CBMS
Catalan Butterfly Monitoring Scheme

cynthia

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Cover

Detail of the underside of the forewing of the Painted Lady, *Vanessa cardui* (photo: Albert Miquel)

A male of the Marbled Skipper, *Carcharodus lavatherae* (photo: Jordi Jubany)

Editorial

Looking back three decades

On 4 March 1988 the first butterfly counts were performed in Catalonia along two transects, El Cortalet and La Rubina, in the Aiguamolls de l'Empordà Natural Park. The first butterflies counted were two Speckled Woods on section 4 at El Cortalet; after 36 years this butterfly walk is still active and the male Speckled Woods along section 4 still defend their territories from the beginning of March onwards.

In 1994, 10 more transects were added to the one walked at El Cortalet as part of an adventurous project that we know today as the Catalan Butterfly Monitoring Scheme (CBMS). Without a group of enthusiastic volunteers (Llorenç Abós, Jordi Artola, Agnès Batlle, Mike Lockwood, Marta Miralles, Segimon Rovira and Mentxu Tossas), some with backing from the management teams of a number of protected areas (El Montseny, El Montnegre, La Garrotxa Volcanic Zone Natural and Collserola Natural Parks, and the Delta del Llobregat Natural Reserves), the project probably would not have got off the ground. Thirty years later, the CBMS has become one of the most important faunal monitoring schemes anywhere in the Mediterranean Basin, and now embraces over 240 transects scattered throughout Catalonia, Andorra and the Balearic Islands. It still depends to a large extent on volunteers who, week in, week out, rigorously and eagerly, count the butterflies that appear along their transects.

Back at El Cortalet, the outlook over the past 30 years regarding the butterflies that fly there has changed notably. The most obvious difference is the decline in the number of species. In the first years of the counts we counted almost 40 species a year, but now we rarely exceed 30. This fall is largely due to the extinction of the Gatekeeper and the Southern Marbled Skipper, as well as the loss of several rare species that once frequented the area. The data from the CBMS network shows that losses of this type are a phenomenon that is being repeated throughout Catalonia. We also know that this loss of species-richness is affecting above all habitat specialists leading to what is known as 'faunal homogenisation'.

Nevertheless, the abundance of butterflies at El Cortalet has in fact increased over the years due to the fact that three sections of the butterfly walk have been transformed and, instead of passing through fields of maize and sunflowers (of no interest to butterflies), they now run through flower-rich hay meadows. These meadows have been colonised over the years by a series of species, including the Silver-studded Blue, which is now the commonest species on this butterfly walk. This shows that butterflies will respond positively to appropriate management and provides hope that we can revert trends in our butterfly populations that are otherwise largely negative. Now it is time to act if we are to offset negative impacts such as climate change. The CBMS is an excellent tool for documenting changes in butterfly populations and can also steer us in the right direction when looking to improve the way in which we manage our country. Let's not waste the time and effort put in by so many people!

The CBMS and BMSAnd network

Situation of the Butterfly Monitoring Scheme in Catalonia, Andorra and the Balearic Islands in the years 2021 and 2022

During the twenty-eighth and twenty-ninth seasons there were, respectively, 141 and 160 active CBMS stations. In all, 41 new stations were incorporated, including a large number in the Balearic Islands and in a number of previously poorly prospected areas of Catalonia. During these two seasons, 358,925 butterflies belonging to 181 species were recorded.

The growth in the CBMS network continued in 2021 and 2002 and reached well over 150 active stations in 2022 (Figs. 1 & 2). The rise in the number of stations was especially notable in 2021, with 25 new butterfly walks representing an increase of 21% compared to the previous year. In 2022 19 new stations were added. Table 1 provides a summary of these incorporations.

These new stations include a range of important environments and greatly increase the representativeness of the CBMS network. Firstly, however, it is worth noting the substantial improvement in the coverage in the Balearic Islands, with nine new stations on Mallorca (5), Menorca (2), Eivissa (1) and even Formentera (1). As of 2022, the CBMS network has 24 stations on the Balearic Islands (12 on Mallorca, 9 on Menorca, 2 on Eivissa and 1 on Formentera).

This monitoring of these islands is interesting since, despite recording data for only a limited number of species, it allows us to explore the particularities of island ecosystems. In the first place, these systems provide information on some of the migrant species that colonise annually from North Africa. These data help identify the conditions associated with the annual arrivals of the commonest migrants such as Painted Lady (*Vanessa cardui)*, Red Admiral (*V. atalanta*), Small (*Pieris rapae*), Large (*P. brassicae*) and Bath (*Pontia daplidice*) Whites, Clouded Yellow (*Colias crocea*), Long-tailed (*Lampides boeticus*) and Lang's Short-tailed (*Leptotes pirithous*) Blues. As well, these counts show that the walks on the Balearic Islands provide valuable information on rarer migrant species including the two *Danaus* species that are only infrequently detected on the mainland. Along with these

migrant species, these islands harbour a number of surprising sedentary species that it is important to monitor. Good examples include the Southern or Austaut's Blue (*Polyommatus celina*), absent from Catalonia; Cardinal (*Argynnis pandora*), with a population on Eivissa that is relatively abundant on the Can Toni d'en Jaume Negre itinerary; Wood White (*Leptidea sinapis*), a rare species on Menorca, Mallorca and Eivissa, and present in six walks on these islands; the Satyrinae Meadow Brown (*Maniola jurtina*), Small Heath (*Coenonympha pamphilus*), Southern Gatekeeper (*Pyronia cecilia*) and Striped Grayling (*Hipparchia fidia*), species that are abundant on all three main islands (*M. jurtina*), on Mallorca and Menorca (*C. pamphilus* and *P. cecilia*) or just on Mallorca (*H. fidia*); and, finally, Green Hairstreak (*Callophrys rubi*), well established on Mallorca and Menorca. In recent years the butterfly monitoring project was the subject of a doctoral thesis written by Pau Colom in which he explores various aspects of the island ecology of these butterflies.

The growth of the CBMS network has also led to better coverage in the Pyrenees (Fig. 1), where historically it has always been difficult to establish stations. In the past two years eight new itineraries have been set up along an altitudinal gradient ranging from 625 m a.s.l. (Trespui, near Gerri de la Sal) to 1,934 m a.s.l. (Bordes d'Envalira, in Andorra). Some of these new walks sample extremely diverse environments, as is the case of the walk at Bordes de Burg (1,719 m) in which in just two years 102 species have been counted, some of which are very rare or even absent from the rest of the network. Some of these Pyrenean itineraries provide strategically key information about certain species under threat in Catalonia and/or the Iberian Peninsula and so represent an important step forward for the network. At Bordes de Burg, for example, the walk monitors the population of Bog Fritillary (*Boloria eunomia*), a species that is well represented in the Andorran BMS but which is extremely localised in Catalonia. At Bordes d'Envalira in Andorra the Violet Copper (*Lycaena helle*), undoubtedly the rarest and most localised butterfly in the whole of the Iberian Peninsula, flies, a fact that confers added value to this itinerary. At the Trencapinyes station in Serra del Cadí there is a good population of the Spanish Argus (*Aricia morronensis)*, which previously was only present in one itinerary in Andorra. Finally, at Alàs in the Lleida pre-Pyrenees the Spring Ringlet (*Erebia epistygne*), another of the rarest butterflies in Catalonia, has appeared. Aside from these rarities, the new Pyrenean walks have increased our knowledge of vulnerable species such as Large (*Phengaris arion*) and Alcon (*P. alcon*) Blues, Geranium Argus (*Eumedonia eumedon*), Purple-edged Copper (*Lycaena hippothoe*) and Great Sooty Satyr (*Satyrus ferula*).

Inland, more arid and continental areas of Catalonia are home to other types of environments that are becoming increasingly well represented on the CBMS network. During the past two season, eight new walks have been incorporated in some of the hitherto least well sampled counties such as La Terra Alta, El Priorat, El Segrià, La Segarra and La Noguera. In general, these itineraries in these counties host butterfly communities that are less diverse but do still harbour characteristic and interesting species. For example, the two new walks in El Priorat, Siurana and Les Salenques, both have populations of the scare Spanish Marbled White (*Melanargia ines*), an endangered species that is rare and very local in Catalonia. Notwithstanding this, perhaps the most interesting aspect of these walks is that they provide data on the evolution of many species well distributed across Catalonia that are being subject to more extreme climatic conditions. It is on these walks that the effects of climate change will almost certainly be most noticeable in the coming years, as persistent drought and ever more extreme heatwaves become more frequent. It will be instructive to see how these climatic changes affect the viability of the butterfly species and communities that inhabit these areas.

The other stations that got underway in 2021 and 2022 are found throughout much of Catalonia, from the coastal and pre-coastal strips in the provinces of Girona and Barcelona (Sant Quirze de Colera, Torroella de Fluvià, Closa del Ter Vell, Pla de Munt, La Rierada, Sant Pere Molanta, Begues, Les Llobateres and Martorell Nou) and further inland, some of which possess notable butterfly communities (La Tossa de Montbui, Puigsagordi, Castellterçol, Dolmen del Cuspinar, Vall del Bac and Baió).

Annual series and species represented

After 29 years of counts, the CBMS has accumulated a massive number of annual series from the many itineraries that are walked (Fig. 3). Of the 223 stations that have at some point been active, 85 (38.1%) have annual series for 10 years or more, which provides valuable data for understanding tendencies in the mid- and long terms that can be linked to the phenomena of climate and landscape change. In both cases, numerous itineraries exist that have undergone significant changes that have had serious impacts on the butterfly fauna.

This widespread coverage now also provides information on the vast majority of Catalan butterflies, To date, data pertaining to 190 of the 204 (93%) species recorded in Catalonia, Andorra and the Balearic Islands has been gathered, even if for some of the rarer species the quantity of data is very modest (Table 2). The number of species detected annually has also increased regularly since the beginning of the project, above all in 2022 when almost 180 species were recorded (Fig. 4).

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Fig. 1. Geographical situation of all the stations that have ever participated in the CBMS (1994–2022) network, with their official number and name. Also shown are the three climatic regions used in the analysis of regional trends in Catalonia.

Fig. 2. Evolution in 1994–2022 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. New stations incorporated into the CBMS network during the 2021 and 2022 seasons.

Table 2. All the butterfly species recorded from any of the CBMS stations in the past 10 years 2013-2022. Also indicated is the number of stations in which each species was recorded each year. Taxonomic order follows the criteria suggested by Fauna Europaea (www.fauna-eu.org).

Photo 1. The new Tossa de Montbui station is located in the Serra de Miralles-Queralt, in the Anoia county. At the culminating point of the itinerary, with great views of the Montserrat mountain and the surrounding plains, the typical hill-topping species congregate in good numbers (photo: Quim Muñoz).

Photo 2. The Bordes de Burg itinerary, in the Farrera valley, exemplifies an exceptionally diverse subalpine environment for butterflies, with many species of great conservation interest (photo: Josep Piqué).

Photo 3. On the route of Les Bordes d'Envalira there is a population of the Violet Copper (*Lycaena helle*), the rarest butterfly in the entire Iberian peninsula (photo: Martí Franch).

Twenty-eighth and twenty-ninth years of the CBMS

Balance of the 2021 and 2022 seasons

The past two seasons were the two worst since the CBMS project began and fully confirm the negative tendency in Catalan butterfly populations noted in recent years. The year 2021 was the worst and 2022 the second worst of the 29 years for which data exist. Such poor results can be directly linked to the ravages of climate change in our region: both 2021 and 2022 were exceptionally hot and dry and have brought about a severe drought that today is still affecting the whole country.

Weather and counts

The year 2021 was moderately hot, with normal values in the north-west corner and southern third of the country, albeit with a number of notable seasonal anomalies (see www.meteocat.com). Season-by-season, winter was warm, above all February, which accentuated the effect of the abnormally warm months of November and December 2020. Although there were a number of marked cold snaps in the Pyrenees, along a broad swathe of coastal and pre-coastal areas no frost days at all were recorded in the winter. Summer was hot, above all in parts of the county of L'Alt Empordà and in central Catalonia, and included a heatwave (temperatures up to 43ºC) on 1–11 August. December was also characterised by high temperatures throughout, above all in upland areas. Nevertheless, the most remarkable feature of the year's weather was the onset of a drought, which was exceptionally severe along parts of the central coastline and in the northern half of the country. A good example is the rainfall recorded at the Fabra Observatory (Serra de Collserola, Barcelona), the lowest ever since records began 108 years ago. Conversely, in the Ebro valley and in parts of the western Pyrenees rainfall was above average and serious flooding occurred in September and November. Seasonally, both the first few months of the year and, above all, spring, summer and December were very dry. This grave drought continues today and has progressively worsened.

The year 2022 was even more extreme than the previous one and can be classified as one of the hottest and driest in Catalonia since at least 1950. Overall, it was 2.7ºC hotter than the average year, the first time ever that the average had been exceeded by over 2ºC. Worse still, this anomaly is almost double the anomaly being recorded throughout the world, which is evidence that global warming is taking place at an exceptionally fast pace in our region. The overall rainfall anomaly in 2022 was -30.4%, which situates 2022 as the driest year since 1950.

In 2021 and 2022 6.8 and 7.3 counts were lost, respectively, on average per station (including the low-effort stations where counts are only performed every two weeks) (Fig. 1a and b). The pattern of weeks lost was similar in both years, with most counts lost during the first third of the season, fewest in the second third, and more again lost during the final third (Fig. 1c and d). Of note is the large number of counts lost in March 2022 (Fig. 2d): 81% counts could not be performed during this week due to a persistent anomaly in the weather that affected most of the country.

Changes in abundance: notable species

The years 2021 and 2022 were the two worst years in the 29 years of the CBMS project, as can be seen from a comparative analysis of the annual indices of the 66 commonest species in the network of stations (Fig. 3). The results from these two years are startling and illustrate the exceptionally worrying state of our butterfly populations. In all, 28 of these 66 species (42%) had their worst-ever CBMS year in either 2021 or 2022; furthermore, in these two years no species recorded either its best- or second-best-ever totals. The year 2021 was exceptionally poor and nine species recorded their worst-ever totals and nine others their second worst-ever figures. The following year was also poor, and six species registered historically low totals and five their second worst-ever years.

These declines in numbers were very general and affected species with a variety of phenologies belonging to practically all families. Affected groups and species included the univoltine Satyrinae (that in many localities represent an important part of the total number of butterflies counted each year) such as Spanish and Southern Gatekeepers *Pyronia bathseba* and *P. cecilia*), Dusky Heath (*Coenonympha dorus*) and Striped and Tree Graylings (*Hipparchia fidia* i *H. statilinus*). Other affected species included some of the common polyvoltine Satyrinae such as Wall Brown (*Lasiommata megera*) and Small Heath (*Coenonympha pamphilus*), univoltine Lycaenidae such as Green Hairstreak (*Callophrys rubi*) and False Ilex Hairstreak (*Satyrium esculi*), and other polyvoltine and more generalist species such as Common Blue (*Polyommatus icarus*), Small Copper (*Lycaena phlaeas*) and Brown Argus (*Aricia cramera*). Two well-known Papilionidae Common Swallowtail (*Papilio machaon*) and Scarce Swallowtail (*Iphiclides feisthamelii*) were also affected, as were some of the best-known Nymphalinae such as Camberwell Beauty (*Nymphalis antiopa*), Large Tortoiseshell (*Nymphalis polychloros*), Two-tailed Pasha (*Charaxes jasius*), Southern White Admiral (*Limenitis reducta*), Queen-of-Spain Fritillary (*Issoria lathonia*) and Marsh Fritillary (*Euphydryas aurinia*). Finally, common Pieridae such as Large White (*Pieris brassicae*), Bath White (*Pontia daplidice*) and Wood White (*Leptidea sinapis*) were likewise not exempt from the generalised decline during these two years.

A number of other rare species not used in the calculations shown in Figure 3 also suffered severe declines in these two seasons. Paradigmatic cases include the Map (*Araschnia levana*) and Ringlet (*Aphantopus hyperantus*), two species found in humid upland areas that are probably suffering the effects of the drought, and others such as Dingy Skipper (*Erynnis tages*), Silver-spotted Skipper (*Hesperia comma*) and Ripart's Anomalous Blue (*Polyommatus ripartii*) found in drier areas whose populations have dropped dangerously during these past two years.

The numbers for the 20 commonest species in the CBMS network in the years 2021 and 2022 are shown in Table 1. The most abundant species that did not succumb to the overall decline were Small White (*Pieris rapae*), Meadow Brown (*Maniola jurtina*) and Speckled Wood (*Pararge aegeria*), whose populations remained stable throughout Catalonia. Somewhat surprisingly, despite a moderate decline, the Iberian Marbled White (*Melanargia lachesis*) was still one of the more dominant species. This is possibly due to the incorporation of a number of new counts in upland areas (where this species' populations are relatively stable) that are now playing a growing role in the general annual index of this species. Other species that have declined in our butterfly communities – despite still being common and even dominant in some areas – include False Ilex Hairstreak, Spanish Gatekeeper and Small Heath, all of which were commoner a couple of decades ago than today. The remaining species in Table 1 have more or less maintained their positions on a historical time scale. It is worth highlighting the Southern or Austart's Blue (*Polyommatus celina*), the sister species in the Balearic Islands to the familiar Common Blue on the mainland. This species is one of the commonest on many of the CBMS stations on these islands and, due to the increase in number of transects walked on the Balearic Islands, it has been incorporated as one of the dominant species.

Neither 2021 nor 2022 were particularly important in a negative or positive sense for migratory species other than the two *Danaus* species, above all the Monarch *D. plexippus*. Surprisingly, the first Monarchs were spotted in the Ebro delta in July and early August, and then more regularly in September to November. However, the arrival of Monarchs was one of the highlights of the season. The first two were noted in the north and east of Mallorca at the end of July and in August, while from September onwards – and above all in October – observations were made in numerous places, with spectacular concentrations in the south of Mallorca and breeding confirmed on the milkweed *Gomphocarpus fruticosus* at least in two localities. Monarchs were also observed on Menorca, Eivissa and Formentera in October, and was recorded from three CBMS stations in Mallorca, including Binifaldó where a breeding colony was established. This arrival of Monarchs on the Balearic Islands was unprecedented, as was the establishment of two breeding colonies that survived the winter 2022–2023, meaning that in the spring and summer of 2023 the species was still present on Mallorca.

The migration by the Plain Tiger *Danaus chrysippus* took place later than usual and for this reason is not well reflected in the CBMS data. In both the Ebro delta and the Aiguamolls de l'Empordà the first regular observations did not occur until the end of September, with significant numbers noted in October and at the beginning of November. This species also colonised the Balearic Islands at the end of summer and breeding colonies were established in the same place as the Monarch. However, unlike its congener, the Plain Tiger was unable to survive the winter of 2022–2023.

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

[2] Schmucki, R., Harrower, C.A. & Dennis E.B., 2021. rims: Computing generalised abundance indices for butterfly monitoring count data. R package version 1.1.0. https://github.com/RetoSchmucki/rbms

[3] Rebassa, M., Tysoe, M. & Colom, P., 2023. Establiment de la papallona monarca (*Danaus plexippus*) a les Illes Balears. *Boll. Soc. Hist. Nat. Balears*.

Fig. 1. Coverage of the counts at the different CBMS stations in (a) 2021 and (b) 2022. The 'low-effort' stations, which due to their fortnightly cycle (or monthly in initial trial years) lose up to half 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 (c) 2021 and (d) 2022.

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 and worst (in descending order) 2021, 2022 and 2016. Calculations were carried out using the methodology described by Greatorex-Davies & Roy (2001)[1] using species' annual indices calculated with the rBMS program[2].

Table 1. Sum of the annual indices and ranking of the abundance of the 20 commonest species in the CBMS network in the 2021 and 2022 seasons.

Table 2. Evolution of the overall annual indices for 123 butterflies recorded in the CBMS network calculated using the rBMS program[2]. Also indicated are the number of stations that provided data for each species, the initial year of the data series used to calculate trends, the annual rates of change calculated for 2021 and 2022 and for the whole period, and the population trends detected by the program.

Fhoto 1. The Monarch (*Danaus plexippus*) provided one of the entomological surprises of the year 2022. From July onwards, Monarchs began to be seen both in the Ebro delta and on Mallorca, but it was not until the end of summer and the beginning of autumn that numbers began to multiply and reach unheard-of proportions on the Balearic Islands. In north-west Mallorca breeding colonies were established on the milkweed *Gomphocarpus fruticosus*, a non-native species. Surprisingly, two of these nuclei survived winter 2022–2023 and were still present during the 2023 counting season (photo: Maties Rebassa).

Drawing 1. Drawing 1. After two years of severe drought, the Camberwell Beauty (*Nymphalis antiopa*), a species closely linked to humid forest environments, has suffered a very remarkable population collapse in 2022 which has taken it to the lowest levels since the beginning of the project (drawing: Martí Franch).

Habitat management and conservation

The abandoning and traditional management of pastures: effects on plants and butterflies

Pyrenean grassland communities hold a wide range of plant and butterfly species that are affected by grazing and if pastures are abandoned. In an experiment performed in the county of El Ripollès traditional grazing in the form of transhumance was seen to favour an increase in butterfly richness and abundance in summer, whilst the exclusion of grazers led to pastures with less plant diversity. An analysis carried out in the county of El Pallars Sobirà showed that, along a gradient of vegetation encroachment, butterfly communities are richest and most abundant in pastures wherever grazing is low intensity but that semi-encroached areas are richest if grazing is more intense.

Introduction

Pyrenean grasslands harbour exceptionally diverse communities of flora and fauna that have been modelled over many centuries by human activities such as grazing. Subalpine pastures in the Pyrenees are rapidly being swallowed up by trees and shrubs and are losing their biodiversity in many areas due above all to the abandoning of traditional extensive grazing regimes.[1-2] This closing up of habitats has been identified in Catalonia as a threat to biodiversity and associated butterfly communities.[3-4] This issue is common to many European countries and, along with agricultural intensification, is regarded as the cause behind the steep decline in the grassland butterfly indicator over the past three decades.[5] Paradoxically, in some areas there is a trend towards overgrazing as, although the number of herds has fallen, herders now tend to buy and group cattle in ever-larger herds. This question has recently motivated the development of studies aimed at diagnosing and applying protocols that can evaluate the ecological state of grasslands based on the number of heads of cattle, which in turn will help favour good practices and promote the recovery of open spaces.[6] The results of these evaluations agree that one of the strategic objectives that will permit the maintenance of Pyrenean pastures and favour their biodiversity is the promotion of extensive grazing.[7-8]

The ecological state of grasslands is a dynamic process that varies in terms of the type of management practices (e.g. the intensity and distribution of grazing),[9-10] which can have positive or negative effects – which are often contradictory – depending on the trophic level or group under study.[11-12] Butterflies form close relationships with the plant species that their larvae feed upon and respond rapidly to changes in grazing management.[13-15]

To determine how grazing and the abandoning of pastures affects the biodiversity in the Pyrenees, the CBMS team has recently set up a number of projects with different focuses that aim to study these plant and butterfly communities. One such study has been conducted in a valley in the Alt Ter Valley (El Ripollès), where a series of plots have been set up that exclude cows to quantify the effects of grazing both inter- and interannually over a marked altitudinal gradient. Another study conducted in the Valls d'Isil (El Pallars Sobirà) has analysed how the grazing pressure (including a representative gradient of progressive encroachment from pasture to scrub) affects plant and butterfly communities.

An exclusion experiment: Alt Ter

In Alt Ter an experiment has been performed in a valley that is grazed using traditional methods by around 220 cows. The majority winter in the coastal county of L'Alt Empordà and then move to mid-altitudes in this valley for a month in June–July. Subsequently, they are moved up to high altitudes until October, when they return to the lower pastures for a few weeks before heading to the lowlands as the weather worsens in December. In the valley 20 60x60-m plots were established at altitudes between 1,300 and 2,000 m in which the plant and butterfly communities were studied. After a control year (2018), cows were excluded by fences from grazing in 10 of the plots, a situation that has been maintained ever since.

In each plot butterflies are counted along a 5-m wide, 500-m long transect using the BMS methodology. The transects form a zigzag in the plot, which were established in homogenous habitats. Each transect is walked three times a year – first half of June, middle of July and first half of August – to coincide with most of the flight periods of the butterfly species that inhabit these grasslands. As well, botanical inventories are carried out following the same transect as the butterfly counts but only during the peak flowering period in July.

Results and discussion

Clear altitudinal gradients were observed in the patterns of plant and butterfly richness, with greatest richness in the plots in the valley bottom at medium altitudes of 1,300–1,500 m (Fig. 1). Certain biotic and abiotic factors are seen to affect richness patterns: one particularly well-marked pattern is the positive correlation between plant and butterfly richness, a result of the feeding specialisation of many butterflies and the trophic cascade effect operating between food plants and butterfly's use of different nectar sources (Fig.1)

Plant richness falls in closed plots as these non-grazed plots become dominated by highly competitive grasses that exclude other plants if the disturbance factors (e.g. grazing) that boost plant diversity disappear.

No effects of the exclusion treatments are apparent on the butterfly communities if the whole altitudinal gradient is contemplated. However, if a narrower altitudinal range is analysed, the results show that in grazed plots the richness and abundance of butterflies increased in July and August, an effect that did not occur in plots that were not grazed (Fig. 2). This finding seems to be related to a change in habitat selection by butterflies due to paral-

lel differences in trophic availability in the two types of plots: nectar availability drops in August in non-grazed plots dominated by grasses, which make them less attractive to butterflies. On the other hand, it seems that grazed plots have comparatively fewer flowers than closed non-grazed plots at the beginning of summer due to the impact of the grazing: however, as the herds move up to the highest pastures in the summer, the grazed plots are able to recover and become more attractive to butterflies in August. This result confirms the positive effects for butterflies of the traditional system of moving of cattle up to higher pastures in July–September.[16-17] Thus, the traditional management systems should be favoured to allow for the flowering and setting of seed, thereby ensuring the sustainable impact of medium-intensity grazing that will benefit the biodiversity.[11]

For more information, see: Ubach, A., Guardiola, M., Oliver, X., Lockwood, M., Artola, J. & Stefanescu, C. 2023. Spatial gradients and grazing effects of a transhumant herd on plants and insect herbivores in Pyrenean subalpine grasslands. *J. Insect Conserv*.

A diagnosis of Valls d'Isil

The Alt Pirineu Natural Park is a hotspot for butterfly diversity and in municipalities such as Alt Àneu 70% of the whole Catalan butterfly fauna has been recorded. In Les Valls d'Isil, situated around the headwaters of the river Noguera Pallaresa, the pastures are an essential part of the landscape. Two valleys were selected in which to perform the diagnosis. El Barranc de Vinyals, at the junction of the passes of Salau and Aulà, is currently heavily pastured by herds of sheep, cows and horses, while El Barranc de Clavera is grazed by a herd of just 50 sheep and a few mares. Vinyals is thus regarded as an area of heavy grazing pressure (HGP), while Clavera is an area of light grazing pressure (LGP). In each valley, three repetitions were performed in three different types of plots representing different levels of disturbance or grazing: (a) heavily grazed plot, (b) semi-abandoned plot with light grazing and (c) non-grazed plot covered by scrub. All plots were situated at around 1,650–1,900 m in areas of subalpine grassland.

As in the previous study, 500-m transects in a zig-zag pattern were walked in each plot, during which butterflies were counted along a 5-m wide strip. Each transect was repeated three times to coincide with most of the flight periods of the butterflies in the area. To study the flora, botanical inventories were performed in each of the plots. Along with plant and butterfly richness and abundance, the Community Specialisation Index (CSI) and preferences for closed or open habitats (TAOc) were studied.[4]

Results and discussion

Significant differences were found in the richness and abundance of butterflies between the two valleys and the degree of scrub encroachment (Fig. 3). Overall, the LGP valley (Barranc de Clavera) had greater species richness (61 species) than the HGP valley (Barranc de Vinyals) (53 species). In the sampling in the LGP plots 13 species were detected that did not appear in the HGP samples, of which five were ringlets belonging to the genus *Erebia* (Yellow-spotted *E. manto*, Autumn *E. neoridas*, Water *E. pronoe*, Bright-eyed *E. oeme* and de Prunner's *E. triaria* Ringlets), along with the Mountain Clouded Yellow (*Colias phicomone*). By contrast, there were five species detected in the HGP valley that did not appear in the LGR including Sooty Copper (*Lycaena tityrus*). In terms of abundance, 922 butterflies were counted in LGP and 410, less than half, in HGP. The encroachment gradient differed between the two valleys. In the LGP valley, richness and abundance were greatest in open grassland and lower in more closed areas; conversely, in the HGV the greatest abundances and richness were in semi-encroached areas, whilst the open grasslands and scrub had lower but similar values.

Despite just a single year of data, the results clearly show that in areas with less grazing pressure there are greater butterfly richness and abundances. In Barranc de Clavera (LGP), the grassland is grazed but the low intensity of the grazing ensures that these areas boast the greatest butterfly diversity and abundances. In Barranc de Vinyals (HGP), on the other hand, the least grazed areas that are becoming scrubbed over have the greatest butterfly richness. Cattle find these areas less accessible and so they are not overgrazed, which allows for a greater richness and variety of microhabitats and, in turn, greater richness of butterflies. It was in one of these areas that Large Blue (*Phengaris arion*) was detected, a threatened species that flies above all in semi-grazed habitats.

Botanically, both the species richness and diversity varied between the zones and there were higher average values in the three communities in HGP than in LGP (average richness: 36.3 species in HGP vs. 31.9 species in LGP; diversity H': 3.42 in HGP and 3.01 in LGP). Although the differences between treatments were not significant, the semi-closed plots had greater floral diversity, both in HGP and in LGP (Fig. 3) but with the highest values HGP. At Clavera, the open grassland was the most plant-rich area in terms of both richness and diversity, while at Vinyals both the semi-open grassland and the scrub were floristically richer and more diverse (Fig. 3). The scrub at Vinyals contained small clearings amongst the shrubs that were occupied by grassland plants; conversely, at Clavera the scrub is denser, more closed and has greater shrub cover, which ensures that its plant communities are more impoverished.

Finally, the habitat indicators were calculated for all the butterfly communities studied and show that for the Community Specialisation Index (CSI) the highest values were in the grassland and semi-closed plots at Clavera, which were significantly different from Vinyals (Fig. 4). However, no significant differences were found between the scrub communities in the two valleys. The communities with the most specialised butterflies were the semi-closed habitats in Clavera, although it must be born in mind that here 10 typically Pyrenean species were present for which no SSI or TAO indices were available. This is due to the poor cover in the CBMS network of subalpine habitats and the lack of information for a series of species that are specialists of this habitat. If these species had been included in the calculations, they would undoubtedly have increased the specialisation value of the grassland butterfly communities as these species fly almost exclusively in this type of grassland.

For more information, see: Ubach, A., Stefanescu, C., Ravera, F., Casas, C., Salvat, A. & Grau, O., 2022. Efectes de l'abandonament de la pastura sobre la biodiversitat de flora i papallones diürnes. General report. General. Museu de Ciències Naturals de Granollers & Parc Natural de l'Alt Pirineu

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Fig. 1. Main relationships observed between plants, butterflies and the altitudinal gradient in El Catllar valley. All relationships are significant. BT: Before the treatment; AT: After the treatment.

Fig. 2. Graphs showing the interaction between butterfly richness (a, b) and abundance (c, d) during sampling in July and August in 2019 (a, c) and 2020 (b, d). Red lines, grazed plots; blue lines, non-grazed plots. The numbers in the labels correspond to the average value of the boxes.

Fig. 3. Box diagrams showing the distribution of plant richness (a), butterfly richness (b), plant diversity (c) and butterfly abundance (d) along the gradient of land abandonment observed in the two valleys. BPR: Low grazing pressure; FPR: High grazing pressure.

Fig. 4. Box diagrams showing the distribution of the values of the butterfly habitat indicators based on their preferences in the CBMS network in a context of the gradient of land abandonment observed in Isil. Red boxes correspond to the valley with low grazing pressure (LGP) and the blue ones to the valley with high grazing pressure (HGP) (drawing: M. Franch).

Drawing 1. In pastures there is a close tie between Mazarine Blue (*Cyaniris semiargus*) and the thrift *Armeria alliacea*, on which females lay their eggs. Both species can withstand grazing pressure.

Photo 1. In the most heavily grazed areas butterflies usually use ruderal plants that cows reject, including this female Mountain Ringlet (*Erebia epiphron*) laying on a thistle (photo: A. Ubach).

The station

Castelltallat, a forested area in the centre of Catalonia severely affected by land abandonment and wildfires

Situated in the county of El Bages and bordering on the counties of L'Anoia and El Solsonès, the low mountains of Serra de Castelltallat peak at a height of 936 m a.s.l. Classified almost in its entirety as an Area of Natural Interest, one of the most characteristic features of this upland area is the depopulation it has suffered in recent decades. There are now practically no settlements, just a series of old farms, the majority of which are abandoned and/or lie ruined. The people who once worked these lands began leaving after the phylloxera crisis devastated the local vineyards and left behind a region that has since become densely forested. However, the large forest fires of the 1990s once again profoundly changed the physiognomy of this interesting upland site.

The itinerary

This butterfly walk traverses an area affected by the 1994 fire, which left some areas – including some of the main stands of black pine (*Pinus nigra*) – intact. It is centred on a farm, Mas Corbera, on the north face of the ridge at an altitude of 780 m a.s.l., and passes through a variety of environments dominated by stands of black pine, along with some holm and deciduous oaks. It also samples areas of cultivation where fodder crops are occasionally sown, as well as pastures where cows graze. Despite being abandoned when the counts began, some of this arable land has recently been cultivated again. The remaining sections cross or follow the edges of the fields and patches of scrub. There are nine sections in all, totalling 2,062 m, with a central loop and two lineal sections to the north and south adjoining the centre. The site was chosen because the person in charge had published a few years beforehand a study of the butterflies of the area.[1] However, in the meantime, the encroachment of the forest has become apparent and black pines are now progressively shading out the transient post-fire scrub. This is probably one of the main reasons why the populations of many butterflies in the area are on the wane. The grazed areas are small and grazing has little impact on the understorey. In the shadiest north-facing areas (section 4), there is a strong colony of primroses *Primula acaulis*, one of the very few known in Catalonia, which explains the presence of Duke of Burgundy (*Hamearis lucina*). As elsewhere in this area, there are a few examples of bladder senna (*Colutea* sp.) including a relatively dense stand near Section 9. As to be expected in this area, the vegetation of the scrub and understorey includes honeysuckles, blackthorn, box, *Dorycnium* sps., thyme, blue aphyllanthes and milkworts (*Astragalus* sp.).

The butterflies

In the study published in 2012 based on field data from the years 2000–2012, the commonest species in absolute terms coincide – with some changes in order – with the CBMS data: Wall Brown (*Lasiommata megera*), Marsh Fritillary (*Euphydryas aurinia*), Provence Chalk-hill Blue (*Polyommatus hispana*) and Wood White (*Leptidea sinapis*). Nevertheless, the following species in the overall ranking differ significantly and the next four commonest species in the CBMS data Small White (*Pieris rapae*), Common Blue (*Polyommatus icarus*), Clouded Yellow (*Colias crocea*) and Speckled Wood (*Parage aegeria*) do not figure amongst the 10 commonest species in the original 2012 study. It should be noted that the presence of Marsh Fritillary amongst the commonest species is due to a single spectacular year (2015) in which 914 individuals were counted. Since then, its numbers have crashed and only four were counted in 2023, surely indicating that, like elsewhere in the county of El Bages, it is doomed to disappear (e.g. Sallent, BMS 40). Other species that have declined steadily in recent years include Meleager's Blue (*Polyommatus daphnis*), Southern Gatekeeper (*Pyronia cecilia*), Spotted Fritillary (*Melitaea didyma*), High Brown Fritillary (*Argynnis adippe*) and, above all, Black-veined White (*Aporia crataegi*) and Western Marbled White (*Melanargia occitanica*). The latter two species have never appeared in the CBMS counts even though, for example, the former was the sixth commonest species in the pre-CBMS counts in 2012. Nevertheless, a total of 82 species have been recorded in the CBMS counts, a total that includes remarkable species such as *H. lucina* whose numbers, despite not being recorded every year, in the past two seasons have exceeded counts in previous years. There are sporadic records of Brown Hairstreak (*Thecla betulae*) and Niobe (*Argynnis niobe*), both new species for the area; the populations of Berger's Clouded Yellow (*Colias alfacariensis*) remain more or less stable but those of Dingy Skipper (*Erynnis tages*) and, above all, Ripart's Anomalous Blue (*Polyommatus ripartii*) are continuing to decline in the area. Finally, it is worth mentioning Iolas Blue (*Iolana debilitata*), a hard-to-detect species known from the area up to recently in the form of eggs, larvae and adults that has never actually appeared 'officially' in the CBMS counts.

The future

In general, butterfly populations in humid upland Mediterranean areas are undergoing declines in both diversity and abundance. In the case of Castelltallat, these declines have been very obvious and the 2023 season was in fact the poorest ever in both senses. A slow recovery back to normality over the following years is to be hoped for but, in light of the way the forests are slowly recovering and the open spaces – which the majority of species depend on – are closing up, this desire may remain unfulfilled. On a more positive note we believe that a few new species may yet appear in the CBMS counts given that both Catalan Furry Blue (*Polyommatus fulgens*) and False Grayling (*Arethusana arethusa*) were detected on occasions in the study pre-2012.

Josep Planes

Photo 1. Abandoned farms are mute witness to a past epoch when the landscape was much more affected by the imprint of human activity. Today, few cultivated open areas remain. (photo: J. Planes)

Fig. 1. Abundance (average annual indices 2017-2002) of the 15 commonest butterflies at the Castellatallat station.

Aerial photo. Route of the butterfly walk at Castelltallat, Bages.

The station

La Rierada, a stretch of riparian woodland in the Serra de Collserola that has undergone great change over the past century

Hidden away in the hills of Serra de Collserola lies the itinerary of La Rierada, which takes its name from a stream, Riera de Vallvidrera, the only semi-permanent water course in this area and home to one of the few patches of riparian woodland that remain. Collserola has become much more forested over the past century and also much drier, which has led to significant changes in its butterfly fauna that once contained species such as Western Marbled White and Small Tortoiseshell.

The walk

The itinerary at La Rierada (CBMS-192) has been active since 2021 and is located at 93 m a.s.l. in the north-west of the Serra de Collserola in the eponymous natural park (municipality of Molins de Rei). Of its nine sections (1620 m), five run alongside a stream, Riera de Vallvidrera or Las Rierada (which gives its name to this walk), while the remaining four follow a track through dry scrub and a Mediterranean forest with pines and holm oaks.

The climate of La Rierada is humid Mediterranean, with an average annual rainfall of 663 mm and an average annual temperature of 15ºC, which is reflected in the vegetation that lines the walk. At first, the itinerary is dominated by riparian woodland, thickets and ruderal vegetation, with a few cultivated fields and bee-hives. Typical plants include narrow-leaved ash (*Fraxinus angustifolia*), southern nettle-tree (*Celtis australis*), field elm (*Ulmus minor*), blackthorn (*Prunus spinosa*), hawthorn (*Crataegus monogyna*), redoul (*Coriaria myrtifolia*), blackberry (*Rubus ulmifolius*), Mediterranean honeysuckle (*Lonicera implexa*), honesty (*Lunaria annua*), garlic-mustard (*Alliaria petiolata*) and grasses. Some stretches have been invaded by tree of heaven (*Ailanthus* sp.) and giant reed (*Arundo donax*), although actions have been undertaken in recent years to eliminate the latter plant and have given rise to ruderal plant communities that are now much frequented by butterflies and other pollinators. Section 5 runs through a holm-oak wood with a few pines, Mediterranean buckthorn and ivy. Section 6 and 7 climb away from the stream and head into dry scrub surrounded by stands of Mediterranean forest dominated by holm oak and Aleppo pine. The final sections traverse scrub formations with rock-rose, ling, rosemary, marjoram, spurges and lentisc, in which most plants flower early in the year and are dry from May through to August, resulting in fewer butterflies than in the initial lower sections of the itinerary.

The butterflies

There are five other butterfly walks in the Serra de Collserola Natural Park, two of which have accumulated over 25 years of data and a total of 70 species. At La Rierada, 1769 butterflies belonging to 45 species have been counted, with patterns of diversity and abundance that are similar to other parts of this protected area.

The richness and abundance of butterflies on this itinerary are moderate in March–May, greater in mid-May–mid-July and fall off towards the end of summer, the poorest time of year for the counts given the lack of floral trophic resources brought on by the drought and extreme heat. Finally, in mid-September there is an upturn coinciding with the arrival of migrants.

The first species to appear every year are Green-veined White (*Callophrys rubi*), Nettle-tree Butterfly (*Libythea celtis*), Brimstone (*Gonepteryx rhamni*) and Cleopatra (*G. cleopatra*). The highlight in August is Striped Grayling (*Hipparchia fidia*), while September is a good month for Lang's Short-tailed Blue (*Leptotes pirithous*) and Two-tailed Pasha (*Charaxes jasius*).

The commonest species are generalists such as Small White (*Pieris rapae*) and typical Mediterranean forests species including Speckled Wood (*Pararge aegeria*), Cleopatra (*Gonepteryx cleopatra*) and Spanish Gatekeeper (*Pyronia bathseba*). Another species with a relatively high annual index is Green-veined White (*Pieris napi*), which is very tied to the riparian woodland.

Other slightly less common species include Wood White (*Leptidea sinapis*) and Brimstone, along with species typically associated with cultivated agricultural areas such as Long-tailed Blue (*Lampides boeticus*), Mallow Skipper (*Carcharodus alceae*), Common Blue (*Polyommatus icarus*) and Bath White (*Pontia daplidice*). On occasions, more specialist species of butterfly appear, including Purple Hairstreak (*Favonius quercus*), Panoptes Blue (*Pseudophilotes panoptes*) and Marsh Fritillary (*Euphydryas aurinia*).

Changes over the past 90 years

La Rierada is especially interesting as it is one of the last remaining examples of riparian woodland in Collserola and because data on the butterflies of the area go back to the period 1934–1970 and the work of J. Vilarrúbia.

Formerly, La Rierada was home to species that are today more typical of montane and other upland areas such as Peacock (*Aglais io*), Small Tortoiseshell (*Aglais urticae*), Silver-washed (*Argynnis paphia*) and Dark-green (*Speyeria aglaja*) Fritillaries, and Black veined-White (*Aporia crataegi*). Other species that once flew in the driest areas of the park include Spanish Festoon (*Zerynthia rumina*) and Escher's Blue (*Polyommatus escheri*), along with others that are today very such scarce – e.g. Southern Small White (*Pieris mannii*), Marsh Fritillary (*Euphydryas aurinia*) and Berger's Clouded Yellow (*Colias alfacariensis*).

This area's species list is truly surprising if we compare it with the butterfly fauna found today in the area. Of the abovementioned species, only one has been found in recent years: a single Marsh Fritillary, much threatened in Collserola, was detected in 2022. Indeed the loss of species has occurred throughout the natural park and has affected other butterflies such as Black Satyr (*Satyrus actaea*), Spanish

Marbled White (*Melanargia ines*), Iolas Blue (*Iolana debilitata*), Purple-shot Copper (*Lycaena alciphron*) and Turquoise Blue (*Polyommatus dorylas*), all recorded from near Barcelona by J. Vilarrúbia.[1] This loss of diversity can probably be blamed on habitat destruction due to construction, the abandoning of agricultural spaces, a lack of forest management, and global climate change.

Clàudia Pla-Narbona

[1] Published in: Gómez-Bustillo, M. & Fernández-Rubio, F., 1974. Mariposas de la Península Ibérica, Volumen I, Ministerio de Agricultura.

Photo. Part of the butterfly walk alongside La Rierada (Riera de Vallvidrera) (photos: C. Pla-Narbona).

Fig. 1. Abundances (average annual indices 2021–2022) of the commonest 15 species on the butterfly walk at La Rierada.

Map. The butterfly walk at La Rierada, in the northwest of the Serra de Collserola.

Article review

Colom, P., Ninyerola, M., Pons, X., Traveset, A., Stefanescu, C. (2022). Phenological sensitivity and seasonal variability explain climate-driven trends in Mediterranean butterflies

The degree of the phenological response and seasonal variability explain populational tendencies associated with climate in Mediterranean butterflies

Proceedings of the Royal Society B, 20220251. DOI 10.1098/rspb.2022.0251.

The CBMS database throws light on trends over the years in populations of Mediterranean butterfly species and on changes in their phenology, that is, their flight periods. The data it has accumulated provide evidence for a highly significant decline in butterfly abundances since the project began in the 1990s. Various studies have shown how the rise in temperature has led to an advance in the flight periods of certain species. These advances are more or less evident depending on the ecology of the species in question and the habitat in which they live. Nevertheless, to date no study has ever related species' phenological changes with their populational trends. In this study published in the *Proceedings of the Royal Society B: Biological Sciences* we highlighted a number of pertinent questions: what are the implications for butterflies if they fly earlier in the year? How does this affect their populations? Do these phenological advances allow species to adapt to climate change and so will the species that best adjust their biological cycles have a greater likelihood of survival?

In an attempt to answer these questions we analysed trends in 553 populations belonging to 51 species in Catalonia and Andorra over a time series of 26 years. The results show once again the alarming decline in Mediterranean butterflies: over half (51%) of these species declined in number during this period. Different ecological characteristics are related to these tendencies. As confirmation of previous work, we show that the most specialised species in terms of habitat and those with a greater preference for open habitats were the ones with the most negative tendencies. Another interesting result was that, amongst the characteristics analysed (e.g. habitat specialisation, the number of generations and the hibernation stage), specialisation by larvae – that is, how species specialise in the use of certain food plants – was the factor that was best correlated with the tendencies. Specifically, species that have the most limited diet were the ones that had suffered the greatest decline.

As these declines in butterfly populations have been taking place, the average temperature in the region has increased by 0.59ºC over the past 26 years. Given this warming effect, it would come as no surprise if most species had advanced their flight periods significantly during these years. Surprisingly, however, only 10% of species have done so. Nevertheless, despite this overall increase in the average annual temperature, temperatures actually fell in February, March and April, months that coincide with an important period in the development of the immature stages of butterflies. Indeed, as part of a more complex analysis we determined the critical period for all butterfly species in which an increase in temperature would most affect their flight period. This allowed us to confirm that the months in which the average temperatures has fallen do in fact coincide – at least in part – to these critical periods for most butterflies.

Independently of their tendencies, 90% of species advance their flight periods in response to an increase in temperature during the critical part of their life cycles. This response, which we quantified in terms of Julian days per degree of temperature, is more or less obvious depending on the species, a characteristic that we define as phenological plasticity. By controlling for the effect of phylogeny and the ecological characteristics of each species, we tested to see whether or not this plasticity would allow us to predict the populational trends in species. The results of this analysis indicate that the species whose flight period is most influenced by temperature (i.e. those that most advance or delay their flight periods depending on the climate) are those that have suffered fewer populational declines in recent decades. Conversely, the species that respond less to temperature have suffered the greatest declines.

All this suggests that the capacity of species to adjust their biological calendar in terms of the climate could be an adaptive characteristic that allows species to synchronise more closely with the trophic resources on which they feed. For example, advancing their flight periods in warm years when plants flower earlier allows butterflies to ensure that the peak of their flight period coincides with the peak of the flowering season. In the same way, this allows species – above all the most specialised ones – to complete their life cycles before their food plants dry up in hot springs. The results of this study reveal how species with less capacity for advancing or delaying their flight periods in response to climate could are also the most threatened by climate change due to falling out of synchronisation with the plants they depend on.

Pau Colom

Fig. 1. On the left, three examples of phenological plasticity in species of the genus *Coenonympha*. From higher to lower plasticity: Pearly Heath (*C. arcania*), Dusky Heath (*C. dorus*) and Small Heath (*C. pamphilus*). On the right, the population trend of these species calculated from the populations studied at work. A minor plasticity is associated with a more negative tendency. Bold values indicate statistically significant trends.

The butterfly

The Provençal Fritillary *Melitaea deione*, a species associated with snapdragons and found from lowland to subalpine habitats

One of the most widespread of all fritillaries in Catalonia is the Provençal Fritillary *Melitaea deione*, a species found from coastal areas to the high Pyrenees. Unlike other similar fritillaries such as Heath (*Melitaea celadussa*) and Meadow (*M. parthenoides*), the Provençal Fritillary can be polyvoltine and is on the wing from mid-spring to the beginning of autumn. It is closely associated with snapdragons (genus *Antirrhinum*), although upland populations that depend on ribwort plantain (*Plantago lanceolata*) are not unusual. Its caterpillars spin obvious silken nests on their foodplants, which they often defoliate completely.

Geographical distribution and situation in the CBMS

The Provençal Fritillary flies only in south-west Europe and North Africa[1,2] where it is common in Portugal, Spain and France, more localised in northern Italy and south-west Switzerland, and confined to a few mountainous areas in Morocco and Algeria. In the Iberian Peninsula it is found above all in upland areas in the north, centre and south, as well as in certain coastal areas. It is absent from the Balearic Islands.[3] In Catalonia it is found throughout (Fig. 1) and, although it flies in a wide variety of habitats, it is essentially a butterfly of Mediterranean habitats, both in coastal and pre-coastal areas. It is particularly abundant in the counties of El Vallès Oriental and La Selva, as well as in other more arid ones such as El Priorat and La Terra Alta. It can also be fairly frequent in certain upland areas, above all in eastern Catalonia and has colonised much of the higher Pyrenees up to around 2,000 m a.s.l. Nevertheless, it is not easy to determine exactly its distribution in the Pyrenees as it can be confused with other fritillaries such as Heath (*Melitaea celadussa*) and Meadow (*M. parthenoides*) that also fly there.[4] The only areas of Catalonia where the Provençal Fritillary seems to be completely absent are the agricultural areas of the Central Depression, Empordà and the Ebro delta, as well as along the southern coastline. In the CBMS counts it has been counted on 97 walks (43%) and is the third commonest species of its genus after Spotted (*Melitaea didyma*) and Knapweed (*M. phoebe*) Fritillaries.

Habitats food plants

As its common name in Catalan (*damer dels conillets*, 'Snapdragon Fritillary') suggests, the Provençal Fritillary is a specialist feeder on snapdragons of the genus *Antirrhinum* (Family Scrophulariaceae). From Catalonia there are records of this species feeding regularly on common snapdragon *A. majus*, *A. barrelieri* and weasel's-snout *A. orontium*, depending on the location of the population. In the centre and north of the country, as well as in the whole of the Pyrenees, the main food plant is common snapdragon, while in the south and south-west it is *A. barrelieri*. More irregularly, it is known to feed on weasel's-snout, a plant found along a broad coastal and pre-coastal strip of the whole Catalan coast. In addition, this fritillary is known to regularly use ribwort plantain (*Plantago lanceolata*) in the mountains of El Montseny and Sant Llorenç del Munt, and it is possible that this plant is used elsewhere wherever snapdragons are uncommon. Unconfirmed is its use of toadflaxes from the genus *Linaria*; only one record exists of the use of this plant from Catalonia despite the numerous records that appear in the general bibliography on the species.

CBMS data show that the Provençal Fritillary is a fairly generalist species able to occupy a variety of habitats if its food plants are present. Its greatest densities occur in arable areas with ruderal vegetation, possibly because snapdragons are common along field margins. Of note are its populations in the county of El Priorat, where the snapdragon *A. barrelieri* is extremely abundant along the edges of the region's many vineyards. Its generalist nature also allows it to appear in CBMS sections dominated by many types of forest and scrub, and even in built-up areas and gardens. In montane grasslands in pre-coastal areas, where its larvae feed on ribwort plantain, it can be very common. This variety of preferred habitats means that its habitat specialisation index is relatively low (3/10, where 10 indicates the most specialised species); however the value for its preference for open or closed areas is relatively high and near the national average (8/10, with 10 indicating species only found in open areas) given that the majority of Catalan butterflies have a preference for open habitats.

Phenology and biological cycle

The Provençal Fritillary is polyvoltine, with most Catalan populations completing two annual generations, the first in spring (April–May, although occasionally from mid-March onwards) and the second in summer (July–August, becoming rarer by September). This pattern varies in terms of the environmental conditions and its phenology varies considerably even in the same locality. Thus, its populations that inhabit hot arid areas of south-west Catalonia (e.g. counties of El Priorat and La Terra Alta) are essentially univoltine, with a single emergence centred on the end of April and beginning of May, and, at best, a few butterflies in July corresponding to a partial second generation (Fig. 2a). By contrast, its populations that fly in pre-littoral mountains are typically bivoltine, with a second generation that is as abundant – or more – as the first (Fig. 2b). The existence of a third generation at the end of summer and beginning of autumn (with a few butterflies on the wing in October) is common in many populations in the coastal range (e.g. mountains of El Montnegre and El Corredor), but also in some inland areas in northern Catalonia (Fig. 2c). The interannual variability in abundance in this third peak suggests that it is only a partial generation. Fewer data from the Pyrenees are available but suggest that the Provençal Fritillary is partially bivoltine, with a summer generation in June–July and an emergence in some years of a few butterflies at the end of summer (Fig. 2d).

This phenological variability is directly related to the ability of its larvae to enter into diapause when they reach the fourth instar (as occurs in many other fritillaries including *Euphydryas* sps.), which enables them to overcome the unfavourable environmental conditions that would otherwise hamper their development or that of a hypothetical second generation (e.g. due to a deterioration in food plants as a period of colder months approaches). The plasticity of the larvae when choosing whether to continue with their development or enter into hibernation is a remarkable feature of this species and explains why partial generations occur so often. To fully understand this phenomenon more laboratory experiments are required to determine how often diapause occurs and how it is linked to factors such as the quality of food plants, temperature and the photoperiod.[5]

As in other species of its genus, females lay groups of eggs on the undersides of the leaves of its food plant in clutches that can reach up to 200 eggs,[2] although often rather fewer (Plate 1a). Its eggs are yellow, with vertical ribbing, and measure just 0.7 mm in diameter. The larvae hatch within 1–2 weeks and then immediately spin a silken web and adopt a gregarious life style on their food plant (Plate 1b). The nests become progressively more visible and often much of the plant is covered by a web in which the first-instar caterpillars remain (Plate 1c). As they grow, the larvae become less gregarious and in the final two instar (of the six) they no longer live in the web but, instead, lead a solitary life on the leaves of their food plant (Plate 1e). The host plant may become totally defoliated, thereby forcing larvae to disperse – often up to a dozen or more metres – to find another food plant.

To pupate, they move away from the host plant and hide amongst the low vegetation or, often under stones or in cracks in rocky walls. The butterfly then emerges from the chrysalid (Plate 1f) some three weeks later.

Alternatively, the fourth-stage larvae enter into hibernation and do not grow any more until the end of the following winter or beginning of spring. To hibernate, the larvae hide, either individually or in small groups, in dead leaves at the base of the food plant, where they spin a small silken refuge in which to shelter (Plate 1d).

Adult behaviour

Both males and female spend a large part of their lives visiting flowers in search of nectar, and observations performed in a dozen upland populations have recorded visits to up to 38 different plants. Of these, some of the most important are wild thyme *Thymus vulgaris* and field scabious *Knautia arvensis* in spring, and marjoram *Origanum vulgare*, small scabious *Scabiosa columbaria* and field-holly *Eryngium campestre* in summer. Aside from these favoured plants, regular observations are made of Provençal Fritillary nectaring on flowers as diverse as sage-leaved cistus *Cistus salviifolius*, brambles *Rubus* sp., dwarf elder *Sambucus*

ebulus, wild carrot *Daucus carota*, a plumeless thistle *Carduus nigrescens* and alfalfa *Medicago sativa*. Adults also use flowers and dead flowerheads (Plate 1g) as places to rest at night (e.g. on field and small scabious).[6] Males are also quite frequent mud-puddlers.

Males combine territorial (i.e. perching on branches of shrubs) and patrolling behaviour. In the latter case, they fly over places where females may emerge or where there are food sources that might be visited by females. Displays often begin when the male detects a female on a flower, leading to mating on the very same flower.[6] Patrollers are less selective and pursue other butterflies of the same colour and size including other fritillaries. Persecutions of females of Lesser Spotted Fritillary (*Melitaea trivia*) have been observed, as has interspecific mating between a male Provençal Fritillary and a female Spotted Fritillary.[7]

Natural enemies

Parasitism by two specialist parasitoids, a braconid wasp and a tachinid fly, both of which lead to high mortality in natural populations, is quite possibly the main cause of mortality in this species (aside from the effects of drought on food plants).[8] Specifically, larvae are regularly attacked by an aggregate species of parasitoid wasp, *Cotesia melitaearum* (Hymenoptera: Braconidae) or by *Erycia fatua* (Diptera: Tachinidae).[8] *Cotesia melitaearum* is a gregarious parasitoid that parasites first-instar larvae and kills them before they pupate. This relationship is extremely close and the species of the *C. melitaearum* aggregate that parasites Provençal Fritillary is genetically differentiated from other taxa of the same aggregate that parasite other related fritillaries.[8] Furthermore, the aggregate species that parasites the Lesser Spotted Fritillary rejects in the laboratory larvae of the Provençal Fritillary, which reinforces the idea that the genetic differentiation in this aggregate translates into differences in behaviour and an extreme specialisation in terms of the hosts they parasitise. Preliminary data from a considerable number of populations of Provençal Fritillary suggest that the incidence of parasitism by *C. melitaearum* is much higher in populations that depend on *Antirrhinum* sps. than on those that feed on *Plantago lanceolata*.[9] If this is confirmed by future studies it would reveal the existence of a spatial mosaic in the parasitism rate related to the use of a particular food plant, which would have interesting repercussions for the population dynamics of this butterfly.

The tachinid *Erycia fatua* is a solitary parasite that parasites the first instars of a wide range of Melitaeini species but which emerges from the pupal stage of the host.[10]

Conservation

According to CBMS data, over the past three decades (1994–2022) populations of the Provençal Fritillary in Catalonia have remained stable (Fig. 3). This general tendency essentially coincides with the tendency in the whole of the humid Mediterranean region (1996–2022) where most of the monitored populations of this species fly. Fewer data are available for the alpine-subalpine region and the tendency there has only been calculated for the past eight years (2015–2022), during which time populations also remained stable.

In terms of particular localities, as of 2022 there were enough data to calculate robust tendences for 25 populations, of which 18 were stable, one had increased, three had decreased, and three had become extinct. Of the extinct populations, of particular interest is that of Can Ferriol in Serra de Collserola (Barcelona), which had been studied uninterruptedly for 29 years. Albeit never particularly abundant, this species appeared regularly with annual fluctuations from 1994 to 2011 but not since. The reasons for this collapse in this population are unknown as in this area few landscape-scale changes have taken place. Nevertheless, the impoverishment of the butterfly community at Can Ferriol has been severe and has affected many other species.[11] Two other well-monitored populations where the Provençal Fritillary has seriously declined are Darnius in the county of L'Alt Empordà and Vall d'Horta in the mountains of Sant Llorenç del Munt. In both cases, forest encroachment is patent and may be the main cause of the decline in this species.[12] By contrast, Olzinelles in the mountains of El Montnegre, where forest and scrub have been cleared,[13] boasts the only population of Provençal Fritillary in the CBMS network with a positive trend.

In conclusion, it is fair to say that currently in Catalonia the Provençal Fritillary is a common species that is not endangered. The two main factors that could threaten it in Catalonia are the encroachment of scrub and forests (as exemplified by the cases of Darnius and La Vall d'Horta) and agricultural intensification, which leads to a serious degradation of field margins where the snapdragons that sustain important numbers of Provençal Fritillary abound.

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

[2] Templado, J., 1976. Datos biológicos sobre *Melitaea deione* (Geyer) (Lep. Nymphalidae). *Bol. Estac. Cent. Ecol.*, 5: 97-101.

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

[4] Stefanescu, C., 2018. Com diferenciar les espècies de *Melitaea* (3). *Cynthia*, 14: 31.

[5] The larvae of the second summer generation of three populations in El Montseny that feed on *Antirrhinum majus* at 600–700 m a.s.l. within a radius of 5 km were monitored in August-September 2023. In one of the populations all larvae visible in nests on the snapdragons in August went into hibernation in the first week of September and were subsequently no longer present on their food plants. A search around the roots of the plants revealed one fourth-instar larva wrapped up in a dry leaf. In the other two populations some of the larvae (probably a maximum of 25%) continued their development throughout September and were active and easy to detect on the plants. These larvae gave rise to a third generation of adults at the end of September and beginning of October. We also reared 15 larvae from this population in the laboratory with a photoperiod of 18D: 6N and a temperature in the range 26–31ºC to emulate the conditions at the beginning of summer. Of these larvae, 10 completed their development and emerged as adults in September, while the other five entered into hibernation. This diversity in the larval development, both between and within populations, seems to be characteristic of the Provençal Fritillary.

[6] Observations of two populations in El Montseny on CBMS-11 and CBMS-12 itineraries (C. Stefanescu, obs. pers.).

[7] Interspecific mating observed on 25/07/2002 on the Can Prat itinerary (CBMS-19) during an abundant emergence of a second generation of Provençal Fritillary (C. Stefanescu, obs. pers.).

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

[9] In spring 2023 25 Provençal Fritillaries were collected from ribwort plantain *Plantago lanceolata* from a population in Sant Llorenç del Munt, 39 from a population in El Montseny, four from *Antirrhinum majus* from another population in El Montseny, and five from *Antirrhinum barrelieri* from El Priorat. None of the larvae collected from *P. lanceolata* were parasitised, whereas three of the larvae from each of the groups from *Antirrhinum* were parasitised by *Cotesia melitaearum*. Larvae collected from *Antirrhinum* and bred in previous years from various sites in El Montseny have always had very high rates of parasitism, unlike those collected from *P. lanceolata*, for which no cases of parasitism by *C. melitaearum* have ever been recorded.

[10] Ford, T.H., Shaw, M.R. & Robertson, D.M., 2000. Further host records of some west Palaearctic Tachinidae (Diptera). *Entomol. Rec. J. Var.*, 112: 25-36.

[11] Stefanescu, C. & Ubach, A., 2023. El seguiment de papallones diürnes al Parc de Collserola. Any 2022. 13 pp. Unpublished report, Museu de Ciències Naturals de Granollers.

[12] CBMS database of vegetation on CBMS itineraries.

[13] Miralles, M., 2011. El seguiment de papallones diürnes a la vall d'Olzinelles (Sant Celoni). *Cynthia*, 10: 14-15.

Fig. 1. Distribution of Provençal Fritillary *Melitaea deione* in Catalonia. The map is based on CBMS data (up to 2022) and records from the platform Ornitho.cat (up to 2021).

Fig. 2. Phenology of the Provençal Fritillary in four populations where this species is abundant: (a) Siurana (CBMS-218) between the humid and arid Mediterranean regions (n = 98 observations); (b) Santa Susanna (CBMS-11) in the humid Mediterranean region (n = 1519 observations); (c) al bosc de Valldemaria (CBMS-27) in the humid Mediterranean region (n = 871 observations); and (d) Els Plaus (CBMS-165) in the alpine-subalpine region (n = 48 observations).

Fig. 3. Population trends in the Provençal Fritillary throughout Catalonia in 1994–2022 based on data from 74 CBMS itineraries. Overall, the tendency is one of stability, as are the trends calculated separately for the humid Mediterranean region (1996–2022) and for the alpine-subalpine region (2015–2022).

Plate 1. (a) Two clutches of eggs on a leaf of *Antirrhinum majus*; (b) Nest with first-instar caterpillars; (c) nest with caterpillars of third and fourth instars; (d) fourth-instar caterpillars in diapause, removed from their silken refuges built amongst dry leaves of oak; (e) solitary caterpillar in the sixth and last instar; (f) chrysalid; (g) an adult who has spent the night on a dry flower head. (photos: J. Jubany).

Identification

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

Of the five species of *Boloria* fritillary in Catalonia,[1] Shepherd's (*B. pales*) and Bog (*B. eunomia*) are the rarest and most difficult to find. Both are upland species only present in the Pyrenees, the former in alpine habitats throughout these mountains and the latter only in humid montane habitats, being relatively common in Andorra but much scarcer in the rest of the Catalan Pyrenees.

Shepherd's Fritillary is well distributed throughout alpine habitats in the Catalan and Andorran Pyrenees and only rarely appears at lower subalpine levels. It flies at 1,500–2,750 m, with a clear preference for habitats at 2,000–2,300 m.[2] It has a single annual generation in July and August, with a maximum in the former. Although its larvae are thought to feed on violets *Viola* sps., there is a knowledge gap regarding its trophic requirements in the Iberian Peninsula and it is possible that they also feed on plantains *Plantago* sps. and plants from the family of the Valerianaceae.[3] It is catalogued as Vulnerable in Catalonia. The Bog Fritillary flies in humid subalpine meadows with abundant bistort *Polygonum bistorta* and alpine bistort *P. vivipara*, its only known foodplants in the Pyrenees.[4] In Catalonia it is a threatened species that lives in a few metapopulations in the counties of L'Alt Urgell and El Pallars Sobirà, and very locally in El Ripollès.[4] It is commoner in Andorra, where it flies in four out of 10 BMSAnd itineraries. It flies at 1,500–2,900 m, but above all at 1,700–1,800 m. It has a single summer generation that is relatively short and early, its peak flight time being June, with just a few observations in the first fortnight of July. Both species hibernate as small or medium-sized larvae.

Constantí Stefanescu

[1] Stefanescu, C., 2022. "Com diferenciar les espècies del gènere *Boloria* (1)". *Cynthia*, 16: 31.

[2] Data from *ornitho.cat*, accessed 9/10/2023.

[3] García-Barros, E.; Munguira, M.L.; Stefanescu, C. & Vives-Moreno, A., 2013. *Lepidoptera: Papilionoidea. Fauna Ibérica, 37.* Museo Nacional de Ciencias Naturales-CSIC, Madrid. 1.213 p.

[4] Ubach, A. & Stefanescu, C., 2022. "Prospeccions sistemàtiques de dues espècies amenaçades: revisió de la distribució i estat de conservació de *Zegris eupheme* i *Boloria eunomia* a Catalunya", *Butll. Soc. Cat. Lep.*, 112: 7-22.

Drawings

SHEPHERD'S FRITILLARY

Upperside: orange with obvious black veins and spots; dark basal area.

Underside: alternating blurred red and yellowish-greenish areas, interspaced with pearly white.

Marked with line

Postdiscal band with black spots that reach the wing-tip.

Marginal black markings are normally separated.

Very marked angle on vein 8 and another somewhat less well-marked one on vein 4.

BOG FRITILLARY

Upperside: orange with obvious black veins and spots; dark basal area.

Underside: pale orange colour with obvious black markings.

Marked with line

Series of pale-yellow spots ringed in black.

Yellow marginal arrow-head markings outlined in black.

The underside of the hind-wing of the Bog Fritillary is very characteristic and separates it immediately from the other Catalan members of this genus. Its main features are the series of round yellowish postdiscal spots ringed in black, and the yellowish marginal markings outlined in black in the shape of arrow-heads. Shepherd's Fritillary can be distinguished from the other Catalan *Boloria* by the angular shape of its hind-wing and by the characteristic large, blurred areas of red and yellowish-greenish on the underside. This species is almost inseparable from Mountain Fritillary *B. napaea*, which is now not thought to fly in the Iberian Peninsula.

Identification

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

In all, six coppers belonging to the genus *Lycaena* fly in Catalunya and Andorra: Small (*Lycaena phlaeas*), Purple-shot (*Lycaena alciphron*), Sooty (*Lycaena tityrus*), Purple-edged (*Lycaena hippothoe*), Scarce (*Lycaena virgaureae*) and Violet (*Lycaena helle*). Whilst the first is very widely distributed, the remaining five are only found in upland habitats and the final four only in the Pyrenees.

The Scarce Copper (*Lycaena virgaureae*) is well distributed throughout the Pyrenees above 1,300 m and can be abundant in the various types of montane and subalpine habitats it flies in. The Purple-edged Copper is less well distributed than the previous species and in the valleys where it flies – above all in humid environments, often near streams – it is generally scarce in number. It is on the wing from the end of June to mid-August. Both species lay their eggs on docks (*Rumex* sp.). The Violet Copper (*Lycaena helle*) is a relict species with a small fragmented distribution in Europe that flies in well-preserved bogs with bistort. Although it has never been found in Catalonia, a single population is known to exist in Andorra along with a few others in the French Pyrenees. It flies in a single short generation from May to Juny.

Andreu Ubach

Drawings

SCARCE COPPER

Upperside: Very bright orange colour.

Marked with line

Pale orange with postdiscal white spots.

Postdiscal white spots.

PURPLE-EDGED COPPERo

Underside: Only species of the genus with grey background.

Marked with line

Metallic reddish without postdiscal spots.

Violet spread.

Metallic orange with postdiscal spots.

Orange submarginal band.

Gray background and black dots edged in white.

VIOLET COPPER

Upperside: with violet reflections. Small size.

Marked with line

Iridescent violet.

Violet less spread.

Orange background.

Prominent orange stripe.

Lycaenidae with a characteristic metallic orange colour. Male Scarce Coppers are unmistakeable, with the upperside of the fore-wings brilliant orange and no markings. The upperside of females are paler orange with dark spots. The undersides of both sexes are similar, with a few white spots standing out from a fairly homogenous mustard-coloured background. The Purple-edged Copper is the only copper to have a grey-coloured background to the underside, with black spots outlined in white. Uppersides in males are reddish-orange with a violet hue and no spots, whilst in females are orange with black postdiscal spots. The upperside of the hind-wing in females has dark shading. The Violet Copper is small and on its upperside the violet iridescence on a metallic-orange background makes it unmistakeable (less obvious in females). On the underside there is an evident orange discal band and a series of white marks, unlike any other members of this genus.

Ajuntament Granollers

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