenced by the interaction between the surface area of suitable habitat and the permeability of the landscape, but also – to a lesser extent – by topographical complexity (fig. 1). In order of importance, the variables that most affect extinction rates are the surface area of suitable habitat, landscape permeability and topographical complexity. Aridity was selected in the model for only a few species. As was to be expected, extinction rates decreased clearly when a greater surface area of suitable habitat was available but also as the topographical complexity increased. By contrast, neither landscape permeability nor aridity had clear effects on extinction rates. Thus, the stations with a greater surface area of suitable habitat and greater topographical complexity are those that have the lowest extinction rates for many species.

How do ecological traits affect the likelihood of colonization and extinction?

Extinction probabilities did not vary greatly between the four different categories of dispersion and habitat specialization that were considered; nevertheless, there were important differences observed in the colonization rates for these four categories (fig. 2). Both the most mobile species (better able to disperse) and the most generalist species in terms of habitat selection have far greater probabilities of colonizing or recolonizing suitable habitat patches than the sedentary or specialist species.

When the importance of the different predictors of colonization and extinction probabilities is analysed in terms of species' dispersive capacity, the only clear influence was topographic complexity (fig. 3). Specifically, this predictor was more important in the case of the species with low dispersive capacities; in other words, the most sedentary species will benefit – i.e. their extinction risk will be reduced – more than other species from greater topographic complexity in the landscape.

The colonization probability is more positively affected by the surface area of suitable habitat in habitat specialists than in generalist species (fig. 4). Thus, above all in specialist species, greater surface area of suitable habitat will make colonization or recolonization of new habitat patches more likely.

Interpretation of the results

This study represents the first time that the colonization and extinction probabilities of a broad range of Catalan butterflies (73 species) have been estimated. The estimates are robust due to the number of CBMS stations used (26, of which two are on the island of Menorca) and the long temporal series of data (in all cases, over 10 years). Moreover, multiseasonal occupancy models, a powerful statistical tool that takes into account the imperfect detectability of species, were employed. Thus, this study is particularly interesting since it uses data from the CBMS network in a novel fashion and applies a methodology that is both complex and rigorous. The models have identified a series of factors that explain a large part of the variability in the colonization and extinction probabilities, both in terms of the ecological level of the species and the environmental characteristics of the zones in which species are found.

Of particular note is the importance of the surface area of suitable habitat as a predictor of extinction probabilities. This result concurs fully with meta-population theory whereby a larger area of occupation means in general a larger population and thus a lower risk of extinction.[1] However, it should be remembered that in our study habitat was defined in a broad sense and included those parts of an itinerary in which high abundances of a particular species are observed. Hence, environments that are not used in a strict sense for reproduction but for feeding and shelter for adults were taken into account.[8] The surface area of suitable habitat also positively affects the colonization probability of the species. This could be due to an indirect statistical effect (a larger area means a greater probability of contact – and therefore colonization – for an individual in dispersion) or the result of a decision taken by the dispersing insect (that is, the dispersers will generally choose the largest habitat patches). The results do not indicate any greater effect for the surface area in species that colonize easily (and also, by definition, have a greater capacity for detecting suitable habitat) – in fact, the opposite is true – and so we believe that it is a purely indirect effect.

An even more important factor in colonization probabilities is landscape permeability. As was foreseeable, greater permeability of the landscape matrix increases colonization probabilities. Surprisingly, however, this effect does not vary between species with good and poor dispersive capacities. The results demonstrate that habitat patches that are surrounded by relatively impermeable matrices are less likely to be colonized or recolonized by butterflies.

Unlike the case of colonization probabilities, landscape permeability does not seem to affect extinction probabilities in any consistent way. This may come as a surprise since *a priori* a greater colonization probability in a more permeable landscape should increase a 'rescue effect' in the case of populations threatened by extinction more feasible. The explanation could be that the permeability of the landscape has simultaneous and opposing effects on extinction: although permeability may decrease the extinction probability via the aforementioned 'rescue effect', it could also increase the ability of butterflies to emigrate if the habitat quality deteriorates.

A third important factor is topographic complexity, which significantly reduces the extinction risk in sedentary species. In fact, we believe that this effect would have been even more important if we had included a greater number of markedly sedentary species. This was not possible because many of these species are very local in distribution and appear in fewer than 10 stations, the threshold we established for including species in the analysis. In fact, the importance of topographic complexity has been confirmed by a second study in which the variability of a population (that is, the size of the fluctuations in the number of individuals in the population) was studied. This parameter, which is quite closely related to the extinction rate of populations, is significantly and negatively influenced by topographical complexity in a group of 20 sedentary species, but has no effect on more mobile species.[15]

The positive effect of topography on the persistence of populations can also be interpreted within the context of climate change and how species in the north and south of their ranges respond. Apparently, responses are stronger in the populations that occupy the more northern parts of these areas, where changes in distributions are becoming more marked.[16] This could be due in part to the predominance of mountainous landscapes in southern areas, which ensures that species with poor dispersal capacity have more micro-climates – and thus, more refugia in the event of extreme climatic situations – within their reach.

As a final consideration, we should add that to preserve the maximum number of species in the human-affected landscapes such as those we have studied, the most effective measure is to increase the quality of the available habitat and the permeability of the landscape that surrounds it. Likewise, it would seem to be especially important to protect areas that are characterized by complex topography – i.e. mountain areas – since they act as buffer zones against the risk of extinction due to their greater number of micro-climates that function as refugia in the event of climatic extremes.

Constantí Stefanescu

[1] Hanski, I., 1999. *Metapopulation ecology*. Oxford University Press, Oxford.

[2] Thomas, C.D. & Hanski, I., 2004. "Metapopulation dynamics in changing environments: butterfly responses to habitat and climate change". In: *Ecology, Genetics, and Evolution of Metapopulation* (Hanski, I. & Gaggiotti, O.E., eds), Elsevier Academic Press, Amsterdam, pàg. 489–514.

[3] Thomas, J. A, Bourn, N. A, Clarke, R.T., Stewart, K.E., Simcox, D.J., Pearman, G.S., Curtis, R. & Goodger, B., 2001. "The quality and isolation of habitat patches both determine where butterflies persist in fragmented landscapes". *Proc. R. Soc., Series B, Biol. Sci.*, 268: 1791–6.

[4] Fleishman, E., Ray, C., Sjögren-gulve, P.E.R., Boggs, C.L. & Murphy, D.D., 2002. "Assessing the roles of patch quality, area, and isolation in predicting metapopulation dynamics". *Conserv. Biol.*, 16: 706–716.

[5] Oliver, T., Roy, D.B., Hill, J.K., Brereton, T. & Thomas, C.D., 2010. "Heterogeneous landscapes promote population stability". *Ecol. Lett.*, 13: 473–84.

[6] Ricketts, T., 2001. "The matrix matters: effective isolation in fragmented landscapes." *Amer. Nat.*, 158: 87–99.

[7] Lizée, M.-H., Manel, S., Mauffrey, J.-F., Tatoni, T. & Deschamps-Cottin, M., 2011. "Matrix configuration and patch isolation influences override the species–area relationship for urban butterfly communities". *Land. Ecol.*, 27: 159–169.

[8] Dennis, R.L.H., 2010. *A Resource-Based Habitat View for Conservation: Butterflies in the British Landscape*. Wiley-Blackwell, Oxford.

[9] Ehrlich, P.R., Murphy, D.D., Singer, M.C., Sherwood, C.B., White, R.R. & Brown, I.L., 1980. "The responses of checkerspot butterfly (*Euphydryas*) populations to the California drought". *Oecologia*, 105: 101–105.

[10] Piessens, K., Adriaens, D., Jacquemyn, H. & Honnay, O., 2009. "Synergistic effects of an extreme weather event and habitat fragmentation on a specialised insect herbivore". *Oecologia*, 159: 117–26.

[11] Fernàndez-Chacón, A., Stefanescu, C., Genovart, M., Nichols, J.D., Hines, J.H., Páramo, F., Turco, M. & Oro, D., 2013. Determinants of extinction-colonization dynamics in Mediterranean butterflies: the role of landscape, climate and local habitat features. *J. Anim. Ecol.*, 83: 276-285.

[12] MacKenzie, D., Nichols, J. & Hines, J., 2003. "Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly". *Ecology*, 84: 2200–2207.

[13] Hines, J., 2006. PRESENCE2: software to estimate patch occupancy and related parameters. *Patuxent Wildlife Research Center, Laurel*.

[14] Brown, J. & Kodric-Brown, A., 1977. "Turnover rates in insular biogeography: effect of immigration on extinction". *Ecology*, 58: 445–449.

[15] Oliver, T.H., Stefanescu, C., Páramo, F. & Roy, D.B., 2014. "Latitudinal gradients in butterfly population variability range are influenced by landscape heterogeneity". *Ecography*, 37: 863-871.

[16] Parmesan, C., Ryrholm, N., Stefanescu, C., Hill, J.K., Thomas, C.D., Descimon, H., Huntley, B., Kaila, L., Kullberg, J., Tammaru, T., Tennent, W.J., Thomas, J.A. & Warren, M., 1999. "Poleward shifts in geographical ranges of butterfly species associated with regional warming". *Nature*, 399: 579-583.

The station

The butterflies of Vall de Riudemeia, Argentona

Situated just 8 km from the coast as the crow flies and at less than 150 m above sea level, this CBMS station monitors a valley with a stretch of riparian woodland composed of bay-trees, oleanders and elms, and the pine- and oakwoods on its northern side. To date 65 species have been detected, of which the populations of Green-underside Blue *Glaucopsyche alexis* and Pearly Heath *Coenonympha arcania* are of great interest. Changes in the vegetation and the progressive encroaching of the surrounding forest are two factors that could affect the valley's butterflies in the future.

The transect

After six months of trials at the end of 2007, the route of the Argentona itinerary along the Vall de Riudemia, a tributary of the Riera d'Argentona, was established. This small valley, running southwest to northeast, almost parallel to the coast, is protected by the hills that surround the town of Argentona. It lies within the Parc de la Serralada Litoral protected areas and has a reasonably low population density compared to the surrounding area, which is characterized by a number of second-home complexes.

This small valley runs in a different direction to the majority of valleys in El Maresme, which generally lie perpendicular to the coastline. It is thus generally much more humid and the stream even has permanent water for a few days after rain during wet autumns. This factor favours the development of riparian vegetation including oleander *Vitex agnus-castus* and bay trees *Laurus nobilis* in its lower course, substituted by elms *Ulmus minor* towards the head of the valley. Pine- and oakwoods clothe the valley sides, while poplars and a few cultivated areas cover the narrow valley floor.

The itinerary is 1,412-m long and is divided into eight sections with an average length of 176 m. The first section begins just at the entrance to the protected area between the properties of Can Navas and Can Tomàs Rajoler, where there is an abundant population of tree of heaven *Ailanthus altissima*, and follows the track that runs upstream towards Òrrius. The second section leaves the track and continues along the streambed whose banks are obscured behind a dense cover of elms, poison hemlock *Conium maculatum* and pendulous sedge *Carex pendula*, as well as a number of invasive species such as American pokeroot *Phytolacca americana* and Jerusalem artichoke *Helianthus tuberosus*. Further on, the itinerary enters into a mixed pinewood where Aleppo *Pinus halepensis*, umbrella *Pinus pinea* and maritime *Pinus pinaster* pines co-exist with holm oaks *Quercus ilex* and a few strawberry-trees *Arbutus unedo*. The understorey is dominated here by sage-leaved *Cistus salviifolius* and grey-leaved *C. albidus* rock-roses and the grass *Brachypodium retusum*. Despite the siliceous nature of the substrata, a few rosemary *Rosmarinus officinalis* and thyme *Thymus vulgaris* bushes are also to be found. Sections 6 and 7 follow part of a track that leads up to the Roman road of Parpers and are bordered by brambles *Rubus ulmifolius* and *R. canescens,* Spanish broom *Spartium junceum* and Mediterranean buckthorns *Rhamnus alaternus*. Finally, the itinerary crosses some abandoned fields, today very overgrown, in which a number of poplars grow.

The forests in the area are exploited commercially and trees – often the largest – are periodically cut down. Above the line of the stream itself runs a high-tension electricity line and nearby there is an underground gas pipeline. Periodically, the areas around these two infrastructures are cleared of vegetation, which partially affects three of the itinerary's sections.

The butterflies

To date, 65 species with an annual average of 53 species of butterfly have been detected on the Argentona butterfly walk. In the period 2008–2013, a total of 12,709 individuals were counted with an annual average of 2,118.2 at a density of 150.2 ind./100 m.

The flight curves show that the number of species and of individuals on the wing is very seasonal: there is a very well-defined peak at the end of spring and beginning of summer (weeks 16–20), probably due to the emergence of two of the itinerary's dominant species, False Ilex Hairstreak *Satyrium esculi* and Spanish Gatekeeper *Pyronia bathseba*. Aside from these two species, the commonest butterflies are Speckled Wood *Pararge aegeria,* Meadow Brown *Maniola jurtina,* Cleopatra *Gonepteryx cleopatra,* Green Hairstreak *Callophrys rubi,* Common Blue *Polyommatus icarus,* Wall Brown *Lasiommata megera* and Small White *Pieris rapae* (fig. 1). All of these species – with the exception of Cleopatra and Green Hairstreak, which in Argentona have average annual abundances of over 8 ind./100 m – are among the ten commonest butterflies recorded in the CBMS. The inclusion of Painted Lady *Cynthia cardui* in the group of the commonest butterflies is due to the over 200 individuals that were counted in 2009 in one of this species' great migration years. In the remaining years, the number of Painted Ladies counted has been ten or even a hundred times fewer.

Given that the maximum altitude of the transect is less than 150 m a.s.l., of note is the stable and relatively abundant population of Pearly Heath, a species that is usually commonest between 600 and 1,200 m. The transect also boasts a population of Green-underside Blue: this species' numbers were stable during the first four years of the transect but in 2012 dropped to zero, a fall probably related to the cold spells that affected the area at the end of winter and beginning of spring. Fortunately, three of these blues were counted in 2013 in what it is hoped will be the beginning of the species' recovery at Argentona.

Thanks to the riparian woodland, Lesser Purple Emperors *Apatura ilia* are detected annually at Argentona, albeit in small numbers. Just before the massive emergence of False Ilex Hairstreak, the transect is graced by a few Ilex *Satyrium ilicis* and White-letter *S. w-album* Hairstreaks. This latter species is very tied to the trees of the riparian woodland but can be observed when it flies down to nectar on the flowers of the woolly bramble. Finally, as in all the CBMS itineraries, there are a number of other species that only appear occasionally but which are of great interest due to their scarcity in Catalonia. This is the case of species such as Chapman's Green Hairstreak *Callophrys avis*, Provence Hairstreak *Tomares ballus* and Mediterranean Skipper *Gegenes nostrodamus*.

Effects on the butterfly populations of changes in the vegetation

A large part of this transect runs along forest tracks, which are kept open by the vehicles that occasionally pass and by the maintenance carried out by the Parc de la Serralada Litoral. The exceptions are section 3, which consists of a footpath that joins two tracks, and section 8, which runs through an area of abandoned fields. When the transect began to be walked, these two sections were open areas covered by shrubs of less than 50 cm in height. However, over the years the scrub has grown and, above all in section 3, many of the holm oaks are now over 3-m high. As yet, this growth in the vegetation has had no obvious affect on the butterfly abundances apart from a slight non-significant decrease in the number of species observed. In coming years it will be interesting to see whether the butterfly numbers along these two sections fall – as is to be expected – as a result of this encroachment by the forest.

Jordi Corbera

Aerial photo. The CBMS transect at Argentona. It is 1,412-m long and has eight sections with an average length of 176 m.

Fig. 1. Average abundance (average of the annual indices during the period 2008–2013) of the 15 commonest butterflies at the Argentona station.

Bibliographical review

García-Barros, E., Munguira, M.L., Stefanescu, C. & Vives Moreno, A., 2013

Lepidoptera: Papilionoidea. Fauna ibérica, 37.

Museo Nacional de Ciencias Naturales. CSIC. Madrid. 1213 pp.

After 36 volumes dedicated to various groups of animals, both vertebrates and invertebrates, volume 37 of the monumental *Fauna Ibérica* has finally appeared. This volume, devoted to the butterflies, consists of the most thorough and up-to-date revision of this taxonomic group in the Iberian Peninsula that has ever been published.

The work follows the format of the other volumes in the series, in which, after a brief introduction, first of all the phylogeny and the systematics of the superfamily Papilionoidea are described. An outline of the world distribution of all butterfly families is given, with special emphasis placed on the chorology of the butterflies of the Iberian Peninsula – the fact that, despite the large number of records, exhaustive data is only available from 15% of 10x10 quadrats is recognised as a limiting factor. The sections devoted to adult morphology and pre-adult phases, as well as their biological cycles and various aspects of their life histories, occupies a large part of the volume's introduction. Much essential information is provided, illustrated with numerous examples of particular species and information derived from relevant modern biological and ecological studies. The classic section on collection, conservation and study techniques makes special mention of the Catalan BMS as an excellent methodology for studying butterflies that generates much good-quality information.

The main part of the book begins with a systematic list of the 226 species of butterflies known from the Iberian Peninsula and the Balearic Islands. Of interest is the note towards the end of the volume (added during the proof-reading stage) that incorporates information from recent studies that have increased the number of species in the initial list. Keys are given for each taxonomic level that reach species level and, in some cases, even to subspecies level. For each species, the scientific name, the author and year of its description, and its common name in Spanish is given, along with its original name and the corresponding bibliographical reference. A detailed description of the adult follows, both of its external morphology and of its genitalia, as well as of the non-adult phases. For certain species, macrophotos of eggs, as well as photos and drawings of parts of the butterfly and its phases (e.g. larvae, chrysalises, genitalia, wing venations, antennas and Jullien organs) are included. Of special note are the wonderful 3-D figures of the gynopigis of certain species. As in other volumes of the *Fauna Ibérica*, the section on geographical distribution is the weakest. The world distribution of the species is given, but for the Iberian Peninsula in most cases only the provinces – or references to mountain ranges – from where the species has been recorded are specified. In just 27 species, a map of the species' Iberian distribution is included. The section on biology is where all the knowledge of each species' biology and ecology accumulated over the previous decades is presented in great detail: preferred habitats and their structures, adult behaviour (territoriality, migration, mating, egg-laying, etc.), larval food plants, phenology, larval behaviour (hibernation, myrmecophily, etc.), enemies, parasitoids and, finally, threats to and the vulnerability of the species' populations.

The volume ends with a vast list of references (+1,400), an exhaustive list of synonyms and combinations, and an alphabetic list of taxons. The appendix consists of photographic plates of collection specimens of all the considered species, both of the upper- and undersides, and males and females in markedly sexually dimorphic species.

In conclusion, this volume represents the benchmark for reference works relating to the butterflies of the Iberian Peninsula and Balearic Islands. Most of the information found in numerous of scientific publications has been synthesized and incorporated in one work, manifest above all in the hundreds of pages dedicated to the species biology and ecology. The authors of this magnificent work – which neither sets out to be a field guide nor a distribution atlas – are to be congratulated for having created in a single volume *the* essential reference work to the butterflies of the Iberian Peninsula.

Jordi Artola and Mike Lockwood

Bibliographical review

Dantart, J. & Jubany, J., 2012.

The butterflies of Andorra

Monograph of CENMA (Centre for the Study of Snow and Mountains of Andorra of the Institute of Andorran Studies). 322 pp.

Here we review a new butterfly guide written by Jordi Dantart and Jordi Jubany, two expert biologists and colleagues who are well known to all CBMS workers. This guide, in which a number of other CBMS and BMSAnd colleagues also cooperated, is highly recommendable since, amongst other reasons, it deals with many of the butterfly species that fly in Catalonia.

The first part of the book consists of a brief overview of the geography of Andorra and of previous studies of the butterflies of Andorra, and is followed by a description of the butterfly communities and families that are present in the country. A separate chapter makes specific reference to the conservation status of the species and the Andorran Butterfly Red List, and reveals that almost 20% of the country's butterflies are of moderate to critical conservation concern and/or are highly vulnerable.

The main body of the guide consists of data sheets for all of the butterfly species recorded in Andorra during the authors' exhaustive study, all of which are illustrated with high-quality photographs and complemented with texts describing the species and their phenology, biology, habitat preferences and distribution, along with their names in Catalan, Spanish, French, English and Latin. It is worth highlighting as well the use of the newly established list of common Catalan names, the consensus resulting from a long and detailed study by specialists in the subject. Much of the information on the biology, phenology and habitat of the species is based on the authors' fieldwork and information generated by the BMSAnd.

At the end of the guide there are notes on the species that are thought to fly in Andorra but whose presence has still to be confirmed. This most up-to-date of guides provides readers with a final pleasant surprise in the form of the confirmation – just as the book was going to press – of the presence of the Chequered Skipper *Carterocephalus palaemon* in Andorra, a species that takes the number of butterflies known to fly in the country to 150.

The final pages include a complete bibliography of the subject and an index of scientific and common Catalan names.

The distribution maps were drawn by Roger Caritg from the CENMA, one of the BMSAnd team of counters.

Quim Muñoz

News

8th Meeting of the collaborators in the Catalan (CBMS) and Andorran (BMSAnd) Butterfly Monitoring Schemes

On 25 February 2012 the biennial CBMS participants meeting was held for all those who collaborate in one way or another with this project. This opportunity to exchange opinions and compare field observations was held in the recently opened Granollers Natural History Museum.

After the initial welcomes, the meeting was got underway by Constantí Stefanescu, the project's coordinator, who gave a talk on the contribution that the CBMS data has made in recent years to the study of climate change and butterfly ecology.

After the first coffee break, innovations regarding the CBMS website and the current situation of the project to define common names for Catalan butterflies were presented.

The post-lunch sessions centred on identification in which various recommendations were made for separating certain 'difficult' species. Once finished, the now traditional identification competition was held.

The final part of the meeting was devoted to a number of CBMS-related projects such as an atlas of the butterflies of La Garrotxa, the butterflies of Andorra and the Biodiversitat Virtual website.

The meeting concluded with the prize giving and the gift for all participants of a T-shirt sporting the CBMS project logo.

Jordi Jubany

The butterfly

The Speckled Wood *Pararge aegeria*, a woodland butterfly

Of all our butterflies, the Speckled Wood is the most closely linked to woodlands. Males defend territories in sunny clearings and along paths and tracks, and when two males interact, the familiar upward spiral flights result. Due to its ecological plasticity, this butterfly does not only live in forests but also inhabits a wide range of other habitats from city parks to areas of intensive agriculture. It is undoubtedly one of the most widespread and abundant butterflies in Catalonia, the Balearic Islands and Andorra.

Geographical distribution and situation in the CBMS

The Speckled Wood is widely distributed in the Western Palaearctic and is found throughout the whole of Europe with the exception of the northernmost part of Scandinavia. It is also found in North Africa as far south as the High Atlas.[1] It has recently colonized the island of Madeira, where it seems to be displacing the autochthonous Madeira Speckled Wood *Pararge xiphia* due to the interaction between the males of the two species.[2-3] Two Speckled Wood subspecies easily separable by coloration fly in Europe: *tircis* is present in central and northern Europe (approximately above 45ºN), while *aegeria* flies in southern Europe and North Africa. Phylogeographical studies place the origin of the species in North Africa 3 million years ago, from where it will have subsequently colonized Europe when the Mediterranean Sea dried out during the Messinian Crisis.[4] These studies also show that the genetic flux between the African and European populations has been negligible over at least the last million years since the time when the re-flooding of the Mediterranean re-established the barrier to dispersion by the species. This isolation has given rise to the curious situation whereby there is more genetic variation between African and southern European populations of the subspecies *aegeria* (despite their morphological similarities) than between the European populations of the subspecies *aegeria* i *tircis*.[4]

The Speckled Wood is one of the commonest butterflies in the Iberian Peninsula as shown by the fact that is has been recorded from all Spanish provinces, as well as all the Balearic islands and Portugal.[5] It is also common in Catalonia, both in the south and the north, from the Pyrenees to the south of Tarragona, and from the coast to the dry inland areas of eastern Catalonia. Its altitudinal distribution – with no clear preferences – ranges from sea level to the subalpine stage. Above 1,400 m, it becomes much scarcer and disappears altogether in alpine habitats above 1,800 m. It appears in almost all of the CBMS and BMSAnd stations (fig. 1), being absent only from the highest in Andorra (Sorteny and Pessons) and from La Tancada in the Ebro delta, where the complete lack of trees and shrubs make this station totally unsuitable for the species. Curiously, it has never appeared in the Montrebei itinerary, despite 11 years of uninterrupted monitoring.

It is also one of the most widespread and abundant butterflies in the Balearic Islands. In fact, the species' maximum density in the whole CBMS network is at the Barranc d'Algendar station on Menorca, where its average densities (37 ind./100 m x year) are twice as high as any other station in Catalonia (around 17 ind./100 m x year in stations such as El Cortalet, the mouth of the river Gaià and Can Miravitges).

Habitats and food plants

The Speckled Wood is one of the few Catalan butterflies with a clear preference for forest habitats and, according to the data from the CBMS itineraries, of all the species detected in the CBMS network it is in fact the most closely associated with woodlands.[6] Nevertheless, it does have a preference for environments with a degree of humidity and in arid areas tends be found above all in riparian woodland.

Females lay their eggs on the leaves of various species of grass, normally individually but also occasionally in groups of two. The difficulty in identifying the genera and species of grasses used complicates the task of ascertaining exactly which plants it uses as food plants. In Spain the following grasses have been identified: *Oryzopsis miliaceum*, *Elymus repens, Brachypodium sylvaticum*, *Poa trivialis* and *Dactylis glomerata*[7] but it is certain that more are in fact used. In a study carried out in two English woods, egg laying was detected on 15 of the 31 grass species present;[8] most of these grass species are common in Catalonia and are quite likely to be used as food plants. Regarding the choice of food plant, the microclimatic conditions of the plant's situation are almost as important as the species of the plant itself.[8] Females only choose plants that experience small temperature ranges, thereby suggesting that the general environment for egg-laying changes as the year progresses: in spring and autumn, egg-laying takes place in more open areas than in the summer, when shadier sites with cooler micro-climates are preferred. These differences are also observed at a general level in the type of environment that populations occupy: in Great Britain, populations have to withstand generally lower temperature and so prefer more open areas (with warmer micro-climates) than their Catalan counterparts.[9]

Biological and phenological cycles

The Speckled Wood has a multivoltine cycle whose variations are difficult to grasp. It has been well studied by various authors in central and northern Europe and under optimum development conditions the egg (photo a) hatches after 6–10 days, the caterpillar grows for 30–40 days and the chrysalis lasts for 10–17 days.[7] The caterpillar (photos b and c) begins to feed as soon as it hatches and passes through four stages (or five if it enters into hibernation). Hibernation takes place as a larva (third stage) or as a pupa, an uncommon behaviour in European butterflies. The chrysalises are either green or brown (photo e) depending on the colouration of the area surrounding the pupation site.

In the centre and north of Europe the fact that both larvae and chrysalis may hibernate means that spring emergence has two peaks, the first corresponding to insects that have hibernated as pupae, and the second to those that have hibernated as caterpillars.[10-11] This pattern is maintained throughout the season and summer generations (one or more, depending on the climate) also have more than one peak due to the origin of their progenitors and to variability in larval development rates. In some populations, mid-aged caterpillars enter into diapause in the summer, which adds a further twist to this already complex biological cycle.[12]

In the northeast of the Iberian Peninsula, the phenology of the Speckled Wood is even more complex as the CBMS data reveal: at any particular site there may be an indeterminate number of generations that cover one of the longest flight periods of any Catalan butterfly (fig. 2). At the stations in which this species is abundant, Speckled Woods are on the wing continually from the first to the last week of the counting period, which indicates that its flight period extends uninterruptedly at least from February to October. In fact, it is not uncommon in all but cold inland mountain areas to come across Speckled Woods in winter, above all during mild winters, albeit in low densities.

Data series show that different phenological patterns exist within the CBMS network, even in areas subject to similar climatic conditions. For example, the flight curves from El Cortalet (Aiguamolls de l'Empordà) and El Barranc d'Algendar (Menorca), two humid coastal sites with woodland in which the species reaches its maximum densities in the CBMS network, are very different. At El Cortalet, population numbers are fairly constant, undergoing only a slight increase between March and September (fig. 2a), while at Algendar, numbers increase progressively until mid-June and then decrease smoothly until the end of September (fig. 2b).

In Mediterranean holm-oak woodland at moderate altitudes, Speckled Woods often reach their maximum abundances in spring and then fall in numbers as the summer advances (fig. 2c: Can Miravitges, in the mountains of the Serralada Litoral near Barcelona), or maintain similar numbers throughout the whole season with only a few small fluctuations in numbers (fig. 2d: Cal Pontarrí, in the Serra del Montmell near Tarragona). The fall in numbers in the summer in the first case could be the result of the greater number of larvae that enter into diapause in summer, a hypothesis that will have to be demonstrated experimentally.

These flight graphs show that the Speckled Wood in Catalonia flies continually throughout most of the year, thereby making it impossible to differentiate discrete generations. One of the factors that helps explain this pattern in Iberian populations is the fact that the annual shortening of the photoperiod, which signals the arrival of the cold season and induces entry into hibernation, is much weaker than in central and northern European populations.[13] In Catalonia, for example, it seems that larvae can continue growing – albeit slowly – throughout autumn and winter provided that temperatures do not drop too low, which explains the presence of adults on the wing at almost any point of the winter. Via outdoor breeding experiments, summer diapause has been shown experimentally to exist in Catalonia.[14] This behaviour will vary in importance in terms of the severity of the summer drought and can be interpreted as a way of confronting a lack of grasses in suitable condition for egg-laying at certain times in the summer.

The phenology of the Speckled Wood is more consistent between sites in montane and subalpine stages, where adult numbers increase gradually as the summer progresses and peak at the end of September/beginning of October (fig. 2e and f). In the Pyrenees, the winter diapause is much more apparent than in the rest of the country and the first adults of the year are not seen until March/April after a number of months of inactivity.

Adult behaviour

The Speckled Wood has played a very important part in the study of the territorial behaviour of certain animals. The classic study by Davies was the first to describe the aggressive interaction between male Speckled Woods.[15] In the woods in which the species lives, males choose one of two different strategies for locating females and mating: they either (1) establish territories in sunny clearings that they defend against intrusion by other males as they wait for a female to arrive, or (2) actively patrol through the wood looking for females. Davies showed that males increased their reproductive success in sunny patches of woodland and so, given that the number of sunny spots in a wood is less than the number of males, males will defend these sites via territorial behaviour directed at other males. Patrolling males occupy these territories if they are vacant or try to force out their established 'owners'. The results of experiments carried out in a wood in England show that the owners of a territory were always able to rebuff attacks by another male by undertaking upward spiral flights, which are also typical of other territorial butterflies. This asymmetry in the outcome of these clashes has been interpreted as an evolutionary strategy that reduces the unnecessary energy expenditure of aggressive flight patterns.

However, other studies have questioned and even rejected Davies' findings.[16,18-20] In particular, Kemp & Wiklund have proved[20] that it is not true that the owner of a territory always wins these clashes, nor (as suggested by another study) that the male who triumphs is always the one with the higher body temperature (determined by experimental manipulation).[19] Their results indicate that in fact the winner is the butterfly that is intrinsically the more aggressive of the two, although the factors that determine the levels of aggression remain unclear

Likewise, other studies have investigated the factors that favour one type of behaviour – territorial or patrolling – over the other.[16-18] In some cases, territorial behaviour decreases at greater temperatures, possibly due to the fact that a sunny territory is of greater value when the environmental temperature is too low to permit continued flight.[16] Another study has found that the type of behaviour can be linked to morphological differences:[18] territorial males have in general a relatively larger thoracic mass and paler colouration than the patrollers. This type of morphology will favour more powerful flight muscles and give greater manoeuvrability, an advantage when a male has to defend his territory in a spiral flight. Despite the above, there are still many aspects of the territorial behaviour of this butterfly that remain unknown and future studies will undoubtedly help to reveal more of its secrets.

Population trends

In a number of countries in central and northern Europe, the Speckled Wood is one of the butterflies whose populations in recent years have undergone the most positive trends. In Great Britain, for example, its populations have increased by 150% over the last 30 years and it has expended into 30% more UTM 10x10 quadrats.[21] These increases may be related to climate change (which has enabled the species to expand into areas that were previously too cold to support viable populations)[22] and the abandoning of forests (which become shadier and more suitable for this species).[23] During this process the species has appeared for the first time in British BMS stations where it was hitherto unknown, and has increased rapidly in number and stabilized around the carrying capacity of the habitat in question.[24]

Despite the fact that climate change is forecasted to have a negative impact on this species in southern Europe,[25] Speckled Wood populations have remained stable over the last 20 years in Catalonia and Andorra (fig. 3). The recent increase in forest cover and the loss of open areas could have compensated the negative impact of climate change. A good example is the Closes del Tec itinerary, where the abandoning of the hay meadows has allowed the forest to encroach and has led to a rapid increase in Speckled Wood numbers (fig. 3) and in other forest species.

The Speckled Wood is without doubt one of the commonest butterflies in Catalonia, Andorra and the Balearic Islands, all home to stable and healthy populations. Its great phenological plasticity (expressed in many ways and the subject of intense research by H. Van Dyck and colleagues) allows it to adapt to humanized environments and work in its favour under a scenario of climate change. It is, thus, not only one of the few butterflies that is able to live in urban areas (e.g. the data from the Turó del Carmel itinerary in Barcelona, and from numerous other Catalan cities) but is also a forest species that is able to maintain populations in areas of intensive agriculture.

Constantí Stefanescu

Fig. 1. Relative abundance (expressed as the values of the annual index/100 m) of the Speckled Wood *Pararge aegeria* at different CBMS sites (1994–2013).

Fig. 2. Phenology of the Speckled Wood at different CBMS stations. (a) El Cortalet (Alt Empordà, 2 m), period 1988–2013, n = 16 021 individuals; (b) Barranc d'Algendar (Menorca, 50 m), 2001–2013, n = 9697 ind.; (c) Can Miravitges (Barcelonès, 136 m), 1999–2013, n = 1974 ind.; (d) Can Pontarrí (Baix Penedès, 438 m), 2000–2013, n = 1369 ind.; (e) Can Jordà (Garrotxa, 539 m), 1994–2013, n = 2740 ind.; (f) various stations in the Pyrenees: Estoll (Cerdanya, 1,092 m), Enclar (Andorra, 1,209 m) and Campllong (Berguedà, 1,288 m), n = 1501 ind.

Fig. 3. Fluctuations in the populations of the Speckled Wood in the CBMS network in the period 1994–2013, calculated with the program TRIM. The tendency is stable for the population as a whole during the time period considered. Also shown is the positive tendency of the population on the Closes del Tec (Alt Empordà) itinerary due to the abandoning of the hay meadows and the encroachment of the woodland.

Photos:
(a) Recently laid egg on a grass leaf; (b) caterpillars do not have their characteristic green colour when they hatch; (c) caterpillar in final stage resting on a grass leaf; (d) prepupa; (e) the pupae are dimorphic and can be green or brown depending on the colouration of their surroundings; (e) a territorial male in a sunny patch along a forest track (photos: a-e, J. Jubany).

[1] Tolman, T. & Lewington, R., 2002. *Guía de las mariposas de España y Europa*. 320 pàg. + 104 pl. Lynx Edicions, Bellaterra.

[2] Owen, D.F., Shreeve, T.G. & Smith, A.G., 1986. "Colonization of Madeira by the speckled wood butterfly, *Pararge aegeria* (Lepidoptera: Satyridae) and its impact on the endemic *Pararge xiphia*." *Ecol. Entom.*, 11: 349-352.

[3] Jones, M.J., Lesley, L.A., Harrison, E.C. & Stevens-Wood, B., 1998. "Territorial behaviour in the speckled wood butterflies *Pararge xiphia* and *P. aegeria* of Madeira: a mechanism for interspecific competition". *Ecography*, 21: 297-305.

[4] Weingartner, E., Wahlberg, N. & Nylin, S., 2006. "Speciation in *Pararge* (Satyrinae: Nymphalidae) butterflies - North Africa is the source of ancestral populations of all *Pararge* species". *Syst. Entom.*, 31: 621-632.

[5] García-Barros, E., Munguira, M. L., Martín Cano, J., Romo Benito, H., Garcia-Pereira, P. & Maravalhas, E. S., 2004. "Atlas de las mariposas diurnas de la Península Ibérica e islas Baleares (Lepidoptera: Papilionoidea & Hesperioidea) ". *Monografías Soc. ent. aragon.*, 11: 1-228.

[6] Habitat preference has been established using data from all the itineraries in the CBMS network for the period 1994–2013 (Herrando *et al.*, in prep.). On the basis of the information on the cover of the plant communities (CORINE classification) along transects, each section of the transect was classified as either 'open' (dominated by grasses and/or herbs or shrubs < 60 cm in height) or 'closed' (dominated by shrubs >60 cm in height or by different types of woodland). The sections that were dominated (more than 75%) by one or other type of community (to avoid mixed habitats) were selected and a Generalized Linear Model (GLM) was applied in which the abundance of a species in a section was the response variable and the percentage of forest habitat (closed community) was the independent factor. The GLM estimates were then used to measure the degree of affinity of every species in the CBMS network for closed or open habitats. In terms of the gradient of habitat preference, the Speckled Wood is the species that shows most preference for forest habitat.

[7] García-Barros, E., Munguira, M.L., Stefanescu, C. & Vives Moreno, A., 2013. "Lepidoptera Papilionoidea". In: *Fauna Ibérica*, vol. 37 (Ramos, M.A. *et al.*, ed.). Museo Nacional de Ciencias Naturales, CSIC, Madrid, 1.213 pàg.

[8] Shreeve, T.G., 1986. "Egg-laying by the speckled wood butterfly (*Pararge aegeria*): the role of female behaviour, host plant abundance and temperature". *Ecol. Entom.* , 11: 229-236.

[9] Suggitt, A.J., Stefanescu, C., Oliver, T., Páramo, F., Anderson, B.J., Hill, J.K., Roy, D.B. & Thomas, C.D., 2012. "Habitat associations of species show consistent but weak responses to climate". *Biol. Lett.*, 8: 590-593.

[10] Shreeve, T.G., 1986. "The effect of weather on the life cycle of the speckled wood butterfly *Pararge aegeria*". *Ecol. Entom.*, 11: 325-332.

[11] Wiklund, C. & Friberg, M., 2011. "Seasonal development and variation in abundance among four annual flight periods in a butterfly: a 20-year study of the speckled wood (*Pararge aegeria*)". *Biol. J. Lin. Soc.*, 102: 635-649.

[12] Wiklund, C., Persson, A. & Wickman, P.O., 1983. "Larval aestivation and direct development as alternative strategies in the speckled wood butterfly, *Pararge aegeria*, in Sweden". *Ecol. Entom.*, 8: 233-238.

[13] Nylin, S., Wickman, P.-O. & Wiklund, C., 1995. "Life-cycle regulation and life history plasticity in the speckled wood butterfly: are reaction norms predictable?". *Biol. J. Lin. Soc.*, 55: 143-157.

[14] Results taken from captive breeding in a site in El Baix Montseny (330 m a.s.l.) using egg clutches laid in various parts of Catalonia.

[15] Davies, N.B., 1978. "Territorial defence in the speckled wood butterfly (*Pararge aegeria*): the resident always wins". *Anim. Behav.*, 26: 138-147.

[16] Wickman, P.O. & Wiklund. C., 1983. "Territorial defence and its seasonal decline in the speckled wood butterfly (*Pararge aegeria*)". *Anim. Behav.*, 31: 1206-1216.

[17] Shreeve, T.G., 1984. "Habitat selection, mate-location and microclimate constraints on the activity of the speckled wood butterfly, *Pararge aegeria*". *Oikos*, 42: 371-377.

[18] Van Dyck, H., Matthysen, E. & Dhondt, A.A., 1997. "Mate-locating strategies are related to relative body length and wing colour in the speckled wood butterfly *Pararge aegeria*". *Ecol. Entom.*, 22: 116-120.

[19] Stutt, A.D. & Willmer, P., 1998. "Territorial defense in speckled wood butterflies: do the hottest males always win?". *Anim. Behav.*, 55: 1341-1347.

[20] Kemp, D.J. & Wiklund, C., 2004. "Residency effects in animal contests". *Proc. R. Soc. Lond. B*, 271: 1707-1711.

[21] Fox, R., Asher, J., Brereton, T., Roy, D. & Warren, M., 2006. *The state of butterflies in Britain and Europe*. Butterfly Conservation and the Centrefor Ecology and Hydrology, Information Press, Oxford.

[22] Hill, J.K., Thomas, C.D. & Huntley, B., 1999. "Climate and habitat availability determine 20th century changes in a butterfly range margin". *Proc. R. Soc. Lond. B*, 266: 1197-1206.

[23] Asher, J., Warren, M., Fox, R., Harding, P., Jeffcoate, G. & Jeffcoate, S., 2001. *The Millennium Atlas of butterflies in Britain and Ireland.* Oxford University Press, Oxford, 433 pàg.

[24] Pollard, E., Rothery, P. & Yates, T.J., 1996. "Annual growth rates in newly established populations of the butterfly *Pararge aegeria*". *Ecol. Entom.*, 21: 365-369.

[25] Settele, J. *et al.*, 2008. *Climatic risk atlas of European butteflies*. BioRisk, 1 (Special Issue). Pensoft Publishers, Sofia, 710 pàg.

[26] Stefanescu, C., Peñuelas, J. & Filella, I. 2009. "Rapid changes in butterfly communities following the abandonment of grasslands: a case study". *Insect Div. and Conserv.*, 2: 261-269.

[27] Merckx, T. & Van Dyck, H., 2006. "Landscape structure and phenotypic plasticity in flight morphology in the butterlfy *Pararge aegeria*". *Oikos*, 113: 226-232.

Identification

How to separate *Euchloe* spp. and *Pontia* spp. (1)

The morphologically most alike species are Western *Euchloe crameri*, Mountain *E. simplonia* and Portuguese *E. tagis* Dappled Whites. The former is widespread in Catalonia and can be confused with the latter two species, very much rarer, or with the similar female Orange-tip *Anthocharis cardamines*.

Although it is found throughout much of Catalonia,[1] the Western Dappled White is most abundant in lowland and Mediterranean mountain areas in which it appears commonly in the CBMS transects. It has a preference for agricultural areas and, above all, for fallow and abandoned land. It is found from sea level up to 1,400-1,600 m in the Pyrenees where its true distribution is unclear and may coincide with that of Mountain Dappled White. In Catalonia, this latter species only lives in the Pyrenees above 1,600 m in small localized populations, and has only been observed to date in the BMS network in three subalpine BMSAnd stations in Andorra. It too flies in open habitats, often with a degree of anthropic disturbance. Portuguese Dappled White, which in the CBMS network has only ever been observed on the Granja d'Escarp itinerary, flies with Western Dappled White in eastern Catalonia in similar habitats but in much small numbers. Western Dappled White is bivoltine and flies first abundantly in February-April and then, in far lower numbers, in May–June. The other two species are univoltine: Portuguese Dappled White flies just in March–May and Mountain Dappled White in June–July. All three species lay their eggs on the flower buds of the Brassicaceae family on which their caterpillars feed (above all, buckler-mustards *Biscutella* spp. and mustards *Sisymbrium* spp. in the case of Western and Mountain Dappled Whites, and candytufts *Iberis* spp. in the case of Portuguese Dappled White).[2] Their pupae hibernate and may take 1–3 years to hatch.[3] Males typically patrol over their territories.

Jordi Dantart

[1] García-Barros, E., Munguira, M. L., Martín Cano, J., Romo Benito, H., Garcia Pereira, P. & Maravalhas, E. S., 2004. "Atlas de las mariposas diurnas de la Península Ibèrica e islas Baleares (Lepidoptera: Papilionoidea & Hesperioidea)". *Monografías Soc. ent. aragon.*, 11: 1-228.

[2] Tolman, T. & Lewington, R., 2002. *Guía de las mariposas de España y Europa*. 320 pàg. + 104 pl. Lynx Edicions, Bellaterra.

[3] Benyamini, D., 2008. "Is *Euchloe falloui* Allard, 1867 (Pieridae) the butterfly with the longest diapause?". *Nota lepid.*, 31(2): 293-295.

[4] Back, W., 1990. "Taxonomische Untersuchungen innerhalb der Artengruppe um *Euchloe ausonia* (Hübner, 1804) (Lepidoptera, Pieridae)". *Atalanta*, 21: 187-206.

[5] Dantart, J., 2005. "*Anthocharis cardamines*, senyal inequívoc de l'arribada de la primavera". *Cynthia*, 4: 16-18.

Drawings

WESTERN DAPPLED WHITE
Upperside (general): white; black wingtip and discal mark on fore-wing; costa with black lines.
Underside (general): tips of both fore-and hind-wings with olive-green with marbled patterning (1st generation) or olive-yellow patterning (2nd generation) enclosing white marks; black discal mark on fore-wing.
Marked with line:
Straight discal mark that does not reach the costa; rounded white marks on wingtip, which generally do not reach the outer margin of the wing; broader discal mark; well-defined marks on wingtip; clearly angled costa.

MOUNTAIN DAPPLED WHITE
Upperside (general): white with black wingtip and discal mark on fore-wing; dark costa.
Underside (general): wing-tips on both fore- and hind-wings with yellowy-green marbled patterning enclosing white marks; black discal mark on fore-wing.
Marked with line: Angled discal mark that reaches the costa, elongated white marks on wingtip that reach the outer edge of the wing, broader, angled discal mark, yellowish wingtip with white, diffuse, elongated marks, clearly angled costa.

PORTUGUESE DAPPLED WHITE
Upperside (general): white with grey-black wingtip and discal mark; costa with black lines.
Underside (general): wingtip of both fore- and hind-wing with greyish-green marbled patterning enclosing white marks; black discal mark on fore-wing.
Marked with line: Straight discal mark that does not reach the costa, rounded white marks on wingtip that do not reach the outer edge of the wing, greyish wingtips, with poorly defined white marks, regularly rounded costa, fewer, smaller white marks.

ORANGE-TIP (female only)
Upperside (general): white; grey-black wingtip and discal mark on fore-wing.
Underside (general): wingtips of both fore- and hind-wings with green marbled patterning enclosing white marks; black discal mark on fore-wing.
Marked with line: Sub-triangular discal mark that does not reach the costa, rounded tip to fore-wing, outer edge uniformly rounded, different shape and size of white marks.

The Eastern Dappled White *Euchloe ausonia* (which was once erroneously thought to fly in Catalonia) and the Western Dappled White are vicariant species, the former found in southeast Europe and the latter in the southwest.[4] Portuguese Dappled White *E. tagis* is smaller than the other two and can be separated by the costa of the hind-wing, which is regularly rounded, and by the green-grey tones on the underside, with fewer, smaller white marks. In both Western and Mountain Dappled Whites the costa on the hind-wing has an obvious angle. As well, in the former, the discal mark is straight and does not reach the costa, while in the latter it is 'kinked' and reaches the costa. As well, the tip of the underside of the fore-wing is green and encloses well-defined white rounded marks in Western Dappled White but is yellowy with elongated, poorly defined white marks in Mountain Dappled White. Female Orange-tips fly differently and in different habitats,[5] but can be confused with both Western and Mountain Dappled Whites. Nevertheless, their regular rounded wings, the sub-triangular discal mark and the pattern of the white marks on the underside of the hind-wing are in theory sufficient to separate this latter species.

Identification

How to separate the species of the genus *Melitaea* (1)

The eight species of the genus *Melitaea* found in Catalonia are difficult to separate. The two smallest, Spotted *M. didyma* and Lesser Spotted *M. trivia* Fritillaries are especially easy to confuse. Nevertheless, certain morphological traits facilitate their identification with a degree of confidence. The Knapweed Fritillary, *M. phoebe*, is the commonest and largest of the genus and is also one of the easiest to identify. None of this group flies in the Balearic Islands. Egg clutches are multiple and the larvae, which live gregariously in silken webs, hibernate when they are half developed.

The Spotted Fritillary *M. didyma* lives throughout Catalonia and Andorra, from sea level up to alpine grasslands. It is common in open habitats – grassland, croplands and waste ground – and can even be abundant in subalpine and alpine meadows. It lays its eggs in groups of 2–10 on narrow-leaved plantain *Plantago lanceolata* and various other plants belonging to the family Scrophulariaceae.[1-2] On the other hand, the Lesser Spotted Fritillary *M. trivia* is much more local in distribution and lives in scattered colonies in the mountains of La Serralada Prelitoral, Serralada Transversal and Pre-Pirineu, mainly at 500–1200 m a.s.l. It is found in sunny open areas – grasslands and croplands – where its food plants, *Verbascum* spp.[1-2] grow; males can also be found hill topping on mountain and ridge tops.[3] It normally lays around 50 eggs. The Knapweed Fritillary *M. phoebe* is found in a wide range of open dry habitats throughout Catalonia, from sea level to 2,000 m. It lays 100–200 eggs on knapweeds *Centaurea* spp., but also on various types of thistles (e.g. *Carduus*, *Cirsium*, *Carlina*).[4] All three species are bivoltine, with long flight periods that last from spring to the beginning of autumn.

Constantí Stefanescu

[1] García-Barros, E., Munguira, M.L., Stefanescu, C. & Vives-Moreno, A., 2013. "Lepidoptera. Papilionoidea". In: *Fauna Ibérica. Vol. 37* (Ramos, M.A. *et al.*, eds). Museo Nacional de Ciencias Naturales, CSIC, Madrid, 1213 pp.

[2] Kankare, M., Stefanescu, C., van Nouhuys, S. & Shaw, M.R., 2005. "Host specialization by *Cotesia* wasps (Hymenoptera: Braconidae) parasitizing species-rich Melitaeini (Lepidoptera: Nymphalidae) communities in north-eastern Spain". *Biol. J. Linn. Soc.*, 86: 45-65.

[3] Pe'er, G., Saltz, D., Thulke, H.-H. & Motro, U., 2004. "Response to topography in a hilltopping butterfly and implications for modelling nonrandom dispersal". *Anim. Behav.*, 68: 825-839.

[4] Martín Cano, J. & Templado, J., 1984. "Los estadios preimaginales y la biología de *Melitaea phoebe* (Denis et Schiffermüller, 1755) (Lep. Nymphalidae)". *Bol. Estac. Cent. Ecol.*, 13: 85-92.

Drawings

SPOTTED FRITILLARY
Upperside (general): bright red, above all males; pointed fore-wing.
Underside (general): pure white background colour, with two well-defined, wide, orange bands.
Marked with line: Chevron-shaped submarginal black marks, continuous orange discal band, rounded black submarginal spots.

LESSER SPOTTED FRITILLARY
Upperside (general): orange rather than reddish; more rounded wings.
Underside (general): yellowy-white background colour, with two wide orange bands; the discal band is less well defined
Marked with line: New-moon-shaped submarginal black marks, orange discal band often interrupted in cell, triangular black submarginal spots.

KNAPWEED FRITILLARY
Upperside (general): contrastingly yellow and orange bands, with black marks
Underside (general): white background colour with two conspicuous orange bands
Marked with line: Black submarginal mark in E3 is large and chevron-shaped, black submarginal mark in E3 is visible and chevron-shaped, orange postdiscal band encompasses round red spots, double series of discontinuous black, straight or curved, marks.

The underside of the hind-wing of Spotted and Lesser Spotted Fritillaries have two wide, bright orange bands that contrast greatly with the white background colour. Spotted Fritillary is slightly larger, has more pointed wings and more reddish uppersides than Lesser Spotted. In upland areas, female Spotted Fritillaries tend to be much darker in colouration. The black submarginal spots on the underside of the hind-wing are always rounded in Spotted Fritillary, but tend to be triangular with the apex pointing towards the base of the wing in Lesser Spotted. Knapweed Fritillary is the largest of this group in Catalonia. Its upperside colour often has contrasting orange and yellow bands and black spots. The chevron-shaped black submarginal mark in space E3 on the upperside of the fore-wing is characteristic. The orange post-discal band on the underside of the hind-wing includes obvious round red spots. Between the two orange bands on the underside of the hind-wing there is a double series of discontinuous either straight or curved black streaks.

Ajuntament Granollers

MUSEU DE CIÈNCIES NATURALS DE GRANOLLERS

Programa de seguiment en conveni amb:

Generalitat de Catalunya
Departament de Territori i Sostenibilitat