CBMS
Catalan Butterfly Monitoring Scheme

cynthia

Bulletin of the Catalan Butterfly Monitoring Scheme 2017/2018 - no. 15

Cover

Detail of the under side of the upper-wing of Striped Grayling, *Hipparchia fidia* (photo: Jordi Jubany)

Black-veined White, *Aporia crataegi*, resting on Field Scabious Knautia arvensis (photo: Oriol Massana)

Editorial

The closing-up of habitats and the loss of butterflies in Catalonia

This fresh edition of *Cynthia* once again corresponds to the results from two CBMS seasons, namely 2017 and 2018. And, once again, we are in a position to award ourselves a pat on the back since our network of butterfly walks is still growing and counts are currently being made at over 90 sites. To a large extent this increase is due to the incorporation of the so-called 'low-effort' stations that has enabled us to include areas of difficult access and spread the network of stations further into the Pyrenees.

During these two years interest has also grown in butterfly communities and their tendencies in areas where ecologically sustainable agriculture is practiced. Thus, we now have three stations in vineyards in the Penedès wine-growing region where the producers are interested in ensuring that their viticulture is compatible with the maintenance of a rich and varied biodiversity. As well, at Sincrotró Alba in the Parc de l'Alba technological centre in Vallès Occidental, butterfly counts are used to test whether or not site management benefits insect communities. This concern for guaranteeing that agricultural practices are compatible with the conservation of the biodiversity is fruit of a long series of studies that indicate that recently there has been an alarming decrease in faunal abundances (including pollinators) in European agricultural habitats, in particular in intensive systems.

Other, very different changes at landscape scale are also negatively affecting Catalan butterfly populations. In the section *Habitat management and conservation*, we present a study that was recently published in the journal *Insect Conservation and Diversity* that quantifies for the first time the impact of forest and scrub encroachment. Thanks to the vegetation data collected along our itineraries, we have been able to show that 90% of our butterflies prefer open areas such as meadows and pastures. Yet, our long-term monitoring reveals that over 70% of the CBMS itineraries are being affected by scrub encroachment, chiefly due to the abandoning of grazing, which is having severe effects on our butterfly numbers. Due to this process, almost 5% of the butterflies monitored along our itineraries have become extinct locally. Moreover, this problem affects both protected and unprotected areas, which suggests that our nature reserves are not being managed correctly even though, supposedly, the conservation of the biodiversity is one of their fundamental objectives. It is thus urgent to change current management strategies in many of our landscapes to prevent the decline of our butterfly communities and of those of other insects from becoming even more severe.

The CBMS and BMSAnd network

Situation of the Butterfly Monitoring Scheme in Catalonia, Andorra and the Balearic Islands in the years 2017 and 2018

During the twenty-forth and twenty-fifth years there were, respectively, 94 and 93 active stations in the CBMS-BMSAnd networks, the highest number ever. In all, 13 new stations were established, two in El Ripollès and three in Alt Penedès, two counties that up to 2017 were not represented in the network. During these two seasons, 346,409 butterflies belonging to 175 species were counted.

In 2017, counts were made at 94 stations, whilst in 2018 there were 93 active itineraries (fig. 1). The number of stations has increased significantly over these two seasons (fig. 2) and there are now 10 more butterfly walks than in 2016. This increase is largely due to the incorporation of low-effort stations, where counts are made fortnightly rather than every week. The development of a more robust methodology for estimating species abundances[2] encouraged us to incorporate into the network these easier to fulfil itineraries. As a result, we have been able to cover areas in counties such as El Ripollès, Alt Penedès and Anoia that to date had been very poorly prospected, and also to recover certain stations with poor access (e.g. Turó de l'Home on the summit of the mountains of El Montseny). Thus, we have exceeded the threshold of 90 stations and so can count on more robust data to help improve our understanding of the tendencies in butterfly populations throughout Catalonia, Andorra and the Balearic Islands.

The available annual series are shown in figure 3. Of the 154 stations that in one year or another have been active, there are 60 (39%) that have generated 10 or more years of data, and 31 with 15 or more years of results. To date, during the 25 years of the project, we have gathered data on butterfly populations from 36 Catalan counties, eight sites in Andorra and seven in Menorca, Mallorca and Eivissa.

New stations

Besòs-Montcada (CBMS-148, Vallès Occidental, 39 m). An itinerary 1522 m in length with eight sections that runs partially alongside the river Besòs in the municipality of Montcada i Reixac. Despite being a fairly heavily degraded area near the Barcelona conurbation, it possesses a notably diverse community of butterflies. During the first two years of walks, a total of 54 species were observed, some of which are abundant and well established (e.g. Southern Gatekeeper (*Pyronia cecilia)*, Spanish Gatekeeper (*P. bathseba)* and Iberian Marbled White (*Melanargia lachesis*)). Other highlights include scarcer species found here at surprisingly low altitude and so near Barcelona: Green-underside (*Glaucopsyche alexis)* and Escher's (*Polyommatus escheri)* Blues, Provence Hairstreak (*Tomares ballus)*, Black-veined White (*Aporia crataegi)*, Peacock (*Aglais io)*, Marsh Fritillary (*Euphydryas aurinia)* and Small (*Coenonympha pamphilus)* and Dusky (*C. dorus)* Heaths. Another interesting species that has appeared in the counts is Mediterranean Skipper (*Gegenes nostrodamus)*, a migrant skipper that has increased in number significantly in Catalonia in recent years. The counts are carried out voluntarily by Juli Mauri and Albert Lleal.

Sant Quintí de Mediona (CBMS-149, Alt Penedès, 431 m). A low-effort itinerary that was walked monthly in 2017 but in 2018 was walked fortnightly. This itinerary and that of Torrelavit are funded by Caves Recaredo as part of a project to analyse the biodiversity of its terrains and vineyards. At Sant Quintí the vines are managed biodynamically in order to preserve the biodiversity and conserve the traditional landscape mosaic that consists of semi-natural fragments of habitat mixed in with the vineyards. The itinerary is 1230 m in length and has 10 sections, which include vineyards (a young and mature one), marginal land (along field edges and tracks), olive groves and semi-natural habitats (thyme scrub and patches of grassland). The sampling effort, initially monthly but subsequently fortnightly, has detected 60 species to date. The itinerary's butterflies are dominated by generalist species such as Small (*Pieris rapae)* and Bath (*Pontia daplidice)* Whites, Common Blue (*Polyommatus icarus)* and Clouded Yellow (*Colias crocea)*. Nevertheless, a number of interesting butterflies have appeared that indicate that the area and its biodiversity are worthy of conservation. Examples of these species include Berger's Clouded Yellow (*Colias alfacariensis*), Black-veined White (*Aporia crataegi)*, Provence Chalkhill (*Lysandra hispana)*, Panoptes (*Pseudophilotes panoptes)* and Chapman's (*Polyommatus thersites)* Blues, Spotted Fritillary (*Melitaea cinxia)*, Gatekeeper (*Pyronia tithonus)*, Dingy (*Erynnis tages)*, Small (*Thymelicus sylvestris)* and Mediterranean (*Gegenes nostrodamus)* Skippers. Of particular interest is the presence of species that are more central European in character, normally very scarce or absent from Mediterranean environments, such as Gatekeeper, Small Skipper and Black-veined White. The counts are carried out by Andreu Ubach.

Torrelavit (CBMS-150, Alt Penedès, 269 m). This itinerary is very close to that of Sant Quintí in the Caves Recaredo estate. It is likewise managed biodynamically but in terms of its biodiversity it is clearly poorer than Sant Quintí due to the type of agriculture that is practiced there, the landscape and the fact that it lies at less altitude and so enjoys a hotter microclimate. It is a short itinerary, just 1003 m, and has seven sections. It includes mature vines, more or less vegetated waysides, and Aleppo pinewoods. In two years of counts only 36 species have been recorded. Generalist species are predominant – e.g. Small (*Pieris rapae)* and Large (*Pieris brassicae)* Whites and Wall Brown (*Lasiommata megera)* – but there are also typical Mediterranean species such as Striped Grayling (*Hipparchia fidia)*, Spanish Gatekeeper (*Pyronia bathseba)*, Cleopatra (*Gonepteryx cleopatra)*, and Spanish Brown Argus (*Aricia cramera)*. Unlike Sant Quintí, at Torrelavit there are very few local or scarce species, although Black-veined White (*Aporia crataegi)*, Woodland Grayling (*Hipparchia fagi)* and Panoptes Blue (*Pseudophilotes panoptes)* are all present. The counts are carried out by Andreu Ubach.

Castelltallat (CBMS-151, Bages, 780 m). A low-effort itinerary in the county of Bages within the Serra de Castelltallat protected area. This long itinerary runs for 2062 m and has nine sections. It runs through, above all, a forested landscape including a series of open spaces that guarantee greater diversity. In 2017, irregular sampling gave 52 species, a number that increased to 69 in 2018 with the beginning of the fortnightly walks. Two very common species here are Provence Chalkhill Blue (*Lysandra hispana*) and Marsh Fritillary (*Euphydryas aurinia)* but there are also good numbers of local species that are declining in Catalonia such as Berger's Clouded Yellow (*Colias alfacariensis)*, Dingy Skipper (*Erynnis tages*) and Ripart's Anomalous Blue (*Polyommatus ripartii)*. The counts are carried out by Josep Planes.

Conca d'Òdena (CBMS-152, Anoia, 393 m). This low-effort itinerary is located in the municipality of Òdena and is the first CBMS itinerary in the county of Anoia. It is located in an area that previous prospections had indicated that there would be a notable diversity of butterflies. The monthly sampling in 2017 gave a total of 56 species and the greater effort in 2018 increased the number of species detected to 65. This itinerary is 1700 m long and has eight sections. It mainly runs through an agricultural mosaic with fragments of woodland mixed in with grassland and arable land. Worthy of note is the abundance of 'Blues', including Escher's (*Polyommatus escheri)*, Small (*Cupido osiris)*, Adonis (*Lysandra bellargus)*, Provence Chalkhill (*Lysandra hispana)*, Green-underside (*Glaucopsyche alexis)* and Black-eyed (*G. melanops)* Blues, and Provence Hairstreak (*Tomares ballus)*, amongst others. Rare species such as Marbled (*Carcharodus lavatherae)* and Mediterranean (*Gegenes nostrodamus)* Skippers have also appeared. The counts are carried out by José Manuel Sesma.

Setcases (CBMS-153, Ripollès, 1434 m). Along with the Tregurà itinerary, this butterfly walk is the first CBMS station to be active in El Ripollès, one of the most diverse counties for butterflies in the whole of Catalonia. The itinerary, with 10 sections, runs through the bottom of the valley of the Ribera del Catllar, a private estate in the environs of the Capçaleres del Ter i del Freser Natural Park. This itinerary is part of a project monitoring different taxonomic groups in the estate and runs through pasture, small partially forgotten hay meadows and stretches of riparian and deciduous woodland. It has been walked fortnightly since it started in 2017 and in total 67 species were counted in the first two years. The microclimate of this valley is very humid and certain species that are particularly associated with wet central European climates are here highly abundant. The most obvious example is the exceedingly abundant The Ringlet (*Aphantopus hyperantus)*, which flies alongside good numbers of Green-veined White (*Pieris napi)*, Speckled Wood (*Pararge aegeria)*, Pearly Heath (*Coenonympha arcania)*, Comma (*Polygonia c-album)* and Scarce Copper (*Lycaena virgaureae)*. Otherwise, there are many of the butterflies found commonly in the Eastern Pyrenees that are poorly represented in the CBMS network: False Heath (*Melitaea diamina)* and Pearl-bordered (*Boloria euphrosyne)* Fritillaries, Turquoise Blue (*Polyommatus dorylas)*, Duke of Burgundy (*Hamearis lucina)*, Tufted Marbled Skipper (*Carcharodus floccifera)* and Purple Emperor (*Apatura iris)*, amongst others. The counts are carried out by Mike Lockwood and Jordi Artola, and are backed financially by the owner of the Catllar Estate.

Tregurà (CBMS-154, Ripollès, 1842 m). This second itinerary in the valley of El Catllar samples a subalpine environment. Apart from the Andorran itineraries, this is the highest butterfly walk in Catalonia, which confers added value to its data. The walk is 1286 m in length and has 12 sections that run along the edge of a pine plantation and the basal part of a large area of subalpine pasture. The final section also crosses a steep gully. A total of 65 species have been detected in the two years that it has been walked, with a very complete representation of subalpine species including five ringlets (Large (*Erebia euryale)*, Piedmont (*E. meolans),* Pyrenean Brassy (*E. rondoui)*, Mountain (*E. epiphron)* and de Prunner's (*E. triaria*)), along with other upland species that are poorly represented in the CBMS network such as Chestnut Heath (*Coenonympha glycerion)*, Purple-edged Copper (*Lycaena hippothoe)*, Turquoise (*Polyommatus dorylas)* and Mazarine (*Cyaniris semiargus)* Blues, and Olive Skipper (*Pyrgus serratulae)*. The counts are carried out by Mike Lockwood and Jordi Artola, and are backed financially by the owner of the Catllar Estate.

Raixa (CBMS – 155, Mallorca, 150 m). This itinerary is situated in the mountains of Serra de Tramuntana on Mallorca and is the first CBMS walk on this island. It was begun in 2012 and although it was not officially incorporated into the CBMS network until 2018, the data from the initial seven years of counts have been entered into the CBMS database. In all, 22 of the 25 species of butterfly known from Mallorca have been detected, which is a similar figure to the counts performed on the island of Menorca. Small Heath (*Coenonympha pamphilus*) and Cleopatra (*Gonepteryx cleopatra*) fly in large numbers, and are accompanied by the African Common Blue (*Polyommatus celina*), which replaces the more familiar Common Blue on the Balearic Islands. Speckled Wood (*Pararge aegeria*) is the commonest species and in summer Southern Gatekeeper *(Pyronia cecilia*) is particularly abundant. The counts are carried out by Matilde Martínez.

La Manresana (CBMS – 156, Anoia, 649 m). This itinerary lies in the municipality of Prats de Rei in an area of the Central Catalan Depression that has been poorly surveyed to date and so fills in a territorial gap in the CBMS network. In 2018 it was walked fortnightly and in all 48 species were recorded in a mixture of habitats including Mediterranean grassland, evergreen and deciduous woodland, and rocky limestone outcrops. Holm-oak formations are common, along with open grassland with annual plants. Small White (*Pieris rapae*) is highly abundant along with Green-veined White (*P. napi*). Here too fly species that are typical of both Mediterranean areas and the Central Depression such as Provence Chalkhill Blue (*Lysandra hispana*) and Large Tortoiseshell (*Nymphalis polychloros*). Also of note are the populations of Lesser Spotted Fritillary (*Melitaea trivia*) and Woodland Grayling (*Hipparchia fagi),* as well as the scarce Marbled Skipper (*Carcharodus lavatherae*). The counts are carried out by Quim Muñoz.

Conca del Bitlles (CBMS – 157, Alt Penedès, 202 m). This walk is situated in the municipality of Torrelavit in the heart of the Penedès wine-growing country. It has eight sections that run through marginal land, Mediterranean grassland, scrub and Aleppo pinewoods on the edge of the vineyards owned by Segura i Viudas. It samples somewhat different environments from the other local walk (Torrelavit; CBMS-150) that takes its name from the municipality. At Conca del Bitlles the walk passes through tall grassland, thickets with Mediterranean coraria, and open pastures dominated by the grass *Oryzopsis paradoxa*. In 2018 48 species were recorded, which situated this itinerary midway between those of Sant Quintí de Mediona and Torrelavit. The typical 'Whites' found in agricultural areas such as

Large (*Pieris brassicae*), Small (*Pieris rapae*) and Bath (*Pontia daplidice*) Whites are common, while the Aleppo pinewoods boast important populations of Striped (*Hipparchia fidia*) and even Tree (*Hipparchia statilinus*) Graylings. The presence of Panoptes Blue (*Pseudophilotes panoptes*) in the thyme scrub contrasts with the population of Comma (*Polygonia c-album*) in the woodland along the stream. Other notable species include the more Central European Glanville Fritillary (*Melitaea cinxia*) and the here rare Blue-spot Hairstreak (*Satyrium spini*). The counts are carried out by Ricard Pintado.

Sant Miquel del Fai (CBMS –158, Vallès Oriental, 544 m). This low-effort itinerary in the municipality of Sant Quirze Safaja lies in an estate belonging to the Barcelona Provincial Council at the confluence of the rivers Rossinyol and Fai in a protected area known as Els Cingles de Bertí. It runs through an upland Mediterranean landscape in the Catalan Pre-Littoral mountains and samples open rocky areas, scrub dominated by honeysuckle, thyme and rosemary, and taller formations with abundant strawberry-trees. In total, there are eight sections that possess a great diversity of butterflies as shown by the 77 species recorded in the first year, 2018, alone. Of note are the high indices of declining species such as Provence Chalkhill Blue (*Lysandra hispana*). The Mediterranean environment and the plants that grow there help sustain good populations of Marsh Fritillary (*Euphydryas aurinia*), while the abundance of strawberry-trees ensures good numbers of Two-tailed Pasha (*Charaxes jasius*) and the probably under-detected Chapman's Green Hairstreak (*Callophrys avis*). Section 1 passes along the bed of the river Rossinyol and is territory for various Nymphalidae including Large Tortoiseshell (*Nymphalis polychloros*), Comma (*Polygonia c-album*), Southern White Admiral (*Limenitis reducta*) and Lesser Purple Emperor (*Apatura ilia*). Some of the rarer species observed in 2018 included Marbled Skipper (*Carcharodus lavatherae*), associated with woundworts *Stachys* sp., and Blue-spot Hairstreak (*Satyrium spini*). The counts are carried out by Andreu Ubach.

Sincrotró Alba (CBMS – 159, Vallès Occidental, 109 m). This low-effort itinerary is walked in the Parc de l'Alba as part of project designed to monitor the biodiversity of this industrial estate in Cerdanyola del Vallès. It is a lowland Mediterranean area dominated by waste ground, scrub and Mediterranean grassland surrounded by a large area of cereal crops. It has nine sections and in 2018 41 species appeared, including good populations of generalist species found in these ruderal environment such as Spanish Brown Argus (*Aricia cramera*) and a number of other generalist Lycaenidae. However, there are also populations of Green-underside (*Glaucopsyche alexis*) and Black-eyed (*Glaucopsyche melanops*) Blues, while a plantation of mixed scrub species encourages the presence of Black-veined White (*Aporia crataegi*) due to the hawthorns that grow there. Also of note along the stream that coincides with sections 2–4 is the presence of Lesser Purple Emperor (*Apatura ilia*), a species that is becoming commoner in this part of Catalonia. Amongst the rare but present species it is also worth highlighting Mediterranean Skipper (*Gegenes nostrodamus*). The counts are carried out by Andreu Ubach.

Els Foquers (CBMS – 160, Osona, 541 m). This itinerary in the municipality of Tavèrnoles, walked and organized by the Osona Naturalists Group, is of great interest. It runs through a series of different montane habitats in eight sections. The vegetation consists of a great abundance of Mediterranean and more upland open spaces with abundances of blue aphyllanthes and grasses, dry and more humid field margins, thickets with Mediterranean coraria, downy oak woodland, and arable fields. In the first year 82 species were registered, which makes it the second most species-rich itinerary in the CBMS network. Mediterranean and upland species are found alongside each other and there are significant populations of both Pearly Heath (*Coenonympha arcania*), the walk's most abundant species, and Small Heath (*C. pamphilus*). Here too we find the CBMS's largest population of Berger's Clouded Yellow (*Colias alfacariensis*) and abundant Adonis Blue (*Lysandra bellargus*). The ecological contrasts present in the area are reflected by the populations of both Panoptes Blues (*Pseudophilotes panoptes*) and one the CBMS's best populations of Spanish Festoon (*Zerynthia rumina*), but also species with very different ecological requirements such as Autumn Ringlet (*Erebia neoridas*) and Map Butterfly (*Araschnia levana*). Up to four species belonging to the genus *Satyrium* fly here due to the plant diversity that is present. Other rare species found here include Brown Hairstreak (*Thecla betulae*), Marbled Skipper (*Carcharodus lavatherae*), Tufted Marbled Skipper (*Carcharodus flocciferus*), Marbled Fritillary (*Brenthis daphne*) and Duke of Burgundy (*Hamearis lucina*). The counts are carried out by Martí Franch, Alba Puntí, Carles Martorell and Jordi Faus.

Species present

In the 2017 season 168,336 butterflies were counted belonging to 173 species, whilst in 2018 178,073 butterflies were counted belonging to 164 species. The number of species detected in these two years is above the yearly average of 163.2 species for 2006–2016, which corresponds to the years that the Andorran stations were fully operational and in which most of the upland Pyrenean species have been recorded. The 173 species detected in 2017 is the highest ever annual total for the CBMS network in its 25 years of history (fig. 4). This was made possible by the incorporation of the low-effort stations, as commented on above

The list of butterflies detected over the past 10 years is given in Table 1. Up to 2016, 188 species had been recorded in the CBMS network out of a total of 201 species known from Catalonia. This figures represents 93.5% of all Catalan species, which gives some idea of how exhaustive this network is. Currently, it is no exaggeration to say that the CBMS counts gather data on over 80% of Catalan butterflies.

The few species that have not yet appeared in the CBMS counts are essentially very local species that fly only in the very highest areas of the Pyrenees, or ones which have only ever been recorded very occasionally in Catalonia and as such do not maintain stable populations here.

In the past two years a single new species, Alpine Grizzled Skipper (*Pyrgus cacaliae*), recorded on the Pessons itinerary in Andorra at an altitude of 2,280 m, has been added to the CBMS list.

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For references, see the original Catalan version.

Fig. 1. Geographical situation of all the stations that have ever participated in the CBMS (1994-2018) network, with their official number and name. Also shown are the generally accepted boundaries of the biogeographical regions present in Catalonia.[1]

Fig. 2. Evolution in 1994–2018 of the number of active stations in the CBMS network.

Fig. 3. Distribution of the complete annual series available for all the stations that have ever participated in the project. Also included are data from the stations of Rubina and Vilaüt, active in 1988 and 1989, respectively before the official start of the CBMS counts.

Fig. 4. Number of species of butterfly detected in each year of the CBMS counts.

Table 1. All the butterfly species recorded from any of the CBMS stations in the 10-year period 2009–2018. Also indicated is the number of stations at which the species was recorded each year. Taxonomic order follows the criteria suggested by Fauna Europaea (www.fauna-eu.org).

Photo 1. Vineyards are an important part of the landscape of the Torrelavit, Sant Quintí de Mediona and Conca del Bitlles itineraries. Here fly many Pieridae throughout the season, with Bath White especially common in its autumn generation. The photo shows section 1 of the Torrelavit itinerary with mature vines (Photo: A. Ubach).

Photo 2. The bed of the river Rossinyol at Sant Miquel del Fai is perfect habitat for the males of many Nymphalidae, including Speckled Wood (*Pararge aegeria*), Southern White Admiral (*Limenitis reducta*), Marsh Fritillary (*Euphydryas aurinia*), Large Tortoiseshell (*Nymphalis polychloros*), Comma (*Polygonia c-album*) and Camberwell Beauty (*Nymphalis antiopa*), amongst others (Photo: A. Ubach).

Photo 3. The Foquers itinerary is full of ecological contrasts and while the more Mediterranean areas are home to Panoptes Blue (*Pseudophilotes panoptes*) and Spanish Festoon (*Zerynthia rumina*), in other parts of the itinerary fly Autumn Ringlet (*Erebia neoridas*) and Map Butterfly (*Araschnia levana*) (Photo: J. Faus).

Photo 4. Large Ringlet (*Erebia euryale*) only appears in eight itineraries, all of them in the Pyrenees. The Tregurà itinerary has the highest annual indices for this species and its counts have revealed that this ringlet has a biennial life cycle; in 2017 it was frequent but in 2018 none were observed (Photo: J. Corbera).

Drawing 1. The new itineraries in El Ripollès provide very valuable data on the Duke of Burgundy (*Hamearis lucina*), an uncommon species with very strong populations in El Catllar. This butterfly is a true habitat specialist, establishing a close association with the plants in the genus *Primula* (Drawing: M. Franch).

Twenty-fourth and twenty-fifth years of the CBMS

Balance of the 2017 and 2018 seasons

The year 2017 saw a notable recovery in Catalan butterfly populations after the historically poor year of 2016. In general, numbers remained constant in 2018, although this was not due to stable populations but, rather, to a combination of significant increases in inland and montane areas and declines in coastal and Pyrenean zones. The high rainfall in 2018 benefitted species such as False Ilex Hairstreak (*Satyrium esculi*) and Meadow Brown (*Maniola jurtina*) but, exceptionally, the heavy rains in the Pyrenees were too abundant to allow most species to complete their life cycles uninterruptedly. Even so, despite the improvement compared to 2016, both 2017 and 2018 are still amongst the six worst years for butterfly abundances since the CBMS counts began.

Weather and counts

The year 2017 was hot and dry reflecting the climate change affecting our country since the 1980s. Indeed, this year ended with a thermal anomaly of over 0.5ºC compared to the average for 1961–90 in practically the whole country (see www.meteocat.com). It was especially marked in montane areas of the northern half of Catalonia and on the coast of Tarragona (e.g. Baix Ebre), where positive anomalies exceeded 1.5ºC. Seasonally, the months of June (exceptionally so), February and March were very hot, as were, to a lesser extent, August and October. Heat waves were associated with the entry of winds from Africa, for example on March 9–11, May 24–28 and June 10–28 (with only June 2003 hotter), odd days in July and, above all, the extreme heat of August 1–5, comparable to the exceptional temperatures of July 2015. Thus, most of the CBMS stations were affected by abnormally high temperatures in 2017.

In terms of rainfall, 2017 was dry, the only exception being certain areas of the Pyrenees (e.g. Pallars Sobirà and Vall d'Aran). The drought hit hardest in the Ebro Delta and part of the Costa Daurada, although much of the pre-Pyrenees and the whole north-east of the country saw 50–70% less rain than the average for 1961–90. After a fairly rainy March everywhere, the rest of the year was dry, above all in November and December. The drought also became very apparent in April, May and June. All in all, this lack of rainfall and the high temperatures gave rise to a serious drought, in particular in the spring.

The year 2018 was very different and, despite being characterized by significant rainfall, was still one of the seven hottest years since 1950. Temperature-wise, only February, March and May (in the CBMS season) were cold, the remaining months being hot or even very hot, for example in January along parts of the central coastline, western regions of Catalonia, the southern pre-littoral mountains, the Ebro valley and, in August, the coast and pre-coastal areas. There were remarkable hot spells in January, a short but intense heat wave in April, heat throughout all of July, a true heat wave in August, and abnormally high temperatures in September.

Yet, the most remarkable aspect of the 2018 weather was the rainfall: more than half of Catalonia's counties registered over 1000 mm of rain and in some normally dry areas the total annual rainfall was the highest since records began. Almost nowhere was spared and only the Ebro Delta and the Alt Empordà plain failed to exceed the average rainfall for the period 1961–1990. The wettest months were January and February, and, particularly, October–November, all outside the CBMS counting period. The areas that received most rain were inland in the northeast, the western Pyrenees and the mountains of Ports de Tortosa.

In 2017 and 2018 6.35 and 6.22 counts, respectively, were lost on average per station, although these figures include the 'low-effort' stations where transects are only walked every fortnight (figs. 1a,b). If these stations are excluded, the averages were 4.06 and 4.51, respectively, that is, 13–15% of the possible counts. Due to the adverse weather conditions, more counts were lost at the stations with weekly counts, above all in spring when rainfall spread across much of the country (figs. 2a,b). Particularly significant was the rain that fell during the last week of April 2017 (week 9), when counts were lost at almost 50% of all stations.

Changes in abundance: overview

The 2017 and 2018 seasons were poor in terms of the commonest butterflies and both can be included amongst the six worst-ever seasons of the 25 years of the CBMS (fig. 3). Even so, these two years were an improvement on 2016, the worst-ever year of counts. In all, counts were performed at 78 stations in both 2016 and 2017, with a significant increase in the number of butterflies per station from 1471.1 ± 1132.0 (mean ± standard deviation) to 1859.7 ± 1392.3 (Student t-test for paired samples, $P < 0.001$). This increase also occurred amongst the number of species per station, with values that rose from 44.14 ± 17.5 to 45.41 ± 17.19 ($P = 0.031$).

It is worth remarking that the similar values for 2017 and 2018 are not a reflection of the stability of butterfly populations in the latter year but, rather, the overall outcome of a series of rises and falls in numbers, in some cases well-marked, with a clear geographical bias. Thus, in many stations in low-lying and montane areas there were notable increases in numbers in 2018, in part due to demographic explosions of False Ilex Hairstreak (*Satyrium esculi*) and Meadow Brown (*Maniola jurtina*), possibly due to the optimum state of their food plants after the abundant rains. By contrast, in the county of Alt Empordà, along the coast of Tarragona and in many Pyrenean stations there was a serious fall in butterfly numbers. As mentioned above, the heavy rainfall failed in many cases to reach coastal areas, while in the Pyrenees the rainfall was so abundant that the daily activity of butterflies was disturbed and numbers were lower.

Changes in abundance: fluctuations in populations

The 20 commonest species at the network's counting stations in the 2017 and 2018 seasons are shown in Table 1. After many years of low numbers, the False Ilex Hairstreak (*Satyrium esculi*) in 2018 once again became the dominant butterfly in the counts. At some stations there were spectacular increases in its numbers, to the extent that in total 22,144 individuals were counted, almost double the number of the second commonest species, the Small White (*Pieris rapae*). These demographic explosions are related to the exceptional sprouting of holm oaks in spring when the larvae are feeding, a phenomenon that has been observed in previous years when this hairstreak was also the commonest species in the CBMS network. The Purple Hairstreak (*Favonius quercus*), another Lycaenidae with a similar biological cycle that also feeds on oaks, underwent a similar increase in 2018 and reached its second-highest ever annual total. Nevertheless, as a species that is much harder to detect, only 1542 of this latter hairstreak were recorded.

The abundant spring rain also favoured many Satyrinae, whose larvae depend on spring grasses. After a number of years in which this group had declined notably, there were high counts of Meadow Brown (*Maniola jurtina*), which reached its second-highest ever numbers, Great Banded Grayling (*Brintesia circe*), and a recovery in the numbers of both Iberian Marbled White (*Melanargia lachesis*) and Pearly Heath (*Coenonympha arcania*), whose numbers had declined enormously in recent years (Table 2).

It is also worth noting that these were remarkable years for two species, Nettle-tree Butterfly (*Libythea celtis*) and Cleopatra (*Gonepteryx cleopatra*), that were commoner than in any other year since the CBMS counts began. Curiously, both hibernate as adults and so it is possible that the significant increases in their numbers was due to especially propitious winter conditions for hibernating adult butterflies. On the other hand, these increases could simply be the reflection of a steady increase in numbers, as the significant positive tendencies in their populations during the study period would seem to indicate (Table 2).

Finally, another exceptional year was that of the Red Admiral (*Vanessa atalanta*) in 2017, when one of the strongest autumn migrations of this Nymphalidae since counts began was recorded. Most of the migrant population arrived in October, outside the official CBMS counting period, which lessened its impact on the counts of this species. Even so, the annual index for Red Admirals in 2017 was the third-highest ever in the past 25 years. However, the situation was reversed in 2018 and its numbers fell to the third-lowest ever since counts began. The other typical migrant Nymphalidae, the Painted Lady (*Vanessa cardui*), flew in average numbers in both 2017 and 2018.

Constantí Stefanescu

For references, see the original Catalan version.

Fig. 1. Coverage of the counts at the different CBMS stations in (a) 2017 and (b) 2018. The 'low-effort' stations, which due to their fortnightly cycle (or monthly in initial trial years) lose a large number of the possible 30 counts, are also included.

Fig. 2. Distribution of the lost counts during the official 30 weeks (1 March–26 September) of counts in (a) 2017 and (b) 2018.

Fig. 3. Ranking of the CBMS seasons in terms of the general abundance of the 66 commonest butterflies in the CBMS network. The best season was 2002 (closely followed by 1995) and worst (in descending order) 2016, 2015 and 2012. Calculations were carried out using the methodology described by Greatorex-Davies & Roy (2001) using species' annual indices calculated with the TRIM programme.

Table 1. Sum of the annual indices and ranking of the abundance of the 20 commonest species in the CBMS network in the 2017 and 2018 seasons.

Table 2. Evolution of the overall annual indices for 107 butterflies recorded in the CBMS network based on an arbitrary value of 1 for 1994. The annual indices were calculated using the TRIM programme.[2] Also indicated are the number of stations that provided data for each species and the population trends detected by the programme.

Photo 1. As seems to be usual in rainy springs, in 2018 the False Ilex Hairstreak (*Satyrium esculi*) was again the most abundant butterfly in Catalonia. Huge concentrations of this butterfly were recorded on flowering brambles and other preferred nectar sources in many itineraries (photo: J. Corbera).

Drawing 1. In 2018, many populations of the Nettle-tree Butterfly, *Libythea celtis*, showed a spectacular increase. Dozens of larvae and pupae were located on the nettle trees, and hundreds of adult butterflies of the new generation were recorded at some pre-littoral sites (drawing: M. Franch).

Drawing 2. The two-tailed Pasha, *Charaxes jasius*, showed opposite extreme counts in 2017 and 2018. After reaching the highest levels ever in 2017, populations collapsed in 2018, probably as a consequence of massive larval mortality during abnormally cold February and March months (drawing: M. Franch).

Habitat management and conservation

Habitat loss due to vegetation encroachment leads to changes and local extinctions in butterfly communities

The abandoning of traditional agricultural practices and the consequent increase in forest mass is an important element in landscape change in the Mediterranean basin. CBMS data have been used to quantify the degree of preference of 147 butterfly species for open or closed habitats, with most species showing a very clear preference for open habitats. We also recorded a process of encroachment in more than 70% of long-monitored transects, which had strong effects on the composition of butterfly communities. 5% of the monitored butterfly populations went extinct in the same period, with a significant bias towards the species preferring open habitats. This study thus confirms the threat that this process poses for butterfly diversity.

Introduction

Forest and scrub encroachment consists of the invasion of open areas by woody plant species in the form of scrub and forest.[1] Although this is a worldwide phenomenon, it is taking place, above all, in developed countries where in recent decades it has become a key element in habitat transformation.[2-3] Its causes are well known and are principally related to the abandoning of traditional agricultural and extensive stock-raising activities but can also be attributed to an increase in atmospheric CO_2 levels and the suppression of forest fires.[1,4] In the Mediterranean basin thousands of years of anthropic pressure has encouraged a rich mosaic of semi-natural grassland, agricultural land and pastures that has drastically diminished in recently years as the vegetation encroaches.[5] Specifically, forest cover in Catalonia increased at a rate of 3,300 ha/year in 1987–2012, while in the same period the amount of agricultural land decreased by 6,300 ha/year.[6]

Vegetation encroachment threatens biodiversity due to the fact that the conservation of many species depends strictly on the survival of open habitats.[7] It causes declines in plant biodiversity and affects the composition of plant communities, and leads to the fragmentation of semi-natural grasslands.[1,8] The identification of biological indicators that respond rapidly to this phenomenon is essential if we are to understand these processes[8], and the close ecological links between butterflies and their habitats makes them a highly relevant group for studying changes in habitat caused by the abandoning of traditional agricultural practices and vegetation encroachment.[9-10] The CBMS database is thus an ideal tool for studying changes in habitat structure occurring in Catalonia in recent decades.

A previous study[11] determined habitat preferences along a gradient of closed to open habitats for butterflies and birds, and showed that the tendencies at population level for butterflies preferring closed habitats were more positive or more stable than for those preferring open habitats. Although such a species-based analysis is useful for understanding how species are responding individually, a community-based analysis is even more useful for exploring changes occurring in the composition of butterfly populations in the long term, and for examining whether or not there are matching patterns occurring in landscape changes operating at a local scale.[12-13] The objective thus is to provide conservation managers with a tool that will be useful for showing how rapidly butterfly communities are responding to forest encroachment.

Currently, insects are declining in general world over and monitoring programmes performed throughout Europe have revealed negative tendencies that show that butterflies are excellent grassland indicator species.[14] Changes in land use linked to overgrazing and vegetation encroachment have been linked to butterfly declines and extinctions.[11,15] Our intention was thus to analyse whether or not butterfly species that show a preference for open areas are more likely to undergo local extinctions, and whether or not the degree of preference for open or closed habitats is a predictor of population tendencies at local scale.

Material and methods

Study area and datasets

For this study data from all CBMS stations up to 2017 (154 stations) were used to develop a specific index of preference in butterfly species for open or closed habitats. For changes in populations, we used data from stations that in the period 1997–2017 had generated data series of 10 or more years.

Preferences for open and closed habitats

Botanical characterization. The botanical characterization of the CBMS transects carried out by Cèsar Gutiérrez since 2000 were used. These characterizations take into account the cover of each plant community as defined by the CORINE habitat classification[16] along the 5-m-wide butterfly transect. As well, a binary classification was established assigning values to closed (-1) and open (+1) plant communities. All forests were classified as closed and grassland as open, whilst scrub and other types of plant communities were classified according to their height. Then, an average value for each individual section of the transect was calculated by multiplying the percentage of each habitat type by its assigned score (-1 or +1). Only indices with a total value over 0.1 were taken into account in subsequent analyses to avoid using sections with a balance between open and closed habitats. Annual butterfly data were associated with the nearest year for which a botanical characterization was available. Botanical characterizations started in 2000 and are repeated every six years in each transect to record changes along the monitoring route.

The TAO index. A TAO (TAncat-Obert; in Catalan tancat = closed, obert = open) index, developed using a formula described in a previous article,[17] allowed us to establish a gradient of preference between -1 i +1 for open and closed habitats. To calculate the index of a species for a particular transect the average densities (examples/100m) in open sections and the average densities in closed sections were calculated. The final index for each species is the average value of all the indices calculated for each transect in which the species in question has appeared. Only species flying in at least five transects with sections classified either as open or closed were used.

Changes in habitat and tendencies in butterfly communities

Vegetation encroachment. The percentage change occurring between the first and most recent botanical characterization for each transect was used to investigate changes in the vegetation along the monitoring route. Thus, the time scale of the study corresponds to 6, 12 or 18 years, depending on how many characterizations have been conducted in the transect in question. An average closed/open value describing vegetation change was calculated for the whole transect. The final values lie on a gradient between -100 (a change towards complete encroachment) and +100 (maximum change towards open habitats).

Community index. A community index (TAOc) was developed for a total of 54 transects with 10 or more years of data. This index takes into account the contribution of the whole community of species in a particular year by calculating the average values of the TAO indices of all the species that appear, multiplied by their abundances. Given that this index was calculated every year for each transect, the annual progression can be monitored to determine whether the tendency is to move towards communities more dominated by butterfly species with preferences for open or for closed habitats.

Modelling. The relationship between changes occurring in butterfly communities and the degree of vegetation encroachment was studied using a generalized linear model incorporating a series of possible explanatory factors: the Shannon-Wiener diversity index for the diversity of CORINE habitats at the initial time of the series, with the hypothesis that a buffer effect would help stabilize a community; the initial TAOc value, which determines whether or not the initial community structure will influence the changes occurring; the time elapsed (i.e. the length of the annual series), and the thermal region to which the transect belongs (a categorical variable). An ANOVA test was also performed to determine in which region the degree of change and vegetation encroachment is most severe.

Species loss and population declines. A local extinction was defined as the absence of a species from a transect in four successive years after four successive years of appearance; thus, an eight-year series was needed to detect an extinction. For each butterfly community two values were calculated: the average TAO index for species that have become locally extinct and the average TAO index for species that have not become extinct. These averages were calculated for 54 transects and a total of 2,515 populations and then values were compared using a paired t-test under the hypothesis that species suffering local extinctions had a preference for open habitats.

Finally, population tendencies at local level were modelled in terms of the degree of vegetation encroachment in each transect and butterfly species' preferences for open or closed habitats. A mixed model was constructed using 2,484 butterfly populations including these two factors, as well as their interaction, with 'itinerary' and 'species' as random factors.

Results

Preference for open or closed habitats

We obtained the I_{TAO} index for a total of 147 species of butterflies (fig. 1), with an average of 50 sites used to calculate this index. The mean value of the index was 0.408, with extreme values of -0.419 for Speckled Wood (*Pararge aegeria*), whose preference was clearly for closed habitats (nº sites=117), and of 1 for Olive Skipper (*Pyrgus serratulae*), which was only recorded in open habitats (nº sites=7). The mean value for the group of species as a whole was highly positively skewed and in total 91% of the species had positive values on the gradient, thereby indicating a preference for open habitats.

Changes and tendencies in butterfly communities

Of the 54 studied sites, 41 (76%) showed changes towards vegetation encroachment. The degree of change varied in the range of 0.1–31.7% between the first and most recent botanical characterizations. The TAOc values show a similar pattern, as in 39 sites (71%) changes have occurred towards domination by species preferring closed habitats (fig. 2).

The relationship between the degree of change in communities and vegetation encroachment is statistically highly significant. The Shannon-Wiener index was also significant, as was the thermal region. The initial TAOc value and the length of the monitoring series were not significantly related to the degree of change. There were also significant differences in the four categories of thermal regions, with greater effects being noted in hotter areas.

Species loss and population declines

A total of 126 extinctions were found to have occurred in 40 of the 54 studied transects. During the study period, 5% of the monitored populations became locally extinct. In 12 cases the species subsequently re-colonized, which gives a total of 114 (4.53%) cases in which a population of a species was never recorded again at the site in question. The average TAO value for extinct populations was 0.393, while for the surviving populations was 0.330. A paired t-test showed significant differences between these values.

A mixed model was created for transect-scale tendencies but showed no significant relationship between the gradient of change and either the TAO index or vegetation encroachment. Nevertheless, there was a highly significant relationship in the interaction between these factors, which indicates that species with a preference for closed habitats tend to have negative tendencies when habitats are opened up and vice versa. A good example of this tendency can be seen by comparing trends in Speckled Wood (*Pararge aegeria*) and Mallow Skipper (*Carcharodus alceae*) (fig. 3).

Discussion and conclusions

In this work we used data from both the CBMS and BMSAnd networks, a dataset that is long enough to establish stable values for the habitat preferences of 147 species of butterfly, the majority of which show a clear preference for open habitats. This preference indicates that they are highly sensitive to changes in habitat caused by vegetation encroachment. In the Mediterranean region the increase in forest cover has been described as one of the main elements determining landscape change in recent decades.[2,18]

Over 70% of the studied transects have experienced some degree of vegetation encroachment in the past two decades, which is illustrative of the importance of this phenomenon. This was matched by a parallel shift in the TAO community index (TAOc) given that 76% of the analysed butterfly communities have tended to become dominated over time by species preferring more closed habitats. Statistical models confirm that vegetation encroachment is a key factor in the observed changes in butterfly communities.

The observed changes in the vegetation were only measured via local monitoring and not on a landscape scale; nevertheless, in the past two decades the increase in forest cover has also been observed in buffer areas around many transects.[11] Our results complement those obtained in 2015, which showed that an increase in forest cover has an impact on both butterfly and bird populations, as revealed by a multi-species indicator.

The degree of change in butterfly communities was greater in transects with less plant diversity (as measured by the Shannon-Wiener index). This is owing to the fact that heterogeneous landscapes promote stable populations by offering a greater diversity of resources and microclimates.[19] The effects of the thermal region show that butterflies in more arid regions are more affected by this phenomenon, which reflects the extensive vegetation encroachment occurring in the Mediterranean that is frequently linked to socio-economic factors such as rural-urban drift.[6]

The lack of relationship with the length of the time-series illustrates how quickly vegetation encroachment occurs, which would thus seem not to be time-dependent. This effect has been detected in other insect groups and demonstrates that their precise habitat requirements and short generation time makes butterflies highly valuable as indicators of environmental change.[10] Neither was there any relationship with the initial TAOc value, which indicates that this phenomenon has an effect that is independent of community composition.

The results obtained from the analysis of local extinctions are worrying: 4.53% of our butterfly populations have become extinct, generally in cases of species with higher TAO values, a finding that shows how vegetation encroachment poses a threat for species with a preference for open areas. To appreciate further why declines are leading to local extinctions it is necessary to take into account the climatic framework since Mediterranean areas are more exposed to extreme climatic events.[21-22] Thus, the interaction between climatic and landscape factors is the essential cause behind these negative tendencies, a problem that must be taken seriously in the context of global change.

We believe that the TAO index and the way in which it serves as an approximation to the butterfly community is a potentially very useful tool for conservation managers aiming to preserve biodiversity, above all in light of the importance of butterflies as bioindicators for insect communities. Insect conservation is essential for guaranteeing ecosystem processes and services at many different levels and in this sense the protection of open landscapes is key. We feel that the reversion to more traditional styles of agriculture and extensive animal husbandry would help mitigate some of the problems outlined in this article.

Andreu Ubach

For references, see the original Catalan version.

Fig. 1. The TAO index calculated for all 147 species present in the CBMS network. In all, 91% of the species appear on the positive axis of the graph indicating their preference for open habitats.

Fig. 2. The Vallgrassa transect (El Garraf) is a good example of changes produced by vegetation encroachment. The TAO community index has decreased over the years due to the changes occurring in the butterfly communities.

Fig. 3. The Mallow Skipper (*Carcharodus alceae*) prefers open environments and is undergoing population declines wherever vegetation encroachment is occurring. By contrast, the Speckled Wood (*Pararge aegeria*) is one of the few butterflies preferring closed environments and it shows positive tendencies where these habitats increase.

Photo 1. The phenomenon of vegetation encroachment is causing biodiversity loss in subalpine meadows, where butterfly communities are especially diverse. In El Catllar (Ripollès), for example, the current grazing pressure has proven not enough to prevent vegetation encorachment in some areas of the valley, where old pastures are becoming invaded by broom (photo: A. Ubach).

Photo 2. The Cleopatra, *Gonepteryx cleopatra*, has been one of the few butterflies favoured by the increase of forest and scrub in Catalonian landscapes (photo: A. Miralles).

Photo 3. The Dingy Skipper, *Erynnis tages*, has experienced a strong decline in Catalonia in the last 25 years due to habitat encroachment (photo: J. Corbera).

The station

Besòs-Montcada, a metropolitan river of butterflies

Situated in the lower reaches of the Besòs valley and on the slopes of Serra de Marina, the Besòs-Montcada CBMS itinerary runs along the final stretch of a gully, Torrent de la Vallençana, as it joins the main river Besòs and then along the river itself. It is highly variable in terms of the habitats it crosses, many of which are degraded and fragmented, and in some cases constantly under threat and prone to disturbance. Nevertheless, the butterflies that are recorded remind us of the ecological importance of open periurban spaces in the heart of the Barcelona Metropolitan Area.

The itinerary

The Besòs-Montcada CBMS station, the 148th in the network, has been active since 2016, although its records only started to be evaluated in 2017. This butterfly walk is situated in the municipality of Montcada i Reixac, and runs from the slopes of Puig Castellar (Serra de Marina) down to Torrent de la Vallençana and on to the river Besòs to the south-west of the town. It is 1,552 m in length and is divided into eight sections (average length: 190 m) at an altitude ranging from 59 to 28 m a.s.l. The climate is Mediterranean with average annual rainfall of 568 mm and average annual temperature of 16ºC. Summers are hot (max. 29ºC in July) and winters relatively cool – despite the proximity of the sea – owing to the marked thermal inversion that occurs in the river valley and affects the itinerary. Most of the sections cross alluvial soils in the Torrent or run alongside the main river Besòs, although section 8 crosses open grassland lying on old clay workings that are testimony to the former industrial activity in this area.

The itinerary passes through a number of different environments including, above all, open dry grassland, thistle-packed fields, dry and damp riverside grassland, forest tracks and the artificial reed beds in the Besòs water purification plant (fed by water from the treatment plant in Montcada). In the highest part, the itinerary also passes through the ecotone between market gardens and thickets, on the one side, and poorly structured scrub, on the other. Thickets dominate the margins of section 5, which is the richest in butterflies. The most natural and varied vegetation is found along the gully, where there are natural stands of holm oak with deciduous oaks, a magnificent stand of southern nettle-trees and an extension of chaste trees that has managed to survive years of transformation and degradation. All in all, the overriding feature of the walk is the fragmentation of its habitats due to ecological barriers such as the road, the river's retaining walls, the sheds and fences in the allotments, fly-tipping, and the water-treatment plant, amongst others, that break up their continuity.

The butterflies

54 species with an annual average of 47, and 9224 individuals (annual average of 4612) have been recorded in 2017 and 2018. Abundance and species diversity begins to rise noticeably in May but peaks in June. From the beginning of June to mid-July a density of 200 ex./1000 m is sustained, which can rise as high as 400 ex./1000 m in mid-June. After the summer drought, there is a secondary peak in species diversity in September due to the appearance of the second generations of bivoltine species, the appearance of individuals belonging to polyvoltine species, and the arrival of the migrant species. Looking at these figures, it is obvious that, even if the species richness is not particularly high, the total abundance of butterflies is fairly generous. This is due to the good numbers of generalist species that fly here (fig. 1): Southern Gatekeeper *Pyronia cecilia* is very common, and there are always good numbers of Small White *Pieris rapae* and, to a lesser extent, Iberian Marbled White *Melanargia lachesis*. Somewhat less common are Southern Brown Argus *Aricia cramera*, Meadow Brown *Maniola jurtina*, Speckled Wood *Pararge aegeria*, Spanish Gatekeeper *Pyronia bathseba* and Wall Brown *Lasiommata megera*, all generalist species. It is also worth highlighting the presence – albeit in small numbers – of specialist species with a variety of habitat requirements such as Peacock *Aglais io,* Provence Hairstreak *Tomares ballus*, and Black-eyed *Glaucopsyche melanops* and Green-underside *G. alexis* Blues.

Open spaces in metropolitan areas and their butterflies

A bird's-eye view of the Besòs-Montcada itinerary and its surroundings does not offer much promise as a site for biodiversity, in general, or butterflies, in particular. If you walk the itinerary it becomes even less welcoming: continuous human impact and presence have helped mould a landscape that is biologically impoverished, very fragile, highly fragmented and threatened. Open spaces in metropolitan areas have been largely transformed and in some cases heavily degraded, and are often visibly fragmented by ecological barriers including large infrastructures and other disturbances that isolate the ecological functions of spaces and habitats and prevent their connectivity. Nevertheless, this and other similar transects demonstrate that a significant abundance of butterflies can exist in these areas with a reasonably wide diversity of species. This suggests that butterflies and other species are capable of taking advantage of the resources that are on offer and do not necessarily need idyllic pristine habitats in which to survive — biodiversity flourishes wherever and however it can. This metropolitan itinerary is perhaps a paradigm of the great ability that butterflies have to act as bioindicators, and shows the importance of these open spaces lacking any specific type of protection as refuges for biodiversity and as reservoirs for species and their ecological functions in an urban and periurban context. The predominance of generalist species probably indicates a simplification of habitats that will lead to a progressive loss of biodiversity.

This itinerary reveals the degree of connectivity between the two ridges of Serra de Collserola and Serra Marina (each with a different type of protection) that converge on either side of the river Besòs in the Parc Fluvial (another type of protected area). As such, like other periurban itineraries it is important as it provides data on the key role of butterflies in our much-degraded periurban landscapes.

Juli Mauri i de los Rios

Fig. 1. Average abundance (average of the annual indices during the period 2017-2018) of the 15 commonest butterflies at the Besòs-Montcada station.

Photo. The itinerary passes through different kind of meadows, artificial reed beds and scrub on the slopes of Serra de Marina (photo: J. Mauri).

Aerial photo. The CBMS transect at Besòs-Montcada, in a highly degraded and fragmented habitat, always prone to disturbance.

The station

Tregurà, a subalpine transect in the Catllar valley, in the heart of the Eastern Pyreness

Until these two stations were incorporated into the network, there were no CBMS stations in the Gironan Pyrenees. The monitoring of butterfly populations in montane, subalpine and alpine habitats is essential for detecting, observing and studying the loss of open spaces and the management of grazing regimes, above all in a region in which the effects of climate change will become ever more marked.

The itinerary

The station of Tregurà is located at 1,800 m a.s.l., in the Catllar valley. The climate of the valley is subalpine, with winter averages below freezing and summer averages around 20ºC; annual rainfall varies between 1,100 mm in the lower part of the valley and 1,200 mm in the higher pastures along the Tregurà itinerary.

This transect is one of the highest in the CBMS network and consists of 12 sections covering a total of 1,286 m (107 m/section). It runs through a mosaic of acid subalpine pastures with juniper (*Juniperus communis* subsp. *alpina*) and alpenrose (*Rhododendron ferrugineum*) scrub, as well as stands of mountain pine (*Pinus uncinata*) planted in the 1950s.

A herd of over 250 cows grazes freely throughout the valley from June to mid-November and, to greater or lesser extent, affects the butterfly populations, above all in the open spaces.

The butterflies

During the two years of counts, at Tregurà, 2,111 butterflies and 65 species at a density of 82,01 ex./100m have been noted.

The phenology is characterized by a single large peak that drops off sharply from mid-August onwards. It is not until around week 13 (end of May) that the first butterflies begin to fly. The higher Tregurà itinerary is not one of the network's most species-rich butterflies walks but still harbours interesting butterflies due, above all, to certain species' dependence on subalpine habitats. Of the 65 species detected, 10 here have the best populations in the whole Catalan CBMS (fig. 1): Large *Erebia euryale*, Piedmont *E. meolans* and Spanish Brassy *E. rondoui* Ringlets, False Heath *Melitaea diamina* and Meadow *M. parthenoides* Fritillaries, Turquoise Blue *Polyommatus dorylas*, Purple-edged Copper *Lycaena hippothoe*, Olive Skipper *Pyrgus serratulae*, and Chestnut Heath *Coenonympha glycerion*. Thanks too to these counts, the biennial life cycle of *Erebia euryale* – with a high annual index one year followed by an index of zero the following year – has become clear.

Most of the first butterflies to fly at this altitude are widespread species or those that only fly in spring or that have an initial spring generation such as Orange-tip *Anthocharis cardamines*, Large White *Pieris brassicae*, Small Copper *Lycaena phlaeas*, Holly Blue *Celastrina argiolus* and Small Tortoiseshell *Aglais urticae*, or more specialized species such as Marsh Fritillary *Euphydryas aurinia*, Duke of Burgundy *Hamearis lucina* and De Prunner's Ringlet *Erebia triaria*. Nevertheless, the rigours of the climate at this altitude ensure that most species are summer flying.

Other high-level species, typical of the Catalan Pyrenees, that fly at Tregurà include Scarce *Lycaena virgaureae* and Purple-shot *L. alciphron* Coppers, Mazarine *Cyaniris semiargus* and Idas *Plebejus idas* Blues, Pearl-bordered *Boloria euphrosyne*, Small-Pearl-bordered *B. selene* and Dark Green *Argynnis aglaja* Fritillaries, Mountain Ringlet *Erebia epiphron* and the spectacular Apollo *Parnassius apollo*.

Management of open spaces in upland areas

Since time immemorial, upland areas have been transformed to extract natural resources such as wood and minerals, and forests have been cut to create grazing and arable areas. In the past century, many of the cultivated areas in the Catllar valley (where three CBMS transects have been established) were abandoned, which led to rapid forest encroachment. In the higher parts, open spaces, however, support a large herd of cows that spend the winter in the Empordà lowlands, most of who return to the valley on foot every spring.

Today, despite the animal husbandry that continues to flourish, the higher pastures are gradually being invaded by scrub and lower down the forests continue to encroach on the few open spaces that remain. Moreover, the last few open areas in the valley bottom are intensely but briefly grazed when the herds arrive or leave the valley. Consequently, for the last few years attempts have been made to improve the overall biodiversity of the open spaces by increasing the size of the pastures and meadows via campaigns to eliminate the broom scrub in higher areas and the hazel woodland in the lower parts of the valley.

At the same time as the CBMS itineraries are walked, the effect of grazing pressure on a diverse community of animals is being studied in order to improve management and make it more compatible with traditional grazing regimes and the maintenance of open spaces and their biodiversity. The aim is to determine which periods of the year are most favourable for certain animal groups found in open spaces, and to decide whether or not to restrict temporally the entry of the cows into certain sensitive spaces and what the optimum density of cows should be.

Jordi Artola and Mike Lockwood

Fig. 1. Average abundance (average of the annual indices during the period 2017-2018) of the 15 commonest butterflies at the Tregurà station.

Photo 1. The itinerary encompasses a variety of subalpine landscape, such as meadows, scrub and stands of mountain pine (photo: M. Lockwood).

Photo 2. The Turquoise Blue , *Polyommatus dorylas*, is a Pyrenean species underrepresented in the CBMS network but with a strong population in the Tregurà itinerary (foto: J. Jubany).

Aerial photo. The CBMS transect at Tregurà, at 1800 m a.s.l., in the Catllar valley, samples typical subalpine habitats in the Eastern Pyrenees.

Article review

Carnicer, J., Stefanescu, C., Vives-Ingla, M., López, C., Cortizas, S., Wheat, C. W., Vila, R., Llusià, J. & Peñuelas, J., 2019

Phenotypic biomarkers of climatic impacts on declining insect populations: A key role for decadal drought, thermal buffering and amplification effects and host plant dynamics.

***Journal of Animal Ecology*, 88: 376–391. https://doi.org/10.1111/1365-2656.12933.**

The analysis over time of the data series that the CBMS network generates has enabled us to calculate that 70% of Catalan butterflies have declined in number over the past two decades. Previous studies have attributed these demographic tendencies to the negative effects induced by recent changes in land use and global warming. Nevertheless, the populations of a single species may exhibit contrasting tendencies that give rise overall to a mosaic of dissimilar trends. This is the case of the Green-veined White (*Pieris napi*), which has declined in lowland areas (e.g. El Cortalet in the Aiguamolls de l'Empordà Natural Park and Cal Tet in the Delta del Llobregat protected area; CBMS itineraries 1 and 4, respectively) but in upland areas has remained stable (e.g. El Puig in El Montseny Natural Park; itinerary 12) or even moderately increased (Can Jordà in the La Garrotxa Volcanic Zone Natural Park; itinerary 9).

In this study published in the *Journal of Animal Ecology* we identified a series of elements operating at local scale that modulate by magnifying or mitigating the regional pressures that these four populations are under. After creating a model incorporating monthly rainfall and temperature data, as well as changes in land use, we observed that the dynamics displayed by these four populations are strongly driven by summer weather conditions. Specifically, we noted that the generalized decline in June rainfall in 1997–2007 was accompanied by a severe fall in Green-veined White numbers in lowland areas (by over an order of magnitude in the Aiguamolls de l'Empordà). By contrast, this intensification of the summer drought had no observable effects on population dynamics in upland areas (e.g. Can Jordà and El Montseny), where in fact Green-veined White abundances increased as rainfall returned to its previous levels.

As previous studies have noted, the responses of organisms to the impact of climate change are influenced by a complex series of interactions between a set of processes that operate simultaneously. Thus, more studies will be required integrating concurrently many elements affecting population dynamics if we are to develop a more complete vision of the situation. We set out to evaluate how habitat structure, host plant characteristics, phenotypical behaviour in the Green-veined White, and this butterfly's response to thermal stress can provide information regarding the degree of climatic vulnerability of its populations.

At each of the study sites we installed sensors around stands of the butterfly's host plant, in both open (in fields and pastures) and closed (in the shade of trees in woods and copses) habitats, that recorded the temperature every hour. We compared the results from these sensors with data from the nearest weather station in the Catalan Meteorological Service's network and calculated that, due to tree cover, in upland woodland the maximum June temperatures were 5.2 ± 0.17ºC lower than those recorded by the nearby weather stations. By contrast, the declining lowland populations had no access to any efficient thermal micro-refuges. In lowland populations, thermal mitigation was up to six times less (0.79 ± 0.32ºC) than in upland areas. Moreover, most host plants were located in open areas where temperatures increased by a further 2ºC.

Thus, the temperatures in open habitats in lowland areas exceed the critical thermal thresholds for larval survival in this species, which we calculated via a series of thermal death time experiments. Nevertheless, these thresholds (minimum exposure of 6 hours at 34.5ºC during the three weeks of larval growth) were not exceeded on 90% of days. Consequently, it is unlikely that this thermal regime alone can have such serious effects on the lowland populations of the Green-veined White.

Indeed, thermal stress was not the only factor that affects this butterfly's populations. In our monitoring of the host plant, we noted that whilst in upland populations there were always garlic mustard (*Alliaria petiolata*) plants present, in lowlands the species' two food plants, hoary cress (*Lepidium draba*) and black mustard (*Brassica nigra*), entered into a state of senescence from June onwards after fruiting. At the same time, during the period of greatest hydric stress the conductance of these latter plants' leaves was significantly reduced, which aggravated the thermal amplification they experienced (in June leaf temperatures reached 38ºC, 14ºC higher than in May). Thus, in summer lowland Green-veined Whites are not only affected by the dearth of shade but also have to cope with a lack of fresh, good-quality host plants. As many experiments have previously demonstrated, the interaction between these two factors will probably negatively affect larval development and even have consequences for the overall demographics of this butterfly's populations.

Finally, this variation in the degree of thermal exposure experienced by different populations may be reflected in contrasting phenotypical characteristics that vary in terms of the specific conditions under which butterflies develop (biomarkers). In our study, the wing size of lowland Green-veined Whites diminished as summer temperatures rose, whilst that of upland populations remained the same. When upland butterflies were raised in captivity under lowland temperatures, their wing size was smaller. This demonstrates that under natural conditions upland populations benefit from protection against thermal exposure. As we have seen, to explain how organisms are affected by the impact of climate change we need data regarding all the numerous different factors that operate simultaneously and how they interact.

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Fig 1. Upland Green-veined White populations benefit from the shade offered by woods. In summer, temperatures in woodland are up to 5ºC lower than outside (Photo: J. Carnicer).

Fig 2. In summer, at lowland sites the host plants of the Green-veined White are scarce and of low quality. Moreover, there are strong temperature amplifications and the butterfly's thermal tolerance thresholds are exceeded (Photo: M. Vives-Ingla).

Drawing. Green-veined White (*Pieris napi)* on garlic mustard, *Alliaria petiolata*, one of the preferred food plants of upland populations. This same food plant is widely used by Large White (*Pieris brassicae*) populations (Drawing: Martí Franch).

The butterfly

Why is the Large Tortoiseshell *Nymphalis polychloros* known as the *Sleeping Beauty* in Catalan?

Despite being a reasonably widespread and spectacular species, the Large Tortoiseshell is often overlooked. This is due largely to its curious phenology: despite living for up to 10 months and so being one of our longest-lived of all butterflies, adults of the Large Tortoiseshell enter into diapause almost immediately after emerging at the beginning of summer and do not reappear until the following season. They spend this long period of inactivity hidden in dark spots in abandoned houses, garages and storerooms, often in company with the Peacock.

Geographical distribution and situation in the CBMS

The Large Tortoiseshell is a Palaearctic species that flies in North Africa – it is particularly common in the Rif – and much of Europe. In the Iberian Peninsula it is widespread, although it has never been recorded from the Balearic Islands.[1] It is common in the northern half of Catalonia but more local in upland areas of the province of Tarragona;[2,3] outside the highest areas, it is also fairly common in Andorra. Its altitudinal range is broad, ranging from sea level to 1900 m a.s.l.,[4] with clear maximum abundances between 600 and 1400 m a.s.l.

In the CBMS network it has been detected in nearly 90 stations, almost 60% of the whole network (fig. 1). Nevertheless, in some stations only dispersing wintering butterflies appear. It is absent from stations in the Ebro Depression, from many coastal sites and nearby inland areas, and from high-level transects in the Pyrenees.

Habitats and food plants

The Large Tortoiseshell is essentially a generalist species as the fact that it has been recorded from 17 of 19 habitat categories included in the CBMS network indicates. The only two habitats from which it has never been recorded are at altitudinal extremes: beaches and alpine meadows.[5] This degree of generalism is explained in part by this species' dispersive capacity and the appearance of individual butterflies – above all, hibernators that have just emerged from diapause – in a series of varied habitats. Breeding areas, however, are more localized and are restricted, above all, to ecotones of montane forests and agricultural areas, often in the vicinity of farmhouses where its food plants are common and males establish their territories. Its ties to forested areas are patent, as shown by its TAO Index of 0.022, well below the average for most Catalan butterflies, which reflects its preference for environments with ample forest and shrub cover.[6]

Its association with forested areas or, at least, with places with stands of trees, can be put down to the fact that it uses a variety of different trees as food plants.[1,7,8] Specifically, in Catalonia egg-laying or caterpillar nests have been recorded from nine different tree species: southern nettle-tree (*Celtis australis*), field elm (*Ulmus minor*), wych elm (*Ulmus glabra*), wild cherry (*Prunus avium*), black poplar (*Populus nigra*), aspen (*P. tremula*), grey willow (*Salix atrocinerea*), weeping willow (*S. babilonica*) and hawthorn (*Crataegus monogyna*). In addition, pre-egg-laying behaviour has been noted on white poplar (*Populus alba*).[7] Despite lacking confirmatory oviposition trials, eggs seem to be laid preferentially on wild cherry, southern nettle-tree or field elm. Laboratory experiments indicate that larval development time varies greatly depending on the food plant: for example, development takes almost 30% longer on hawthorn (35 days) than on field elm (28 days) and southern nettle-tree (25 days) owing to the difference in the nitrogen and water content of the leaves.[8] The fact that, despite these differences in development time, polyphagy occurs at local level could be related to the lack of any correlation between larval mortality and the length of development time; this is an evident possibility given the high and very heterogeneous larval mortality rates (i.e. not dependent on the food plant) found in natural populations.[7]

Phenology and biological cycle

As occurs in many other species of butterfly of the tribe Nymphalini, the Large Tortoiseshell is univoltine and hibernates as an adult. Its common name in Catalan – *Nimfa Dorment* (i.e. Sleeping Beauty) – is a reflection of the long period of time every year that the adult is inactive. The first Large Tortoiseshells leave hibernation very early in the year and can be seen on sunny days in February and, above all, March. By contrast, the fresh butterflies that emerge as the single annual generation between mid-May and mid-July, enter very quickly into diapause and remain there until the end of winter or beginning of spring of the following year.

The cryptic colouration of the underside of the wings acts as camouflage during the adult butterfly's long period of diapause. To hibernate, butterflies typically choose a dark, well-hidden site in abandoned or non-permanently inhabited buildings such as farmhouses, garages and storerooms.[7,9] They are often found alongside the Peacock (*Aglais io*) and are also found regularly in nest boxes placed for edible dormouse (*Glis glis*) in oak and beech forests in the mountains of Montnegre, Montseny and Guilleries. These wooden boxes measuring 30x15x15 cm (Photo f) are placed at heights of 2.5–3 m directly on the trunks of sessile oaks (*Quercus petraea*) or beeches (*Fagus sylvatica*).[7] Data show that Large Tortoiseshells hibernate in both Mediterranean environments (e.g. the Vallesana Plain at altitudes of 150–300 m a.s.l.) and in the more upland areas (700–1200 m a.s.l.) where the species is most abundant.

A remarkable aspect of the phenology of the Large Tortoiseshell, which is shared by the Camberwell Beauty (*Nymphalis antiopa*), is how difficult it is to spot a fresh butterfly belonging to the annual emergence in spring or summer. This is most noticeable in Mediterranean environments[10] and so, ostensibly, its annual flight curve falsely indicates that the old individuals from the previous year appearing after hibernation are commoner than those of the current year (fig. 2). This also reflects the short period of time in which the majority of Large Tortoiseshells are active after emergence, as shown by the large number of observations that exist of butterflies already in diapause in July.[7]

Once they leave hibernation at the end of winter or beginning of spring, the Large Tortoiseshells mate and the females very quickly begin to look for egg-laying sites. Egg-batches consist of groups of 100–200 eggs, generally placed carefully around the end of a thin branch (2–3 mm in diameter) (Photo a). Observations of egg-laying or females exhibiting egg-laying behaviour take place above all in March and occasionally in April. On the other hand, nests of caterpillars (in different stages) are found chiefly between the second half of April and the first half of June.[7]

Eggs take 2–3 weeks to hatch. The larvae are gregarious and live near the egg-laying site in a simple silken cocoon on a young leaf (Photo b). Whilst still gregarious, the larvae change leaves and establish a new nest with each moult. In the final stage after moulting into the fifth instar, the larvae adopt a solitary lifestyle and disperse over its host plant. Towards the end of the gregarious phase, due to the accumulation of defoliated branches covered in silk and numerous excrements, larval nests become very visible.

Once fully grown, the larvae generally abandon the food plant and enter a wandering phase[11] that may involve long journeys until they find an appropriate place to pupate. In the Large Tortoiseshell, an average distance of 17.1 m (max. 25 m) has been recorded for a group of seven larvae located near the elm on which they had fed[7]; nevertheless, movements of over 50 m, documented in the Camberwell Beauty, are probably not rare.[12] The chrysalis is well camouflaged whether hidden amongst the vegetation or at the base of tree trunk near ground level or higher up (up to 2 m or more) on rocky outcrops, under the eaves of farm buildings or in other similar sites (Photo d). This final phase is short, lasting only around two weeks.

Natural enemies

Attacks by predators and parasitoids have been documented throughout the life cycle of the Large Tortoiseshell.[7] Of the parasitoids, a species of Hymenoptera (family Scelionidae) has been reported as attacking the eggs (Photo e)[7] and various Diptera (family Taquinidae) parasitize the larvae; depending on the species in question, they will kill the caterpillar or chrysalis (e.g. *Sturmia bella*, whose larva leave behind a characteristic thread when they leave the pupa; Photo h).[7,13] The Hymenoptera (family Chalcididae) *Pteromalus puparum* parasitizes the chrysalis when the cuticle is still soft.[7,14] We lack sufficient data to be able to calculate the impact of these parasitoids but it is likely that attacks by both Taquinidae and Pteromalidae species cause great mortality in this species of butterfly.

Insectivorous birds are most likely amongst the commonest predators whose attacks explain the sudden disappearance of nests of gregarious larvae.[7] In the final two stages, the larvae have very obvious spines that protect them – despite their conspicuous behaviour – from attack by visual predators (Photo c).[15] Nevertheless, the spines on the earliest stages of the larvae are softer and act as no protection against birds, which justifies their more retiring behaviour. Indeed, it has been shown that at dusk groups of larvae move onto the underside of the leaves, where they remain hidden until the following day, thereby reducing the chances of being detected by visual predators.[7]

The prepupal and pupal stages also suffer from great mortality rates due to attacks by ants, possibly by small mammals, or by the parasitoid *Pteromalus puparum*.[7]

Finally, overwintering adults are preyed upon by small mammals including the Yellow-necked Mouse (*Apodemus flavicollis*) and Wood Mouse (*Apodemus sylvaticus*).[7] These two rodents have been identified as the main predators of hibernating Large Tortoiseshells in northern Europe[16] and there is no reason to think that the situation in Catalonia is any different.

Adult behaviour

The Large Tortoiseshell is often overlooked as adults are not gregarious and are closely tied to forested habitats. Most observations take place at the end of winter and beginning of spring when males are establishing and defending territories: territorial activity takes place above all at midday and at the beginning of the afternoon, for example, in forest clearings, along tracks, and around trees that produce sap that attract females. As occurs in all territorial Nymphalidae, interactions between males are obvious and easy to detect, whilst interactions between males and females – above all, mating – are very hard to spot.

Data on the trophic resources used by adults are relatively scarce.[7] In spring when there are few mature fruit, hibernating adults often feed on the male catkins of grey willow, on the sap exuded by trees such as evergreen and deciduous oaks and aspen, or on honeydew produced by aphids covering branches and leaves. Occasionally, adults visit the flowers of trees and shrubs such as almond (*Prunus amygdalus*), wild cherry, plum (*P. domestica*), blackthorn (*P. spinosa*) and even those of box (*Buxus sempervirens*) and tree heath (*Erica arborea*). The importance of tree sap in spring is reinforced by the fact that males have been repeatedly observed to establish territories on the trees they visit in an attempt to mate with the females that also come to feed.

During the brief time in which the adults of the fresh generation are active, Large Tortoiseshells rarely visit flowers. Records of nectaring include butterflies on bramble (*Rubus* sp.), elderberry (*Sambucus ebulus*) and, most frequently, large-leaved lime (*Tilia platyphyllos*). By contrast, in one particular part of the mountains of El Montseny, Large Tortoiseshells are regularly noted feeding on mature fruit, specifically on wild cherries. This preference for mature or rotten fruit is corroborated by the regularity with which adults are attracted to traps baited, for example, with semi-rotten bananas.[17] In the eastern Pyrenees adults have also been observed visiting the sap produced as a result of attacks by the weevil (family Curculionidae) *Larinus sturnus* on the flowerheads of the woolly thistle *Cirsium eriophorum*. Adults will also occasionally feed on carnivore excrements.

Finally, it is worth noting that adults are regularly observed on the ground taking humidity or salts from the soil or wet leaves. This behaviour is exhibited by both old hibernating individuals and freshly emerged butterflies about to enter into diapause. Both females and males have been reported as feeding in this way, which suggests that, apart from being simply a male-type behaviour designed to extract salts,[18] it also occurs as part of active searching for water.

Population trends

In 1994–2018, the Large Tortoiseshell populations in Catalonia underwent serious oscillations but with no significant positive or negative tendencies (fig. 3). Amongst Catalan butterflies, it is one of the 10% of species with most variable population numbers, as shown by the calculation of the coefficient of variation of its annual indices of relative abundance (0.868 compared to an average of 0.536 for a total of 107 species).

Its populations hit a high in the middle of the first decade of the twenty-first century, in stark contrast to the serious declines both before and after this period (e.g. in 1998–2000 and 2015–2017). These fluctuations are very similar to those observed in populations of Camberwell Beauty (the correlation between the data series of their populations is $r_p = 0.87$, $P < 0{,}001$), which suggests that the population dynamics of these two species are influenced by similar factors. However, without a more targeted study we can only speculate as to which environmental factors lie behind these synchronized fluctuations. The severe impact that natural enemies seem to have on the Large Tortoiseshell (and by implication the Camberwell Beauty as well) would seem to indicate that fluctuations in its populations are closely related to density-dependence responses.

The Large Tortoiseshell is regarded as stable in Europe, although population levels have been very low in parts of north-west Europe in recent years.[19] Even so, in this part of the continent this butterfly undertakes irruptions and, for instance, in the past two years observations have become frequent in both the Netherlands and England.[20]

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For references, see the original Catalan version.

Fig. 1. Relative abundance (expressed as the values of the annual index/100 m) of the Large Tortoiseshell at CBMS and BMSAnd stations (1994–2018).

Fig. 2. Phenology of the Large Tortoiseshell (a) at 88 lowland CBMS stations (Mediterranean environment, n = 308 individuals); (b) at 42 montane stations (Eurosiberian environment, n = 412 individuals); and (c) at 19 high-mountain stations (alpine and subalpine environments, n = 271 individuals). Data gathered in 1994–2018 in Catalonia and Andorra.

Fig. 3. Population fluctuations in the Large Tortoiseshell in the CBMS and BMSAnd network in 1994–2018. Its trend, calculated with the TRIM program, is stable.

Photo. The Large Tortoiseshell is one of the most spectacular butterflies in our fauna. The fresh individuals of the new annual generation (such as the one in the picture), which appear mostly in May-June, are brightly coloured, highly contrasting with the dull-coloured butterflies coming out of the hibernation (photo: J. Jubany).

Plate. (a) A typical egg-cluster laid around the end of a thin branch of nettle-tree; (b) first instar larvae clustered on top of an elm leaf, close to the old egg-batch; (c) fifth and last instar larva with highly developed defensive spines; (d) two prepupae and one pupa, in a rocky wall; (e) A newly emerged Scelionidae from a parasitized egg; (f) nest boxes for edible dormouse (*Glis glis*) are regularly used by Large Tortoiseshell as hibernation sites; (g) an adult coming out from hibernation, basking on a tree trunk in a winter sunny day; (h) a dead pupa parasitized by the tachinid *Sturmia bella* (photographs: a-g, J. Jubany; h, J.R. Salas).

Identification

How to separate the species of the genus *Argynnis* (2)

The other three Catalan *Argynnis* species – Dark-green *A. aglaja*, High-brown *A. adippe* and Niobe *A. niobe* Fritillaries – form a very homogenous group. The first two are the commonest and most widely spread, but all three can be found together at some sites and their separation can be problematical, above all between the latter two.

All three are typically found in upland grassland areas, but they will also fly in open scrubby and shrub-dominated habitats.[1,2] Their altitudinal optimum is fairly similar, 1,000–1,800 m a.s.l., but they are all found outside these limits: *A. aglaja* reaches the greatest altitudes and is found in subalpine and alpine pastures, whilst *A. adippe* flies at lower levels and is even found in open spaces in Mediterranean areas. All three fly over much of the Pyrenees and pre-Pyrenees (other than the eastern-most areas). In addition, both *A. aglaja* and *A. adippe* fly in the mountains of the Serralada Transversal, El Montseny, the Prelittoral ranges and Els Ports, as well as the uplands of the county of La Segarra.[2] *A. niobe*, on the other hand, is less frequent and to the south of the Pyrenees is only found in the mountains of El Montsant and Prades.[2] In the CBMS network, *A. aglaja* and *A. adippe* appear in almost a third of the stations, but *A. niobe* in only 4%. All three are univoltine, although the adults of both *A. aglaja* and *A. adippe* can be on the wing from June through to September, with a peak in July. Where they coincide, *A. niobe* tends to be the earliest to fly. All lay their eggs one-by-one on leaves or twigs close to the violets that will act as the food plant of their larvae. They overwinter as formed larvae in the egg or as a first instar larva. Data from the CBMS counts suggest that Catalan populations of *A. aglaja* and *A. adippe* are stable; tendencies in the Catalan populations of *A. niobe*, on the other hand, are still poorly known.

Jordi Dantart

For references, see the original Catalan version.

Drawings

DARK-GREEN FRITILLARY
Upperside: orange-brown, brighter in male than female, with black markings.
Underside: fore-wing orange, with yellowish wing apex with black marks; hind-wing greenish with silvery spots and a yellowish submarginal band.
Marked with line
three series of androchonial scales on Cu1, Cu2 i 1A
more rounded wing
green background colour with silvery spots
submarginal band without spots

HIGH-BROWN FRITILLARY
Upperside: orange-brown, paler in female, with black markings.
Underside: fore-wing orange, with yellowish apex with black markings; hind-wing with orange background colour with a variable diffusion of green scales, silvery spots (sometimes absent), and a series of red spots.
Marked with line
two series of thick androchonial scales on Cu1 i Cu2
more pointed wing
series of large red-brown spots with silvery pupil

NIOBE FRITILLARY
Upperside: orange-brown with black markings; female with diffusion of grey scales.
Underside: fore-wing orange, with yellowish apex with black markings; hind-wing with creamy orange background, silvery spots (sometimes absent), and a series of red spots.
Marked with line
two series of thin androchonial scales on Cu1 i Cu2
more pointed wing
series of small large red-brown spots with silvery pupil
black edging to silvery spots
white spot, generally with black pupil

These three fritillaries can be separated by the underside of their hind-wings. The Dark-green is green with silvery spots and a yellowish submarginal band with no red-brown spots. The other two are more difficult to separate, in part because they are so variable. The High-brown is bigger; its hind-wind underside is yellow-orange in colour, with a greater or lesser extension of green scales (all green in f. *chlorodippe*), with silvery spots or otherwise (f. *cleodoxa*), and a series of postdiscal-submarginal red-brown spots, with or without silvery pupils. The Niobe is smaller, its underside is yellow-orange but has fewer green scales, silvery spots or spots with the same colour as the background colour (f. *eris*). As well, there is a postdiscal-submarginal series of red-brown spots, with or without pupils, and a normally white spot with a black pupil at the base of the cell.

Identification

How to separate the species of the genus *Limenitis*

In Catalonia fly two species belonging to the genus *Limenitis*, Southern White Admiral, *L. reducta*, and White Admiral, *Limenitis camilla*. Both are essentially forest species, although the Southern White Admiral also appears in a variety of open habitats. They are easy to separate when resting; nevertheless, in flight as they glide along forest edges identification is somewhat less simple.

The Southern White Admiral is widespread in Catalonia, being absent only from parts of the Central Depression, the Ebro Delta and alpine habitats in the high Pyrenees.[1] On the other hand, the White Admiral is restricted to humid woodland in the northern half of the country, being especially common in the mountains of the Serralada Transversal, Les Guilleries and El Montseny. Its southern-most limit is the Serra de Collserola near Barcelona.[1] Both species are absent from the Balearic Islands.[2] The altitudinal range of these two species largely coincides, with optimum altitudes in the range 400–800 m a.s.l. They rarely fly above 1,600 m a.s.l.; whilst the Southern White Admiral is not rare at sea level, the White Admiral is only occasionally found below 300 m a.s.l. Both are typical species of humid gullies, thickets and woodland clearings and edges, although the Southern White Admiral is also common in maquis shrubland and garrigue if its food plants, various species of honeysuckles, are present. The males of both species are territorial and perch on branches in patches of sun to wait for females to arrive. Both males and females regularly visit flowers to nectar, above all brambles in the case of the White Admiral. The two species are well represented in the CBMS network: for the Southern White Admiral data has been recorded for almost 120 itineraries, whilst for its congener more than 50 CBMS stations have provided data. The Southern White Admiral is trivoltine, with generations on the wing between May and September,[3] while the White Admiral is bivoltine with generations flying between April and October. Eggs are laid singly on various species of honeysuckle (above all, Mediterranean honeysuckle *Lonicera implexa* and Etruscan honeysuckle *L. etrusca* in the Southern White Admiral, and Atlantic honeysuckle *L. periclymenum* in the White Admiral).[1-3]

Constantí Stefanescu

For references, see the original Catalan version.

Drawings

SOUTHERN WHITE ADMIRAL
Upperside: dark with blue iridescence.
Underside: combination of red and white markings, and black spots on a grey background.
Marked with line
blue iridescence
obvious white discal patch
a single line of black submarginal spots

WHITE ADMIRAL
Upperside: Very dark with matt brown colouration.
Underside: combination of red and white markings, and black spots on a grey background.
Marked with line
no blue iridescence; brown
small white discal spot is hard to see
two lines of black submarginal spots

These two 'white admirals' are similar in size, colouration (dark, almost black, with a broad white band crossing both wings) and behaviour. The main difference is the blue iridescence on the upperside of the Southern White Admiral since its congener is characterized by a dull matt brown background colour. The Southern also has a white discal mark on its fore-wing that is all but absent in its near relative. The patterning on the underside in both species is more complex, with a red-brown and dark grey background colour, white markings and black spots. However, whilst the Southern White Admiral has a single submarginal line of black spots, in the White Admiral there is a double series of spots. There is no sexual dimorphism in either species.

Ajuntament Granollers

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