BUTTERFLIES OF GREDOS (SPAIN)

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from the European Butterflies Group

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SUMMARY

Gredos mountain range is located in Central Spain in Castilla y León province and hosts a huge variety of biodiversity among many different habitats, from lowland oak forests up to alpine prairies. 2022 has been the hottest year on record in Spain, and climate change is rapidly altering the conditions experienced by species. Butterflies, as ectotherms, respond quickly to changes in climate and they have been used as an indicator taxon to understand how climate change is affecting species. In this work, I have analysed changes over time in the distributions of butterfly species which are endemic to the Iberian Peninsula or have a notable conservation status by revisiting in 2021 and 2022 sixteen fieldwork sites with historical data from the 1980s. Results show that most of the butterfly species have maintained their populations over time in Gredos, some of them increasing their distribution like the Rock Grayling *Hipparchia hermione* or the Iberian Sooty Copper *Lycaena bleusei*. Also, we have seen a change in the altitudinal distributions of certain species like the Lulworth Skipper *Thymelicus acteon* moving up to higher locations. These results highlight the importance of Gredos mountain range as a hotspot for butterfly diversity with the presence of rare and endemic species from the Iberian Peninsula.

1. INTRODUCTION AND METHODS

Locations in the Iberian Peninsula acted as climatic refugia during the Last Glacial Maximum, hosting a rich biodiversity of many taxa mainly located in mountain areas where landscape heterogeneity was higher (Abellán and Svenning, 2014). Currently, anthropogenic climate change is causing species to experience warmer and drier conditions driving species to change their distributions altitudinally and latitudinally. There is already evidence of upward shifts of insects in mountain regions in Spain: butterflies in Guadarrama mountain range have already moved up due to climate change (Wilson *et al.*, 2005) and a similar trend appeared in the Pyrenees for bumblebees (Marshall *et al.*, 2020). The effect of climate change on insect species has been studied in several mountain areas in the Iberian Peninsula, but not yet in the Gredos mountain range, at the same latitude as Guadarrama. Other impacts of climate change are wildfires, which every year are becoming more recurrent in the Iberian Peninsula. In 2021, there was the biggest wildfire ever registered in the Comunidad de Castilla y León burning 22.000 ha of mainly shrubland in an area very close to one of our fieldwork sites in Navalacruz (Ávila).

Gredos mountain system is located in the Sistema Central within Ávila province in the Castilla y León region (Figure 1) and part of it is protected as a *Parque Regional*. The mountains have an altitudinal range from 400 m to 2592 m (Pico Almanzor) and cover an area of 150 km long and 50 km wide. The region's climate is montane Mediterranean characterized by a summer drought followed by heavy precipitations due to the terrain orography. However, there are huge differences in the climate and the landscape between the south face and the north face of Gredos: at the south face, there is a transition from agricultural land and oak forests at the lowest sites to pine forests higher up, being very dry landscapes during summer, especially at lower altitudes. At the north face, the landscape is dominated by scrubs above 1500 m, and below there are pine and oak forests, and is a much more humid landscape than the south face. The geology of the study area is composed by granites and gneisses.

In this project, I tested for changes in the distribution of endemic species from the Iberian Peninsula, Near Threatened species from the *Red list of European Butterflies* (Van Swaay *et al.*, 2010) and other interesting mountain-restricted species like *Erebia triarius* and *Erebia meolans* which have restricted distributions but have been misidentified in the past (Table 1). The methodology is based on re-sampling 16 sites over the altitudinal gradient with different orientation and habitats (Table 2), that were sampled between 1984 and 1987 by Viejo and Martín (1988) to cover the range of environmental variation present in the landscape. By consulting with J. L. Viejo, I was able to revisit the same locations again over the period of May to August 2021 and 2022 (5 visits per year) to get two different snapshots on the current situation of these particular butterfly species (Table 1). I have used the Pollard and Yates (1994) method walking 500 m transects checking butterfly species presence and abundance. I have also checked the 1980s specimens for all the focal species, present at the Universidad Autónoma de Madrid entomology collection, to confirm their presence in each site and check that they were properly identified. I have also compiled the dates and number of visits to each site (counts in 1984-87 were based on collections from unequal numbers of visits to each site) to account for changes in sampling effort in future analyses.

Table 1. Endemic (*), Near Threatened (NT) and other interesting species present in Gredos mountain system. Species names are as shown in Wiemers *et al.* (2018). ** Considered as vulnerable by Munguira *et al.* (1991) about Lycaenid species in the Iberian Peninsula.

Species	Common name	Family	Flight period	IUCN class.
Aricia morronensis *	Spanish Argus	Lycaenidae	May-August	LC
Eumedonia eumedon	Geranium Argus	Lycaenidae	April-August	LC**
Erebia meolans	Piedmont Ringlet	Nymphalidae	June-August	LC
Erebia triarius	De Prunner's Ringlet	Nymphalidae	May-June	LC
Hipparchia hermione	Rock Grayling	Nymphalidae	July-August	NT
Hipparchia statilinus	Tree Grayling	Nymphalidae	June-October	NT
Lycaena bleusei *	Iberian Sooty Copper	Lycaenidae	March-October	LC
Pseudophilotes panoptes	Panoptes Blue	Lycaenidae	March-June	NT
Thymelicus acteon	Lulworth Skipper	Hesperiidae	May-August	NT

Table 2. Field sites in Gredos, ranked by ascending altitude (Figure 1 for geographic location). All sites are South or North of the main mountain ridge apart from the mountain pass at 11.

ID	Location	Altitude	Mountain face	Habitat type
1	Cerro del Águila	398 m	South	Oak forest
2	Candeleda	685 m	South	Mixed pine-oak forest
3	El Hornillo	781 m	South	Agricultural land
4	Hoyocasero	1156 m	North	Oak forest
5	Soto del Arenal	1230 m	South	Pine forest
6	Navalguijo	1250 m	North	Grasslands
7	Mingo Fernando	1294 m	South	Pine forest and rocky open patches
8	Navalperal de Tormes	1316 m	North	Grasslands with oak trees
9	Collado de la Centenera	1345 m	South	Scrub with scattered pines
10	La Cebedilla	1373 m	South	Pine forest and rocky open patches
11	Puerto del Pico	1400 m	Ridge	Open grassland
12	Navacepeda de Tormes	1432 m	North	Mixed pine-oak forest
13	Navarredonda de Gredos	1498 m	North	Grassland with scattered pines
14	La Plataforma de Gredos	1860 m	North	Alpine prairie
15	Puerto de la Peña Negra	1923 m	North	Alpine prairie
16	Prado de las Pozas	1956 m	North	Alpine prairie

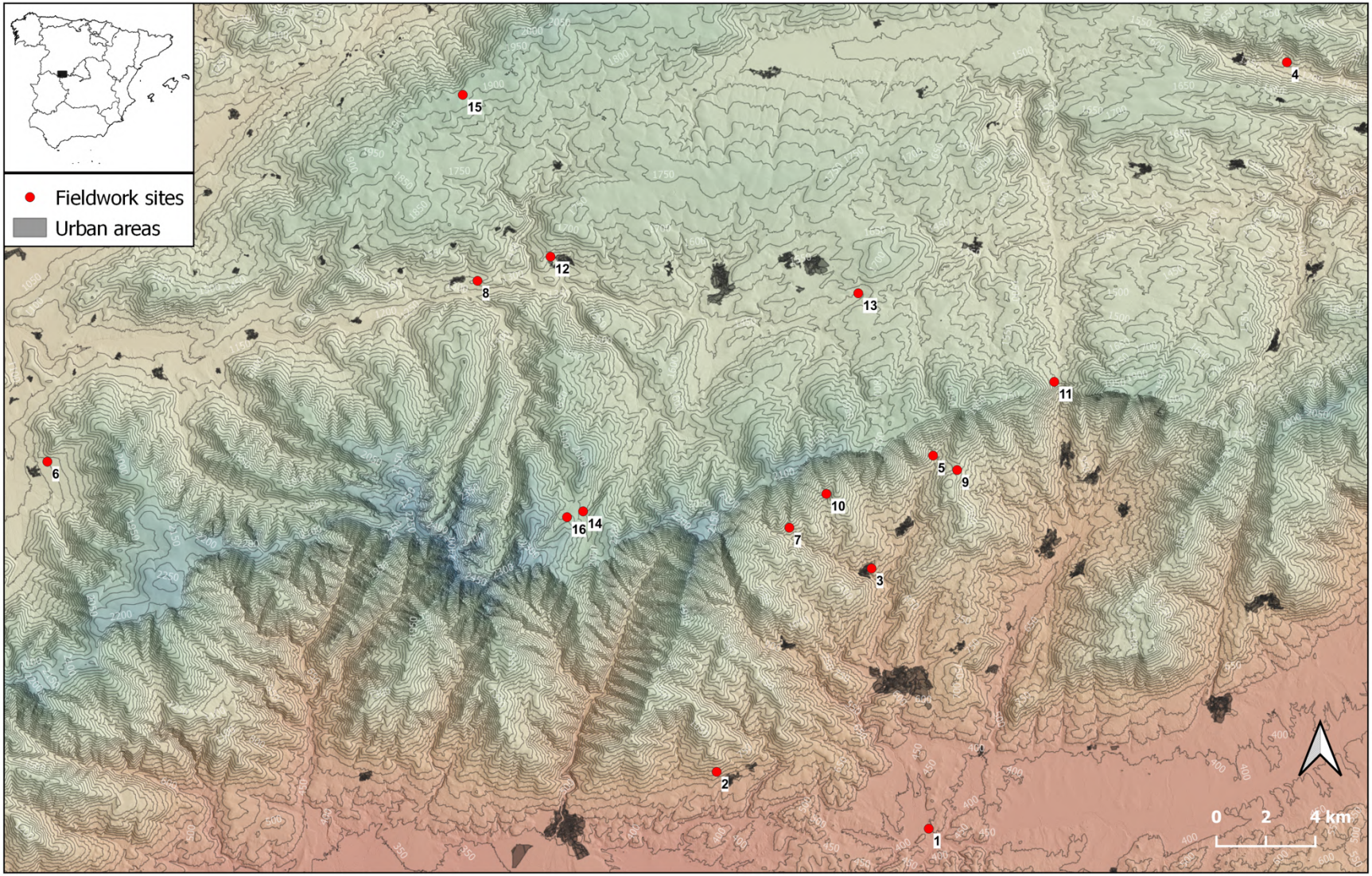


Figure 1. Location of the 16 fieldwork sites across Gredos mountain range.

2. RESULTS

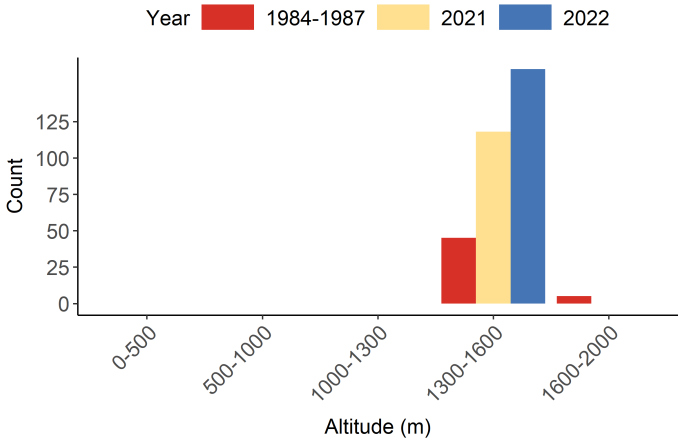
All focal species except for *Erebia triarius* were seen in the historical survey (1984-1987), with a total abundance of 163 individuals. In 2021, we saw 488 individuals of these species, with no individuals seen of *Eumedonia eumedon* or *Erebia triarius*. In the most recent survey, in 2022, we saw even more individuals than 2021, a total of 566 but still no *Eumedonia eumedon* or *Erebia triarius* (for more detailed information, see Table 3 and species distribution maps in the Annex).

Table 3. Focal species presence in Gredos mountain system in each survey. Note that the total counts in 2021 and 2022 are each based on a total of five counts per year across the 16 x 500 m transect sites. The totals in 1984-87 are based on unequal numbers of collections at the sites.

Species	Survey	Number of sites seen	Altitudinal range	Total count
Aricia morronensis	1984-87	4	1400-1860 m	50
	2021	1	1400 m	118
	2022	2	1345-1400 m	161
Eumedonia eumedon	1984-87	1	1156 m	10
	2021	-	-	-
	2022	-	-	-
Erebia meolans	1984-87	2	1860-1956 m	17
	2021	2	1860-1956 m	19
	2022	3	1400-1956 m	13
Erebia triarius	1984-87	-	-	-
	2021	-	-	-
	2022	-	-	-
Hipparchia hermione	1984-87	6	1250-1498 m	36
	2021	14	685-1956 m	227
	2022	13	398-1956 m	238
Hipparchia statilinus	1984-87	7	685-1956 m	11
	2021	8	398-1373 m	34
	2022	9	398-1400 m	42
Lycaena bleusei	1984-87	8	398-1432 m	12
	2021	8	398-1432 m	72
	2022	12	398-1498 m	76
Pseudophilotes panoptes	1984-87	2	1230-1400 m	2
	2021	3	1156-1250 m	13
	2022	1	1156 m	8
Thymelicus acteon	1984-87	5	398-1432 m	25
	2021	3	1156-1294 m	5
	2022	8	398-1498 m	28

***Aricia morronensis* (Ribbe, 1910)**

The **Spanish Argus** is an endemic species from the Iberian Peninsula and is present in open rocky habitats above 1300 m where its host plant grows (*Erodium carvifolium*). This species was found in four different places in the historical survey: Navacepeda de Tormes, La Plataforma de Gredos, Navarredonda and Puerto del Pico with a total abundance of 50 individuals. In recent surveys (2021 and 2022), 279 individuals were identified in two transects: Puerto del Pico where the host plant is very abundant and the nearby site Collado de la Centenera where it was not seen in the historical survey.



The Spanish Argus reaches its highest abundance at Puerto del Pico and flies throughout the summer (May-August). The site has very open habitat with low vegetation on which cattle graze at a low intensity: the food plant and butterfly are widespread and abundant especially in the drier areas of the site. In early 2022 the area of open grassland was increased by clearing an area of scrub (Figure 2), which is likely to increase the habitat available for the Spanish Argus.

Figure 2. Puerto del Pico at 1400 m, showing an area of scrub clearance on the right.

***Eumedonia eumedon* (Esper, 1780)**

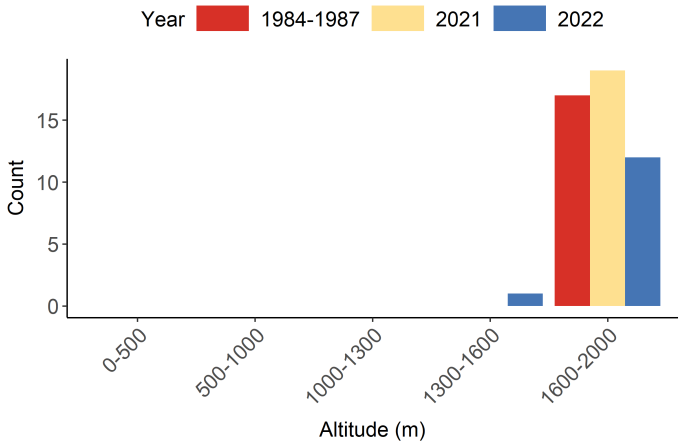
The **Geranium Argus** is found in mountains and is not very abundant in the Iberian Peninsula, where populations are mostly restricted to the north and isolated populations in Andalusia. It was seen in Hoyocasero (site 4 in Figure 1) in the historical survey and is still observed nearby (J.P. Cancela, M. Munguira, *pers. comm.*) but we did not find any on the 2021-2022 transects although *Geraniaceae* are present in the site as potential host plants. This site is one of the most species-rich for butterflies that was surveyed, and is also adjacent to the site of the fire at Navalacruz in 2021. Fortunately, there was no clear evidence from the data that the fire had negatively affected the local habitat and butterfly community in 2022 compared with 2021.

***Erebia triarius* (Prunner, 1798)**

De Prunner's Ringlet is a mountain grassland species that flies in May to June and is more abundant above 1300 m, and populations in the Iberian Peninsula are located mainly in the north. This species was not confirmed in any of the surveys in Gredos. This species is much more abundant at high altitudes in the Sierra de Guadarrama which is also in Sistema Central (NW from Gredos) and it is thought that rare historical records of the species in Gredos may have been misidentifications of the Piedmont Ringlet *Erebia meolans*.

***Erebia meolans* (Prunner, 1798)**

The **Piedmont Ringlet** is found in open alpine grasslands between 1400 and 2000 m, flying around June to August. This species was seen in la Plataforma and Prado de las Pozas transect in the historical surveys, with a total abundance of 17 individuals. In the recent surveys, it was seen in these two transects as well but also in Puerto del Pico. Gredos mountain range is one of the most southern populations of this species in the Iberian Peninsula.

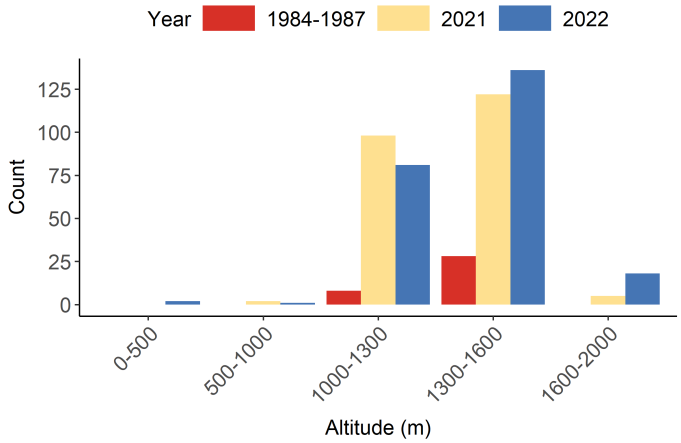


The transect above la Plataforma de Gredos (Figure 3) was the one with the highest density of the Piedmont ringlet in Gredos with a typical open habitat landscape with some scattered *Juniperus* spp.

Figure 3. Fieldwork site above la Plataforma de Gredos at 1860 m.

***Hipparchia hermione* (Linnaeus, 1764)**

The **Rock Grayling** is a very common butterfly in the Sistema Central, occupying many types of habitats like pine forests or oak forests up to 2000 m mainly in rocky landscapes. In 1984-87 this species was seen in 6 study sites ranging from 1250 up to 1500 m on both sides of Gredos mountain range with a total abundance of 36 individuals. In 2021 and 2022 we have seen much more individuals (465 in total) in many more transects (15), from the lowest (398 m, 685 m) to the highest sites (1956 m), showing that this species appears to have expanded its distribution throughout partially wooded as well as more open landscapes across the whole mountain range.

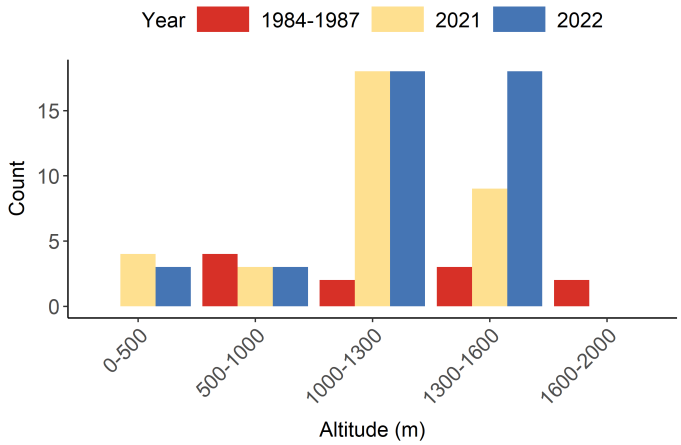


Mingo Fernando site is one of the transects with the highest abundance of the Rock Grayling in Gredos mountain range (Figure 4).

Figure 4. Mingo Fernando fieldwork site at 1300 m.

***Hipparchia statilinus* (Hufnagel, 1766)**

The **Tree Grayling** is a generalist species that lives from open habitats to forested landscapes up to 2000 m. It appeared in 7 different transects in the historical survey, from 685 up to 1956 m with a total abundance of 11. In the recent surveys, it was seen in 10 different transects, disappearing from the highest ones but observed at lower sites like Cerro del Águila (398 m).

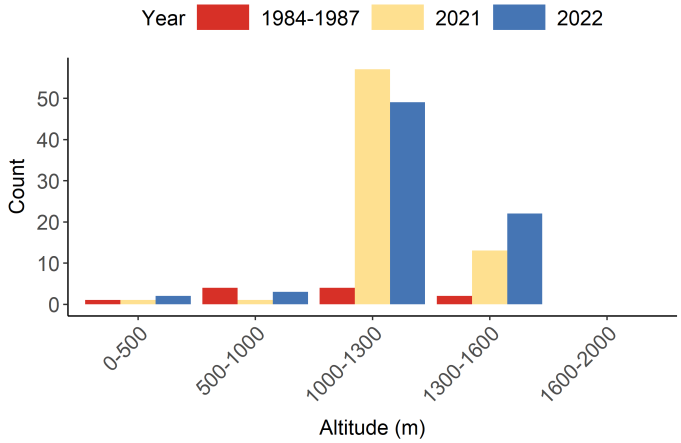


At sites above 1600 m (e.g., Prado de las Pozas, Figure 5), the Tree Grayling was not seen in 2021-22, being most abundant at 1000-1600 m. We might have missed this species at higher sites because we finished the recent surveys in mid-August, whereas all historical observations at the highest sites were in late August or September. Nevertheless, a previous study found that the Tree Grayling had declined at the highest altitude sites in nearby Sierra de Guadarrama from 1967-73 to 2004 (Wilson *et al.*, 2005).

Figure 5. The highest studied fieldwork site at Prado de las Pozas.

***Lycaena bleusei* (Oberthür, 1884)**

The **Iberian Sooty Copper** is an endemic species from the Iberian Peninsula being very abundant in Sistema Central (Gredos and Guadarrama) and appears in grasslands up to 1800 m. It was seen in 8 transects in the historical survey ranging from 398 up to 1432 m with a total abundance of 12. In recent surveys, it has been seen in 12 transects with similar altitudinal range as before but with a higher abundance (148 individuals).

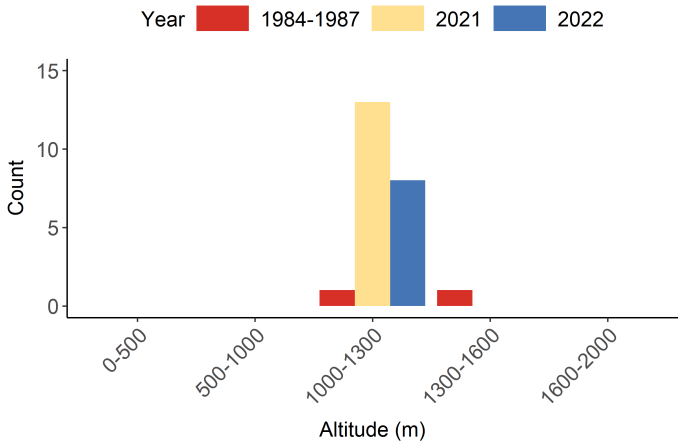


Hoyocasero transect in Navalacruz is the transect with the highest abundance of the Iberian Sooty Copper (Figure 6) and also one with the highest diversity of butterflies across all studied sites, which in 2022 did not appear to be affected negatively by the nearby fire in August 2021.

Figure 6. Hoyocasero fieldwork site at 1160 m.

***Pseudophilotes panoptes* (Hübner, 1813)**

The **Panoptes Blue** is also an endemic species from the Iberian Peninsula and is common in dry and open landscapes with Thyme (*Thymus vulgaris*) up to 1400 m. In the historical surveys it was seen only in two transects (Soto del Arenal and Puerto del Pico) between 1230 and 1400 m. In recent surveys, we identified it again in Soto del Arenal but not in Puerto del Pico. Also, it was observed in two more transects, Hoyocasero and Navalguijo (Figure 7), both on the north side of the mountain range, where it was not seen in the historical surveys.

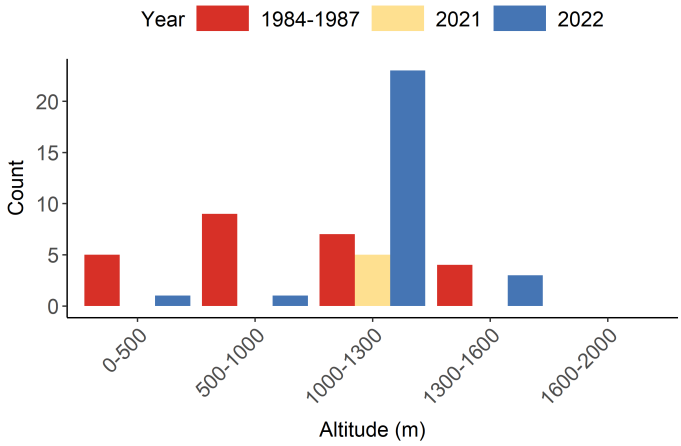


The data suggest that the Panoptes Blue has a narrow altitudinal distribution within the study area around 1000-1300 m. It is worth noting that this species flies during spring time, so it is possible that by starting the surveys in May it might be possible to miss it especially from low altitude sites: however, *P. panoptes* was not seen at any of the sites when the transects were set up in mid-April 2021.

Figure 7. Navalguijo site at the north face of Gredos mountain range.

***Thymelicus acteon* (Rottemburg, 1775)**

The **Lulworth Skipper** is listed as Near-threatened in the *European Red List of butterflies* from the IUCN and in the Iberian Peninsula is common in open landscapes with the presence of grasses. It was seen in five transects in the historical survey with a total abundance of 25 individuals. In the recent survey, abundance and distribution was similar, however, it was seen in several transects where it was not seen in the past like Hoyocasero or Navarredonda, both at the north side of Gredos.



The counts suggest that the Lulworth Skipper may have moved its distribution upwards, being much more abundant between 1000 and 1300 m now, whereas in the 80s it was more abundant between 500 and 1000 m. Candeleda (685 m) is one of the places where *T. acteon* has reduced drastically his abundance (Figure 8).

Figure 8. Candeleda site at the south face of Gredos mountain range.

3. DISCUSSION AND CONCLUSIONS

After revisiting the fieldwork sites, we have confirmed the presence of seven out of nine focal species. Both Iberian endemic species have well-established populations in Gredos mountain range specially in certain locations like Puerto del Pico (*Aricia morronensis*) and Hoyocasero (*Lycaena bleusei*). The four Near-Threatened species (*Hipparchia hermione, Hipparchia statilinus, Pseudophilotes panoptes* and *Thymelicus acteon*) have also shown an apparently positive trend increasing their abundances and distributions across Gredos. However, it is important to note that the methodology was not the same among surveys, and that the sampling effort in the recent surveys might have led to our recording more individuals than historically.

Thymelicus acteon has shown evidence that it is shifting its distribution upwards, which is expected as climate keeps warming over time. Similar results have been found for several butterfly species in Guadarrama mountain range (NW of Gredos) by Wilson *et al.* 2005, although not specifically for *T. acteon* which has rather isolated populations in Guadarrama without a clear altitudinal association. It appears that *T. acteon* may be associated with relatively moist areas of low-lying grassland in central Spain, and that it may therefore be vulnerable to summer drought – which could explain why it might shift its distribution to less drought prone areas at higher altitudes. The other species presented here do not show clear evidence of uphill elevation shifts in Gredos, although my ongoing analyses of the altitudinal ranges of a wider set of butterfly species suggest that some have disappeared from sites at the lower limits of their altitude ranges (especially sites 1 and 2 below 700 m) since 1984-87. Nevertheless, the species show differing trends depending on factors such as their habitat associations, with this report showing that some species may have expanded their distributions at both low and high elevations (*Hipparchia hermione*) or even shifted their distribution downhill (*Hipparchia statilinus*).

The *Erebia triarius* distribution overlaps with *Erebia meolans* in the Iberian Peninsula (Figure 9) mainly in northern mountain ranges. Our data appear to confirm that the predominant Erebia species in Gredos is *E. meolans* and not *E. triarius* which may have been misidentified in the past.

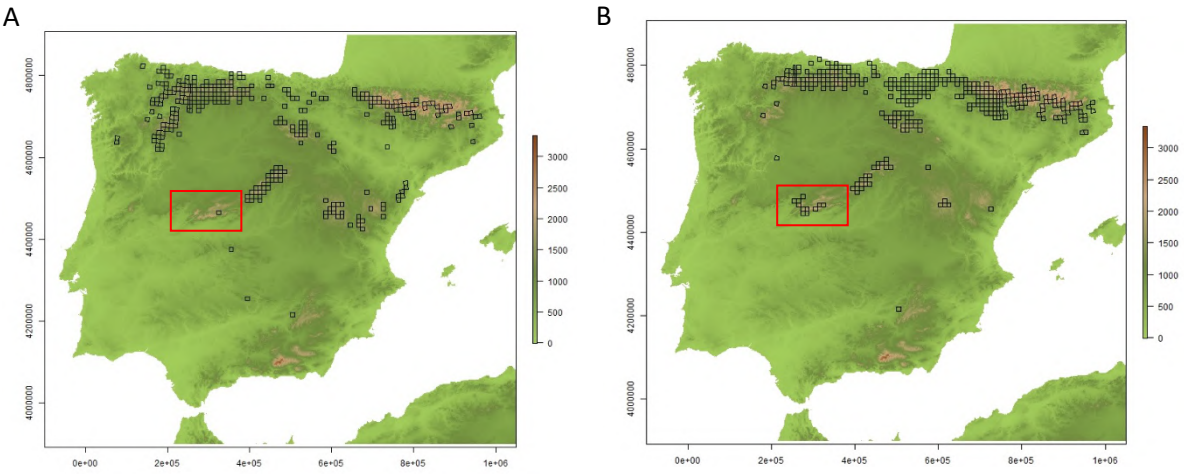


Figure 9. *Erebia triarius* (A) and *Erebia meolans* (B) distribution in the Iberian Peninsula showing 10km squares with presence from 1980 onwards. Red square shows Gredos. Data taken from García-Barros *et al.* (2004) and updated with recent records until 2018.

The other species not observed in 2021-22, *Eumedonia eumedon*, has a population near to our Hoyocasero field site (Figure 6) which represents an apparently isolated point in its distribution in the Iberian Peninsula (Figure 10). It would be interesting to know whether there are other areas of suitable habitat or populations of the species surviving nearby.

Figure 10. The Geranium Argus distribution in the Iberian Peninsula showing 10km squares with presence from 1980 onwards. Red square shows Gredos. Data taken from García-Barros *et al.* (2004) and updated with recent records until 2018.

Overall, the results for the species included here do not suggest generalized changes in the abundance or distribution of butterfly species of primary conservation interest in the Sierra de Gredos between 1984-87 and 2021-22. There are indications that species associated with partly wooded or scrubby landscapes, such as the Rock Grayling *Hipparchia hermione* have increased their abundance and distribution, in common with a general increase in abundance of species associated with more “closed” habitats across the Iberian Peninsula (Ubach *et al.*, 2020; Mingarro *et al.*, 2021). These effects of changes in rural land-use, depopulation and habitat abandonment are of interest in terms of the effects they are having on mountain biodiversity, and I plan to investigate them more during the course of my research.

One way that conservation management can counteract the effects of rural abandonment is by deliberately removing areas of regenerating scrub or woodland. This appears to have happened in early 2022 in Puerto del Pico (Figure 11) and is likely to increase the area of suitable habitat for the Spanish Argus *Aricia morronensis* and its larval host plant *Erodium carvifolium*, which is abundant in the drier areas of grassland at the site. *E. carvifolium* is the host plant used in Sistema Central (Gredos and Guadarrama) but other *Erodium spp.* are used by the Spanish Argus in different parts of the Iberian Peninsula (Zarzo Arias *et al.*, 2019). *A. morronensis* was also observed nectaring on the flowers of the larval food plant. Another site in the region where the Spanish Argus was observed in the 1980s is Navarredonda de Gredos in the northern part of the region. It is an area of open clearings in pine woodland grazed by cattle and horses: here the sward is shorter than at Puerto del Pico, partly inundated in spring time, but drying out noticeably during summer. *A. morronensis* was not observed in 2021 or 2022 on the transect: a broader search for the species and his larval host plant in the vicinity of the Navarredonda transect may be needed to confirm whether suitable habitat or populations of the species are still present, and if so, whether these are restricted to areas which are still open but grazed less heavily than the majority of the site.

Figure 11. Scrub clearings at Puerto del Pico.

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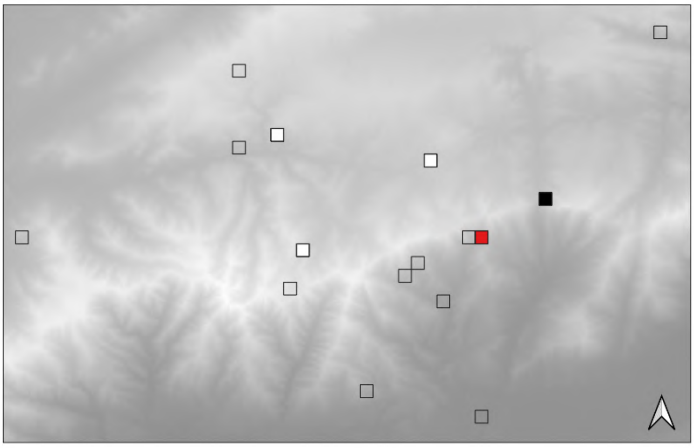
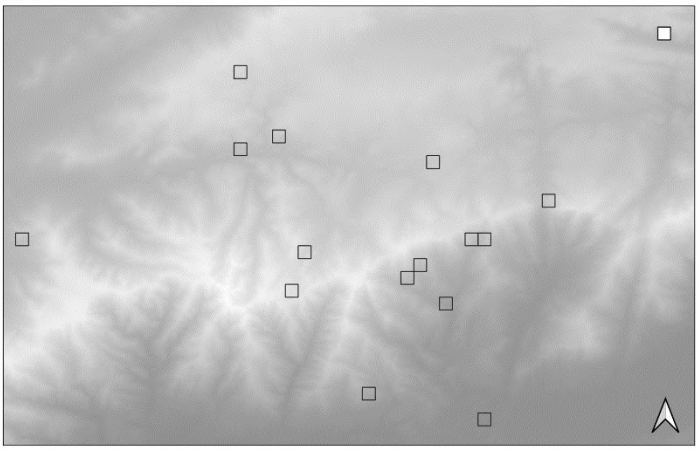
6. ANNEX

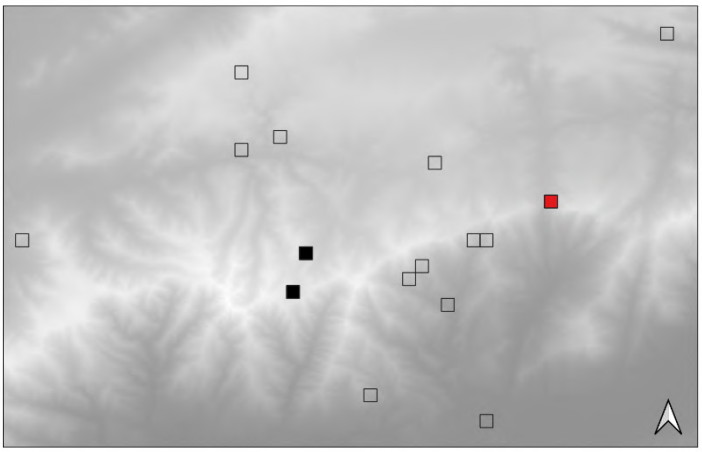
Species distribution maps: White boxes show presence in the historical surveys (1984-1987) but not in the recent surveys (2021-2022). Red boxes show presence in the recent surveys but not in the historical. Black boxes show presence in both historical and recent surveys. Empty boxes show no presence in either of the surveys.



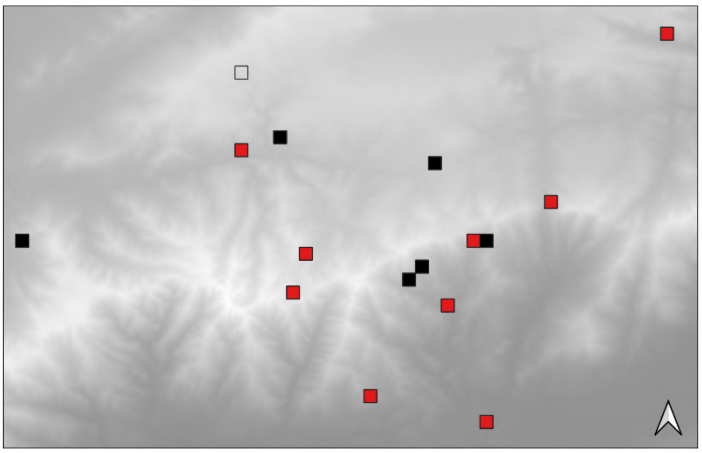
Spanish Argus
Aricia morronensis



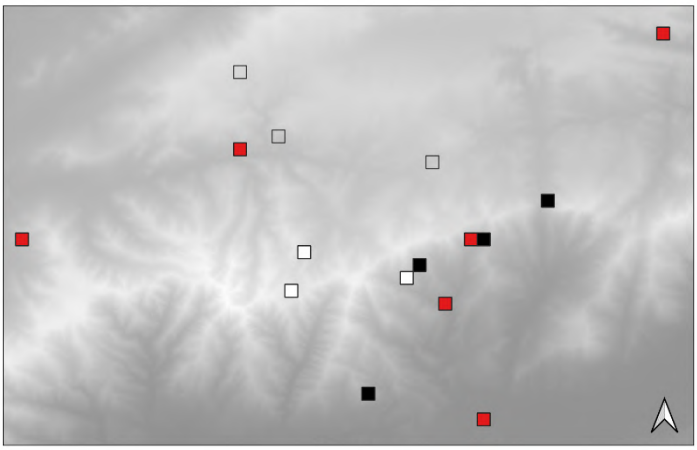
Geranium Argus
Eumedonia eumedon



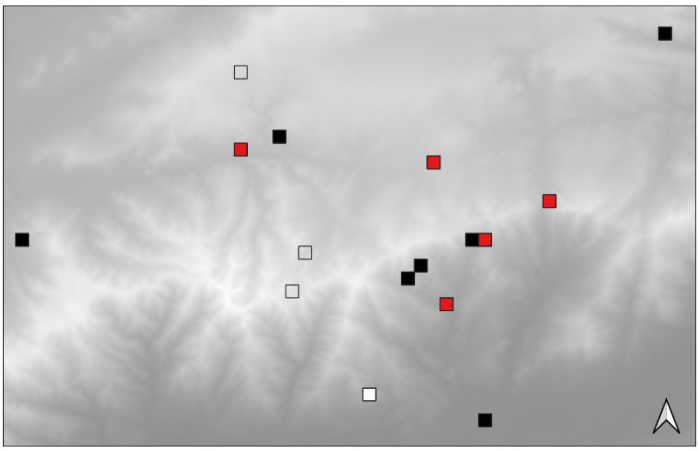
Piedmont Ringlet
Erebia meolans



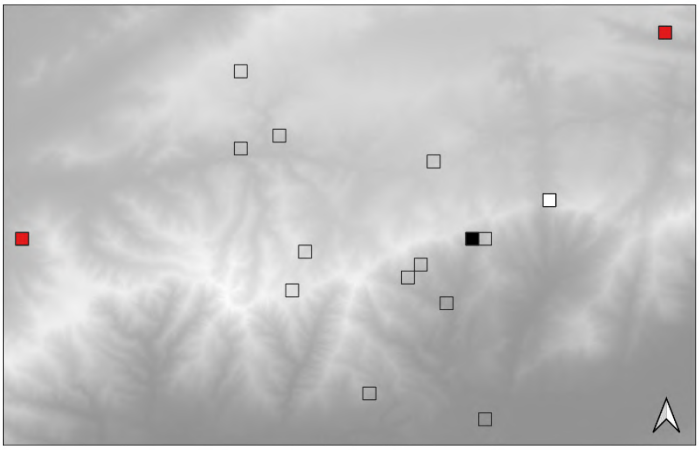
Rock Grayling
Hipparchia hermione



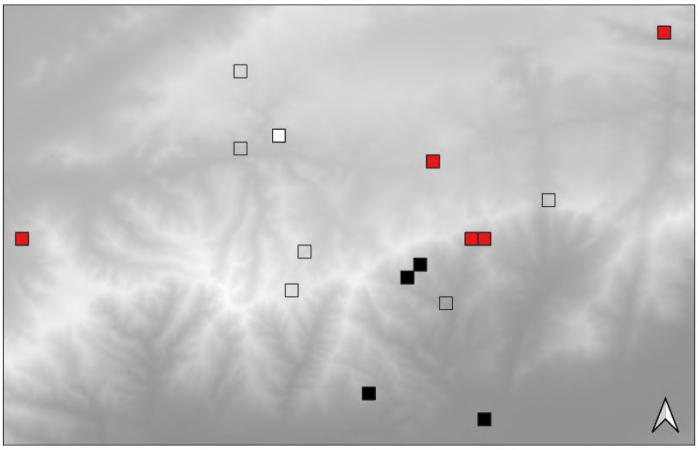
Tree Grayling
Hipparchia statilinus



Iberian Sooty Copper
Lycaena bleusei



Panoptes Blue
Pseudophilotes panoptes



Lulworth Skipper
Thymelicus acteon