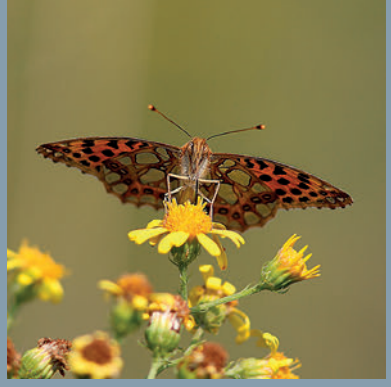
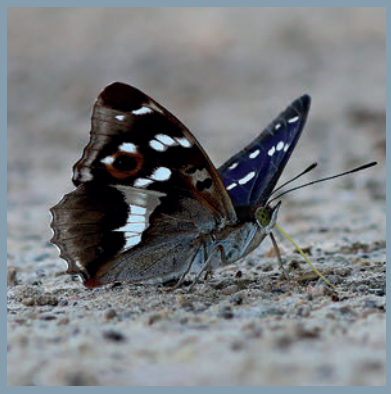
Ferrantia

ISSN 1682 - 5519





Butterflies in Luxembourg: distribution, trends and conservation

Xavier Mestdagh
Lionel L'Hoste
Nicolas Titeux
(editors)

90 **2024**

Travaux scientifiques du Musée national d'histoire naturelle Luxembourg

Ferrantia

90

Butterflies in Luxembourg: distribution, trends and conservation

Xavier Mestdagh
Lionel L'Hoste
Nicolas Titeux
(editors)

Luxembourg, 2024

Travaux scientifiques du Musée national d'histoire naturelle Luxembourg

Butterflies in Luxembourg: distribution, trends and conservation
Xavier Mestdagh, Lionel L'Hoste, Nicolas Titeux (editors)

Contents

Preface

It is with great pleasure and a sense of accomplishment that I introduce you the Ferrantia volume "Butterflies in Luxembourg: distribution, trends and conservation", including an updated Red List of the butterflies of Luxembourg. This atlas represents the culmination of years of dedicated efforts from around 250 volunteers and professionals committed to the study and conservation of butterflies in our country. It has been co-financed by the Ministry of the Environment, Climate and Biodiversity, the Luxembourg Institute of Science Technology (LIST) and the National Museum of Natural History (MNHN).

Butterfly inventories in Luxembourg have a rich history, with first records dating back as far as the mid-19th century. However, it was only the establishment of the Luxembourg Butterfly Monitoring Scheme (LUBMS) in 2010 that brought real structure to these efforts and allowed to further intensify them. LUBMS has since been instrumental in improving our knowledge of butterfly populations and their trends across the country.

LIST coordinates the programme including national inventories and monitoring while depending on the active participation of volunteers as well as national and regional stakeholders such as natur&ëmwelt, Biological Stations, Nature and Forest Agency (ANF), or MNHN. Their contributions have not only expanded the scope of our monitoring efforts but have also fostered a sense of stewardship for butterfly conservation in the community.

In this atlas you will find the insights from LUBMS across five chapters and an abstract highlighting its key elements as well as the main conclusions from the Red List assessment. It shows that despite increased conservation efforts since the adoption and implementation of the 1st and especially the 2nd national biodiversity strategy (PNPN) in 2017, about one third of the species present in Luxembourg are threatened to a certain extent, while even more show negative trends. However, it also depicts positive developments such as the country's now unique richness of butterfly species in the Minette region, dominated once by industry leaving behind a destroyed natural environment. Such findings make me hopeful that we can preserve and restore butterfly populations and nature in general throughout the entire country through the proper implementation of our 3rd national biodiversity strategy for 2030. When we set the right incentives and apply the necessary conservation and restoration measures, nature can indeed bounce back, and once destroyed or degraded biotopes can, again, harbour a wide range of (endangered) species. Hence, the inclusion of an entire chapter for land managers and stakeholders on the ground, offering best management practices for the major biotopes occupied by butterflies.

Looking ahead, it will be essential to continue our monitoring efforts through LUBMS. Only by further refining population trend estimates and regularly updating the Red List, we will be able to adapt our conservation strategies to ensure the long-term viability of butterfly populations in Luxembourg. Furthermore, this will be of value to help steering our nature conservation efforts in general, considering the importance of this taxonomic group as an indicator of biodiversity and the state of ecosystems. Their figures make it possible, as quantitative indicators, to measure the extent of changes in ecosystems and, given that they are updated regularly and often annually, to quickly highlight these changes without having to wait, for example, for the next atlas to be published. That said, I also recognise the value of ongoing collaboration at European level to pool information on the conservation status of this significant taxonomic group, as it is produced, for example, in the form of the grassland butterfly indicator.

To conclude, I would like to express my gratitude to all the individuals and organisations involved in butterfly monitoring and conservation efforts. Your dedication is not only appreciated but essential to the preservation of Luxembourg's natural heritage. And to LIST, I express my sincere appreciation for their continued support of our monitoring activities. I finally encourage citizens who would like to actively engage in LUBMS or simply contribute to collecting standardised butterfly records to get in contact with the main authors of this atlas. Their valuable contribution will be much appreciated. Together, we can ensure a better future for butterflies in Luxembourg.

© SIP / Claude Piscitelli

Serge Wilmes

Minister of the Environment,
Climate and Biodiversity

Financial support

LUXEMBOURG
INSTITUTE OF SCIENCE
AND TECHNOLOGY
LIST

THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG
Ministry of the Environment,
Climate and Biodiversity

Acknowledgements

First, we would like to thank each recorder (either volunteer or professional) who contributed to the collection - from one to hundreds - of records, vital for the achievement of this atlas. Hereafter, we decided to cite, in alphabetical order, only the recorders for which we have reliable information on their identity. In some cases, their identity could not be unambiguously established from the data extracted from the encoding systems. Recent recorders have not been separated from historical recorders.

We are very grateful to all people who provided us with their illustrations for this atlas. Their names are explicitly mentioned in the legend underneath each illustration across the different chapters.

Our thanks go as well to the butterfly experts who provided information on the status of butterflies in Luxembourg's neighbouring regions: Steffen Caspari for Saarland and Rheinland-Pfalz (Germany), Julien Dabry and David Demerges for Lorraine (France) and Philippe Goffart for Wallonia (Belgium). Aurore Trottet (IUCN), David Allen (IUCN) and Chris van Swaay (De Vlinderstichting, The Netherlands) gave us invaluable information on the Red List assessment procedure. Many thanks to Dirk Maes (INBO, Belgium) for the discussions on the methodology.

Many thanks to the very conscientious reviewers who provided comments on earlier versions of the different chapters.

We hope readers will find this atlas helpful and enjoyable. Any volunteer who would like to actively participate in the Luxembourg Butterfly Monitoring Scheme or simply contribute to collect standardised records can contact the authors or send an email to lupoms@list.lu.

The production of this atlas would not have been possible without the financial support of the Ministry of the Environment, Climate and Biodiversity (MECB), the National Museum of Natural History of Luxembourg (MNHNL) and the Luxembourg Institute of Science and Technology (LIST).

List of recorders

René Assa, Anouk Audry, Hubert Baltus, Mikis Bastian, Doris Bauer, Patrick Bausch, Georges Bechet, Jean Bernard, René Bicheler, Francis Birlenbach, Gilles Biver, Lilly Bodson, Guy Bollendorf, Joey Bom, Sandra Bornhofen, Fabienne Bouche, Yannick Bouhy, Robert Bour, Myriam Braun, Paul Braun, Carlo Braunert, Cédric Brodin, Mélanie Cardew, Evelyne Carrières, Béatrice Casagranda-Hardt, Alexander Caspari, Steffen Caspari, Sandra Cellina, Samuel Chalifour, Svenja Christian, André Claude, Michelle Clemens, Guy Colling, Thierry Cordenos, Andy Corlier, Julie Craenen, Jennifer Cross, Josy Cungs, Laura Daco, Lisa de Deus, Tiago De Sousa, Sabine Demuynck, Martina Divis, Alain Dohet, Danielle Dolisy, Bernard Ducarme, Auguste Dutreux, Sébastien Elixander, Nora Elvinger, Edmée Engel, Jenny Epstein, Marcel Etringer, Bruno Eusebi, Johanna Ewen, Alain Faber, Robert Faber, Pascal Fautsch, Fernand Feitz, Claude Felten, Claudine Felten, Nora Feltz, Alain Frantz, Alexander Franzen, Mandy Frisch, Michel Frisch, Arno Frising, Mario Gaspar, Dirk Gerber, Raoul Gerend, Karl-Georg Gessner, Liza Glesener, Christine Goedert, Diego Gomez Oliveira, Elena Granda Alonso, Philipp Gräser, Kate Greenwood, Nathalie Grotz, Lynn Grund, J. Guelf, Jean-Michel Guinet, Nico Haagen, Camille Hahn, Jenny Hans, Johanna Hardenberg, Marc Hastert, Claude Heidt, Marcel Hellers, Thierry Helminger, J. Hermann, Jan Herr, Raoul Heusbourg, Vic Hilger, Jörg Hilgers, Lucien Hoffmann, J. Hoffmann, Tom Hoffmann, Eike Jablonski, Kevin Jans, Marc Jans, Alan Johnston, Claudine Junck, Marie Kayser, Martine Kemmer, Constant Kemp, Sonja Kettenmeyer, Luc Kieffer, Elisabeth Kirsch, Pierre Kirsch, Katharina Klein, Fernand Klopp, Francis Knoch, Lucien Knol, Marie Koll, Claude Kolwelter, Yves Krippel, François Kuborn, Karsten Kuepper, Cathia Lahure, P. Lambert, Henriette Larsel, Max Lauff, Lionel L'Hoste, Daniela Livada, Dave Lutgen, Jeremy Majerus, Luc Majerus, Jean-Marie Mangen, David Marcus, Philip Markosso, Youri Martin, Nicolas Mayon, Coby Meester, Bob Meewis, Claude Meisch, Edouard Melchior, Florence Menage, Xavier Mestdagh, D. Meyer, Marc Meyer, Joosje Misbeek, Nadine Modert, Georges Moes, Mireille Molitor, Mikka Mootz, Alfred Mousset, Hubert Mullenberger, Léon Muller, Sonja Naumann, René Neumann, Friedhelm Nippel, Francesca Olivero, Max Oly, Marc Owaller, Malika Pailhès, Nico Pantaleoni, John Park, Alphonse Pelles, Marianne Peltier, Raymond Peltzer, Claude Pepin, Louis Perrette, Manou Pfeiffenschneider, Luana Plantone, Roland Proess, Eva Rabold, Timo Ranki, Paul Rassel, Léopold Reichling, Thomas Reinelt, Julien Reiners, Philippe Reinert, Jenny Renaut, Erwin Rennwald, Frank Richarz, Jean-Philippe Rolin, Oliver Röller, Pierre Rosman, Georges Rothe, Claude Schiltz, Nathalie Schirtz, Gérard Schmidt, Lucille Schmitz, Nico Schneider, Simone Schneider, Louis Scholer, Heinz Schon, Fernand Schoos, Romain Schoos, Armin Schopp-Guth, Isabelle Schrankel, Max Schroeder, Monika Schulz, Lisa Siebenaler, Evan Smolen, Frank Sowa, Theo Speaight, Raf Stassen, Aloysius Staudt, Corinne Steinbach, Max Steinmetz, Norbert Stomp, Ronny Strätling, Marc Theis, Marc Thiel, Arthur Thill, Jos Thill, P. Thill, Julie Thillen, Marie-Thérèse Tholl, Steve Thoma, Patrick Thommes, Philippe Thonon, Nicolas Titeux, Emma Trignol, Armand Turpel, Rainer Ulrich, Fernando Useros Lopez, Chris van Swaay, John Vangestel, Arnold Vanvliet, Paulo Veloso, Francesco Vitali, Sarah Vray, Camille Wagner-Rollinger, Tania Walisch, Sophie Wambach, Philippe Waxweiler, Dieter Weber, Odile Weber, Andrée Weigel, André Weiler, Carmen Weisgerber, Pit Weisgerber, Jean Weiss, Jean-Claude Weiss, Matthias Weitzel, Jean-Paul Welz, Andreas Werno, Wolfgang Wipking, Christiane Wolff, Claire Wolff, Jean-Paul Wolff, Anne Wolter and, Andreas Zapp.

Abstract

Butterflies are one of the most studied and best surveyed groups of insects worldwide. They have a positive image among the public and their conspicuousness and colourfulness make them easy to identify at the species level in the field. As they are found in many biotopes and are particularly sensitive to climate conditions, habitat degradation, pesticides and other forms of pollution, butterflies are often used as indicators reflecting the impacts of environmental change on biodiversity.

Butterfly recording in Luxembourg started in the 1850s and the first atlas and Red List of butterflies were both published in the 1980s, with an update of the Red List in 2000. Since then, several studies in Europe and beyond have reported important declines in butterflies. The Luxembourg Butterfly Monitoring Scheme (LUBMS) was initiated in 2010 to collect standardised data on butterfly populations across the country and to better document the changing state of biodiversity at a national scale. Building on the amount of data collected during the last decade, this book provides an updated overview of the distribution and trends of butterflies in Luxembourg.

Butterfly records were extracted in May 2021 from the national biological database of the National Museum of Natural History of Luxembourg and from specific databases made available by other institutions in Luxembourg. A total of 154,218 records collected according to pre-defined and structured procedures (standardised records) or without applying any standardised approach (casual records) were used to depict the current (2010-2020), recent (1990-2009) and historical (before 1990) distribution for each butterfly species across the country. Quantitative methods were implemented to account for the heterogeneous survey efforts over time when comparing the current and past distribution of the species.

Data extracted from databases include records of 125 butterfly species and 5 species complexes (i.e., groups of closely related species almost indistinguishable in the field): 15 species considered as with dubious presence, 15 species considered as encoding mistakes, 95 species and 5 species complexes considered as having been recorded in Luxembourg until 2020. For the latter, detailed information is provided on their current, recent, and historical distribution in Luxembourg, their trends in the country, their habitat requirements (including most frequently used biotopes, host plants for caterpillars and nectar resources for adults), their lifecycle and flight season, and the most important challenges for their conservation. For each species, maps show the temporal changes in their national distribution and, when enough data were available, the modelled availability of suitable habitats across the country at high spatial resolution. Distribution changes along with other criteria were used to evaluate the risk of extinction for each species based on the International Union for Conservation of Nature (IUCN) Red List system. Fifteen species have gone regionally extinct between 1854 and 2003. Among the 76 extant butterfly species that were evaluated against the IUCN criteria, 24 are threatened with extinction (among which 6 are critically endangered) and 7 are near threatened. The remaining 45 species are of least conservation concern, but more than half of them are experiencing a decrease in their area of occupancy. The southwestern part of the country (Minette) is the region harbouring the highest species richness and the highest number of species threatened with extinction – it is among the Prime Butterfly Areas in Europe. Management recommendations are provided for each butterfly species individually but also for the main types of biotopes (e.g., grasslands, heathlands, forests, urban areas) used by butterflies in Luxembourg.

Altogether, the distribution maps, Red List assessment and management recommendations presented here provide practitioners and other stakeholders with new knowledge and data for better conservation actions and for informed decision-making. The long-term continuation of the ongoing LUBMS programme need to be guaranteed because future assessments of trends in butterfly abundance and distribution will gain in robustness as more standardised data become available. An increasing number of citizen scientists are engaging in the LUBMS programme and other pollinator monitoring initiatives across the country; this will undoubtedly contribute to increasing our capacity to evaluate the conservation status of butterflies in Luxembourg.

1 Introduction to butterflies in Luxembourg

Sarah Vray[1,✉], Xavier Mestdagh[1], Lisette Cantú-Salazar[1], Lionel L'Hoste[1], Youri Martin[1] and Nicolas Titeux[1]

[1] Luxembourg Institute of Science and Technology (LIST)
5 Avenue des Hauts-Fourneaux
L-4362 Esch-sur-Alzette, Luxembourg

✉ Corresponding author: sarah.vray@list.lu

1.1 Taxonomy and ecology of butterflies

Butterflies are insects belonging to the order Lepidoptera (from the Greek "lepis" meaning scale and "pteron" meaning wing), which also includes moths. They are characterised by their proboscis coiled in a spiral at rest and which can expand to suck up the nectar of flowers, as well as by their four wings covered by thousands of coloured scales overlapping one another like roof tiles. Butterflies (i.e., Rhopalocera) can be distinguished from moths (i.e., Heterocera) based on three criteria: they are all diurnal (although several moths are too, such as zygaenids), their thin antennae end up in clubs (and are not filiform, comb-shaped, or feathery; Fig. 1.1), and their wings are vertical at rest (and not flat on the body) or parallel to the ground when basking (except for the Hesperiidae family, i.e., skippers). In 2007, there were about 160,000 species of Lepidoptera described around the world, with an average of about a thousand new species described yearly (Kristensen, Scoble & Karsholt 2007). A total of 482 butterfly species were recorded in continental Europe (excluding the Caucasus region), of which 142 are endemic (i.e., are found nowhere else in the world than in Europe; van Swaay et al. 2010).

Butterflies go through four distinctive stages during their development (Fig. 1.2): egg, caterpillar (or larva), chrysalis (or pupa), and adult (or imago). They are called Endopterygota (or Holometabola) because they undergo a complete metamorphosis between the pupal and the adult stages. The duration of the larval stage varies from about two weeks to two years depending on the species and the region where it lives. For 67% of the European species, individuals overwinter at the larval stage (Munguira, Garcia-Barros & Cano 2009). Males usually emerge from their chrysalis before females, which allows them to easily find females to mate. Adults can live from a few days to several months depending on the species. Around 66% of European species are univoltine (i.e., they have one generation per year) and others are bi- or multivoltine (i.e., they have two or more generations per year), or even biennial (i.e., they take two years to complete their lifecycle), sometimes with a latitudinal and altitudinal variation. In general, the number of generations per year, the timing and duration of each developmental stage and the individual longevity are strongly influenced by larval and adult feeding habits and by climatic conditions (Settele et al. 2009). For example, higher temperatures induce faster larval growth and the lengthening of the favourable season caused by global warming can increase the number of generations per year (Altermatt 2010; Settele et al. 2009), which can be detrimental to some butterfly species (e.g., for *Lasiommata megera;* Van Dyck et al. 2014).

With a few exceptions, most butterfly caterpillars are phytophagous. They feed on plant leaves and are often specialised on a very limited number of host-plant species, and sometimes even on a single species or on plants growing in specific microclimatic conditions. In contrast, adults are more generalist in their diet. They eat nectar from a multitude of nectariferous plants (and sometimes sap, decomposed food, and animal waste), although they can show different floral preferences depending on sex and species (Erhardt 1991). As they feed on nectar, adults fly from flower to flower and thus contribute to their pollination.

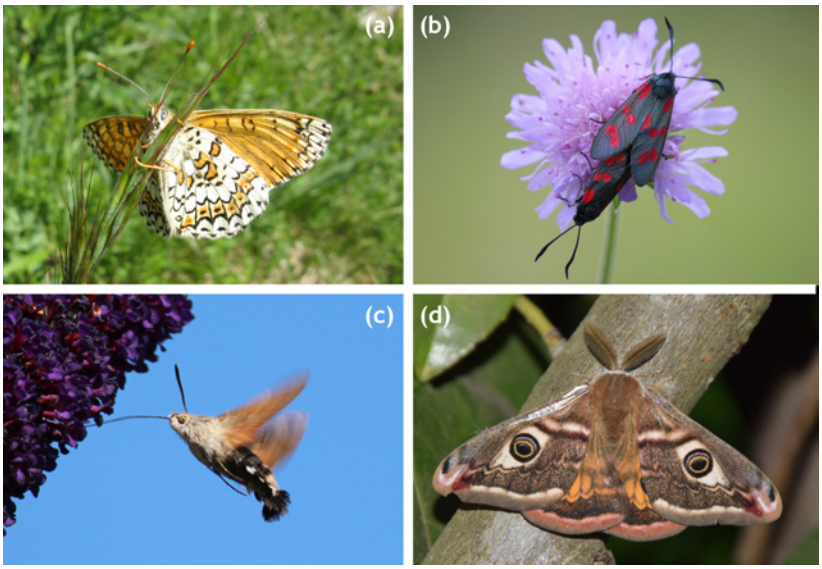


Fig. 1.1: Butterflies have thin antennae ending up in clubs, such as (a) *Melitaea cinxia*, while moths mainly have filiform antennae, such as (b) *Zygaena filipendulae* and (c) *Macroglossum stellatarum*, or comb-shaped / feathery antennae, such as (d) *Saturnia pavonia.* Photos a, b, c: Sarah Vray; d: Francis Birlenbach.

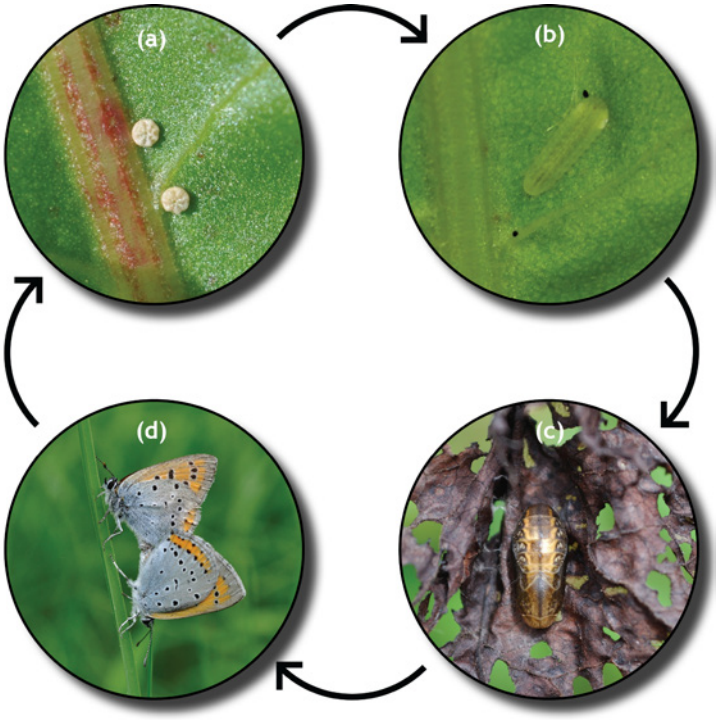


Fig. 1.2: Lifecycle of the Large copper (*Lycaena dispar):* (a) eggs; (b) caterpillar (or larva); (c) chrysalis (or pupa); and (d) adults (or imagoes). Photos a, b, c: Youri Martin; d: Sarah Vray.

Habitats for butterflies can greatly vary from one species to another. The habitat of a species is defined as the set of biophysical resources and conditions necessary to complete its lifecycle, including its reproduction (Dennis, Shreeve & Van Dyck 2003; Hall, Krausman & Morrison 1997). Butterfly habitat may include different biotopes (i.e., areas distinguished by particular and uniform environmental conditions, such as soil, vegetation and climate, that host a characteristic assemblage of organisms, e.g., woodland, heathland; Calow 1999), each containing resources needed at a particular stage of the butterfly's lifecycle. Food resource quality and availability play a key role in determining the dynamics of butterfly populations in a landscape. It includes the host plant(s) for the larvae, as well as the nectar resources for adults, which should be closely connected in space depending on the dispersal abilities of the species. Sexual partners are also a resource to consider. Males can spend a considerable amount of time searching for a female, and they may need particular landscape features depending on their behavioural strategy (e.g., territorial males). Females need favourable sites to lay their eggs, on or close to the host plants for the larvae. Furthermore, as butterflies are ectothermic species (i.e., their main heat source is external and not metabolic), weather and (micro-)climatic conditions (temperature, humidity, insolation, wind speed…) also strongly affect their habitat use, as well as their population dynamics and spatial distribution (Hill et al. 2002; Warren et al. 2001). For instance, females of *Pararge aegeria* lay their eggs almost exclusively under direct sunlight (Braem & Van Dyck 2021), and their caterpillar need particular temperature and humidity levels to accomplish their development (Gibbs, Wiklund & Van Dyck 2011).

Finally, interactions with other animal species, such as competitors, parasites, and predators (e.g., birds, lizards, spiders) can also affect the populations and distribution of butterflies (e.g., Stefanescu 2000). Most of European butterfly species are affected by parasitoids (Shaw, Stefanescu & Van Nouhuys 2009), i.e., insects (mainly from Diptera and Hymenoptera orders) whose larvae feed on the eggs, larvae, pupae, or adults of other insects. Parasitoids can have severe impacts on the populations of their host butterflies, such as *Euphydryas aurinia* and *Aporia crataegi* (Gripenberg et al. 2011; Klapwijk & Lewis 2014). Along with parasitism, other types of symbiotic interactions (i.e., long-term interactions between two different species) also exist. In the Lycaenidae family, many species benefit from ants as an additional resource in their habitat (Pierce et al. 2002). These butterflies have a symbiotic association with ants (sometimes specialised to only one or two ant species), which can be either mutualistic, such as for *Plebejus argus*, where ants protect their caterpillars in exchange of food (Jordano et al. 1992), or parasitic, such as for species from the *Phengaris* genus (e.g., *P. arion*), where caterpillars are fed by the adult ants or directly feed on ants' brood (Als et al. 2004; Thomas & Wardlaw 1992). As several of these species (e.g., *Plebejus argus* and *Phengaris arion*) are completely dependent on ants, their populations are also constrained by the habitat requirements of their host-ant species.

Several ecological profiles exist among butterflies, based on their life history traits (e.g., habitat use, climatic requirements, dispersal abilities). Some species are generalist in their resource use; they tend to use a high variety of host plants and nectar resources and occur in a large range of biotopes (e.g., *Maniola jurtina* and *Pieris napi*). In contrast, specialist butterflies tend to use a smaller number of host-plant species and are found in particular biotopes. This is for example the case of *Boloria eunomia*, which is mainly observed in wetlands, where females lay their eggs only on the host plant *Bistorta officinalis* and adults only feed on flowers of this same plant species. However, some specialist species are not necessarily rare. The caterpillar of *Aglais urticae* is specialised on a very common plant species (*Urtica dioica*), so that the butterfly is also ubiquitous. The distinction between generalists and specialists can sometimes change according to the resources needed during the different developmental stages. For example, most species are specialist with respect to their larval host plants but generalist regarding their nectar resources. Moreover, this can also vary regionally or along climatic gradients. For instance, the British populations of several species tend to be more specialised than their conspecific European populations (Dennis 1977). Ecological profiles of butterfly species can highly influence their population trends. Generally, the least declining species are the most mobile and generalist ones, or the ones specialised on common and widespread resources and biotopes (Warren et al. 2021).

1.2 Butterflies as indicators of environmental conditions

Butterflies are known to be particularly sensitive to environmental changes (Parikh, Rawtani & Khatri 2021; Thomas et al. 2004; Van Dyck et al. 2015), and the presence or absence of these organisms closely reflects the quality of the environment. An increase or decrease in their diversity in an area informs about its changing quality and functionality, as well as on the impact of that change on plants and animals in interaction with butterflies or using the same resources. They are therefore often used as bioindicators in ecological studies or for the implementation and monitoring of restoration and conservation actions (Legal et al. 2020; Syaripuddin, Sing & Wilson 2015; Thomas 2005). This criterion of sensitivity to environmental changes, their positive image amongst the public, and their conspicuousness and colourfulness making them easy to identify at the species level in the field, make butterflies one of the most studied groups of insects in the world.

1.3 Butterflies and global environmental change

According to the IUCN Red List for butterflies of continental Europe (van Swaay et al. 2010), about a third of the 435 assessed species experienced a decline in their populations between 2000 and 2010 in Europe, with 8.5% threatened and 10% near threatened species. The major threats are land use changes causing loss and fragmentation of butterfly habitats, climate change, as well as pesticides and pollution (Thomas 2016; Warren et al. 2021).

The most impacting land use changes for butterflies are the modifications of agricultural practices, especially in grasslands. Grasslands experienced severe changes during the last century that had a negative impact on butterflies, for instance by reducing host plant availability and nectar supply. In many European countries, the main changes in grasslands were intensification of mowing and grazing, massive use of nitrogen fertilisers (leading to the homogenisation of the flora), conversion of grasslands to arable crops, drainage of wetlands to convert them into spruce plantations, and land abandonment (leading to shrub encroachment). Changes in woodland management (e.g., planting of exotic coniferous trees, abandonment of coppicing) can also be a threat to forest butterflies relying on clearings, forest edges or forests with low canopy density (Warren et al. 2021). All these modifications led to the conversion of large and continuous areas with favourable butterfly habitat into small patches isolated from each other within anthropogenic landscapes (Thomas 2016). Butterfly populations that survive in these residual patches are confronted with a reduced habitat extent (which can host a smaller number of individuals) as well as limited exchanges of individuals with other populations, which makes them more vulnerable to local extinctions due to environmental, demographic, and genetic stochastic events (Fischer & Lindenmayer 2007; Frankham 2005; Hanski, Moilanen & Gyllenberg 1996).

With land use, climate is the main factor determining the geographical distribution of a species. Each species has its own range of climatic conditions under which it can persist (i.e., its climatic niche; e.g., Martin et al. 2020). Climate change can affect butterflies both directly (e.g., their physiology and phenology) and indirectly, for example by altering the temporal and spatial synchrony with species in interaction with them (e.g., host plants, nectar resources, parasites; e.g., Donoso et al. 2016). Extreme climatic events, such as droughts, can also have severe impacts on butterflies (McDermott Long et al. 2017). With global warming, the climatic niches of most species are moving poleward or upward (Chen et al. 2011; Parmesan et al. 1999; Rödder et al. 2021; Wilson et al. 2005). In Europe, butterflies have not been able to track this shift fast enough (Devictor et al. 2012), mostly due to the fragmentation of their habitats that decreases the connectivity between suitable areas for such organisms with limited dispersal abilities. In 2008, the Climatic Risk Atlas of European Butterflies (Settele et al. 2008) predicted that, by 2080, 24% of the 294 modelled species would lose more than 95% of climatically suitable areas and 78% would lose more than 50%, under the worst-case scenario of climate change. Some species have however been very successful in expanding their northern range limit, such as *Pieris mannii* which reached Luxembourg in the 1970s (Goedert 2014), *Brenthis daphne* which reached Germany in mid-1990s (Settele et al. 2008), or *Lycaena dispar* which reached the border

of the Ardennes massif in 2010s (Martin, Titeux & Van Dyck 2021) and is predicted to continue its expansion in the future (Martin et al. 2013).

Pesticides (mainly insecticides and herbicides) and pollution (mainly nitrogen deposits) also have a negative impact on both adult butterflies and caterpillars, directly or indirectly (Davis, Lakhani & Yates 1991; Gilburn et al. 2015; Kurze, Heinken & Fartmann 2018; Öckinger et al. 2006). Furthermore, as some species have their caterpillars feeding on crop plants, they are considered as "pests" in agriculture (e.g., *Pieris brassicae* and *P. rapae* feeding on cabbage) and are not protected in many countries.

1.4 Environmental conditions in Luxembourg

The Grand Duchy of Luxembourg covers 2,586 km^2. Around one-third is currently covered by forests, and around half is used for agriculture (Fig. 1.3a). The country has experienced strong human population growth especially over the last 30 years, from 379,300 inhabitants in 1990 to 626,108 in 2020 (STATEC / CTIE 2021). Consequently, built-up areas covered from 4.3% of the country in 1990 to 10.1% in 2019 (Administration du Cadastre et de la Topographie 2020). In parallel, the cover of agricultural and wooded areas decreased from 91.8% in 1990 to 84.8% in 2019.

The country is divided in two major geological areas: the Oesling in the North and the Gutland in the South (Fig. 1.3b). The Oesling (or Éislek) is a plateau at an altitude from 400 to 550 m covering around one third of the country. It is part of the Ardennes massif (i.e., extension of the Ardennes massif in Belgium, the Eifel and the Hunsrück in Germany) and has a silty-stony soil coming from the schistose bedrock. The Oesling is a homogeneous ecological region in its own and is characterised by a semi-mountainous landscape with narrow and deep valleys, mainly covered with conifers. The Gutland (or Guttland) is a hilly plain at an altitude from 250 to 400 m covering the remaining two third of the country. Its geology is mainly composed of sandstone and marl from the Jurassic-Triassic formations (i.e., extension of Lorraine in France and Belgium, and Bitburger Gutland in Germany), and its landscape is characterised by cuestas, i.e., an alternation of valleys (sometimes with rocky cliffs) and hills with silty cover. The south-western part of the Gutland is the ecological region called Minette (or Minett) and covers 4% of the country. It is a former mining basin exploiting deposits rich in iron ore and characterised by clay-stony soil on limestone. The landscape of this region has been heavily modified by the underground (1850-1981) and open-pit (1948-1965) mining for iron ore extraction and steel industry. Finally, the south-eastern part of the Gutland is the ecological region called Moselle (or Musel) and covers only 2% of the country. The Moselle valley is enclosed between dolomitic cliffs but also widens in broad alluvial plains. This region is mainly covered with vineyards introduced during the period of the Roman Empire. Detailed elevation, geological and pedological maps of Luxembourg can be consulted on geoportail.lu or downloaded from data.public.lu.

The Natura 2000 network covers 702 km^2 (27% of the country) in Luxembourg (Fig. 1.3b). It includes 416 km^2 and 419 km^2 of sites protected under the European Habitats (92/43/EEC) and Birds (79/409/EEC) Directives, respectively, with some of them partially overlapping.

Luxembourg has a continental climate approaching the sub-Atlantic climate. This temperate and humid climate is characterised by relatively cold and wet winters, and relatively cool and rainy summers (Fig. 1.4), with annual mean temperature of 9.7°C and annual mean precipitation of 800 mm between 1990 and 2020 in the Gutland (MeteoLux 2020). Temperatures in the Oesling are generally lower than in the Gutland. Climate data can be downloaded on data.public.lu.

1.5 Butterfly recording in Luxembourg

The first checklist of butterflies in Luxembourg dates back to the 1850s, with the publications of Dutreux from 1853 to 1856 (e.g., Dutreux 1853), followed by Müllenberger in 1901-1906 (e.g., Müllenberger 1901) and by Wagner-Rollinger in 1950-1979 (Wagner-Rollinger 1980). In 1979, a Luxembourgish naturalist journal dedicated to insects ("Päiperlek Lëtzebuerger Entomologesch Zäitschrëft", 1979-1990) was created by the Luxembourg Naturalist Society (SNL, "Société des

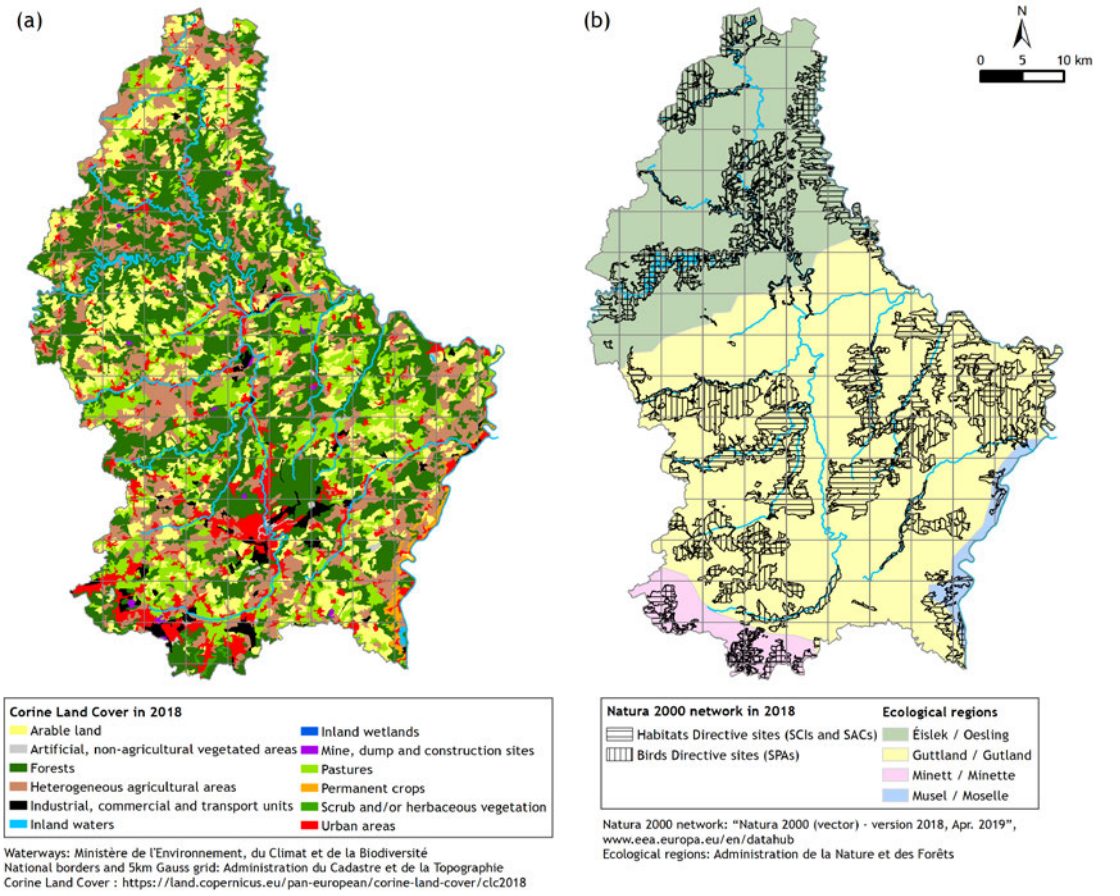


Fig. 1.3: (a) Land cover of Luxembourg in 2018; (b) The main ecological regions and the Natura 2000 network existing in 2018, composed of sites designated under the Habitats Directive (SCIs: Sites of Community Importance, and SACs: Special Areas of Conservation) and the Birds Directive (SPAs: Special Protection Areas).

naturalistes luxembourgeois"). The first study on the biotopes used by butterflies in Luxembourg was published in 1980 (Wagner-Rollinger 1980). One year later, the first preliminary butterfly atlas of Luxembourg was published (Meyer & Pelles 1981a). The preliminary atlas, produced with a small amount of data available at the time (as compared to the present atlas), reported 92 species recorded between 1960 and 1980. In the same year, the first Red List of Luxembourg's butterflies and moths reported 9 butterfly species as already extinct in the country, and 47 species were classified in one of several threatened categories (Meyer & Pelles 1981b). In the frame of several specific studies, local assemblages of butterflies were then recorded in some species-rich sites, such as the "Haardt" area, a former mining site converted into a nature reserve in the south-east of the Minette (Cungs 1991).

As a growing number of studies have shown that butterflies are declining across Europe (van Swaay, Warren & Loïs 2006; Warren et al. 2021), there has been an urgent need to monitor their populations in order to understand the drivers of decline and to guide conservation practices. Standardised methods are key to record butterflies in a comparable manner over time and estimate trends in their distribution and abundance. To this aim, the Luxembourg Butterfly Monitoring Scheme (LUBMS) was initiated in 2010, using standardised field procedures for data recording each year across the country in a set of around 30 sites.

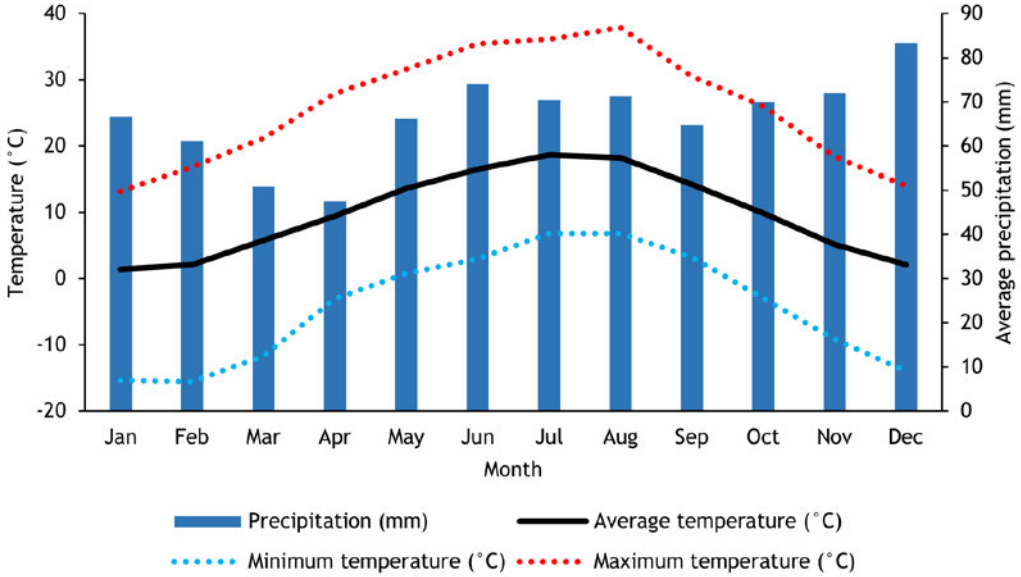


Fig. 1.4: Climograph showing the monthly average, minimum and maximum temperatures and the monthly average precipitation during the period 1990-2020 in Luxembourg Findel Airport (in the Gutland), 376m altitude (MeteoLux 2020).

As the sites were selected randomly, the spatial distribution of the sampling effort allows for an adequate representation of the various environmental conditions prevailing in the country (see details in Chapter 2). After only one year of sampling, three species considered as absent or extinct from Luxembourg in 1981 were recorded (Mestdagh et al. 2011). In 2016, the LUBMS joined the European Butterfly Monitoring Scheme (eBMS; www.butterfly-monitoring.net), which aims to gather national BMS datasets and standardise sampling protocols from several European countries. These records have been contributing to the development of several large-scale butterfly indicators used by the European Environment Agency (e.g., van Swaay et al. 2011, 2019, 2022).

Nowadays, anyone interested can participate in the recording of butterflies in Luxembourg. Butterflies are recorded for different purposes such as creating species checklist, documenting species distributions, describing their ecology, assessing population abundance and trends, supporting the implementation of site conservation or restoration strategies, or simply as a hobby. As the conditions in which observations are recorded influence their potential usefulness for scientific studies and assessments, two types of butterfly surveys are currently part of the LUBMS. They are both co-operated by the Luxembourg Institute of Science and Technology (LIST) and natur&ëmwelt, with financial support of the Ministry of the Environment, Climate and Biodiversity (MECB) (see Chapter 2 for details). First, the transect-based butterfly survey uses the Pollard walk method (Pollard 1977), according to which recorders count the number of individuals of each butterfly species along pre-defined transects in the 30 randomly selected sites (see above), during repeated surveys along the season. Second, the site-based butterfly survey is targeting specific biotopes (e.g., dry meadows) and therefore habitat specialists. It uses the timed count method in which the number of individuals of each butterfly species is estimated in a predefined site for 15 minutes. Since 2020, both types of surveys have been using the "ButterflyCount" mobile app (https://butterfly-monitoring.net/ebms-app), developed by Butterfly Conservation Europe and the UK Centre for Ecology and Hydrology for the recording of European butterfly observations and connected to the web portal www.butterfly-monitoring.net. Beside these two main types of standardised surveys, any opportunistic observations are easily recorded through the data portal of the National Museum of Natural History of Luxembourg

(MNHNL; www.data.mnhn.lu), the institution responsible for the management of knowledge on the natural heritage in Luxembourg. The MNHNL manages the centralisation of naturalistic records in a database commonly known as RECORDER (https://mdata.mnhn.lu/). This database also gathers observations encoded through the iNaturalist web portal and mobile app (www.inaturalist.lu) as well as data from the Global Biodiversity Information Facility (GBIF; www.gbif.org).

1.6 Rationale for a butterfly atlas in Luxembourg

Studies reporting the decline of butterflies are plentiful in Europe (e.g., van Swaay, Warren & Loïs 2006; Warren et al. 2020, van Swaay et al. 2022). In order to identify the species most at risk of extinction at the national level, it is crucial to document the geographical distribution of each species as well as its dynamics over time. As butterfly survey has considerably intensified in Luxembourg since the preliminary atlas (Meyer & Pelles 1981a) and Red List (Meyer & Pelles 1981b), the publication of the present atlas is both timely and important.

In this atlas, we first focus on describing the data and methods used to generate the species distribution maps and trends (**Chapter 2**). In **Chapter 3**, we assess the extinction risk of the butterfly species breeding in Luxembourg using the IUCN categories and criteria. In the species accounts (**Chapter 4**), we present each butterfly species recorded in Luxembourg with information on its lifecycle (including the phenology of adult records), habitat requirements (including host-plant species), geographical distribution, availability of suitable habitats, population trend and specific recommendations for management. In **Chapter 5**, we synthesise the main biotopes important for butterflies, their conservation status in Luxembourg, and options for their management.

1.7 References

Administration du Cadastre et de la Topographie 2020. - Territory and environment. Land use 1972 - 2019. Available at: https://statistiques.public.lu/stat/TableViewer/tableView.aspx.

Als T. D., Vila R., Kandul N. P., Nash D. R., Yen S. H., Hsu Y. F., Mignault A. A., Boomsma J. J. & Pierce N. E. 2004. - The evolution of alternative parasitic life histories in large blue butterflies. Nature 432: 386–390.

Altermatt F. 2010. - Climatic warming increases voltinism in european butterflies and moths. Proceedings of the Royal Society B: Biological Sciences 277: 1281–1287.

Braem S. & Van Dyck H. 2021. - On the role of direct sunlight for egg-laying behaviour: lessons and ideas from the Speckled wood. Ecological Entomology 46: 800–806.

Calow 1999. - Blackwell's Concise Encyclopedia of Ecology (11th ed.). Blackwell Sciences, Oxford, UK, 168 p.

Chen I. C., Hill J. K., Ohlemüller R., Roy D. B. & Thomas C. D. 2011. - Rapid range shifts of species associated with high levels of climate warming. Science 333: 1024–1026.

Cungs J. 1991. - Beitrag zur Faunistik und Ökologie der Schmetterlinge im ehemaligen Erzabbaugebiet "Haardt" bei Düdelingen (Insecta, Lepidoptera). Travaux scientifiques du Musée d'histoire naturelle de Luxembourg 17: 1–364.

Davis B. N. K., Lakhani K. H. & Yates T. J. 1991. - The hazards of insecticides to butterflies of field margins. Agriculture, Ecosystems and Environment 36: 151–161.

Dennis R. L. H. 1977. - The British Butterflies. Their Origin and Establishment. E. W. Classey, Faringdon, UK, 336 p.

Dennis R. L. H., Shreeve T. G. & Van Dyck H. 2003. - Towards a functional resource-based concept for habitat: a butterfly biology viewpoint. Oikos 102: 417–426.

Devictor V., van Swaay C., Brereton T., Brotons L., Chamberlain D., Heliölö J., Herrando S., Julliard R., Kuussaari M., Lindström Å., Reif J., Roy D. B., Schweiger O., Settele J., Stefanescu C., Van Strien A., Van Turnhout C., Vermouzek Z., WallisDeVries M., Wynhoff I. & Jiguet F. 2012. - Differences in the climatic debts of birds and butterflies at a continental scale. Nature Climate Change 2: 121–124.

Donoso I., Stefanescu C., Martínez-Abraín A. & Traveset A. 2016. - Phenological asynchrony

in plant–butterfly interactions associated with climate: a community-wide perspective. Oikos 125: 1434–1444.

Dutreux A. 1853. - Index des Lépidoptères recueillis dans le Grand-Duché de Luxembourg (avec indication des espèces qui s'y rencontrent, des localités où on les trouve et des plantes servant de nourriture aux chenilles). Institut Grand-Ducal Section Science 1: 134–144.

Erhardt A. 1991. - Flower preferences, nectar preferences and pollination effect of Lepidoptera. Advances in Ecology 1: 239–260.

Fischer J. & Lindenmayer D. B. 2007. - Landscape modification and habitat fragmentation: a synthesis. Global Ecology and Biogeography 16: 265–280.

Frankham R. 2005. - Genetics and extinction. Biological Conservation 126: 131–140.

Gibbs M., Wiklund C. & Van Dyck H. 2011. - Temperature, rainfall and butterfly morphology: does life history theory match the observed pattern? Ecography 34: 336–344.

Gilburn A. S., Bunnefeld N., McVean Wilson J., Botham M. S., Brereton T. M., Fox R. & Goulson D. 2015. - Are neonicotinoid insecticides driving declines of widespread butterflies? PeerJ 2015: 1–13.

Goedert C. 2014. - Ökologische Untersuchungen zu den Populationen von Pieris mannii Mayer 1851 nördlich der Alpen und speziell im Naturschutzgebiet Haardt bei Düdelingen (Lepidoptera, Pieridae). Lycée technique de Bonnevoie, 96 p.

Gripenberg S., Hamer N., Brereton T., Roy D. B. & Lewis O. T. 2011. - A novel parasitoid and a declining butterfly: Cause or coincidence? Ecological Entomology 36: 271–281.

Hall L. S., Krausman P. R. & Morrison M. L. 1997. - The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25: 173–182.

Hanski I., Moilanen A. & Gyllenberg M. 1996. - Minimum Viable Metapopulation Size. The American Naturalist 147: 527–541.

Hill J. K., Thomas C. D., Fox R., Telfer M. G., Willis S. G., Asher J. & Huntley B. 2002. - Responses of butterflies to twentieth century climate warming: Implications for future ranges. Proceedings of the Royal Society B: Biological Sciences 269: 2163–2171.

Jordano D., Rodríguez J., Thomas C. D. & Fernández Haeger J. 1992. - The distribution and density of a lycaenid butterfly in relation to Lasius ants. Oecologia 91: 439–446.

Klapwijk M. J. & Lewis O. T. 2014. - Spatial ecology of host-parasitoid interactions: A threatened butterfly and its specialised parasitoid. Journal of Insect Conservation 18: 437–445.

Kristensen N. P., Scoble M. J. S. & Karsholt O. 2007. - Lepidoptera phylogeny and systematics: The state of inventorying moth and butterfly diversity. Zootaxa 1668: 699–747.

Kurze S., Heinken T. & Fartmann T. 2018. - Nitrogen enrichment in host plants increases the mortality of common Lepidoptera species. Oecologia 188: 1227–1237.

Legal L., Valet M., Dorado O., de Jesus-Almonte J. M., López K. & Céréghino R. 2020. - Lepidoptera are relevant bioindicators of passive regeneration in tropical dry forests. Diversity 12: 231.

Martin Y., Titeux N. & Van Dyck H. 2021. - Range expansion, habitat use and choosiness in a butterfly under climate change: marginality and tolerance of oviposition site selection. Ecology and Evolution ece3.7202: 1–10.

Martin Y., Van Dyck H., Dendoncker N. & Titeux N. 2013. - Testing instead of assuming the importance of land use change scenarios to model species distributions under climate change. Global Ecology and Biogeography 22: 1204–1216.

Martin Y., Van Dyck H., Legendre P., Settele J., Schweiger O., Harpke A., Wiemers M., Ameztegui A. & Titeux N. 2020. - A novel tool to assess the effect of intraspecific spatial niche variation on species distribution shifts under climate change. Global Ecology and Biogeography 29: 590–602.

McDermott Long O., Warren R., Price J., Brereton T. M., Botham M. S. & Franco A. M. A. 2017. - Sensitivity of UK butterflies to local climatic extremes: which life stages are most at risk? Journal of Animal Ecology 86: 108–116.

Mestdagh X., Baltus H., Renneson J.-L., Hoffmann L. & Titeux N. 2011. - Espèces nouvelles et retrouvées chez les papillons de jour au Luxembourg. Bulletin de la Société des naturalistes luxembourgeois 112: 97–108.

MeteoLux 2020. - Climate data from 1.1.1990 to 31.12.2019, in Station Meteolux Luxemburg Flughafen Findel. Available at: https://www.meteolux.lu.

Meyer M. & Pelles A. 1981a. - Atlas provisoire des Insectes du Grand-Duché de Luxembourg. Lepidoptera, lère partie. Travaux scientifiques du Musée d'histoire naturelle de Luxembourg 1: 1–147.

Meyer M. & Pelles A. 1981b. - Rote Liste der Schmetterlinge Luxemburgs. Bulletin de la Société des naturalistes luxembourgeois 83–84: 41–52.

Müllenberger H. 1901. - Beiträge zu der Schmetterlingskunde des Luxemburger Landes. Bulletin de la Société des naturalistes luxembourgeois 11: 420–423.

Munguira M. L., Garcia-Barros E. & Cano J. M. 2009. - Butterfly herbivory and larval ecology. : 43–54, in Settele J., Shreeve T., Konvicka M. & Van Dyck H. (eds.), Ecology of Butterflies in Europe. Cambridge University Press, Cambridge, 513 p.

Öckinger E., Hammarstedt O., Nilsson S. G. & Smith H. G. 2006. - The relationship between local extinctions of grassland butterflies and increased soil nitrogen levels. Biological Conservation 128: 564–573.

Parikh G., Rawtani D. & Khatri N. 2021. - Insects as an Indicator for Environmental Pollution. Environmental Claims Journal 33: 161–181.

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

Pierce N. E., Braby M. F., Heath A., Lohman D. J., Mathew J., Rand D. B. & Travassos M. A. 2002. - The Ecology and Evolution of Ant Association in the Lycaenidae (Lepidoptera). Annual Review of Entomology 47: 733–771.

Pollard E. 1977. - A method for assessing changes in the abundance of butterflies. Biological Conservation 12: 115–134.

Rödder D., Schmitt T., Gros P., Ulrich W. & Habel J. C. 2021. - Climate change drives mountain butterflies towards the summits. Scientific Reports 11: 1–12.

Settele J., Kudrna O., Harpke A., Kühn I., van Swaay C., Verovnik R., Warren M., Wiemers M., Hanspach J., Hickler T., Kühn E., van Halder I., Veling K., Vliegenthart A., Wynhoff I. & Schweiger O. 2008. - Climatic Risk Atlas of European Butterflies. BioRisk 1: 1–712.

Settele J., Shreeve T., Konvicka M. & Van Dyck H. 2009. - Ecology of Butterflies in Europe (1st ed.). Cambridge University Press, Cambridge, 513 p.

Shaw M. R., Stefanescu C. & Van Nouhuys S. 2009. - Parasitoids of European butterflies. : 130–156, in Settele J., Shreeve T. G., Konvicka M. & Van Dyck. H. (eds.), Ecology of Butterflies in Europe. Cambridge University Press, Cambridge, 513 p.

STATEC / CTIE 2021. - Population and employment. Evolution of total, luxembourgish and foreign population on 1st January 1961 - 2021. Available at: https://statistiques.public.lu/stat/TableViewer/tableView.aspx.

Stefanescu C. 2000. - Bird predation on cryptic larvae and pupae of a swallowtail butterfly. Butlletí del Grup Català d'Anellament 17: 39–49.

Syaripuddin K., Sing K.-W. & Wilson J.-J. 2015. - Comparison of Butterflies, Bats and Beetles as Bioindicators Based on Four Key Criteria and DNA Barcodes. Tropical Conservation Science 8: 138–149.

Thomas J. A. 2005. - Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. Philosophical Transactions of the Royal Society B: Biological Sciences 360: 339–57.

Thomas J. A. 2016. - Butterfly communities under threat. Science 353: 216–218.

Thomas J. A., Telfer M. G., Roy D. B., Preston C. D., Greenwood J. J. D., Asher J., Fox R., Clarke R. T. & Lawton J. H. 2004. - Comparative

Losses of British Butterflies, Birds, and Plants and the Global Extinction Crisis. Science 303: 1879–1881.

Thomas J. A. & Wardlaw J. C. 1992. - The capacity of a Myrmica ant nest to support a predacious species of Maculinea butterfly. Oecologia 91: 101–109.

Van Dyck H., Bonte D., Puls R., Gotthard K. & Maes D. 2015. - The lost generation hypothesis: could climate change drive ectotherms into a developmental trap? Oikos 124: 54–61.

van Swaay C., Cuttelod A., Collins S., Maes D., López Munguira M., Šašić M., Settele J., Verovnik R., Verstrael T., Warren M., Wiemers M. & Wynhof I. 2010. - European Red List of Butterfies. Publications Office of the European Union, Luxembourg, 58 p.

van Swaay C., Dennis E., Schmucki R., Sevilleja C., Balalaikins M., Botham M., Bourn N., Brereton T., Cancela J. ., Carlisle B., Chambers P., Collins S., Dopagne C., Escobés R., Feldmann R., Fernández-García J. M., Fontaine B., Gracianteparaluceta A., Harrower C., Harpke A., Heliölä J., Komac B., Kühn E., Lang A., Maes D., Mestdagh X., Middlebrook I., Monasterio Y., Munguira M. L., Murray T. E., Musche M., Õunap E., Paramo F., Pettersson L., Piqueray J., Settele J., Stefanescu C., Švitra G., Tiitsaar A., Verovnik R., Warren M. S., Wynhoff I. & Roy D. B. 2019. - The EU Butterfly Indicator for Grassland species: 1990-2017. Technical Report. Butterfly Conservation Europe & ABLE/eBMS, 23 p.

van Swaay C., Dennis E., Schmucki R., Sevilleja C., Åström S., Balalaikins M., Barea-Azcón J.M., Bonelli S., Botham M., Cancela J.P., Collins S., De Flores M., Dapporto L., Dopagne C., Dziekanska I., Escobés R., Faltynek Fric Z., Fernández-García J.M., Fontaine B., Glogovčan P., Gracianteparaluceta A., Harpke A., Harrower C., Heliölä J., Houard X., Judge M., Kolev Z., Komac B., Kühn E., Kuussaari M., Lang A., Lysaght L., Maes D., McGowa0n D., Mestdagh X., Middlebrook I., Monasterio Y., Monteiro E., Munguira M.L., Musche M., Olivares F.J., Õunap E., Ozden O., Pavlíčko A., Pendl M., Pettersson L.B., Rákosy L., Roth T., Rüdisser J., Šašić M., Scalercio S., Settele J., Sielezniew M., Sobczyk-Moran G., Stefanescu C., Švitra G., Szabadfalvi A., Tiitsaar A., Titeux N., Tzirkalli E., Ubach A., Verovnik R., Vray S., Warren M.S., Wynhoff I. & Roy D.B. 2022. - European Grassland Butterfly Indicator 1990-2020 Technical report. Butterfly Conservation Europe & SPRING/eBMS (www.butterfly-monitoring.net) & Vlinderstichting report VS2022.039, 27 p.

van Swaay C., van Strien A. J. & Plate C. L. 2011. - European Butterfly Indicator shows decline grassland species. Landschap 28: 5–14.

van Swaay C., Warren M. & Loïs G. 2006. - Biotope use and trends of European butterflies. Journal of Insect Conservation 10: 189–209.

Wagner-Rollinger C. 1980. - Les biotopes de nos papillons diurnes (Lépidoptères Rhopalocères). P. Worré-Mertens, Luxembourg, 64 p.

Warren M. S., Hill J. K., Thomas J. A., Asher J., Fox R., Huntley B., Roy D. B., Telfer M. G., Jeffcoate S., Harding P., Jeffcoate G., Willis S. G., Greatorex-Davies J. N., Moss D. & Thomas C. D. 2001. - Rapid responses of British butterflies to opposing forces of climate and habitat change. Nature 414: 65–69.

Warren M. S., Maes D., van Swaay C. A. M., Goffart P., Van Dyck H., Bourn N. A. D., Wynhoff I., Hoare D. & Ellis S. 2021. - The decline of butterflies in Europe: Problems, significance, and possible solutions. Proceedings of the National Academy of Sciences 118: e2002551117.

Wilson R. J., Gutiérrez D., Gutiérrez J., Martínez D., Agudo R. & Monserrat V. J. 2005. - Changes to the elevational limits and extent of species ranges associated with climate change. Ecology Letters 8: 1138–1146.

2 Organisation and methods

Xavier Mestdagh[1,*,✉], Lisette Cantú-Salazar[1,*], Sarah Vray[1,*], Lionel L'Hoste[1], Youri Martin[1] and Nicolas Titeux[1]

*These authors contributed equally to this work

[1] Luxembourg Institute of Science and Technology (LIST)
5 Avenue des Hauts-Fourneaux
L-4362 Esch-sur-Alzette, Luxembourg

✉ Corresponding author: xavier.mestdagh@list.lu

2.1 Butterfly dataset

The atlas is based on 154,218 butterfly records collected from 1800 to 2020. A record is defined as an observation of butterfly presence encoded in a database. Observations not encoded in any database were not considered in this atlas. Records used in this atlas were extracted on the 3rd of May 2021 from the national biological database managed by the National Museum of Natural History of Luxembourg (MNHNL; www.mdata.mnhn.lu) and supplemented with observations encoded in other databases available from naturalists and biological stations. Records collected in the frame of the Luxembourg Butterfly Monitoring Scheme (LUBMS, see corresponding section below) were also used. Records potentially available from databases outside Luxembourg were not included in this atlas. As shown on Fig. 2.1, the number of records and the number of observers has been increasing over time, especially during the last few years. Before the 1970s, butterfly records were collected by a very small number of observers and this number slightly increased in the next decades because of the creation of an entomological group by the Luxembourg Naturalist Society (SNL), with a journal dedicated to insects ("Päiperlek Lëtzebuerger Entomologesch Zäitschrëft"). Surveys were intensified in the early 2000s following an update of the Red List (Meyer 2000) but the yearly number of observers remained very low (less than 15) until 2010. The number of observers and records has then increased sharply from 2010 after the onset of the LUBMS, the implementation of several nature conservation projects (e.g., LIFE, INTERREG, Fonds de Protection de l'Environnement), and citizen science projects (iNaturalist, Maacht Mat, Aktioun Païperlek).

2.2 Selection of the atlas periods

The main aim of an atlas is to document the spatial distribution of the species and their changes over time. As illustrated on Fig. 2.1 and Fig. 2.2, the number of records is highly heterogeneous in time and space. To highlight changes in species distribution while considering temporal heterogeneity in the number of records, butterfly data were split into three successive time periods: before 1990, from 1990 to 2009, and from 2010 to 2020. The number of records during the first period (before 1990) and the second period (1990-2009) is lower than in the more recent period (2010-2020). During the second period (1990-2009), records were mainly concentrated in the southwest. A better spatial coverage of the country was reached during the third period (2010-2020) (Fig. 2.2). This period reflects the most recent distribution of butterflies as known since the implementation of the LUBMS (see section "Survey effort" below).

2.3 Butterfly records used in the atlas

2.3.1 Casual records

Casual records were obtained without applying any standardised survey procedure or sampling design. Ancillary information related to the

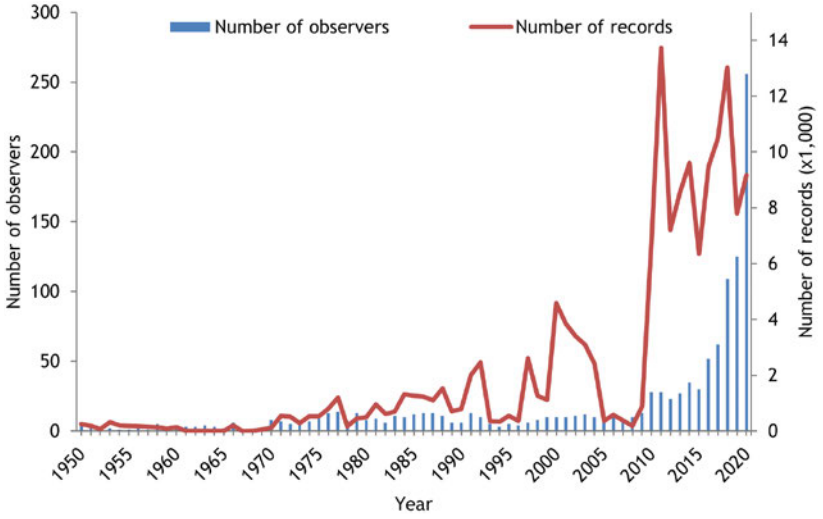


Fig. 2.1: Trends in the number of butterfly records (red) and the number of observers (blue) from 1950 to 2020.

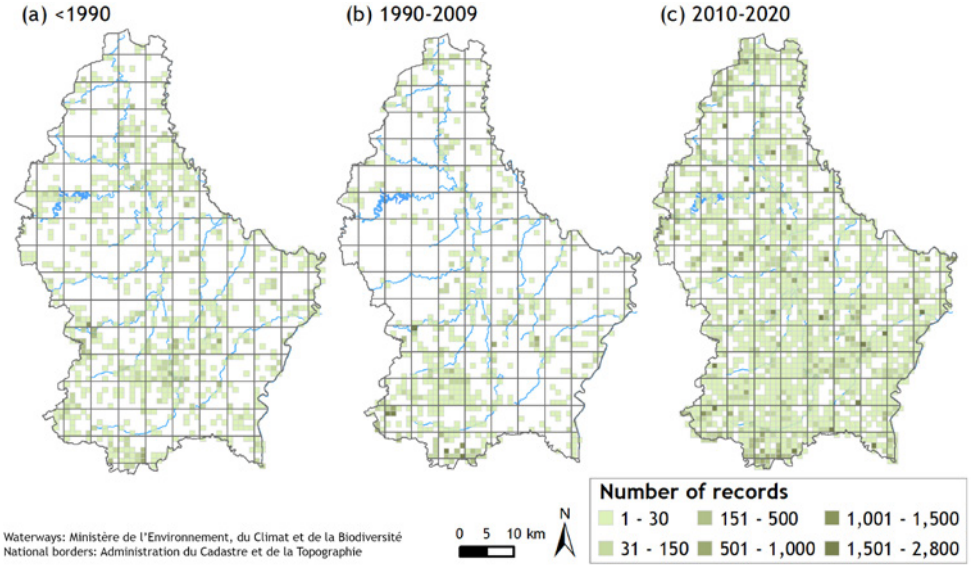


Fig. 2.2: Number of records per 1-km grid cell (graduated green colour) during the three atlas periods (a, b and c).

observation (e.g., weather conditions, time spent recording butterflies) is therefore often missing, as well as information related to the observation of other species. An example of this type of records is that of a Brimstone (*Gonepteryx rhamni*) observed on a roadside from a car. There is no indication that the observer was paying attention to the other species present on the same site or that weather conditions were favourable for observing butterflies. The only information available is the presence of that butterfly species at that place and at that moment. These records are typically encoded through data.mnhn.lu or iNaturalist encoding systems.

2.3.2 Standardised records

Standardised records come from a standardised survey procedure and are collected under suitable weather conditions. The LUBMS and the surveys

targeting certain species are designed for collecting standardised records. Standardised records were essential to estimate the survey effort in the frame of this atlas (see section "Survey effort" below). If only a single Brimstone (*Gonepteryx rhamni*) was recorded present along a transect during the LUBMS survey, we assumed that other species were searched but not detected during this survey because we know that the observer was paying attention and was requested to record all butterflies observed during a standardised survey.

The number of standardised records greatly increased with time (Fig. 2.3).

2.4 The Luxembourg Butterfly Monitoring Scheme

The Luxembourg Butterfly Monitoring Scheme (LUBMS) was initiated in 2010 (Mestdagh et al. 2011; Titeux, Moes & Hoffmann 2009) and co-financed by the Ministry of the Environment, Climate and Biodiversity (MECB) and the Luxembourg Institute of Science and Technology (LIST). This scheme combines two types of surveys for long-term butterfly monitoring at a national scale:

1. The "**site-based survey**" aims to update and track changes in the national distribution of butterflies. Initially targeting suitable biotopes for the four butterfly species covered by the European Habitats Directive (92/43/EEC) and present in Luxembourg (*Lycaena dispar*, *Lycaena helle*, *Phengaris arion* and *Euphydryas aurinia*), this type of survey was also applied to other biotopes (e.g., forest). Potentially suitable sites were identified based on available geospatial data (e.g., land use / land cover, cadastre of open biotopes, aerial photographs or satellite imagery) and historical observations of species. Sites are surveyed up to four times between May and August. Observed butterflies, survey duration and survey area are recorded on biomonitor.mnhn.lu, or through the mobile app "ButterflyCount" (https://butterfly-monitoring.net/ebms-app).
2. The "**transect-based survey**" is based on the "Pollard Walks" procedure where butterflies are counted along sections of the transects with the aim to produce a relative abundance index. A series of 30 transects was selected using a stratified random sampling procedure to sample the various environmental conditions in the countryside across Luxembourg. Additional transects have been defined in 2016 to assess the impact of the ecological restoration from LIFE Eislek and LIFE Orchis projects. Each transect is surveyed up to 12 times per year following a standardised field survey procedure (Sevilleja et al. 2019). Data collected are encoded on http://www.butterfly-monitoring.net/ or using the mobile app "ButterflyCount". Between 2010 and 2020, butterfly counts on transects have been conducted in 131 1-km grid cells, representing 4.7% of the 2,789 1-km cells covering the country (including partial cells on borders).

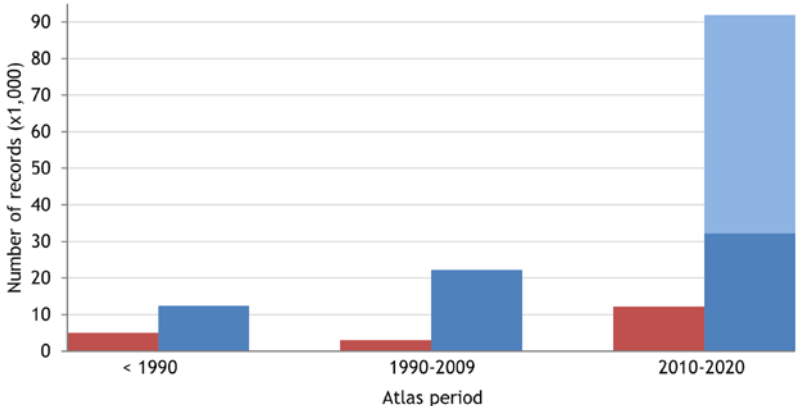


Fig. 2.3: Type and number of butterfly records during the three atlas periods. Casual records are represented in red, standardised records in blue. Light blue represents butterfly records coming from the transect-based surveys conducted during the Luxembourg Butterfly Monitoring Scheme (LUBMS).

2.5 Data formatting and validation

As the dataset used in this atlas was compiled from several sources, we harmonised the nomenclature and formats used across these different sources (e.g., date, species names, butterfly life stages, and geographic coordinates). Butterfly species names are based on the nomenclature of Wiemers et al. (2018). Only records at a minimum spatial resolution of 1 km were considered.

An online data validation tool (https://data.mnhn.lu/en/verification) was used to highlight any potential encoding or species determination mistake and to apply the necessary corrections before the integration into the national database. Records prior to the implementation of the online validation tool were manually validated by applying different filters on the species name, the recording date and location.

2.6 Checklist of butterfly species in Luxembourg

Records of 130 butterfly species or complexes of species (i.e., species virtually indistinguishable externally) in Luxembourg have been found in the present database (Tab. 2.1):

- 15 species considered as with dubious presence in Luxembourg due to the lack of clear evidence (e.g., specimen, picture), the lack of suitable habitat, the lack of known population in the surroundings, or potential misidentification with a similar species;
- 15 species considered as encoding errors because the known distribution is clearly far from Luxembourg;
- 95 species and 5 complexes of species (i.e., *Colias hyale/alfacariensis*, *Leptidea sinapis/juvernica*, *Melitaea athalia/aurelia*, *Hipparchia hermione/fagi* and *Pontia daplidice/edusa*) considered as having been recorded in Luxembourg to date.

Tab. 2.1: Checklist of butterfly species recorded in Luxembourg, with information on their presence in Luxembourg (according to the validation rules applied in this atlas), the existence of past or recent breeding evidence in Luxembourg and their main habitat requirements.

Family	Species	Presence in Luxembourg	Breeding in Luxembourg	Last record year (location for extinct species)	Habitat requirements
Hesperiidae	*Erynnis tages*	occurring	yes	2020	open biotopes
	Carcharodus alceae	occurring	yes	2020	open biotopes
	Spialia sertorius	occurring	yes	2020	open biotopes
	Pyrgus malvae	occurring	yes	2020	generalist
	Pyrgus malvoides	encoding error	no	-	-
	Pyrgus armoricanus	occurring	yes	2020	open biotopes
	Pyrgus alveus	dubious	no	-	-
	Pyrgus serratulae	occurring	yes	2018	open biotopes
	Pyrgus cirsii	dubious	no	-	-
	Pyrgus carthami	dubious	no	-	-
	Carterocephalus palaemon	occurring	yes	2017	forest biotopes
	Heteropterus morpheus	encoding error	no	-	-
	Thymelicus sylvestris	occurring	yes	2020	open biotopes
	Thymelicus lineola	occurring	yes	2020	open biotopes
	Thymelicus acteon	occurring	yes	2019	open biotopes
	Hesperia comma	occurring	yes	2020	open biotopes
	Ochlodes sylvanus	occurring	yes	2020	generalist

Tab. 2.1: (continued)

Family	Species	Presence in Luxembourg	Breeding in Luxembourg	Last record year (location for extinct species)	Habitat requirements
Papilionidae	*Parnassius apollo*	dubious	no	-	-
	Zerynthia polyxena	encoding error	no	-	-
	Iphiclides podalirius	extinct	yes	1992 (Esch-sur-Alzette)	-
	Papilio machaon	occurring	yes	2020	generalist
Pieridae	*Leptidea sinapis/juvernica*	occurring	-	2020	generalist
	Aporia crataegi	occurring	yes	2020	open biotopes
	Pieris brassicae	occurring	yes	2020	generalist
	Pieris rapae	occurring	yes	2020	generalist
	Pieris mannii	occurring	yes	2020	generalist
	Pieris napi	occurring	yes	2020	generalist
	Pieris bryoniae	encoding error	no	-	-
	Pontia daplidice/edusa	vagrant	-	1979 (Eich)	-
	Anthocharis cardamines	occurring	yes	2020	generalist
	Colias hyale/alfacariensis	occurring	-	2020	-
	Colias crocea	occurring	yes	2020	open biotopes
	Gonepteryx rhamni	occurring	yes	2020	generalist
Riodinidae	*Hamearis lucina*	extinct	yes	1996 (Moersdorf)	-
Lycaenidae	*Thecla betulae*	occurring	yes	2020	forest biotopes
	Favonius quercus	occurring	yes	2020	forest biotopes
	Satyrium acaciae	extinct	likely	1854 (Grevenmacher)	-
	Satyrium ilicis	occurring	yes	2020	forest biotopes
	Satyrium w-album	occurring	yes	2020	forest biotopes
	Satyrium pruni	occurring	yes	2020	forest biotopes
	Satyrium spini	extinct	likely	1984 (Wasserbillig)	-
	Callophrys rubi	occurring	yes	2020	forest biotopes
	Lycaena helle	occurring	yes	2020	open biotopes
	Lycaena virgaureae	extinct	yes	1994 (Hosingen)	-
	Lycaena tityrus	occurring	yes	2020	open biotopes
	Lycaena dispar	occurring	yes	2020	open biotopes
	Lycaena phlaeas	occurring	yes	2020	generalist
	Lycaena hippothoe	occurring	yes	2020	open biotopes
	Lampides boeticus	vagrant	no	1962 (Echternach)	-
	Cupido argiades	occurring	yes	2020	open biotopes
	Cupido minimus	occurring	yes	2020	open biotopes
	Celastrina argiolus	occurring	yes	2020	forest biotopes
	Glaucopsyche alexis	occurring	yes	2020	open biotopes
	Phengaris alcon	dubious	no	-	-

Tab. 2.1: (continued)

Family	Species	Presence in Luxembourg	Breeding in Luxembourg	Last record year (location for extinct species)	Habitat requirements
Lycaenidae	*Phengaris arion*	occurring	yes	2020	open biotopes
	Phengaris teleius	dubious	no	-	-
	Phengaris nausithous	dubious	no	-	-
	Iolana iolas	encoding error	no	-	-
	Pseudophilotes baton	extinct	likely	1952 (Grevenmacher)	-
	Pseudophilotes bavius	encoding error	no	-	-
	Cyaniris semiargus	occurring	yes	2020	open biotopes
	Polyommatus damon	dubious	no	-	-
	Polyommatus dorylas	extinct	likely	1950 (Leudelange, Niederanven, Steinfort)	-
	Polyommatus menelaos	encoding error	no	-	-
	Polyommatus thersites	encoding error	no	-	-
	Polyommatus icarus	occurring	yes	2020	generalist
	Polyommatus daphnis	encoding error	no	-	-
	Lysandra coridon	occurring	yes	2020	open biotopes
	Lysandra bellargus	occurring	yes	2020	open biotopes
	Aricia agestis	occurring	yes	2020	open biotopes
	Plebejus argus	occurring	yes	2020	open biotopes
	Plebejus idas	dubious	no	-	-
	Plebejus argyrognomon	dubious	no	-	-
Nymphalidae	*Libythea celtis*	encoding error	no	-	-
	Limenitis populi	occurring	yes	2019	forest biotopes
	Limenitis camilla	occurring	yes	2020	forest biotopes
	Limenitis reducta	dubious	no	-	-
	Apatura iris	occurring	yes	2020	forest biotopes
	Apatura ilia	occurring	yes	2020	forest biotopes
	Argynnis paphia	occurring	yes	2020	forest biotopes
	Speyeria aglaja	occurring	yes	2020	open biotopes
	Fabriciana adippe	occurring	yes	2020	open biotopes
	Fabriciana niobe	dubious	no	-	-
	Issoria lathonia	occurring	yes	2020	generalist
	Brenthis daphne	occurring	yes	2020	forest biotopes
	Brenthis ino	occurring	yes	2020	open biotopes
	Boloria pales	encoding error	no	-	-
	Boloria eunomia	occurring	yes	2020	open biotopes
	Boloria selene	occurring	yes	2020	open biotopes
	Boloria euphrosyne	extinct	yes	2003 (Lasauvage)	-
	Boloria dia	occurring	yes	2020	open biotopes
	Boloria distincta	encoding error	no	-	-

Tab. 2.1: (continued)

Family	Species	Presence in Luxembourg	Breeding in Luxembourg	Last record year (location for extinct species)	Habitat requirements
Nymphalidae	*Melitaea cinxia*	occurring	yes	2020	open biotopes
	Melitaea diamina	occurring	yes	2020	open biotopes
	Melitaea phoebe	extinct	yes	1984 (Pétange)	-
	Melitaea didyma	extinct	likely	1977 (Kautenbach)	-
	Melitaea athalia/aurelia	occurring	-	2020	open biotopes
	Melitaea parthenoides	dubious	no	-	-
	Euphydryas maturna	extinct	yes	1960-80 (Pétange)	-
	Euphydryas aurinia	occurring	yes	2020	open biotopes
	Nymphalis antiopa	occurring	yes	2011	forest biotopes
	Nymphalis polychloros	occurring	yes	2020	forest biotopes
	Aglais urticae	occurring	yes	2020	generalist
	Aglais io	occurring	yes	2020	generalist
	Vanessa atalanta	occurring	yes	2020	generalist
	Vanessa cardui	occurring	yes	2020	generalist
	Polygonia c-album	occurring	yes	2020	generalist
	Araschnia levana	occurring	yes	2020	generalist
	Pararge aegeria	occurring	yes	2020	forest biotopes
	Lasiommata megera	occurring	yes	2020	generalist
	Lasiommata paramegaera	encoding error	no	-	-
	Lasiommata maera	occurring	yes	2020	open biotopes
	Lopinga achine	extinct	likely	1979 (Luxembourg)	-
	Coenonympha glycerion	dubious	no	-	-
	Coenonympha arcania	occurring	yes	2020	open biotopes
	Coenonympha hero	extinct	likely	1977 (Dirbach, Kautenbach)	-
	Coenonympha pamphilus	occurring	yes	2020	generalist
	Pyronia tithonus	occurring	yes	2020	generalist
	Aphantopus hyperantus	occurring	yes	2020	generalist
	Maniola jurtina	occurring	yes	2020	generalist
	Erebia aethiops	extinct	yes	1966 (Pétange)	-
	Erebia medusa	occurring	yes	2020	open biotopes
	Melanargia galathea	occurring	yes	2020	open biotopes
	Brintesia circe	extinct	likely	1984 (Kalkesbaach)	-
	Minois dryas	dubious	no	-	-
	Chazara briseis	vagrant	no	1976 (Untereisenbach)	-
	Hyponephele lycaon	encoding error	no	-	-
	Hipparchia semele	occurring	yes	2020	open biotopes
	Hipparchia hermione/fagi	vagrant	-	1979 (Canach, Lenningen)	-
	Danaus chrysippus	encoding error	no	-	-

Past or recent breeding evidence (Tab. 2.1) has been assessed based on the existence of records indicating local reproduction (i.e., eggs, larvae, chrysalis, mating pairs) and national literature. Some species with a lack of clear breeding evidence have been assumed as "likely" breeding (or having bred) in Luxembourg based on the amount and frequency of records, literature from the surrounding regions and species continental distribution range. Species that have been sporadically recorded in Luxembourg outside their normal breeding range were considered as "vagrant". Breeding evidence was not assessed for complexes of species.

Chapter 4 is dedicated to the 95 species and 5 complexes of species considered as having been recorded in Luxembourg to date (i.e., "occurring", "vagrant" or "extinct" species). Out of them, 17 species (including 2 vagrant species with no breeding evidence) and 2 complexes of species have not been recorded during the latest atlas period. Chapter 3 focuses on species having (likely) bred in Luxembourg and extinction risk was not evaluated for complexes of species.

2.7 Analyses

2.7.1 Species phenology

The phenology (i.e., the timing of lifecycle events) of a species may change over time. This timing is mainly driven by weather conditions and can be highly variable from one year to another. These changes may potentially cause a temporal mismatch between butterflies and their interacting species (e.g., host plants, parasites), with strong impact on their population viability. It is therefore interesting to evaluate temporal changes in the phenology of the different species.

Phenological histograms were built to represent the flight season based on records of adult butterflies. For each species and for each of the last two atlas periods separately (1990-2009 and 2010-2020), the number of records were first aggregated by date and by 1-km resolution grid cell (according to the LUREF epsg2169 grid system with the coordinates X:48000 Y:57000 as origin), and these aggregated records were counted within 10-day time intervals. These counts were plotted as frequency distribution over time (Fig. 2.4). When for a given species the total number of records was below 30 for the period 1990-2009, the records before 1990 were added and the histogram reflected the phenology during the first two periods combined. In addition, a smooth curve representing the moving average centred over three consecutive 10-day time intervals was drawn if the total number of butterfly records available was greater than or equal to 30. With this approach, the short-term fluctuations are smoothed out and the overall pattern of the flight season is highlighted. The phenological histogram of *Anthocharis cardamines* is shown on Fig. 2.4 as an example. This early-flying species shows a recording peak in late April – early May with a slight shift between 1990-2009 and 2010-2020 highlighting an earlier flight season during the most recent period.

2.7.2 Survey effort

One of the main goals of this atlas is to highlight temporal changes in the distribution of species with maps and with metrics quantifying such changes. A simple approach to produce those metrics would be to calculate the number of 1-km grid cells where a species has been recorded in each atlas period. However, as illustrated on Fig. 2.1, Fig. 2.2 and Fig. 2.3, the number of butterfly records is highly variable over time and in space at least partly due to variation in survey effort. With this basic approach, a species might be shown to be expanding its distribution because of increased survey effort over time.

To avoid such a biased assessment, survey effort has been estimated. From the atlas database, we identified 28,296 complete surveys (1,882 before 1990; 3,255 in 1990-2009; 23,159 in 2010-2020). A survey was considered as complete when:

- the observer paid attention to and recorded all adult butterfly species observed;
- the weather conditions were adequate to allow the detection of adult butterflies during the survey.

Those two conditions are directly taken into consideration and fulfilled in field protocols such as for the LUBMS. When the field protocol is not known (mainly for records before 2010), these conditions were assumed as being fulfilled when several species have been recorded during a survey in a site and when the list of recorded species included

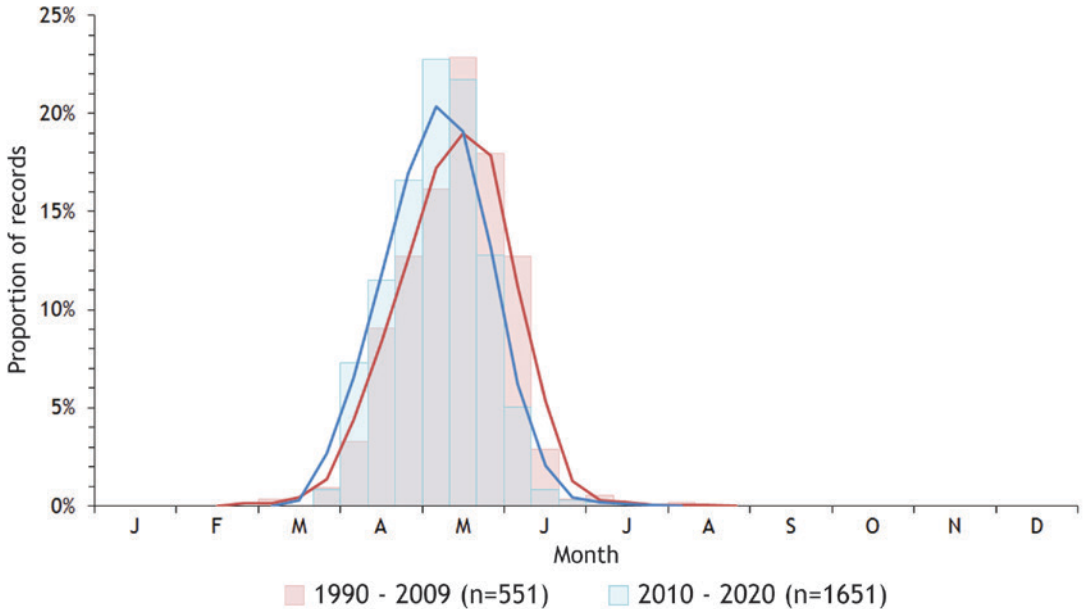


Fig. 2.4: Flight season of *Anthocharis cardamines* representing the frequency distribution of species records over time at a 10-day temporal resolution. The last two atlas periods are shown in red (1990-2009) and in blue (2010-2020). The curves result from a smoothing procedure based on a moving averaging approach.

generalist species (Tab. 2.1). When a single species or a list of specialist species only (open- or forest-biotope species) were recorded, the survey was not considered as complete.

For each species, the survey effort was calculated during each atlas period and in each 1-km grid cell as the number of complete surveys carried out during the flight season of the species. The flight season of a species includes weeks with at least 2.5% of all records collected during the period 1990-2020 for that species. To estimate metrics reflecting changes in distribution (see next sections), the first two atlas periods (<1990 and 1990-2009) were combined and compared to the most recent period (2010-2020). Therefore, the survey effort was also estimated for these two periods (hereafter <2010 and 2010-2020 respectively). To estimate the survey effort in 2010-2020, we discarded records collected along the randomly selected transects of the LUBMS established from 2010 to sample the various environmental conditions in the countryside across Luxembourg because those surveys have no counterpart before 2010.

The four species protected by the European Habitats Directive and occurring in Luxembourg have been specifically targeted during various surveys before and after 2010 (search for eggs, caterpillars, or adults), producing a total of 1,344 targeted surveys with no record of the species. For those species, the survey effort in each 1-km grid cell is therefore based on the number of complete surveys (as described above) and the number of targeted surveys.

2.7.3 Temporal changes

Temporal changes have been assessed based on the two metrics presented below – Area of Occupancy (AOO) and the Extent of Occurrence (EOO) – compared between two time periods (<2010 and 2010-2020). Beyond the survey effort, these two metrics could also be affected by isolated breeding populations that are distant from the rest of the distribution range of the species or by dispersing individuals that are recorded at the margin of this range. Information associated with a record (comment, number of individuals, presence of suitable biotopes) is often used to filter out records of dispersing individuals, but such information is often insufficient or inadequate for historical records. To ensure a consistent data treatment across time periods (especially for records before 1990), we opted for not filtering out potential

records of dispersing individuals for the calculation of the change metrics. We assumed that dispersing individuals were likely to be recorded in a similar way during the two time periods (<2010 and 2010-2020).

2.7.3.1 Change in Area of Occupancy (AOO)

The Area of Occupancy (AOO) is a metric that represents the area occupied by a species and it is defined here as the number of 1-km grid cells where the species has been recorded. It is an easily calculated metric to indirectly assess the population size of a species based on distribution records (IUCN Standards and Petitions Committee 2022). Yet, this number of grid cells is directly related to survey effort in terms of both temporal frequency and spatial coverage (see Fig. 2.1, Fig. 2.2 and Fig. 2.3). Hence, we applied a set of rules to make the comparison of AOO between <2010 and 2010-2020 as robust as possible.

Instead of calculating the absolute difference in the number of grid cells where the species has been recorded in <2010 and in 2010-2020, we estimated extinction and colonisation rates between <2010 and 2010-2020 based only on grid cells where we consider having sufficiently reliable information on the presence and absence of the species to make these estimations.

To estimate the extinction rate for a species, we used grid cells (1) where the species was recorded in <2010 and (2) where it was also recorded in 2010-2020 or where at least two complete surveys were carried out during the flight season of the species in 2010-2020 (see section "Survey effort" above). We considered this set of grid cells as the most complete and representative source of information to infer the extinction rate (r_e). This rate was estimated as the proportion of grid cells where the species was not recorded in 2010-2020 among this set of cells. For some species, the number of representative grid cells retained for estimating extinction rate was low and we considered that such an estimation was not reliable when this set of cells was less than 20% of the total number of cells where the species was recorded in <2010. We adopted a similar approach to estimate colonisation rates (r_c). Here, we used grid cells (1) where the species was recorded in 2010-2020 and (2) where it was also recorded in <2010 or where at least two complete surveys were carried out during the flight season of the species in <2010. Among this set of grid cells, we estimated the colonisation rate as the proportion of grid cells where the species was not recorded in <2010. We estimated the colonisation rate for a species when the number of retained cells was higher than 20% of the total number of cells where the species was recorded in 2010-2020.

We then estimated three unknown quantities among the set of grid cells where the species was recorded in <2010 and/or in 2010-2020 (N_{Tot}): the number of extinctions (N_e, i.e., grid cells where the species was estimated to get extinct between <2010 and 2010-2020), the number of colonisations (N_c, i.e., grid cells that the species was estimated to have colonised between <2010 and 2010-2020) and the number of grid cells where the species persisted (N_p, i.e., grid cells where the species was present both in <2010 and in 2010-2020). For this estimation, we solved the following system of multiple equations:

- $N_{Tot} = N_p + N_e + N_c$
- $N_e = r_e * (N_e + N_p)$
- $N_c = r_c * (N_c + N_p)$

In this way, we first used subsets of cells considered as reliable to estimate extinction and colonisation rates (i.e., only those cells where observations and/or survey effort were considered sufficient to infer the presence or absence in <2010 and in 2010-2020) and we then extrapolated these rates to estimate extinctions, colonisations and persistence among the whole set of grid cells where the species was recorded in <2010 or in 2010-2020 irrespective of the survey effort.

We then calculated a relative AOO for each period and each species as follows:

- Relative $AOO_{<2010} = N_p + N_e$
- Relative $AOO_{2010\text{-}2020} = N_p + N_c$

The change in relative AOO between <2010 and 2010-2020 for each species was calculated with the formula:

Change in relative AOO =

$$100 * \frac{\text{Relative } AOO_{2010\text{-}2020} - \text{Relative } AOO_{<2010}}{\text{Relative } AOO_{<2010}}$$

As an example, *Aglais io* has been recorded in 785 grid cells: 311 in <2010 and in 589 in 2010-2020.

From the 311 cells with presence in <2010, 164 were retained to estimate the extinction rate either because the species was still recorded in 2010-2020 (n=115) or because they were sufficiently surveyed in 2010-2020 to infer the absence of the species (n=49). The remaining 147 grid cells were not used to estimate the extinction rate (49 / 164 = 30%). From the 589 cells with presence in 2010-2020, only 148 were retained to estimate the colonisation rate (22%) following the same approach. Based on these rates, we estimated that the species was present in 653 grid cells in <2010 (Relative $AOO_{<2010}$) and in 590 cells in 2010-2020 (Relative $AOO_{2010-2020}$), with 458 cells with estimated persistence between <2010 and 2010-2020. The change in relative AOO is therefore estimated at (590 - 653) / 653 * 100 = -9.7%. The area of occupancy of the species is therefore estimated as stable (see Tab. 2.2), but ignoring potential differences in survey effort would have led to a strong overestimation of increasing area of occupancy with a change in AOO estimated at (589 - 311) / 311 * 100 = +89% between <2010 and 2010-2020. Another interesting example species is *Lycaena helle* for which we estimated a moderate decrease in area of occupancy (change in relative AOO of -27%) whereas overlooking differences in survey effort would lead to the conclusion that the area of occupancy of the species is moderately increasing (change in relative AOO of +25%).

It is important to note, however, that our approach was implemented to correct for temporal differences in survey effort (reflected as the number of complete surveys) but not to control for potential spatial differences in survey effort between <2010 and 2010-2020. Spatial heterogeneity in survey effort might differ between <2010 and 2010-2020 with possible consequences on the observed presence of at least some species and on the estimated changes in their area of occupancy.

2.7.3.2 Change in Extent of Occurrence (EOO)

The EOO is the area encompassing all the sites where the species is occurring (IUCN 2012). For each butterfly species, we estimated the EOO in each period using the Minimum Convex Polygon (MCP) method, which is one of the simplest techniques to estimate a species' EOO (IUCN Standards and Petitions Committee 2022). An MCP was fitted around the records of the species corresponding to each period (<2010 and 2010-2020) and the area of Luxembourg enclosed by the polygon was calculated (i.e., areas of the polygon overlapping neighbouring countries were excluded). Given the paucity of practical methods applicable to all spatial distributions, and the need to estimate EOO consistently across species and periods, the MCP was chosen here as a pragmatic measure of the spatial spread of risk (e.g., Fox et al. 2022). We calculated the change in EOO for each species with enough records to compute an MCP (i.e., >2) using the following formula:

$$\text{Change in EOO} = 100 * \frac{EOO_{2010-2020} - EOO_{<2010}}{EOO_{<2010}}$$

2.7.3.3 Trends

Changes in relative AOO and EOO have been used for assessing extinction risk of the species in Chapter 3 and for describing the overall trend of each species in Chapter 4. In Chapter 3, quantitative change thresholds are applied to assign each species to a Red List threat category based on the IUCN criteria. In the species accounts of Chapter 4, we used the change threshold reported in Tab. 2.2 to describe the overall trend of the species based on these two metrics.

Tab. 2.2: Interpretation of changes in relative AOO and EOO for the assessment of the overall species trend.

Change in AOO or EOO	Trend
more than +50%	strongly increasing
between +21% and +50%	moderately increasing
between +11% and +20%	slightly increasing
between -10% and +10%	stable
between -11% and -20%	slightly decreasing
between -21% and -50%	moderately decreasing
less than -50%	strongly decreasing

When relative AOO and EOO showed contrasting changes for a species, the difference in direction or magnitude of change was briefly described in its species account.

2.7.4 Modelling the spatial distribution of the species

Field records document the distribution of the species in the country but only in a fragmented way as they are collected in a series of sampling locations (transects or sites). One of the most commonly used approach to gain insight into large-scale distribution of a species is called "species distribution modelling" (Drew, Wiersma & Huettmann 2011; Elith & Leathwick 2009; Franklin 2010; Guisan & Thuiller 2005). Species distribution models (SDMs) establish a statistical link between the locations where a target species was recorded and a series of environmental variables describing key abiotic and/or biotic conditions relevant to the ecological requirements of the species. These models may then be used to inform on the potential suitability of habitats for the species in areas where its presence is not necessarily known or was not recorded. A full suite of algorithms and platforms is now available to develop species distribution models. We used the Maximum Entropy (MaxEnt) algorithm as implemented in its software version 3.3.3k (Phillips, Anderson & Schapire 2006). As we compiled butterfly records derived from different types of surveys in this atlas, we relied on information on the presence of the species but less easily on their absence. MaxEnt is one of the modelling techniques that deals with this presence-only information and was chosen for that reason. A comprehensive overview of the principles and implementation of MaxEnt can be found in Dudík, Phillips & Schapire (2007) and Elith et al. (2011).

Butterfly records from the period 2010-2020 were spatially aggregated within 200-m resolution grid cells and constituted the presence information that was fed into the models. A species-specific selection of appropriate environmental variables is a crucial step in species distribution modelling and can significantly influence modelling outcomes. Environmental variables known to affect butterfly distributions such as climate, topography and land cover (e.g., Habel et al. 2021) were calculated within the same grid cells as the ones used above to document the presence of the species across the country. Each butterfly species was allocated to one of these three groups: specialists of forest, specialists of open biotopes, and generalists (Tab. 2.1), using information from van Swaay et al. (2006). For each group, a tailored set of environmental variables was used to develop the models (Tab. 2.3), but we removed highly correlated variables to avoid misleading effects in the models based on the protocol of Dormann et al. (2013), which was applied for each species separately.

For each species, models were calibrated ten times based on a random subsampling of the butterfly presence data in the 200-m resolution grid cells and the entire country as background information representing the available environmental conditions. These individual models were then combined to produce an averaged prediction ranging between 0 and 1 in each grid cell. As we used presence-only information to build the models, these predictions could not be interpreted as a true probability of presence of the species. Instead, the value in a certain grid cell represented the extent to which the environmental conditions within that cell were similar to those where the butterfly species was recorded. The reliability of the models was evaluated for each species based on widely used statistics (omission rates based on the Maximum training sensitivity plus specificity logistic threshold and area under the curve) and a standard approach that splits the whole set of available data into a part (i.e., 90%) that is used to train the models and another part (i.e., 10%) that is used to test their predictions. Models were not built or were considered unreliable for the species when at least one of the following conditions was met:

- the records were mostly available at the level of a complex of species (*Melitaea aurelia* and *M. athalia*, *Leptidea sinapis* and *L. juvernica*, and *Colias hyale* and *C. alfacariensis*);
- the species may have been overlooked due to its resemblance to other species (*Pieris rapae*, *P. napi and P. mannii*);
- the species was considered as a migrant, hence a substantial proportion of its records might reflect migration and not the suitability of its breeding habitat (*Vanessa atalanta*, *V. cardui*, *Colias crocea*);
- the species was considered as expanding its distribution range in Luxembourg through waves and large interannual fluctuations that are unlikely to reflect equilibrium with the availability of its suitable habitats across the country (*Cupido argiades*);

Tab. 2.3: Environmental variables used in the species distribution models for each group of species.

Generalist species	Open-biotope species	Forest-biotope species	Theme	Description	Unit	Date	Scale / resolution	Source
X	X	X	Climate	Annual mean temperature	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Mean diurnal range	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Isothermality	-	1970-2000	30 s	1
X	X	X	Climate	Temperature seasonality	°C * 100	1970-2000	30 s	1
X	X	X	Climate	Max temperature of warmest month	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Min temperature of coldest month	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Temperature annual range	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Mean temperature of wettest quarter	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Mean temperature of driest quarter	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Mean temperature of warmest quarter	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Mean temperature of coldest quarter	°C * 10	1970-2000	30 s	1
X	X	X	Climate	Annual precipitation	mm	1970-2000	30 s	1
X	X	X	Climate	Precipitation seasonality	Fraction * 100	1970-2000	30 s	1
X	X	X	Climate	Precipitation of wettest month	mm	1970-2000	30 s	1
X	X	X	Climate	Precipitation of driest month	mm	1970-2000	30 s	1
X	X	X	Climate	Precipitation of wettest quarter	mm	1970-2000	30 s	1
X	X	X	Climate	Precipitation of driest quarter	mm	1970-2000	30 s	1
X	X	X	Climate	Precipitation of warmest quarter	mm	1970-2000	30 s	1
X	X	X	Climate	Precipitation of coldest quarter	mm	1970-2000	30 s	1
X	X	X	Climate	Mean annual potential evapotranspiration	cm/month	1997-2007	200 m	2
X	X	X	Climate	Growing degree days above 5°C	°C	1997-2007	200 m	2
X	X	X	Elevation	Mean elevation	m	2001	5 m	3
X	X	X	Elevation	Coverage of flat areas	%	2001	5 m	3
X	X	X	Elevation	Mean orientation	°	2001	5 m	3
X	X	X	Elevation	Coverage of steep slope (>15%)	m^2	2001	5 m	3
X	X	X	Elevation	Mean percent slope	%	2001	5 m	3
X	X	X	Elevation	Topographical moisture index	-	2001	5 m	3
X	X	X	Land cover	Urban areas	m^2	1999-2007	01:15.0	4
X		X	Land cover	Annual crops	m^2	1999-2007	1:15,000	4
X	X	X	Land cover	Meadows and pastures	m^2	1999-2007	1:15,000	4
X	X	X	Land cover	Dry grasslands	m^2	1999-2007	1:15,000	4

Generalist species	Open-biotope species	Forest-biotope species	Theme	Description	Unit	Date	Scale / resolution	Source
	X		Land cover	Species-rich *Nardus* grasslands, on siliceous substrates (Habitats Directive code: 6230)	m^2	2013	1:1,000	5
	X		Land cover	Lowland hay meadows (*Alopecurus pratensis, Sanguisorba*) (Habitats Directive code: 6510)	m^2	2013	1:1,000	5
X	X	X	Land cover	Wetlands	m^2	2013	1:1,000	5
X	X	X	Land cover	Shrub-covered areas	m^2	1999-2007	1:15,000	4
X	X	X	Land cover	Broad-leaved forests	m^2	1999-2007	1:15,000	4
		X	Land cover	Medio-European acidophilous [*Fagus*] forests (*Luzulo-Fagetum*)	m^2	2002	1:10,000	6
		X	Land cover	Medio-European acidophilous [*Quercus*] forests (*Luzulo-Quercetum*)	m^2	2002	1:10,000	6
		X	Land cover	Medio-European acidophilous [*Quercus*] forests (*Sileno-Quercetum petraea*)	m^2	2002	1:10,000	6
		X	Land cover	Medio-European neutrophile [*Fagus*] forests (*Melico-Fagetum*)	m^2	2002	1:10,000	6
		X	Land cover	[*Quercus*] - [*Fraxinus*] - [*Carpinus betulus*] woodland on eutrophic and mesotrophic soils (*Primulo-Carpinetum*)	m^2	2002	1:10,000	6
		X	Land cover	Sub-Atlantic calciphile [*Quercus*] - [*Carpinus betulus*] forests (*Querco-Carpinetum*)	m^2	2002	1:10,000	6
		X	Land cover	Riverine [*Alnus*] woodland	m^2	2002	1:10,000	6
X	X	X	Land cover	Mixed forests	m^2	1999-2007	1:15,000	4
X	X	X	Land cover	Coniferous forests	m^2	1999-2007	1:15,000	4
		X	Land cover	Spruce, firs, Douglas firs	m^2	2002	1:10,000	6
		X	Land cover	Pines	m^2	2002	1:10,000	6
X	X	X	Rivers	River length	m	-	-	7
X	X	X	Distance	Distance to closest forest	m	2007	1:15,000	8
X	X	X	Distance	Distance to closest headwater stream (1^{st}-3^{rd} Strahler order)	m	-	-	7
X	X	X	Distance	Distance to closest larger stream (4^{th}-10^{th} Strahler order)	m	-	-	7
X	X	X	Geology	Predominant geological substrate	categorical	1992	1:100,000	9
X	X	X	Soil	Predominant soil type	categorical	1970	1:100,000	10

Sources: **1** https://www.worldclim.org/data/worldclim21.html, **2** Climatic Atlas of the GD of Luxembourg - Administration des services techniques de l'agriculture et Service Météorologique de l'Aéroport de Findel, **3** Digital Elevation Model (DEM) of Luxembourg - Administration du Cadastre et de la Topographie, **4** Land cover map of Luxembourg (OBS99 and OBS07) - Ministère de l'Environnement, du Climat et de la Biodiversité, **5** Cadastre des biotopes de l'Article 17 de la loi sur la protection de la nature - Ministère de l'Environnement, du Climat et de la Biodiversité, **6** Phytosociological map of forest vegetation in Luxembourg - Administration de la Nature et des Forêts, **7** Waterways of Luxembourg - Ministère de l'Environnement, du Climat et de la Biodiversité, **8** Land cover map of Luxembourg (OBS07) - Ministère de l'Environnement, du Climat et de la Biodiversité, **9** Geological map of Luxembourg - Ministère des Travaux Publics (Service Géologie), **10** Soil map of Luxembourg - Administration des services techniques de l'agriculture (Service Pédologie)

- the species was recorded in few (i.e., less than 25) 200-m resolution grid cells;
- the absolute difference between test omission rate and training omission rate was more than 15%;
- the absolute difference between test AUC (area under the curve) and training AUC was higher than 0.1;
- the test omission rate for the species was higher than the test omission rates for any of the 8 species with the closest number of records used to build the models.

Models that did not meet any of these exclusion criteria were deemed reliable and were used to create habitat suitability maps (see below).

2.8 Species distribution maps

Two different types of distribution maps are presented in the atlas. All maps are projected with the Luxembourg 1930 Gauss CRS (EPSG: 2169), where Gauss grid is shown in grey at 5-km spatial resolution.

2.8.1 Distribution change maps

The purpose of the distribution change maps is to highlight changes in species distribution between atlas periods (Fig. 2.5 and Tab. 2.4). The 5-km resolution grid cells in blue (light and dark) show where the species has been recorded recently (2010-2020) but not during the previous atlas period (1990-2009). Orange grid cells (light and dark) show where the species was recorded previ-

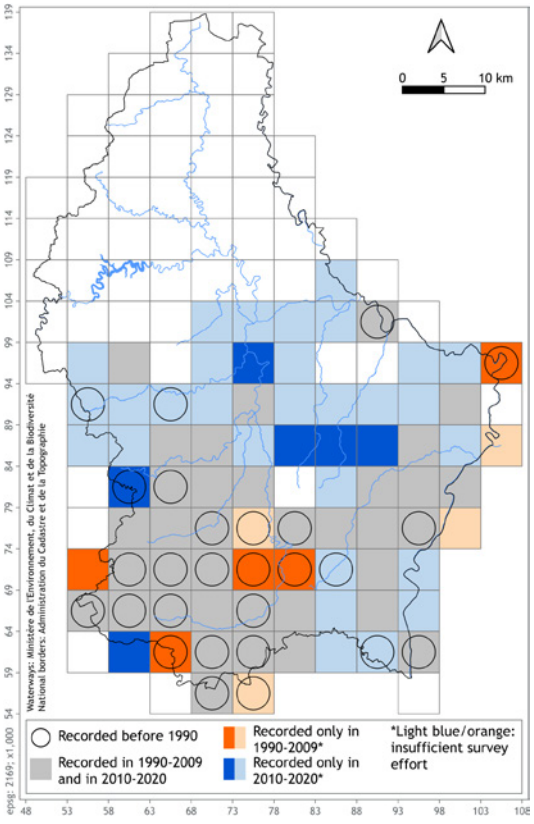


Fig. 2.5: Distribution change map for *Lycaena dispar*.

Tab. 2.4: Icons and colours used in the distribution change maps at 5-km spatial resolution.

Icon	Recorded before 1990	Recorded in 1990-2009	Recorded in 2010-2020	Interpretation
○	Yes	-	-	Historical distribution records
		Yes	No	Species recorded in 1990-2009 but not in 2010-2020 **Dark orange:** species not recorded in 2010-2020 although at least two complete surveys were undertaken during its flight season **Light orange:** species not recorded in 2010-2020 and number of complete surveys considered insufficient during that period (< 2)
		Yes	Yes	Species recorded both in 1990-2009 and in 2010-2020
		No	Yes	Species recorded in 2010-2020 but not in 1990-2009 **Dark blue:** species not recorded in 1990-2009 although at least two complete surveys were undertaken during its flight season **Light blue:** species not recorded in 1990-2009 and number of complete surveys considered insufficient during that period (< 2)

ously (1990-2009), but not recently (2010-2020). Grey grid cells show where the species has been recorded during the latest two atlas periods (1990-2009 and 2010-2020).

Light blue and orange grid cells show where the survey effort is considered insufficient (i.e., less than two complete surveys during the flight season of the species) in 1990-2009 or 2010-2020, respectively. Grid cells in light orange therefore show where the species was no longer recorded in 2010-2020 but could have been undetected due to a low survey effort between 2010 and 2020. Light blue grid cells show where the species was recently recorded but could have been undetected before due to a low survey effort in 1990-2009.

Records before 1990 are displayed for information (empty black circle) without comparison with other atlas periods due to the considerably low survey effort (see above "Survey effort").

2.8.2 Habitat suitability maps

Habitat suitability maps cover the period 2010-2020 only and show two pieces of information for each species (Fig. 2.6 and Tab. 2.5):

- species records at 1-km spatial resolution (black dots) in 2010-2020;
- habitat suitability for the species (graduated green colour) as predicted by the models at 200-m spatial resolution (see "Modelling the spatial distribution of the species").

Habitat suitability is a continuous value ranging between 0 and 1 from low to high suitability of the environmental conditions for the species in the grid cell. High values indicate environmental conditions that are similar to those prevailing in the sites where the species was recorded. These maps therefore show how the suitability of environmental conditions for a given species varies across the country

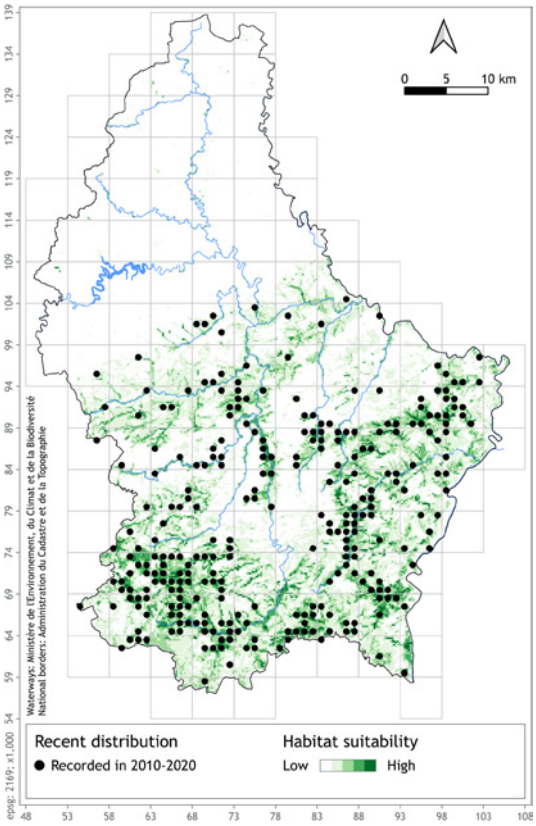


Fig. 2.6: Habitat suitability map for *Lycaena dispar*.

at a spatial resolution of 200 meters. Such habitat suitability maps are notably useful for management or conservation purposes because they identify areas potentially suitable for the species (i.e., with the most suitable conditions) or where the species is likely present but not recorded so far. Habitat suitability is shown for species only when the models were considered reliable (see "Modelling the spatial distribution of the species"), otherwise only the presence records at 1-km resolution are shown on the distribution maps.

Tab. 2.5: Icons and colours used in the habitat suitability maps for the period 2010-2020. Habitat suitability values were reclassified in graduated colour classes using the "Natural Breaks (Jenks)" method implemented in QGIS.

Icon	Interpretation
●	Species recorded in 2010-2020
Low ▭ High	Habitat suitability derived from the models as a continuous value between 0 (lowest habitat suitability) and 1 (highest habitat suitability)

2.9 References

Dormann C. F., Elith J., Bacher S., Buchmann C., Carl G., Carré G., Marquéz J. R. G., Gruber B., Lafourcade B., Leitão P. J., Münkemüller T., Mcclean C., Osborne P. E., Reineking B., Schröder B., Skidmore A. K., Zurell D. & Lautenbach S. 2013. - Collinearity: A review of methods to deal with it and a simulation study evaluating their performance. Ecography 36: 027–046.

Drew C. A., Wiersma Y. F. & Huettmann F. 2011. - Predictive Species and Habitat Modeling in Landscape Ecology. Springer, New York, 313 p.

Dudík M., Phillips S. J. & Schapire R. E. 2007. - Maximum Entropy Density Estimation with Generalized Regularization and an Application to Species Distribution Modeling. Journal of Machine Learning Research 8: 1217–1260.

Elith J. & Leathwick J. R. 2009. - Species Distribution Models: Ecological Explanation and Prediction Across Space and Time. Annual Review of Ecology, Evolution, and Systematics 40: 677–697.

Elith J., Phillips S. J., Hastie T., Dudík M., Chee Y. E. & Yates C. J. 2011. - A statistical explanation of MaxEnt for ecologists. Diversity and Distributions 17: 43–57.

Fox R., Dennis E. B., Brown A. F. & Curson J. 2022. - A revised Red List of British butterflies. Insect Conservation and Diversity 15: 485–495.

Franklin J. 2010. - Moving beyond static species distribution models in support of conservation biogeography. Diversity and Distributions 16: 321–330.

Guisan A. & Thuiller W. 2005. - Predicting species distribution: offering more than simple habitat models. Ecology Letters 8: 993–1009.

Habel J. C., Teucher M., Gros P., Schmitt T. & Ulrich W. 2021. - Land use and climate change affects butterfly diversity across northern Austria. Landscape Ecology 36: 1741–1754.

IUCN 2012. - IUCN Red List Categories and Criteria: Version 3.1 (2nd ed.). IUCN, Gland, Switzerland and Cambridge, UK, iv + 32 p.

IUCN Standards and Petitions Committee 2022. - Guidelines for Using the IUCN Red List Categories and Criteria. Version 15. Prepared by the Standards and Petitions Committee. 116 p.

Mestdagh X., Baltus H., Renneson J. L., Hoffmann L. & Titeux N. 2011. - Espèces nouvelles et retrouvées chez les papillons de jour au Luxembourg. Bulletin de la Société des naturalistes luxembourgeois 112: 97–108.

Meyer M. 2000. - Red List of Butterflies and Moths of Luxembourg: Rhopalocera and Heterocera. National Museum of Natural History. Available at: https://ps.mnhn.lu/recherche/redbook/butterflies/default.htm.

Phillips S. J., Anderson R. P. & Schapire R. E. 2006. - Maximum entropy modeling of species geographic distributions. Ecological Modelling 190: 231–259.

Sevilleja C. G., van Swaay C., Bourn N., Collins S., Settele J., Warren M. S., Wynhoff I. & Roy D. 2019. - Butterfly Transect Counts: Manual to monitor butterflies. Report VS2019.016. Wageningen, 15 p.

Titeux N., Moes M. & Hoffmann L. 2009. - Élaboration d'un programme de surveillance et de monitoring de la biodiversité au Luxembourg. Ministère du Développement durable et des Infrastructures (Département de l'environnement) & Centre de Recherche Public – Gabriel Lippmann, Luxembourg, 378 p.

van Swaay C., Warren M. & Loïs G. 2006. - Biotope use and trends of European butterflies. Journal of Insect Conservation 10: 189–209.

Wiemers M., Balletto E., Dincă V., Fric Z. F., Lamas G., Lukhtanov V., Munguira M. L., van Swaay C. , Vila R., Vliegenthart A., Wahlberg N. & Verovnik R. 2018. - An updated checklist of the European Butterflies (Lepidoptera, Papilionoidea). ZooKeys 811: 9–45.

3 Red List of the butterflies of Luxembourg

Lisette Cantú-Salazar[1,✉], Xavier Mestdagh[1], Lionel L'Hoste[1], Youri Martin[1], Sarah Vray[1] and Nicolas Titeux[1]

[1] Luxembourg Institute of Science and Technology (LIST)
5 Avenue des Hauts-Fourneaux
L-4362 Esch-sur-Alzette, Luxembourg

✉ Corresponding author: lisette.cantu@list.lu

3.1 The Red List system

Red Lists aim to identify those species at greatest risk of extinction and the critical factors that are responsible for this risk. Though not explicitly designed to be used for setting conservation priorities, Red Lists can be combined with additional information, such as biological traits, costs or practicality of recovery action to guide conservation priorities (IUCN 2012a; IUCN Standards and Petitions Committee 2022). They usefully complement the reporting under the Habitats Directive (which focuses only on some species protected by the EU nature legislation), as well as national legislations and action plans. In this chapter, we assess the extinction risk of butterfly species that are known to breed in Luxembourg, and we identify those that are most threatened at the Luxembourg extent.

To measure the risk of extinction of the butterfly species in Luxembourg, we used the International Union for Conservation of Nature (IUCN) Red List system as a basis, which is the best-known worldwide conservation status ranking scheme. It uses comprehensive rules based on quantitative criteria to produce a relative estimate of the likelihood of extinction of the taxon. By providing an explicit, quantitative and objective framework, this system can be applied consistently by different people, over time, to classify the broadest range of species, thus facilitating comparisons across widely different taxa, countries or biotopes (Juslén et al. 2016). While recognising that the IUCN criteria are designed for global assessments and that their application to very restricted geographical areas (such as Luxembourg) is discouraged, an extinction risk assessment using the IUCN Red List framework, in conjunction with the guidelines for applying the IUCN Red List Criteria at regional and national levels (IUCN 2012b), was considered the most useful approach in order to allow for consistency in future assessments.

The first Red List assessment of the butterflies in Luxembourg was published in 1981 (Meyer & Pelles 1981a), and a second Red List was later published online (Meyer 2000). The extinction risk of each butterfly species is likely to have changed substantially since those assessments. In addition, the approaches used for those assessments were not based on the IUCN system, which prevents us from comparing extinction risk across periods and to other regions. For assessments to remain current and relevant, the IUCN recommends that species statuses are re-examined at least every 10 years, preferably every 5 years, resources permitting (IUCN 2016). Given the substantial evidence for the rapid decline of these insects in anthropogenic landscapes in western Europe (e.g., Warren et al. 2021), a new assessment for this taxonomic group was considered appropriate. It should be noted that detailed and relevant data are rarely available across an entire range of species, even for those relatively well-known such as butterflies; however, the IUCN Red List criteria, quantitative in nature, are designed to use various types of data and efforts at applying the criteria are encouraged even in the absence of complete or high-quality data (IUCN 2012b; IUCN Standards and Petitions Committee 2022). We advise for regular updates as more data becomes available to evaluate each species using as many criteria as possible, as recommended by the IUCN (IUCN 2016).

3.2 Methods and data sources

3.2.1 Species selection

For all butterfly species known to breed in Luxembourg (see full list of species in Chapter 2, Tab. 2.1), we gathered all available unique records collected in the country. The methods used for the collection of these records are detailed in Chapter 2. Only native butterfly species that breed or that likely bred in Luxembourg since the 19th century were included in this assessment. All butterflies were assessed at species level; subspecies were not considered. Vagrant species (i.e., those that have been found only occasionally within the boundaries of a region without breeding evidence) were excluded, as indicated in the IUCN regional guidelines (IUCN 2012b), as well as species where evidence for their historical native resident status was doubtful or assumed resulting from an encoding error. Cryptic species (i.e., species virtually indistinguishable externally, grouped in complexes) and species with a risk of highly unreliable determinations due to their similarity with closely related species were not evaluated. This concerned *Colias hyale/alfacariensis*, *Hipparchia hermione/fagi*, *Leptidea sinapis/juvernica*, *Melitaea athalia/aurelia*, *Pontia daplidice/edusa* and *Pieris mannii* (which may have been overlooked due to its resemblance to other whites such as *Pieris rapae*). For one butterfly species, *Cupido argiades*, the number of records has largely fluctuated between 1979 and 2020, dropping from 10 in 1979 to 0 in 1990-2009, and rapidly increasing since 2010 (365 records); however, the exact year since the species started to breed in Luxembourg (i.e., to produce offspring) is not confirmed. This species was already described in Meyer & Pelles (1981b) as showing waves of colonisation followed by a period of absence. In addition, it might have been under-detected between 1990-2009 due to confusion with similar species. This species is thus not included in this Red List assessment but may be included in subsequent assessments if breeding is confirmed within the region for at least 10 consecutive years (IUCN 2012b).

3.2.2 IUCN categories

The IUCN categories used in this national assessment are as defined in the IUCN Red List Categories and Criteria: Version 3.1 (IUCN 2001; IUCN 2012a). We followed the Guidelines for Using the IUCN Red List Categories and Criteria (Version 15; IUCN Standards and Petitions Committee 2022) and the Guidelines for Application of IUCN Red List Criteria at Regional and National Levels (Version 4.0; IUCN 2012a,b). Eleven categories are used for listing species in regional Red Lists following the IUCN system (Fig. 3.1):

- Three categories refer to the deficiency of data or the non-eligibility of the species for assessment: Data Deficient (DD), Not Applicable (NA – e.g., introduced species) and Not Evaluated (NE). NE indicates that no attempt to evaluate the status of the taxon has been made, whereas DD indicates that data were insufficient to place the taxon into a category;
- Three categories denote extinct species: Extinct (EX – globally extinct species), Extinct in the Wild (EXW – the species only persists in captivity) and Regionally Extinct (RE – extinct species in the focal region);
- Five categories reflect varying degrees of threat of extinction: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) and Least Concern (LC). Taxa in any of the three first categories (CR, EN, VU) are collectively referred to as "threatened". The category LC is applied to taxa that do not qualify as threatened or NT.

3.2.3 IUCN criteria

The IUCN Red List system uses five quantitative criteria to classify species according to their extinction risk:

(A) population decline (in the past over a period of 10 years or 3 generations, whichever is longer, or projected into the near future);

(B) geographic range size and fragmentation, decline or fluctuation;

(C) small population size and fragmentation, decline or fluctuation;

(D) very small or geographically restricted population;

(E) quantitative analysis indicating the probability of extinction in the wild.

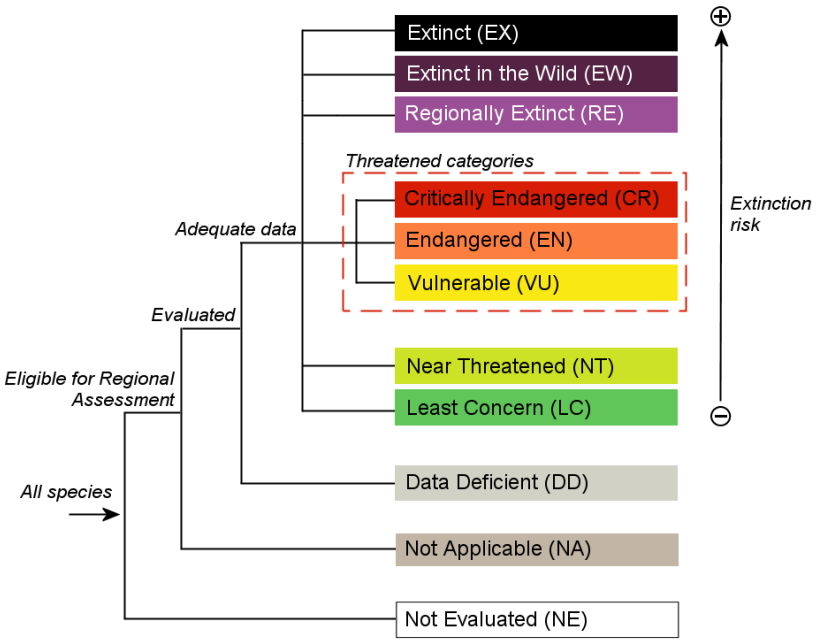


Fig. 3.1: Structure of the IUCN Red List categories (from IUCN 2012a, b).

By applying simple quantitative rules relating to population size, range size and rate of decline of both, species are allocated to the categories of extinction risk. These criteria also include subcriteria that must be used to justify more specifically the listing of a taxon under a particular category. Each species is evaluated against as many IUCN criteria as data allow, and only one of the criteria needs to be met to list a species in any of the categories of threat. The Red List category that results in the highest level of extinction risk among the different criteria is assigned to the taxon.

Despite butterflies being one of the best surveyed taxa in Luxembourg, only few IUCN criteria could be applied. Given the limitations and the nature of available data, only **criterion A** (population reduction) was applied to the whole set of species and other criteria were applied to some species where data permitted. A decline in the area of occupancy (AOO) and/or the extent of occurrence (EOO) was used as the basis for estimating population reduction (criterion A2c). Criterion A2c refers to a population reduction that has occurred in the last 10 years or over three generations (whichever is longer) based on a decline in AOO, EOO and/or habitat quality, where the causes of reduction may not have ceased or may not be understood or may not be reversible. As detailed in Chapter 2, EOO is defined as "the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of occurrence of a taxon" (IUCN 2012a). The AOO represents the area of suitable habitat occupied by the taxon, reflecting the fact that this will not usually occur throughout the entire area of its EOO, which may contain unoccupied or unsuitable habitats. EOO and AOO reflect two different processes: the intent behind EOO is to measure the degree to which risks from threatening factors are spread spatially across the taxon's geographical distribution, whereas AOO reflects vulnerability to spatially explicit threats. It is therefore useful to estimate both metrics in Red List assessments.

A systematic collection of distribution and abundance data for butterflies in Luxembourg only started in 2010; thus, much more data were available in 2010-2020 than before 2010 (hereafter <2010, see Chapter 2, Fig. 2.2 and Fig. 2.3). Following the rationale of Adriaens et al. (2015), we assumed that a longer, but less intensively surveyed reference period would compensate for a shorter but more intensively surveyed recent

period. Thus, for each species, we calculated the changes in EOO and AOO between <2010 and 2010-2020 as a proxy for population change. The methods used for calculating these two metrics are detailed in Chapter 2. Briefly, we estimated the EOO for each butterfly species in each period using the Minimum Convex Polygon (MCP) method, which is one of the simplest techniques to estimate a species' EOO (IUCN Standards and Petitions Committee 2022), and a pragmatic measure of the spatial spread of risk.

The change in EOO for each species with enough records to compute an MCP (i.e., >2) was calculated as:

$$\text{Change in EOO} = 100 * \frac{EOO_{2010\text{-}2020} - EOO_{<2010}}{EOO_{<2010}}$$

To estimate change in the AOO for each species and to reduce the differences between the less intensively surveyed period <2010 and the more intensively surveyed period 2010-2020, we first estimated extinction and colonisation rates between both periods based only on grid cells where sufficient information on the presence and absence of the species allowed these estimations. We then extrapolated these rates to estimate extinctions, colonisations and persistence among the whole set of grid cells where the species was recorded in <2010 or in 2010-2020, to calculate a relative AOO for each period (see details in Chapter 2).

The change in relative AOO between <2010 and 2010-2020 for each species was calculated with the formula:

Change in relative AOO =

$$100 * \frac{\text{Relative } AOO_{2010\text{-}2020} - \text{Relative } AOO_{<2010}}{\text{Relative } AOO_{<2010}}$$

Each species was assigned to the highest Red List category obtained by applying the following IUCN quantitative thresholds for criterion A2c to both EOO and AOO metrics (IUCN Standards and Petitions Committee 2022):

- CR: ≥ 80% reduction
- EN: ≥ 50% reduction
- VU: ≥ 30% reduction

In addition, a species was classified as NT when the reduction in EOO or AOO was close to qualifying for the VU category: between 20 and 30% decline (e.g., Adriaens et al. 2015; Maes et al. 2012). Species that did not meet the above thresholds were classified as LC.

Criterion B aims to identify species with restricted distributions, which in addition, 1) have severely fragmented populations or are present in few locations (defined as distinct areas in which a single threatening event can rapidly affect all individuals of the taxon present), and/or 2) undergo a form of continuing decline, and/or 3) exhibit extreme fluctuations (in the present or near future). To qualify for criterion B, the IUCN EOO and/or AOO thresholds must first be met for one of the categories of threat, then the species must meet at least two of the three subcriteria listed above. Thus, in addition to estimates on EOO and/or AOO, this criterion requires information on those three additional risk factors. The definition of each of these subcriteria and the IUCN thresholds in terms of EOO (B1) or AOO (B2) are detailed in the IUCN guidelines (IUCN Standards and Petitions Committee 2022). The IUCN area quantitative thresholds for classifying a butterfly species as EN or VU under criterion B1 (EOO < 5,000 km² and < 20,000 km²) and as VU under criterion B2 (AOO < 2,000 km²) are too high in relation to the extent of Luxembourg, which has an area of 2,586 km². Thus, only the threshold for CR was used for B1 (EOO < 100 km²), and the thresholds for CR or EN (AOO < 10 km² and < 500 km²) were used for B2. As recommended in the IUCN guidelines, a reference scale of 4 km² (2 x 2 km) grid cells was used for estimating AOO to assess criterion B2.

Information on all three subcriteria was not available for any of the butterfly species assessed. However, it was possible to derive the number of locations, as defined by the IUCN, by using as a proxy an estimate of the number of subpopulations occurring within an area that may be affected by a single threatening event (see details below). Subpopulations were defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (IUCN Standards and Petitions Committee 2022). Following Fox et al. (2022), if a species met the IUCN thresholds for at least one of the three subcriteria (in this case, a small number of locations) in addition to the IUCN EOO and/

or AOO thresholds as described above, it was classified as Near Threatened under criterion B.

Subcriterion "number of locations". For each species, the total number of subpopulations, whether under threat or not, was first estimated by grouping all 200-m grid cells that were within dispersal distance from each record collected between 2010-2020. Subsequently, all 1-km grid cells within dispersal distance from the aggregated 200-m grid cells were grouped. Since measures of dispersal were not available for butterfly species occurring in Luxembourg, data on wingspan and four data sets with different measures of dispersal compiled by Sekar (2012) were used to estimate a dispersal distance for each butterfly species in our set. According to Sekar (2012), wingspan is the usually preferred surrogate for body size, which is in turn the most intuitive species-specific trait established to affect dispersal ability. Although not the only factor affecting dispersal, the authors suggest that it can be used as a satisfactory proxy for analyses involving many species. First, all butterfly species were ranked according to their wingspan and grouped in three classes with the aid of frequency plots. The information on mean dispersal distances (MDD, in meters) available for species in each class was then used to obtain an average MDD for that class. This average MDD was used as a dispersal distance for all species allocated to that class as follows: a) Small (11-15mm), 60 m; b) Medium (15.5-20.5mm), 300 m; c) Large (21-38mm), 450 m. For each species, its estimated average MDD was compared to the mobility scores and indices given in Sekar (2012). When a species was scored as a low disperser by any of these indices (i.e., very sedentary to sedentary), but its estimated average MDD fell within the Medium and Large categories (i.e., 300m or 450m), this was downgraded to the next lower MDD class.

Subpopulations occurring within an area that may be affected by a single threatening event were counted as a single location. When parts of the distribution of a species were not considered as affected by any such threat, the number of locations in the unaffected areas were set to the number of subpopulations in those areas (IUCN Standards and Petitions Committee 2022). For species meeting the IUCN EOO and/or AOO thresholds for criterion B, subpopulations in the Minette area were considered as one location, given the documented threats that some butterfly species (e.g., *Euphydryas aurinia*) face in that area, such as the combined, local effects of frequent off-trail hiking, mountain biking, unleashed dogs running or campfires (Herr & Cungs 2021), in addition to the extreme droughts expected to increase due to climate change, which can cause direct and indirect mortality to all the subpopulations in the Minette in a short period, with little opportunity for recovery. For these species, 1-km grid cells in the Minette were nevertheless already aggregated, given their MDD.

Criterion C, which aims to identify taxa with small populations that are currently declining or may decline in the near future, was not used because estimates of population size in terms of the total number of mature individuals in all areas – or all subpopulations – as defined in the IUCN guidelines are not existing for any butterfly species in Luxembourg. In general, few taxa have data on both population size and decline rates at the necessary resolution to apply this criterion (IUCN Standards and Petitions Committee 2022).

Similarly, **criterion D**, related to very small or restricted populations, was not used because it also needs information on population sizes based on numbers of mature individuals. On the other hand, criterion D2 allows categorising species as Vulnerable if these have a very small AOO (typically < 20 km²) or occur in a very small number of locations (≤ 5) where there is a credible threat that could cause rapid extinction. Both the AOO and the number of locations, as estimated for criterion B2, were used to assess species under criterion D2.

Criterion E, indicating extinction probability, was not used because no quantitative analyses to estimate such probability (e.g., a population viability analysis) has been conducted or published for any butterfly species in Luxembourg.

3.2.4 Rescue effect

According to the IUCN criteria for regional assessments (IUCN 2012b), the resulting IUCN Red List category should be lowered by one category if populations in neighbouring regions can exert a rescue effect on Luxembourg's populations due to immigration of propagules. To assess if there was a potential ameliorating effect on extinction risk for each butterfly species provisionally classified as threatened or near threatened (after following

the methods described above) due to potential source populations within plausible immigration distance, we asked butterfly experts from Luxembourg's neighbouring regions (see Acknowledgements and Supporting Material) to provide, for each of those butterfly species present in their region, information on: 1) their breeding status (breeding status: yes or no); 2) the population trend (positive, stable, negative, or unknown), 3) distance of the closest population to Luxembourg's border (5 km, 10 km, 25 km, >50 km) and 4) potential for propagules to reach Luxembourg (yes, no, or unknown). Experts provided information for Wallonia (Belgium), Saarland and Rheinland-Pfalz (Germany) and Lorraine (France). For each region, a rescue effect from each species breeding in those regions was considered as plausible if the population trend was stable or positive, and if there was potential of propagules reaching Luxembourg. If a species was provisionally classified as threatened or near threatened (CR, EN, VU or NT) in Luxembourg but there was a potential rescue effect from at least one of the neighbouring regions, the status was downlisted by one Red List category. The resulting IUCN Red List categories, both before and after considering a possible rescue effect, are presented in the Results (see also Supporting Material).

3.3 Results

Extinction risk was assessed for butterfly species known to breed or to have likely bred in Luxembourg between 1800 and 2020 using the IUCN classification system. Results show that fifteen species have gone regionally extinct between 1854 (*Satyrium acaciae*) and 2003 (*Boloria euphrosyne*) (Tab. 3.1).

Before taking into account the possibility of butterfly populations in Luxembourg's neighbouring regions exerting a rescue effect, 7 butterfly species were classified as CR, 14 as EN, 7 as VU, 5 as NT and 43 as LC (Fig. 3.2a). For 16 species, the resulting Red List category obtained after applying the IUCN criteria was lowered by one due to the possibility of a rescue effect:

- one species (*Lasiommata maera*) was downlisted from CR to EN;
- nine species (*Apatura iris*, *Cupido minimus*, *Erynnis tages*, *Lysandra bellargus*, *Melitaea diamina*, *Speyeria aglaja*, *Spialia sertorius*, *Thecla betulae*, *Thymelicus acteon*) were downlisted from EN to VU;
- four species (*Carterocephalus palaemon*, *Glaucopsyche alexis*, *Lysandra coridon*, *Satyrium w-album*) were downlisted from VU to NT;
- two species (*Coenonympha arcania*, *Lycaena dispar*) were downlisted from NT to LC.

Thus, after considering this potential rescue effect, 24 butterfly species were classified as threatened with extinction (Tab. 3.1, Fig. 3.2b): 6 species were classified as CR (*Euphydryas aurinia*, *Fabriciana adippe*, *Hesperia comma*, *Hipparchia semele*, *Lycaena hippothoe* and *Pyrgus serratulae*; Fig. 3.3), 6 as EN (*Boloria selene*, *Lasiommata maera*, *Limenitis populi*, *Phengaris arion*, *Plebejus argus*, and *Satyrium ilicis*; Fig. 3.4), and 12 as VU (*Apatura iris*, *Boloria eunomia*, *Cupido minimus*, *Erynnis tages*,

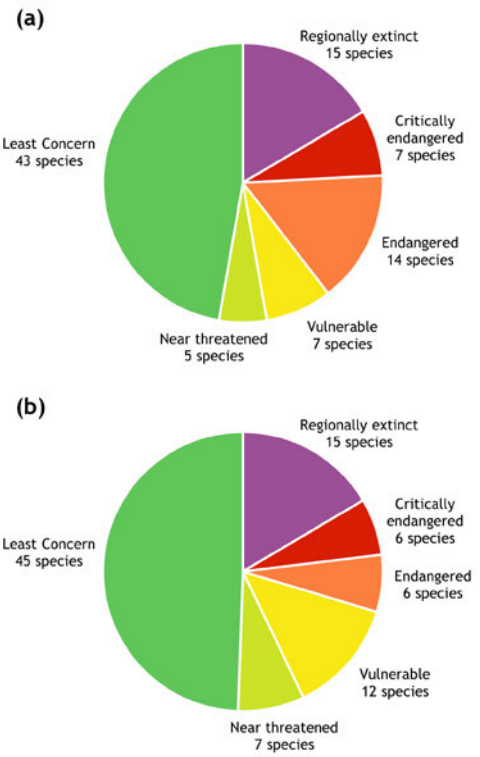


Fig. 3.2: Number of evaluated butterfly species in Luxembourg in each IUCN Red List category, (a) before and (b) after considering a possible rescue effect from the neighbouring regions (Wallonia, Saarland, Rheinland-Pfalz, or French Lorraine).

Tab. 3.1: IUCN Red List of the butterflies in Luxembourg. Each species was assigned to the highest Red List category obtained by applying the IUCN quantitative thresholds for criteria A2c, B1, B2 and/or D2 (see text). A final Red List Category was obtained after considering a possible rescue effect from the neighbouring regions (Wallonia, Saarland, Rheinland-Pfalz, or French Lorraine). When a possible rescue effect existed in at least one of these regions (Possible Rescue effect = Yes), the category was downlisted by one. European and European Union (EU) IUCN Red List Categories for each species are from van Swaay et al. (2010).

Species	Criterion A2c EOO	Criterion A2c AOO	Criterion B1 EOO	Criterion B2 AOO	Criterion D2	IUCN Red List Category before rescue effect	Possible Rescue effect	IUCN Red List Category after rescue effect	European IUCN Red List Category	EU IUCN Red List Category
Regionally Extinct (RE) – 15										
(between brackets the year of the last record in Luxembourg)										
Boloria euphrosyne (2003)						RE		RE	LC	LC
Brintesia circe (1984)						RE		RE	LC	LC
Coenonympha hero (1977)						RE		RE	VU	VU
Erebia aethiops (1966)						RE		RE	LC	LC
Euphydryas maturna (1960-80)						RE		RE	VU	LC
Hamearis lucina (1996)						RE		RE	LC	LC
Iphiclides podalirius (1992)						RE		RE	LC	LC
Lopinga achine (1979)						RE		RE	VU	VU
Lycaena virgaureae (1994)						RE		RE	LC	LC
Melitaea didyma (1977)						RE		RE	LC	LC
Melitaea phoebe (1984)						RE		RE	LC	LC
Polyommatus dorylas (1950)						RE		RE	NT	NT
Pseudophilotes baton (1952)						RE		RE	LC	LC
Satyrium acaciae (1854)						RE		RE	LC	LC
Satyrium spini (1984)						RE		RE	LC	LC
Critically Endangered (CR) – 6										
Euphydryas aurinia	CR [-92%]	EN [-65%]		NT	VU	CR	No	CR	LC	LC
Fabriciana adippe	CR [-97%]	EN [-57%]		NT	VU	CR	No	CR	LC	LC

Tab. 3.1: (continued)

Species	Criterion A2c EOO	Criterion A2c AOO	Criterion B1 EOO	Criterion B2 AOO	Criterion D2	IUCN Red List Category before rescue effect	Possible Rescue effect	IUCN Red List Category after rescue effect	European IUCN Red List Category	EU IUCN Red List Category
Hesperia comma	CR [-93%]	VU [-44%]		NT	VU	CR	No	CR	LC	LC
Hipparchia semele	CR [-99%]	VU [-36%]	NT	NT	VU	CR	No	CR	LC	LC
Lycaena hippothoe	CR [-91%]	CR [-87%]		NT	VU	CR	No	CR	LC	NT
Pyrgus serratulae	CR [-96%]	EN [-50%]	NT	NT	VU	CR	No	CR	LC	NT
Endangered (EN) – 6										
Boloria selene	EN [-59%]	VU [-43%]				EN	No	EN	LC	LC
Lasiommata maera	CR [-98%]	EN [-57%]		NT	VU	CR	Yes	EN	LC	LC
Limenitis populi	EN [-57%]	EN [-50%]			NT	EN	No	EN	LC	NT
Phengaris arion	EN [-74%]	VU [-36%]		NT	VU	EN	No	EN	EN	EN
Plebejus argus	EN [-52%]	VU [-39%]				EN	No	EN	LC	LC
Satyrium ilicis	LC [-9%]	EN [-70%]				EN	No	EN	LC	LC
Vulnerable (VU) – 12										
Apatura iris	LC [-10%]	EN [-51%]				EN	Yes	VU	LC	LC
Boloria eunomia	NT [-26%]	VU [-34%]				VU	No	VU	LC	LC
Cupido minimus	EN [-53%]	NT [-30%]				EN	Yes	VU	LC	LC
Erynnis tages	EN [-73%]	EN [-62%]				EN	Yes	VU	LC	LC
Lycaena helle	VU [-35%]	NT [-27%]				VU	No	VU	EN	LC
Lysandra bellargus	EN [-64%]	LC [15%]				EN	Yes	VU	LC	LC
Melitaea diamina	EN [-73%]	VU [-33%]				EN	Yes	VU	LC	NT
Nymphalis antiopa				NT	VU	VU	No	VU	LC	LC
Speyeria aglaja	LC [-6%]	EN [-50%]				EN	Yes	VU	LC	LC
Spialia sertorius	EN [-71%]	VU [-42%]				EN	Yes	VU	LC	LC
Thecla betulae	LC [-12%]	EN [-57%]				EN	Yes	VU	LC	LC
Thymelicus acteon	EN [-54%]	NT [-21%]				EN	Yes	VU	NT	NT

Tab. 3.1: (continued)

Species	Criterion A2c EOO	Criterion A2c AOO	Criterion B1 EOO	Criterion B2 AOO	Criterion D2	IUCN Red List Category before rescue effect	Possible Rescue effect	IUCN Red List Category after rescue effect	European IUCN Red List Category	EU IUCN Red List Category
Near Threatened (NT) – 7										
Aporia crataegi	LC [2%]	NT [-30%]				NT	No	NT	LC	LC
Callophrys rubi	LC [4%]	NT [-21%]				NT	No	NT	LC	LC
Carterocephalus palaemon	VU [-44%]	VU [-31%]				VU	Yes	NT	LC	LC
Erebia medusa	NT [-23%]	NT [-27%]				NT	No	NT	LC	LC
Glaucopsyche alexis	LC [2%]	VU [-39%]				VU	Yes	NT	LC	LC
Lysandra coridon	VU [-45%]	LC [2%]				VU	Yes	NT	LC	LC
Satyrium w-album	NT [-30%]	VU [-45%]				VU	Yes	NT	LC	LC
Least Concern (LC) – 45										
Aglais io	LC [2%]	LC [-10%]				LC		LC	LC	LC
Aglais urticae	LC [2%]	LC [2%]				LC		LC	LC	LC
Anthocharis cardamines	LC [1%]	LC [-8%]				LC		LC	LC	LC
Apatura ilia	LC [47%]	LC [-7%]				LC		LC	LC	LC
Aphantopus hyperantus	LC [3%]	LC [1%]				LC		LC	LC	LC
Araschnia levana	LC [4%]	LC [-12%]				LC		LC	LC	LC
Argynnis paphia	LC [7%]	LC [8%]				LC		LC	LC	LC
Aricia agestis	LC [-2%]	LC [42%]				LC		LC	LC	LC
Boloria dia	LC [-6%]	LC [-17%]				LC		LC	LC	LC
Brenthis daphne		LC [1900%]				LC		LC	LC	LC
Brenthis ino	LC [5%]	LC [-13%]				LC		LC	LC	LC
Carcharodus alceae	LC [8%]	LC [23%]				LC		LC	LC	LC
Celastrina argiolus	LC [11%]	LC [17%]				LC		LC	LC	LC
Coenonympha arcania	LC [3%]	NT [-22%]				NT	Yes	LC	LC	LC
Coenonympha pamphilus	LC [3%]	LC [-1%]				LC		LC	LC	LC

Tab. 3.1: (continued)

Species	Criterion A2c EOO	Criterion A2c AOO	Criterion B1 EOO	Criterion B2 AOO	Criterion D2	IUCN Red List Category before rescue effect	Possible Rescue effect	IUCN Red List Category after rescue effect	European IUCN Red List Category	EU IUCN Red List Category
Colias crocea	LC [10%]	LC [37%]				LC		LC	LC	LC
Cyaniris semiargus	LC [5%]	LC [-10%]				LC		LC	LC	LC
Favonius quercus	LC [14%]	LC [-12%]				LC		LC	LC	LC
Gonepteryx rhamni	LC [3%]	LC [-4%]				LC		LC	LC	LC
Issoria lathonia	LC [12%]	LC [33%]				LC		LC	LC	LC
Lasiommata megera	LC [7%]	LC [-19%]				LC		LC	LC	LC
Limenitis camilla	LC [21%]	LC [0%]				LC		LC	LC	LC
Lycaena dispar	LC [6%]	NT [-24%]				NT	Yes	LC	LC	LC
Lycaena phlaeas	LC [4%]	LC [-12%]				LC		LC	LC	LC
Lycaena tityrus	LC [12%]	LC [-9%]				LC		LC	LC	LC
Maniola jurtina	LC [2%]	LC [3%]				LC		LC	LC	LC
Melanargia galathea	LC [4%]	LC [1%]				LC		LC	LC	LC
Melitaea cinxia	LC [28%]	LC [-6%]				LC		LC	LC	LC
Nymphalis polychloros	LC [15%]	LC [-17%]				LC		LC	LC	VU
Ochlodes sylvanus	LC [3%]	LC [-4%]				LC		LC	LC	LC
Papilio machaon	LC [1%]	LC [-15%]				LC		LC	LC	LC
Pararge aegeria	LC [9%]	LC [-7%]				LC		LC	LC	LC
Pieris brassicae	LC [2%]	LC [-18%]				LC		LC	LC	LC
Pieris napi	LC [1%]	LC [-8%]				LC		LC	LC	LC
Pieris rapae	LC [3%]	LC [-7%]				LC		LC	LC	LC
Polygonia c-album	LC [8%]	LC [11%]				LC		LC	LC	LC
Polyommatus icarus	LC [5%]	LC [1%]				LC		LC	LC	LC
Pyrgus armoricanus	LC [2701%]	LC [900%]				LC		LC	LC	LC
Pyrgus malvae	LC [2%]	LC [-14%]				LC		LC	LC	LC

Tab. 3.1: (continued)

Species	Criterion A2c EOO	Criterion A2c AOO	Criterion B1 EOO	Criterion B2 AOO	Criterion D2	IUCN Red List Category before rescue effect	Possible Rescue effect	IUCN Red List Category after rescue effect	European IUCN Red List Category	EU IUCN Red List Category
Pyronia tithonus	LC [3%]	LC [-1%]				LC		LC	LC	LC
Satyrium pruni	LC [21%]					LC		LC	LC	LC
Thymelicus lineola	LC [2%]	LC [5%]				LC		LC	LC	LC
Thymelicus sylvestris	LC [2%]	LC [1%]				LC		LC	LC	LC
Vanessa atalanta	LC [3%]	LC [11%]				LC		LC	LC	LC
Vanessa cardui	LC [4%]	LC [-17%]				LC		LC	LC	LC
Not Evaluated (NE) – 12										
Colias alfacariensis						NE		NE	LC	LC
Colias hyale						NE		NE	LC	LC
Cupido argiades						NE		NE	LC	LC
Hipparchia fagi						NE		NE	NT	NT
Hipparchia hermione						NE		NE	NT	NT
Leptidea juvernica						NE		NE		
Leptidea sinapis						NE		NE	LC	LC
Melitaea athalia						NE		NE	LC	LC
Melitaea aurelia						NE		NE	NT	LC
Pieris mannii						NE		NE	LC	LC
Pontia daplidice						NE		NE	LC	LC
Pontia edusa						NE		NE	LC	LC

Fig. 3.3: The Critically Endangered butterfly species in Luxembourg: (a) *Euphydryas aurinia* (photo: Roland Proess), (b) *Fabriciana adippe* (photo: Lionel L'Hoste), (c) *Hesperia comma* (photo: Nicolas Titeux), (d*) Hipparchia semele* (photo: Alain Dohet), (e) *Lycaena hippothoe* (photo: Hubert Baltus), and (f) *Pyrgus serratulae* (photo: Stéphane Vitzthum).

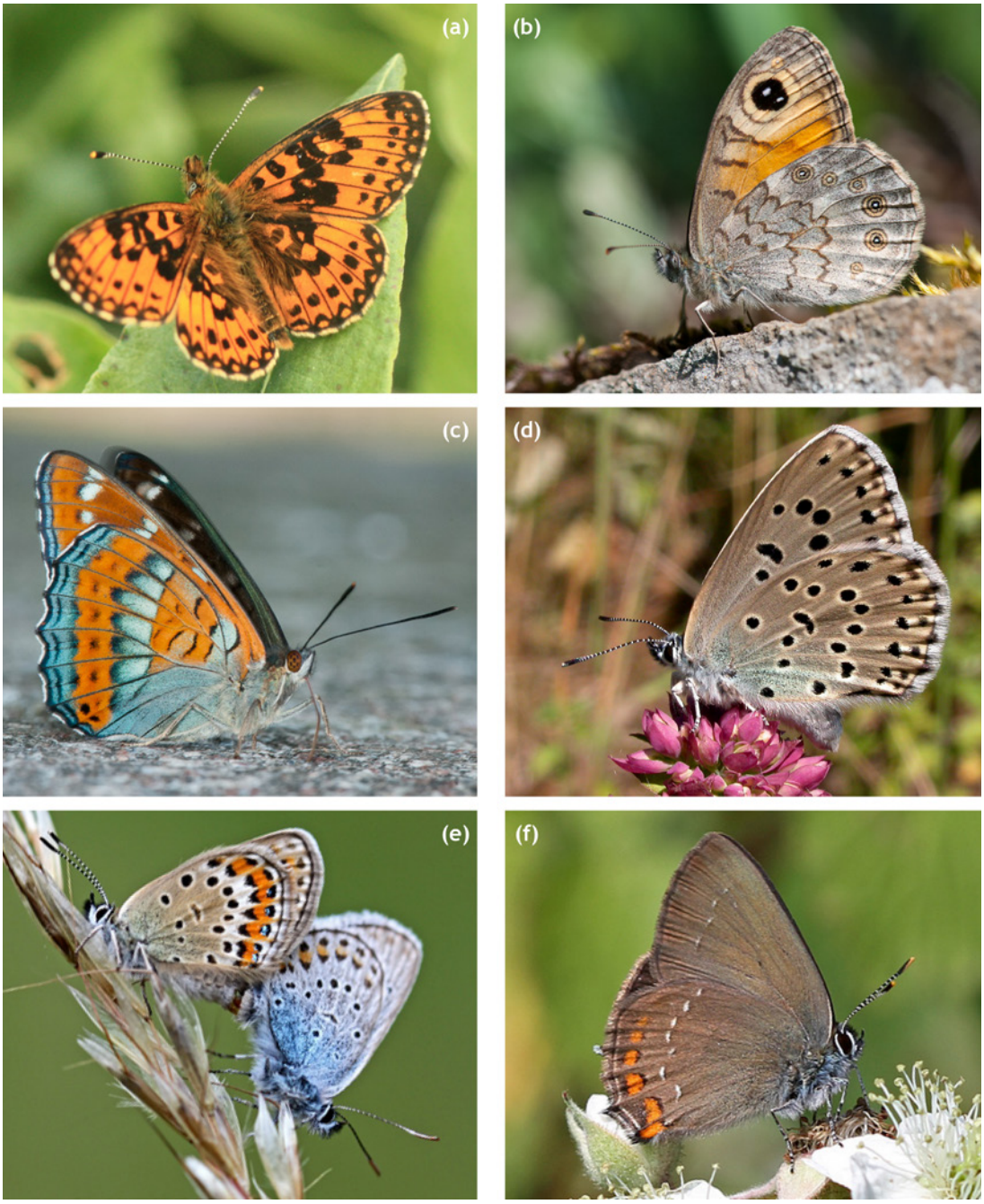


Fig. 3.4: The Endangered butterfly species in Luxembourg: (a) *Boloria selene* (photo: Alain Dohet), (b) *Lasiommata maera* (photo: Stéphane Vitzthum), (c) *Limenitis populi* (photo: Stéphane Vitzthum), (d) *Phengaris arion* (photo: Nicolas Titeux), (e) *Plebejus argus* (photo: Hubert Baltus), and (f) *Satyrium ilicis* (photo: Hubert Baltus).

Lycaena helle, *Lysandra bellargus*, *Melitaea diamina*, *Nymphalis antiopa*, *Speyeria aglaja*, *Spialia sertorius*, *Thecla betulae*, and *Thymelicus acteon*). A further 7 species were considered as NT (*Aporia crataegi*, *Callophrys rubi*, *Carterocephalus palaemon*, *Erebia medusa*, *Glaucopsyche alexis*, *Lysandra coridon*, and *Satyrium w-album*) and the remaining 45 species were classified as LC.

3.4 Discussion

The IUCN Red List classification system allows to objectively assess the status of individual species or whole taxonomic groups. This system was used here as a guide to assess the extinction risk of the breeding butterflies of Luxembourg. Despite the lack of data to apply all the IUCN criteria to all butterfly species, it was possible to evaluate the extinction risk for 76 extant butterfly species using estimations of Area of Occupancy and/or Extent of Occurrence as proxies for population decline, and/or to identify species with restricted distributions which in addition are subjected to at least one risk factor, namely a small number of locations, where a threatening event can rapidly affect all individuals present at a location.

Following Maes et al. (2019), we compared the results of this Red List with the European and European Union (EU) IUCN Red Lists (van Swaay et al. 2010) to identify species that show a mismatch between their status in Luxembourg and at the European extent (Tab. 3.1). We also compared our results with those of Maes et al. (2019), who attributed numerical values proportionate to the threat statuses in the different national Red List categories of 34 European countries (which used IUCN criteria in their majority or had a similar classification as the one used by the IUCN). They calculated a weighted Red List value for every species (wsRLV), using the square root of the country's area as a weighting factor - an alternative method to overcome the differences in Red List approaches among countries and to complement the European IUCN Red List.

Fifteen butterfly species that bred or likely bred in Luxembourg have gone regionally extinct. Of these, *Coenonympha hero*, *Euphydryas maturna*, *Lopinga achine* and *Polyommatus dorylas* are listed as VU or NT at the European and/or EU extents. *Pseudophilotes baton* has a wsRLV corresponding to the VU threshold, while *Hamearis lucina*, last recorded in 1996 in Luxembourg, has a wsRLV corresponding to the Red List category NT at the European level. Some regionally extinct species are either threatened or becoming nearly extinct in neighbouring regions. For instance, *Iphiclides podalirius*, last recorded in 1992 in the south of Luxembourg, is considered as critically endangered in Rhineland-Palatinate (Schmidt 2013) and as regionally extinct in Saarland (Caspari & Ulrich 2020). In the case of the species complexes *Hipparchia hermione/fagi* and *Pontia daplidice/edusa*, these are considered as extinct in Luxembourg but could not be evaluated because it was not possible to know with certainty which species from the complex were present and likely breeding in the country before becoming regionally extinct.

Overall, 26.4% of the butterfly species evaluated here were classified as threatened (CR, EN or VU) after considering a potential rescue effect from Luxembourg's neighbouring regions. This percentage is three times higher than at the European level, where 8.5% of assessed species were considered as threatened (van Swaay et al. 2010), and 1.5 times higher than the percentage of species in Europe (17%) with a wsRLVs > 30 (Maes et al. 2019), corresponding to the thresholds of decline for classifying species in one of the Red List threat categories. Of the species classified as threatened in Luxembourg, only *Phengaris arion* and *Lycaena helle* are listed as threatened in the European and/or EU Red Lists, although *Lycaena hippothoe*, *Pyrgus serratulae*, *Limenitis populi*, *Melitaea diamina* and *Thymelicus acteon* are considered as NT. However, *Euphydryas aurinia* and *Boloria eunomia*, both listed as LC at the European extent, have a wsRLV corresponding to the thresholds for being classified as VU and NT, respectively. *Euphydryas aurinia*, *Phengaris arion* and *Lycaena helle* are listed in Annexes II and/or IV of the Habitats Directive, and are considered as high-priority species in Luxembourg, targeted by specific Action Plans to guarantee their long-term conservation (Herr & Cungs 2021; Lestang 2020; Molitor & Schiltz 2013). Irrespective of European legislation, population trends of all these species should be closely monitored in Luxembourg.

Of the species classified as LC in Luxembourg, *Nymphalis polychloros* is classified as VU in the EU Red List, while *Lycaena dispar*, *Pyrgus armoricanus* and *Pyronia tithonus* have a wsRLV corresponding

to the threshold for being classified as NT at the European and/or EU level. As for the other species from the Habitats Directive, a specific Action Plan was developed for *L. dispar* in Luxembourg, mainly aiming to protect and restore important vegetation types for the survival of this species, such as wet meadows and fallow land (Junck, Proess & Rennwald 2009). It is important to note that Least Concern does not imply that these species are of no conservation concern, but solely that, in terms of extinction risk, these are of lesser concern relative to species in other threat categories (IUCN Standards and Petitions Committee 2022). Likewise, listing taxa in the NE category indicates that even though no estimation of extinction risk has been made, this should not be treated as if they were not threatened. For instance, among the 12 species that were not evaluated here (Tab. 3.1), *Melitaea aurelia* is considered as NT at the European extent and has a high wsRLV value at the EU extent, corresponding to the category VU.

Given the small size of Luxembourg, a potential rescue effect from several surrounding regions may have a large impact on the final extinction risk assessment. It is for instance important to note that a large proportion of species (9 out of 14) classified as EN before the potential rescue effect were downlisted to VU after the rescue effect. A careful approach should be taken, and specific evaluations conducted, to ensure that the potential rescue effect is indeed possible, considering all relevant factors such as habitat suitability and functional connectivity across borders. As this information is currently lacking, we opted for presenting and highlighting differences between the extinction risk assessments before and after the potential rescue effect.

Population trends based on abundance data are much more sensitive to detecting declines than those based on distribution trends, as used in this assessment (van Strien, van Swaay & Kéry 2011), and should thus be the preferred method to apply IUCN criterion A. However, it is important to consider that long time series are required to produce robust assessments of extinction risk for insects based on Criterion A (Fox et al. 2019) and abundance data is lacking before 2010 in Luxembourg. The long-term continuation of the ongoing national butterfly monitoring scheme (LUBMS) should thus be guaranteed in order to update the Red List regularly, as proposed by the IUCN (2016), for instance every ten years, using statistical smoothing of long-term abundance and occurrence time series data (e.g., Fox et al. 2022) and as many criteria as possible. As an example of the importance of using as many criteria as possible, *Nymphalis antiopa* was classified as VU under criterion D2, due to its occurrence in only one location, but there were no sufficient data to allow the use of criterion A. The species is known to be affected by climate change and in the neighbouring region of Saarland, it appears only occasionally as a migratory butterfly, the breeding populations now being extinct (Caspari & Ulrich 2020).

A re-evaluation is especially important for species whose status is known or suspected to be deteriorating, as well as for species listed as NT. For instance, 26 species classified as LC (after considering a possible rescue effect) show a negative trend in their AOO (15 species presenting a decline of ≥10%) - these species should be closely monitored, and their extinction risk re-evaluated using abundance data, as mentioned above. It will then be very important to apply the IUCN system consistently to classify the broadest range of species and facilitate comparisons across assessment periods and regions. The results of this Red List, for instance, cannot be compared to the first butterfly Red List produced by Meyer & Pelles (1981a), due to the use of very different approaches to conduct the assessment, or to an update of that list (Meyer 2000) due to the lack of information on the methods used. Future assessments will gain in robustness as more data become available, but it will be necessary to carefully apply methodological approaches and IUCN criteria that allow comparisons with the assessment presented here.

3.5 Acknowledgements

We are very grateful to the butterfly experts who provided information on the status of butterflies in Luxembourg's neighbouring regions: Steffen Caspari for Saarland and Rheinland-Pfalz (Germany), Julien Dabry and David Demerges for Lorraine (France) and Philippe Goffart for Wallonia (Belgium). Aurore Trottet (IUCN), David Allen (IUCN) and Chris van Swaay (De Vlinderstichting) gave us invaluable information on the assessment procedure.

3.6 Supporting material

The processed data that support the findings of this Red List assessment are openly available at https://ps.mnhn.lu/pub/Cantú-Salazar_et_al_Table_S1_Detailed_IUCN_Red_List_assessment_for_butterflies_in_Luxembourg.

3.7 References

Adriaens T., San Martin y Gomez G., Bogaert J., Crevecoeur L., Beuckx J.-P. & Maes D. 2015. - Testing the applicability of regional IUCN Red List criteria on ladybirds (Coleoptera, Coccinellidae) in Flanders (north Belgium): opportunities for conservation. Insect Conservation and Diversity 8: 404–417.

Caspari S. & Ulrich R. 2008. - Rote Liste der gefährdeten Tagfalter (Rhopalocera und Hesperiidae) und Widderchen (Zygaenidae) des Saarlandes, 4. Fassung. : 343–382, in Rote Liste gefährdeter Planzen und Tiere des Saarlandes. Ministerium für Umwelt des Saarlandes und Delattinia, Saarbrücken.

Caspari S. & Ulrich R. 2020. - Rote Liste und Gesamtartenliste der Tagfalter (Rhopalocera et Hesperiidae) und Widderchen (Zygaenidae) des Saarlandes. 5. Fassung. : 13, in Ministerium für Umwelt und Verbraucherschutz und Delattinia (Hrsg) (ed.), Rote Liste gefährdeter Planzen und Tiere des Saarlandes. Saarbrücken und Landsweiler-Reden. Available at: https://rote-liste-saarland.de/wp-content/uploads/2021/06/SL-210-RL-Tagfalter_PDF_Version-2020.pdf

Fox R., Dennis E. B., Brown A. F. & Curson J. 2022. - A revised Red List of British butterflies. Insect Conservation and Diversity 15: 485–495.

Fox R., Harrower C. A., Bell J. R., Shortall C. R., Middlebrook I. & Wilson R. J. 2019. - Insect population trends and the IUCN Red List process. Journal of Insect Conservation 23: 269–278.

Herr J. & Cungs J. 2021. - Plan national pour la protection de la nature 2. Plans d'actions espèces. Damier de la succise (*Euphydryas aurinia*). Version janvier 2021. Administration de la nature et des forêts, Luxembourg, 15 p. Available at: https://environnement.public.lu/dam-assets/documents/natur/plan_action_especes/PAE-aurinia-minette.pdf

IUCN 2001. - IUCN Red List Categories and Criteria: Version 3.1. (IUCN Species Survival Commission, Ed.). IUCN, Gland, Switzerland and Cambridge, UK, ii + 30 p.

IUCN 2012a. - IUCN Red List Categories and Criteria: Version 3.1 (2nd ed.). IUCN, Gland, Switzerland and Cambridge, UK, iv + 32 p.

IUCN 2012b. - Guidelines for Application of IUCN Red List Criteria at Regional and National Levels: Version 4.0. IUCN, Gland, Switzerland and Cambridge, UK, iii + 41 p.

IUCN 2016. - Rules of Procedure for IUCN Red List Assessments 2017–2020. Version 3.0. Approved by the IUCN SSC Steering Committee in September 2016. Available at: https://nc.iucnredlist.org/redlist/content/attachment_files/Rules_of_Procedure_for_IUCN_Red_List_2017-2020.pdf.

IUCN Standards and Petitions Committee 2022. - Guidelines for Using the IUCN Red List Categories and Criteria. Version 15. Prepared by the Standards and Petitions Committee. Available at: https://www.iucnredlist.org/documents/RedListGuidelines.pdf.

Junck C., Proess R. & Rennwald E. 2009. - Plan d'action Cuivré des marais *Lycaena dispar*. Plan national pour la protection de la nature (PNPN 2007-2011) - Plans d'actions espèces. Ministère du Développment durable et des Infrastructures - Département de l'environnement. Available at: https://environnement.public.lu/dam-assets/documents/natur/plan_action_especes/lycaena_dispar.pdf.

Juslén A., Pykälä J., Kuusela S., Kaila L., Kullberg J., Mattila J., Muona J., Saari S. & Cardoso P. 2016. - Application of the Red List Index as an indicator of habitat change. Biodiversity and Conservation 25: 569–585.

Lestang L. 2020. - Plan d'actions espèces pour la protection de la nature au Grand-Duché de Luxembourg : l'azuré du serpolet, *Phengaris arion* (Linnaeus 1758). Version du 08/07/2020. Administration de la nature et des forêts, Luxembourg, 35 p. Available at: https://environnement.public.lu/dam-assets/documents/natur/plan_action_especes/Phengaris-arion.pdf

Maes D., Vanreusel W., Jacobs I., Berwaerts K. & Van Dyck H. 2012. - Applying IUCN Red List

criteria at a small regional level: A test case with butterflies in Flanders (north Belgium). Biological Conservation 145: 258–266.

Maes D., Verovnik R., Wiemers M., Brosens D., Beshkov S., Bonelli S., Buszko J., Cantú-Salazar L., Cassar L. F., Collins S., Dincă V., Djuric M., Dušej G., Elven H., Franeta F., Garcia-Pereira P., Geryak Y., Goffart P., Gór Á., Hiermann U., Höttinger H., Huemer P., Jakšić P., John E., Kalivoda H., Kati V., Kirkland P., Komac B., Kőrösi Á., Kulak A., Kuussaari M., L'Hoste L., Lelo S., Mestdagh X., Micevski N., Mihoci I., Mihut S., Monasterio-León Y., Morgun D. V., Munguira M. L., Murray T., Nielsen P. S., Ólafsson E., Õunap E., Pamperis L. N., Pavlíčko A., Pettersson L. B., Popov S., Popović M., Pöyry J., Prentice M., Reyserhove L., Ryrholm N., Šašić M., Savenkov N., Settele J., Sielezniew M., Sinev S., Stefanescu C., Švitra G., Tammaru T., Tiitsaar A., Tzirkalli E., Tzortzakaki O., van Swaay C., Viborg A. L., Wynhoff I., Zografou K. & Warren M. S. 2019. - Integrating national Red Lists for prioritising conservation actions for European butterflies. Journal of Insect Conservation 23: 301–330.

Meyer M. 2000. - Red List of Butterflies and Moths of Luxembourg: Rhopalocera and Heterocera. National Museum of Natural History. Available at: https://ps.mnhn.lu/recherche/redbook/butterflies/default.htm.

Meyer M. & Pelles A. 1981a. - Rote Liste der Schmetterlinge Luxemburgs. Bulletin de la Société des naturalistes luxembourgeois 83–84: 41–52.

Meyer M. & Pelles A. 1981b. - Atlas provisoire des Insectes du Grand-Duché de Luxembourg. Lepidoptera, lère partie. Travaux scientifiques du Musée d'histoire naturelle de Luxembourg 1: 1–147.

Molitor M. & Schiltz C. 2013. - Plan national pour la protection de la nature. Plan d'actions espèces. Cuivré de la Bistorte, *Lycaena helle* (Denis et Schiffermüller, 1775). Version décembre 2013. Natur&ëmwelt – Fondation Hëllef fir d Ńatur, 23 p.

Schmidt A. 2013. - Rote liste der Großschmetterlinge in rhein-land-Pfalz. Ministerium für Umwelt, Landwirtschaft, Ernährung, Weinbau und Forsten Rheinland-Pfalz, Mainz, 160 p.

Sekar S. 2012. - A meta-analysis of the traits affecting dispersal ability in butterflies: can wingspan be used as a proxy? Journal of Animal Ecology 81: 174–184.

van Strien A. J., van Swaay C. & Kéry M. 2011. - Metapopulation dynamics in the butterfly *Hipparchia semele* changed decades before occupancy declined in The Netherlands. Ecological Applications 21: 2510–2520.

van Swaay C., Cuttelod A., Collins S., Maes D., López Munguira M., Šašić M., Settele J., Verovnik R., Verstrael T., Warren M., Wiemers M. & Wynhof I. 2010. - European Red List of Butterfies. Publications Office of the European Union, Luxembourg, 58 p.

Warren M. S., Maes D., van Swaay C., Goffart P., Van Dyck H., Bourn N. A. D., Wynhoff I., Hoare D. & Ellis S. 2021. - The decline of butterflies in Europe: Problems, significance, and possible solutions. Proceedings of the National Academy of Sciences 118: e2002551117.

4. Butterfly species in Luxembourg

Lionel L'Hoste[1,✉], Sarah Vray[1], Lisette Cantú-Salazar[1], Michelle Clemens[2], Marcel Hellers[3], Marie Kayser[4], Youri Martin[1], Nicolas Titeux[1], Daniel Waxweiler[1] and Xavier Mestdagh[1]

[1] Luxembourg Institute of Science and Technology (LIST)
5 Avenue des Hauts-Fourneaux
L-4362 Esch-sur-Alzette, Luxembourg

[2] Biological Station, Intercommunal Syndicate SIAS
L-2633 Senningerberg, Luxembourg

[3] Scientific collaborator of the Luxembourg National Museum of Natural History (MNHN)
L-2160 Luxembourg, Luxembourg

[4] MK Ecology, L-9365 Eppeldorf, Luxembourg

✉ Corresponding author: lionel.lhoste@list.lu

Author contributions: XM processed and managed the data. Except for the "Trends" section, MH wrote the original drafts accounts for all extinct species (and provided the Luxembourgish names of all species), MK for *Lycaena helle*, and MC for three lycaenids (*Lycaena dispar*, *L. hippothoe* and *L. tityrus*) and two nymphalids (*Boloria eunomia* and *B. selene*). LLH, SV, XM, and NT completed and reviewed these species accounts and wrote all other accounts. DW, XM and SV contributed to the production of the maps, LLH produced the phenological histograms. LCS calibrated the species distribution models (SDMs) used for the maps, estimated the trends with NT and XM, and generated the Red List assessments. LLH, SV, XM, LCS, YM and NT contributed to the revision of this chapter.

4.1 Species richness

Fig 4.1 shows (a) the number of recorded species (i.e., the species richness) and (b) the number of recorded species threatened with extinction (i.e., threatened species richness) – as resulting from the Red List assessment in Chapter 3 after considering a possible rescue effect from the neighbouring regions – in each 5-km grid cell during the latest atlas period (2010-2020). In addition, an assessment of the survey effort (see Chapter 2) in each 5-km grid cell is shown as the total number of complete surveys within the grid cell (Fig 4.1a) or as their relative distribution from April to September (Fig 4.1b).

It is important to note that the number of recorded species is positively correlated with the number of complete surveys carried out in the grid cell (Fig. 4.2), which highlights the interest of complete surveys (i.e., looking for and recording all species, not only the rarest or threatened ones). Grid cells with the lowest species richness are usually the least well surveyed ones. It is clearly the case in the area between Echternach, Beaufort and Larochette for instance. Moreover, in some grid cells, the survey effort is not homogeneously distributed during spring and summer (Fig 4.1b). For instance, grid cells in the north-western Oesling (close to the Belgian border) were subject to surveys targeting *Lycaena helle* and were therefore mostly carried out during springtime, with much less complete surveys in summer. The genuine species richness is therefore likely underestimated in many grid cells either because of a low survey effort (low number of complete surveys) and/or because the survey effort was restricted to a particular time window and did not adequately cover the flight season of all butterfly species. Despite these limitations, the Minette is the region harbouring the highest species richness (with a maximum of 72 species recorded in a single 5-km grid cell; Fig 4.1a) and the highest number of species threatened with extinction (Fig 4.1b). This area is highlighted at the continental scale as a priority site for the conservation of butterflies as it is among the Prime Butterfly Areas in Europe (van Swaay & Warren 2003). Some other areas (i.e., the north-western Oesling and some dry grasslands around Niederanven and Rosport) also show a high number of (threatened) species. However, none of the grid cells harbour all the 24 butterfly species assessed as threatened with extinction in Chapter 3. Some threatened species, such as

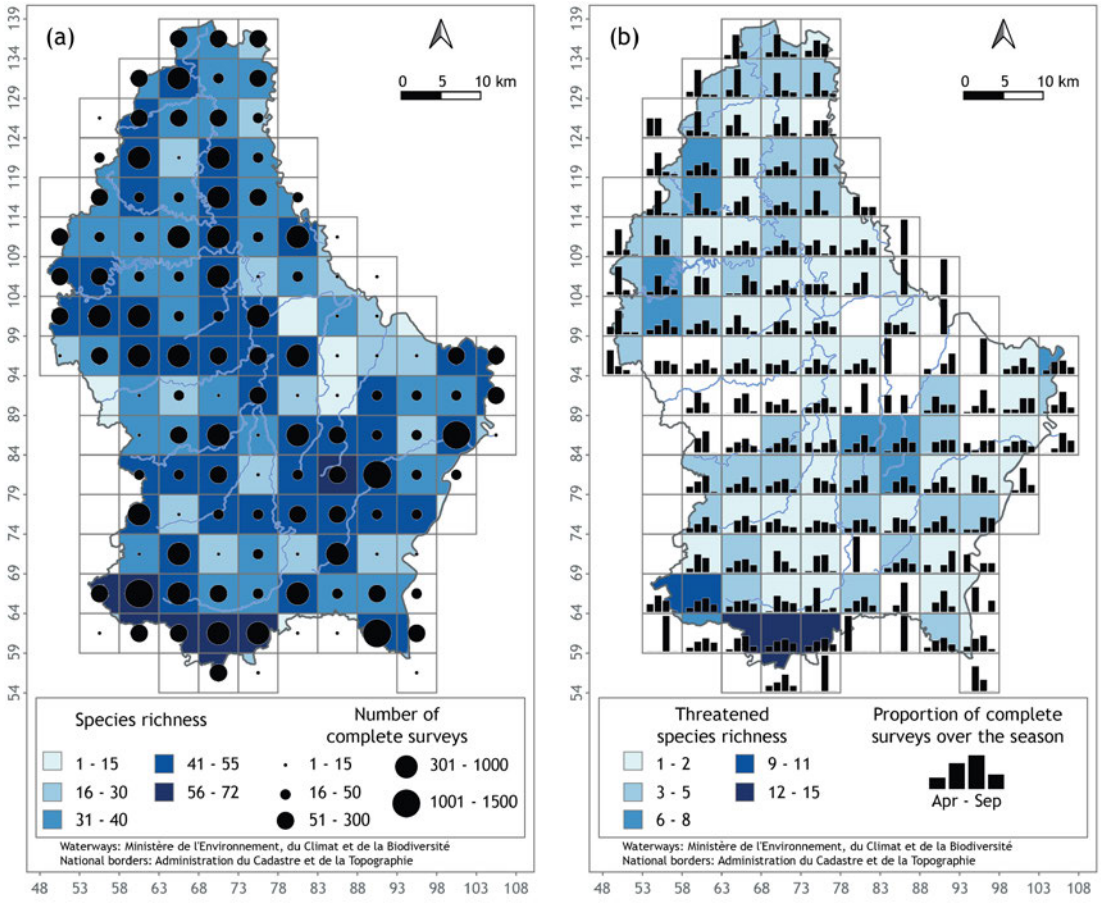


Fig 4.1: (a) Number of recorded species (species richness) and (b) number of recorded species threatened with extinction (threatened species richness) – as resulting from the Red List assessment in Chapter 3 after considering a possible rescue effect from the neighbouring regions – in each 5-km grid cell during the atlas period 2010-2020. Survey effort is shown as (a) the total number of complete surveys in the grid cell during 2010-2020 and (b) their relative distribution over the season from April to September.

Apatura iris, *Plebejus argus* or *Thymelicus acteon*, are also patchily distributed across the country and not restricted to the Minette (Fig. 4.3), the north-western Oesling (Fig. 4.4) or around Niederanven and Rosport. It is therefore important not to concentrate all conservation and restoration efforts in these areas only.

4.2 Flight season and seasonal species richness

Fig 4.5a shows the temporal distribution of the number of adult records (as a percentage of the total number) and the species richness per 10-day intervals over the year during the period 2010-2020, all species included. Fig 4.5b-d focus on groups of species according to their main habitat requirements as defined in Chapter 2 (Tab. 2.1) based on van Swaay, Warren & Loïs (2006). June was the month with the highest number of records across all species. The highest species richness (i.e., 79 different species) was recorded in the second decade of June. Regarding the proportion of records, specialists of forests and generalists were more abundant in mid-July, while the peak for specialists of open biotopes was slightly earlier (late June).

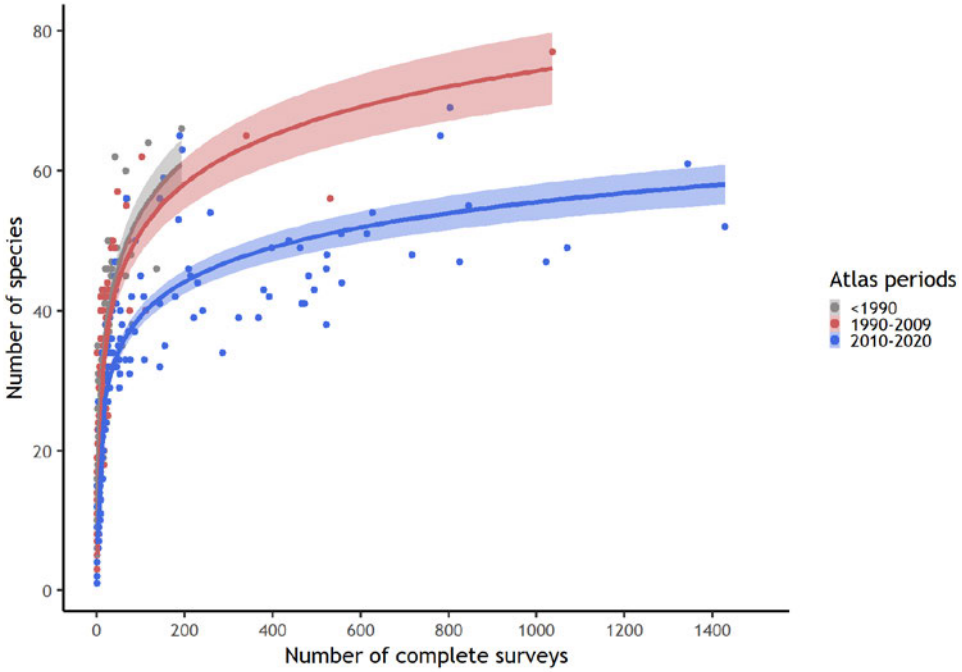


Fig. 4.2: Species richness according to the number of complete surveys carried out in each 5-km grid cell during the three atlas periods. Only data from the complete surveys were used to calculate species richness (maximum number of species: <1990: 66, 1990-2009: 77, and 2010-2020: 69 species). Each point represents a grid cell in the corresponding period, whereas each curve represents the logarithmic relationship.

Fig. 4.3: Typical biotopes from the Minette, including dry grassland, early-successional vegetation, cliff as legacies of the iron ore mining industry (Perchesbierg, Tétange, 16/08/2021, Jan Herr).

Fig 4.4: Typical valley in the Oesling with dominance of *Bistorta officinalis* (Seibur, Wincrange, 01/06/2009, Xavier Mestdagh).

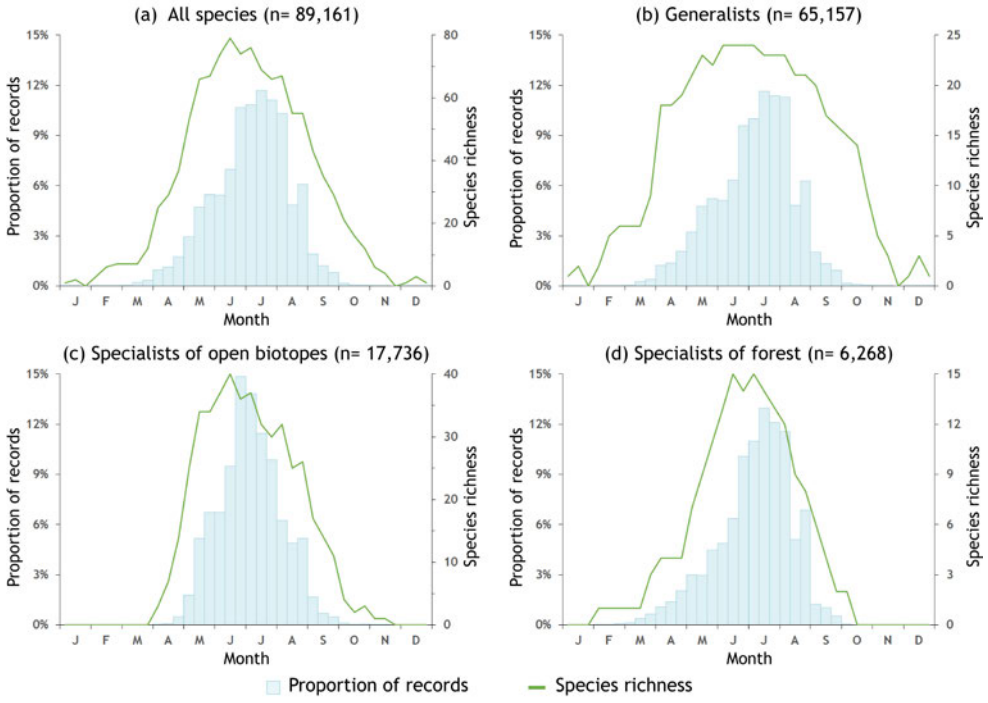


Fig 4.5: Frequency distribution of the number of adult butterfly records (histogram) and the species richness (curve) over the year for (a) all species and for (b-d) each group of species (as described in Tab. 2.1 from Chapter 2) during the period 2010-2020.

4.3 Species accounts

The next pages present the 95 butterfly species and 5 complexes of species considered as having been recorded in Luxembourg to date (see Tab. 2.1 in Chapter 2), with information on their protection status in Luxembourg (Règlement grand-ducal du 9 janvier 2009) and in the European Union (Habitats Directive 92/43/EEC), the Red List category for Luxembourg (results shown are considering a possible rescue effect from the neighbouring regions - see details in Chapter 3) and for the European Union (van Swaay et al., 2010). It also includes information on their lifecycle (including the flight season), habitat requirements (including larval host plants and nectar resources when relevant), distribution within and outside Luxembourg, population trends, and management recommendations for promoting suitable habitats (see Chapters 2, 3 and 5 for additional information).

Fig 4.6: Several dozens of *Aporia crataegi* and one *Melitaea* sp. observed mud-puddling on the ground (Chantepérier, Alps (F), 09/07/2016, Xavier Janssens).

HESPERIIDAE

Erynnis tages
(Linnaeus, 1758)

L: Donkelen Déckkapp

E: Dingy skipper

G: Dunkler Dickkopffalter

F: Point de Hongrie

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

This moth-like skipper is well camouflaged on the bare ground during basking and is characterised by a very fast darting flight with a very quick take off. Tens of individuals can be observed at a single site.

Lifecycle

Bivoltine. Flies mostly from mid-April to late August with a first peak in late May, and a second one, smaller, in early August. Overwinters as final-stage caterpillar.

Habitat

Open and sunny biotopes, such as dry grasslands, non-exploited quarries, railway lines, rocky embankments, and wastelands.

Fig. 4.7: *Erynnis tages* (Photo: Alain Dohet).

Fig. 4.8: *Erynnis tages* (Photo: Hubert Baltus).

Nectar resources – Typically feeds on yellow flowers, particularly *Hippocrepis comosa*, *Lotus corniculatus*, *L. pedunculatus*, and *Medicago lupulina*.

Larval host plants – Lays single dome-shaped eggs on the upper side of leaves of these same plant species.

Distribution

Luxembourg – Almost exclusively distributed in dry grasslands of the Minette, with a few isolated records and small patches of suitable habitat in the Gutland.

Worldwide – From western Europe to eastern Asia.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -62%

Relative change in extent of occurrence (geographical range): -73%

Strongly decreasing. Formerly widespread in the Gutland with a scattered distribution in the Oesling, its range strongly shrank and is mostly restricted to the Minette with a few remaining locations in the Gutland.

Management

Avoiding shrub encroachment in dry grasslands with regular cutting and extensive grazing. Promoting late mowing of road verges.

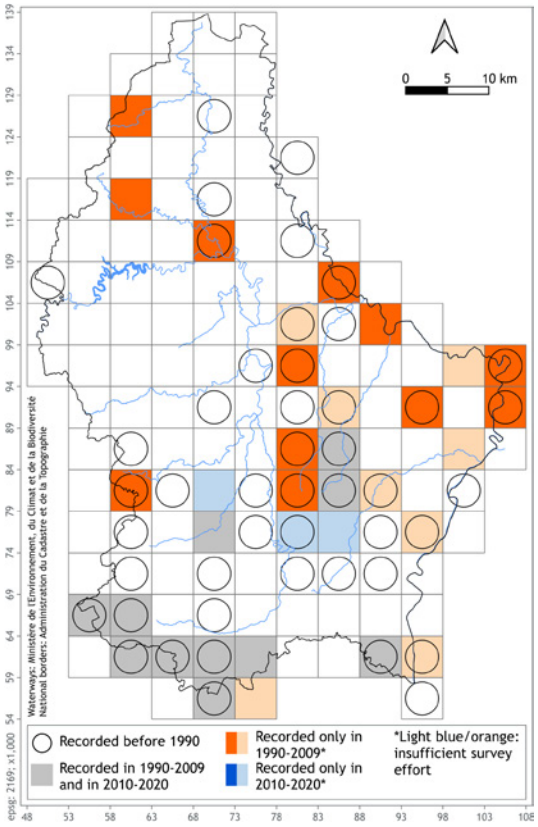


Fig. 4.9: Distribution change map at 5-km spatial resolution for *Erynnis tages*.

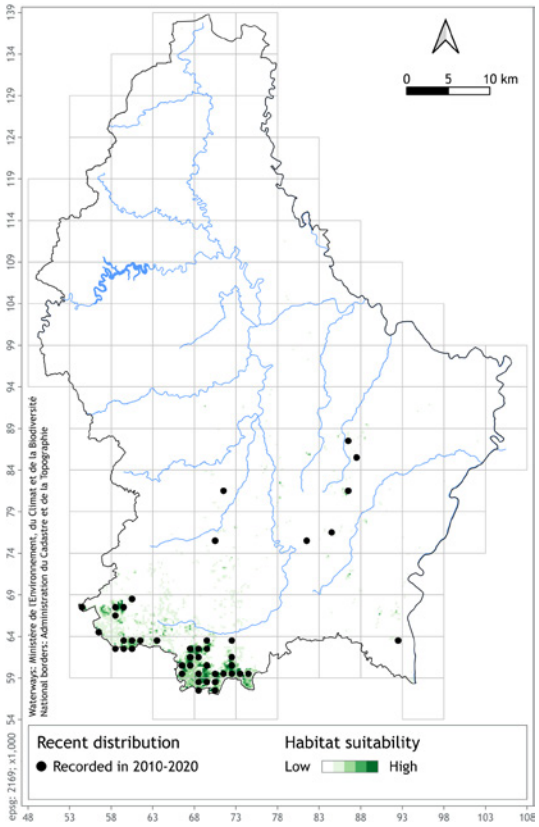


Fig. 4.10: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Erynnis tages*.

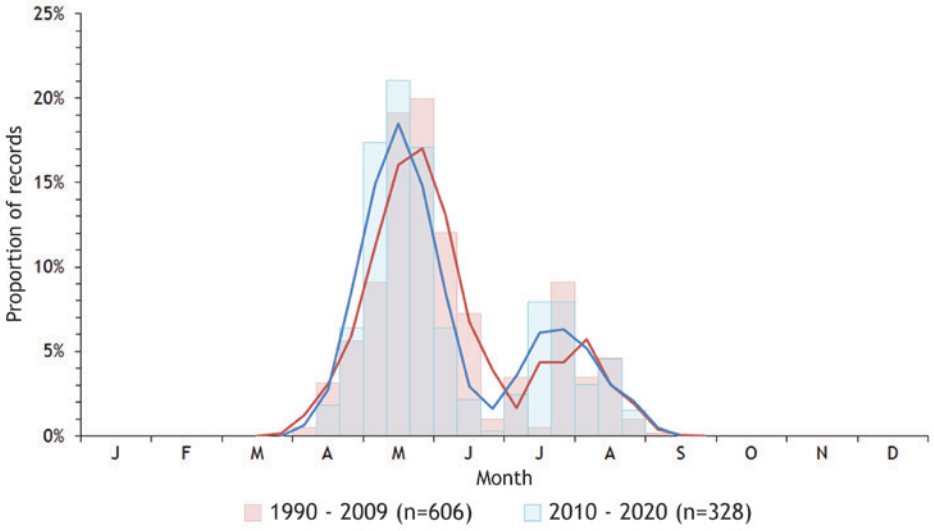


Fig. 4.11: Flight season of *Erynnis tages* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Carcharodus alceae
(Esper, 1780)

L: Malven-Déckkapp

E: Mallow skipper

G: Malven-Dickkopffalter

F: Hespérie de l'alcée

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Moth-like in appearance, this little skipper is very discreet and moves quickly, making it difficult to detect.

Lifecycle

Mostly bivoltine, sometimes three generations per year. Flies from April to September, with a first peak in late May and a second one, steeper, in late July. Due to overlap between generations, eggs, caterpillars, chrysalis, and adults possibly found at the same time. Overwinters as final-stage caterpillar.

Habitat

Relatively warm and dry biotopes, such as dry grasslands, quarries, wastelands, flower-rich meadows, and road verges.

Fig. 4.12: *Carcharodus alceae* (Photo: Hubert Baltus).

Fig. 4.13: *Carcharodus alceae* (Photo: Alain Dohet).

Larval host plants – Lays single eggs on the leaves of various species from the Malvaceae family, such as *Althaea officinalis*, *A. rosea*, *Malva alcea*, *M. moschata*, *M. neglecta*, and *M. sylvestris*.

Distribution

Luxembourg – Patchily distributed across most of the country.

Worldwide – From southern Spain across southern and central Europe to northern India and China.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +23%

Relative change in extent of occurrence (geographical range): +8%

Although recorded in a moderately increasing number of 1-km grid cells, its range was considered as stable. Some local extinctions occurred mostly in northern Oesling while it expanded its range in western Oesling and in the southwest of the country.

Management

Promoting late mowing or unmown refuge areas for road verge management, as well as extensive grazing of meadows and maintenance of wasteland areas.

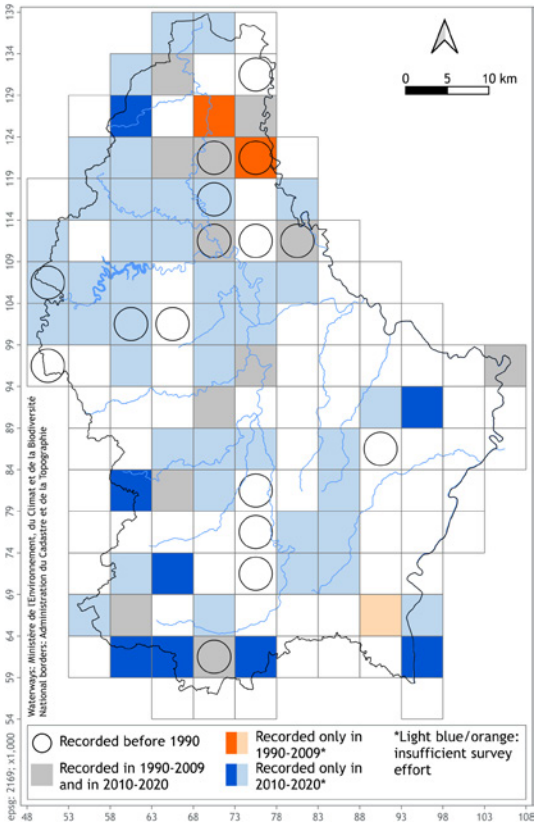


Fig. 4.14: Distribution change map at 5-km spatial resolution for *Carcharodus alceae*.

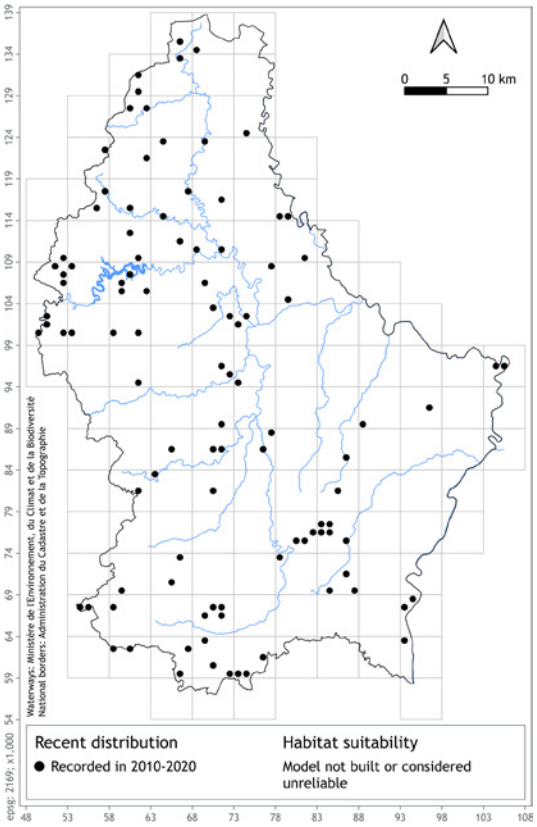


Fig. 4.15: Distribution map at 1-km spatial resolution for *Carcharodus alceae*.

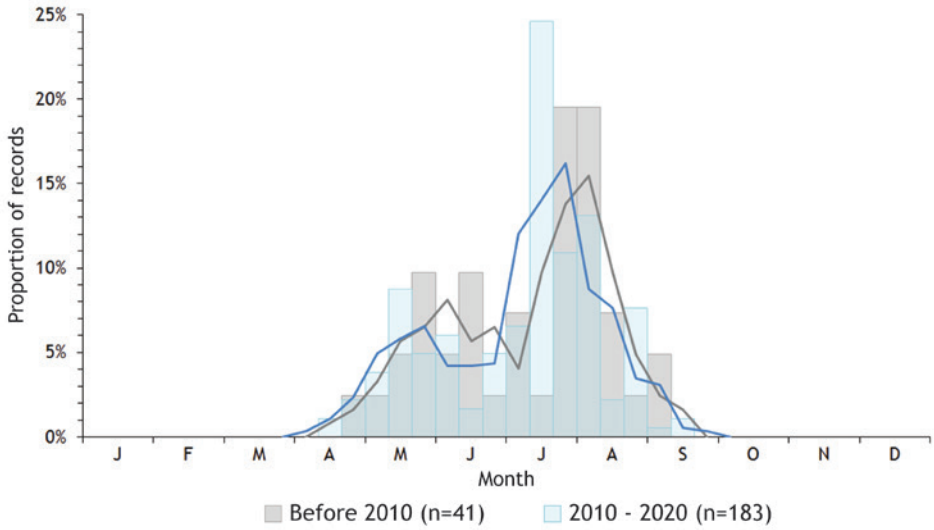


Fig. 4.16: Flight season of *Carcharodus alceae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Spialia sertorius

(Hoffmansegg, 1804)

L: Roude Fleckendéckkapp

E: Red underwing skipper

G: Roter Würfel-Dickkopffalter

F: Hespérie des sanguisorbes

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

This little skipper typically basks on bare ground and can be recognised by a reddish to fawn background colour on the underside of its wings, as well as a reddish-brown colour at the end of its abdomen.

Lifecycle

Univoltine but has become bivoltine since the last few years (second generation observed in late summer). Flies mostly from May to early July with a peak in late May. Overwinters as caterpillar.

Habitat

Warm and south-facing slopes with sparse vegetation such as dry grasslands (on calcareous or schist substrate), flower-rich meadows, quarries, and road verges.

Fig. 4.17: *Spialia sertorius* (Photo: Hubert Baltus).

Fig. 4.18: *Spialia sertorius* (Photo: Martin Heyeres).

Larval host plants – Lays eggs primarily on *Sanguisorba minor*, more rarely on *Centaurea* spp., *Malva* spp., *Potentilla neumanniana*, *Rubus idaeus*, and *S. officinalis*.

Distribution

Luxembourg – Nowadays, almost exclusively distributed in the Minette, with a few records in the Moselle and the eastern half of the Gutland. Suitable habitats mostly available the Minette and, to a lower extent, in the Moselle and central Gutland.

Worldwide – From northwestern Africa to central Europe.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -42%

Relative change in extent of occurrence (geographical range): -71%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted to cover only the Minette and a few other isolated locations. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Continuously managing dry grasslands with extensive grazing (cattle/sheep) to avoid shrub encroachment.

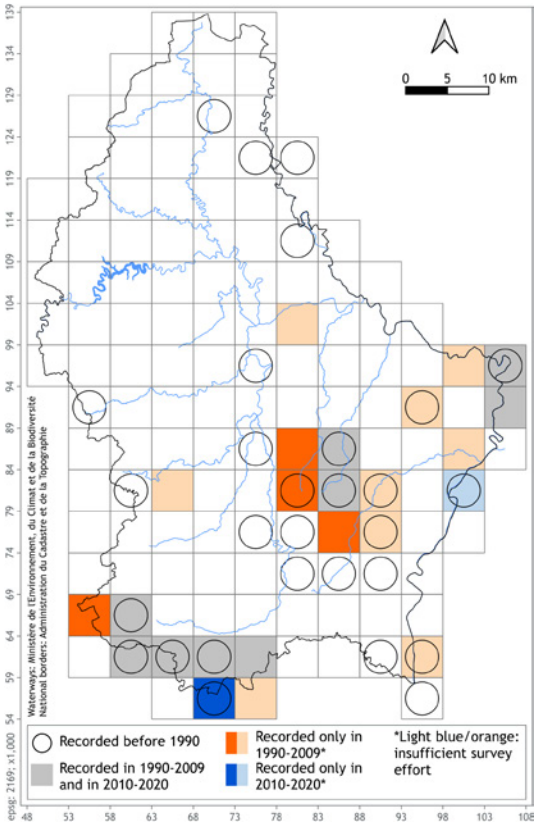


Fig. 4.19: Distribution change map at 5-km spatial resolution for *Spialia sertorius*.

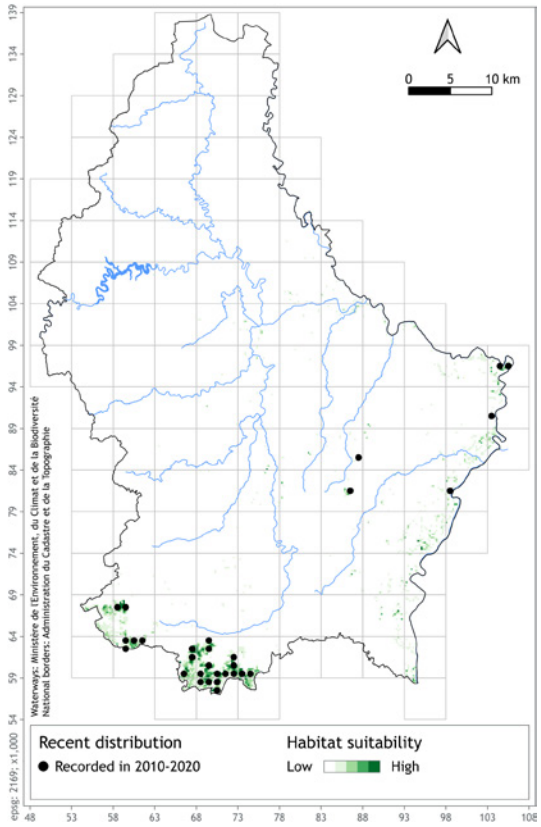


Fig. 4.20: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Spialia sertorius*.

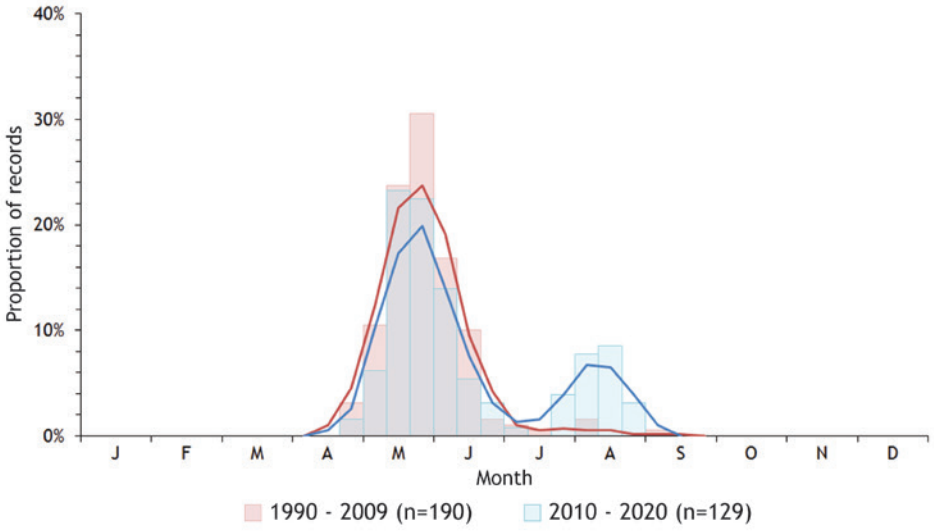


Fig. 4.21: Flight season of *Spialia sertorius* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Pyrgus malvae
(Linnaeus, 1758)

L: Malve-Fleckendéckkapp

E: Grizzled skipper

G: Kleiner Würfel-Dickkopffalter

F: Hespérie de la mauve

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Pyrgus malvae flies very quickly and erratically just above the ground, making it difficult to follow. It is the smallest species of the *Pyrgus* genus present in Luxembourg. Unlike other *Pyrgus* species in the country, it displays well-contrasted patterns on the upper side of its hindwings.

Lifecycle

Mainly univoltine. Flies mostly from April to June, with a steep peak in late May. Overwinters as chrysalis.

Habitat

Various and sometimes very small patches with sparse vegetation, such as flower-rich meadows, dry calcareous grasslands, forest clearings, quarries, wastelands, wetlands, and road verges with abundant host plants.

Fig. 4.22: *Pyrgus malvae* (Photo: Roland Proess).

Fig. 4.23: Pyrgus malvae (Photo: Xavier Mestdagh).

Larval host plants – Lays single eggs on various species from the Rosaceae family, such as *Agrimonia eupatoria*, *Fragaria vesca*, *Geum urbanum*, *Potentilla argentea*, *P. erecta*, *P. neumanniana*, *Rosa canina*, and *Rubus fruticosus*.

Distribution

Luxembourg – Distributed across the whole country, but with higher densities in the Minette, the central Gutland and northwestern Oesling. Suitable habitats available in every region, especially in forest edges and in valley-bottom grasslands.

Worldwide – Most of Europe, parts of temperate Asia to Japan.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -14%

Relative change in extent of occurrence (geographical range): +2%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Limiting the fertilisation and promoting late mowing and/or extensive grazing of grasslands, forest paths and road verges.

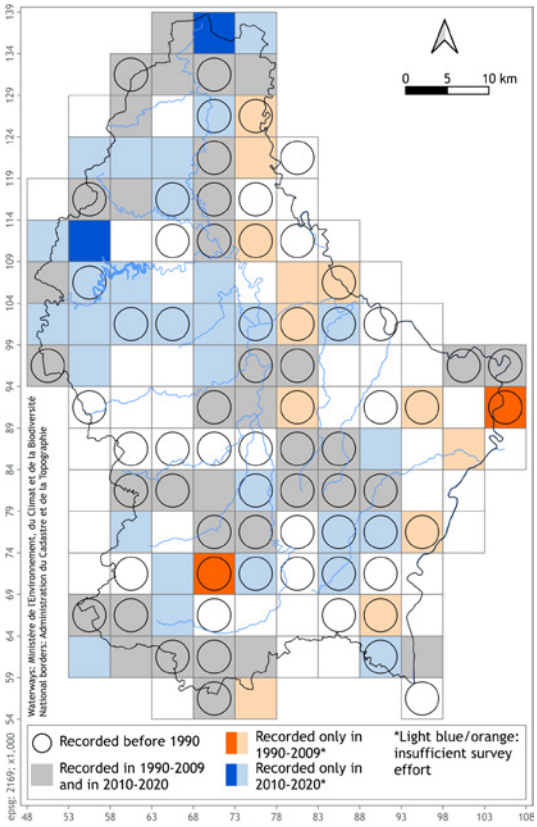


Fig. 4.24: Distribution change map at 5-km spatial resolution for *Pyrgus malvae*.

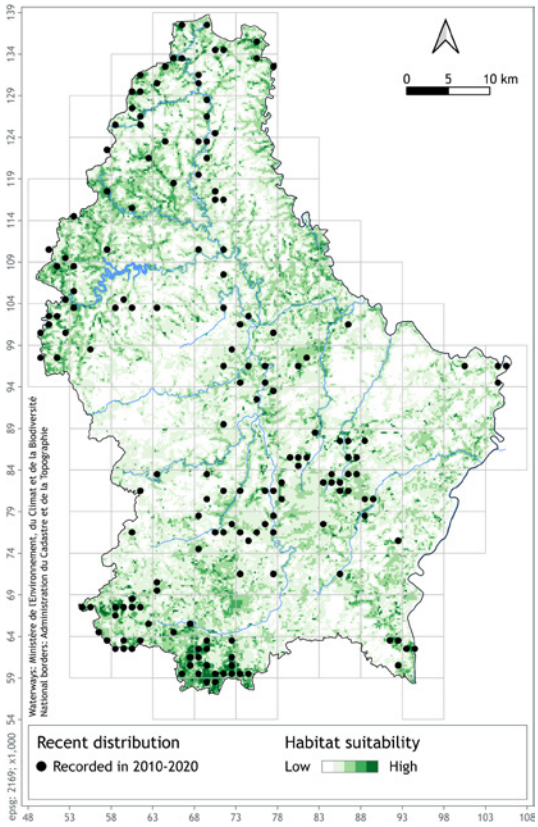


Fig. 4.25: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Pyrgus malvae*.

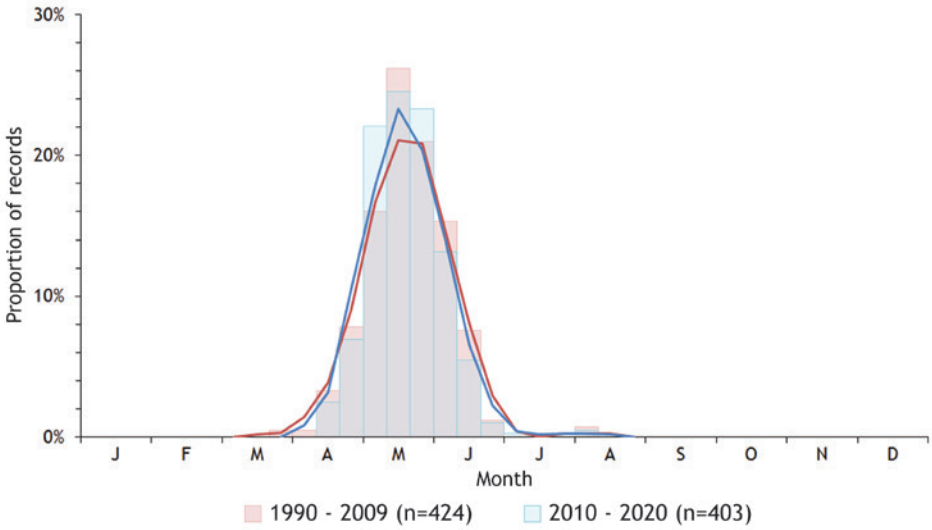


Fig. 4.26: Flight season of *Pyrgus malvae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Pyrgus armoricanus
(Oberthür, 1910)

L: Fangerkraut-Déckkapp

E: Oberthür's grizzled skipper

G: Mehrbrütiger Würfel-Dickkopffalter

F: Hespérie des potentilles

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Species identification within the genus *Pyrgus* is rather difficult and often necessitates the examination of genitalia. However, *Pyrgus armoricanus* is distinguishable from *P. malvae* in the field because it has a larger size, a less contrasted pattern on the upper side of its hindwings and a second generation in August.

Lifecycle

Bivoltine. Flies mostly in August, the spring generation being usually unnoticed. Overwinters as caterpillar.

Habitat

Flower-rich meadows, dry grasslands, road verges but often observed far from apparently suitable biotopes, which suggests high dispersal abilities.

Fig. 4.27: *Pyrgus armoricanus* (Photo: Hubert Baltus).

Fig. 4.28: *Pyrgus armoricanus* (Photo: Nicolas Titeux).

Nectar resources – Preferentially feeds on species from the *Globularia* and *Potentilla genera* during spring, and on *Origanum vulgare* and *Thymus* spp. during summer.

Larval host plants – Lays single eggs on *Potentilla erecta*, *P. neumanniana* and *P. reptans*.

Distribution

Luxembourg – Mainly distributed in the Gutland, with a few isolated records in the Oesling. Suitable habitats mostly available in the Minette and in the eastern half of the Gutland.

Worldwide – Widespread across southern Europe and temperate Asia. Luxembourg is at the northern limit of its global range.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +900%

Relative change in extent of occurrence (geographical range): +2701%

Strongly increasing. Might have been overlooked before 2010.

Management

Limiting the fertilisation and maintaining extensive grazing in grasslands. Promoting late mowing of road verges.

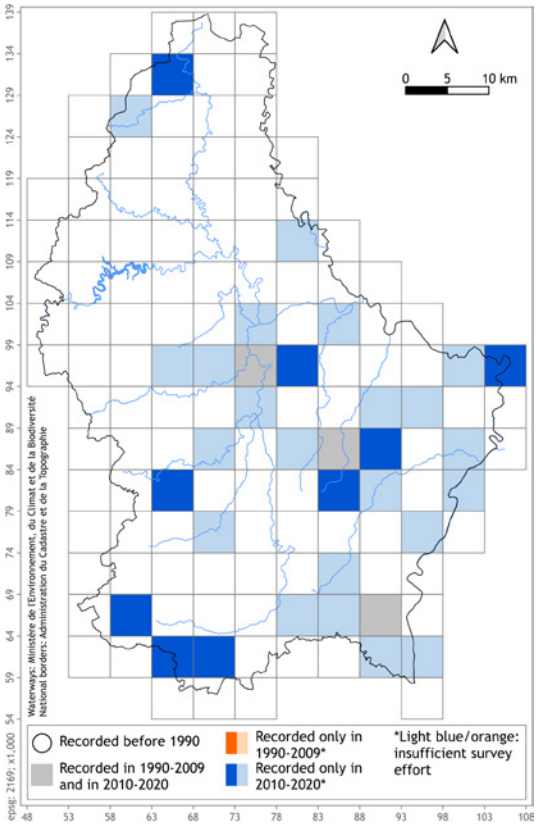


Fig. 4.29: Distribution change map at 5-km spatial resolution for *Pyrgus armoricanus*.

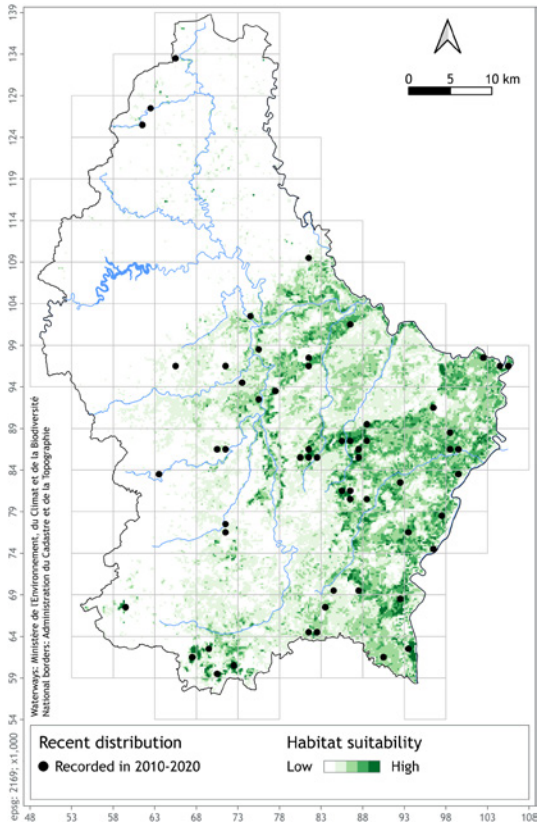


Fig. 4.30: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Pyrgus armoricanus*.

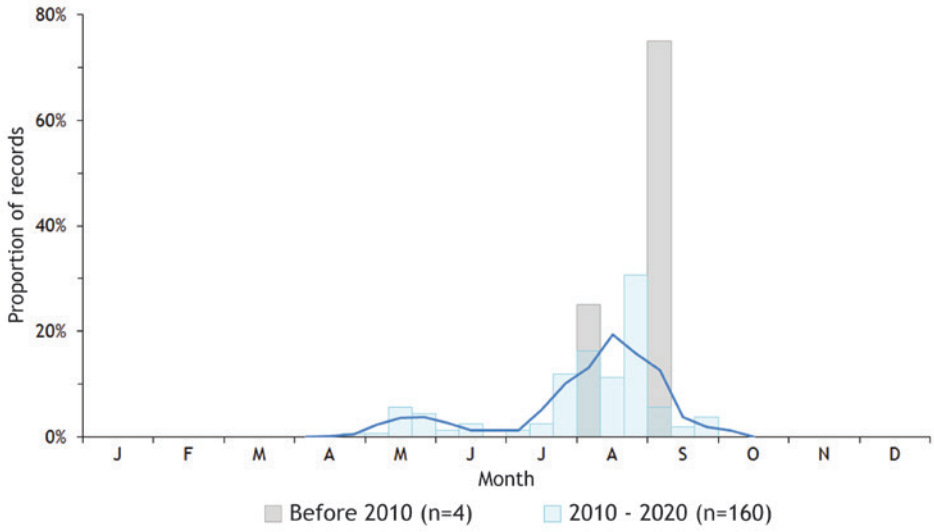


Fig. 4.31: Flight season of *Pyrgus armoricanus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Pyrgus serratulae
(Rambur, 1839)

L: Schwarzbronge Fleckendéckkapp

E: Olive skipper

G: Schwarzbrauner Würfel-Dickkopffalter

F: Hespérie de l'alchémille

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Critically Endangered	Near Threatened

Pyrgus serratulae is rather similar to *P. armoricanus*. Close examination of the underside of the wings and flying period can provide a clue, but formal species identification requires the examination of genitalia.

Lifecycle

Univoltine. Flies mostly from mid-May to late June. Overwinters as caterpillar.

Habitat

Xeric and warm biotopes with patchy vegetation or rocky areas, mainly dry calcareous grasslands.

Larval host plants – Lays single eggs mainly on *Potentilla neumanniana*, but sometimes also on other species from the *Potentilla* and *Alchemilla genera*.

Fig. 4.32: *Pyrgus serratulae* (Photo: Philippe Mothiron).

Fig. 4.33: *Pyrgus serratulae* (Photo: Philippe Mothiron).

Distribution

Luxembourg – Nowadays, exclusively distributed with low population densities in a limited part of the Minette.

Worldwide – From southern and central Europe to north-eastern China. Luxembourg is at the northern margin of its global range.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -50%

Relative change in extent of occurrence (geographical range): -96%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted in 2010-2020: it totally disappeared from the Gutland. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Avoiding the fertilisation of calcareous dry grasslands and promoting extensive grazing to maintain open sparse vegetation.

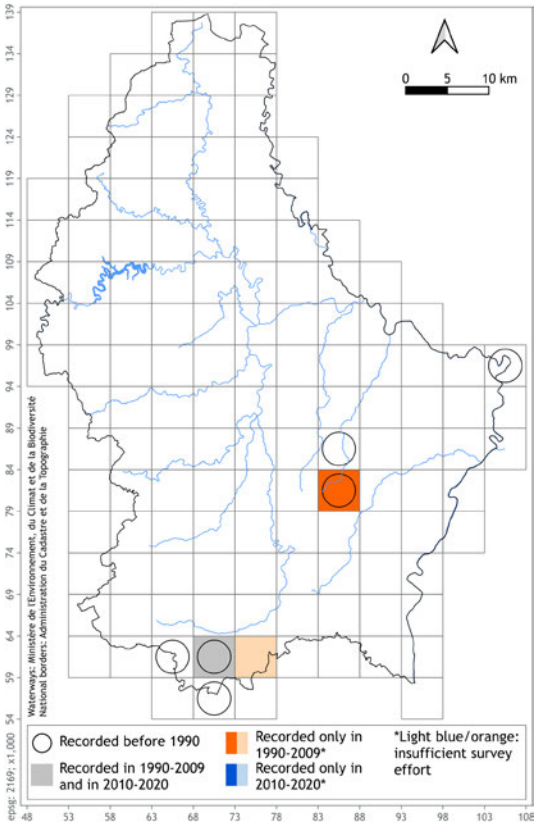


Fig. 4.34: Distribution change map at 5-km spatial resolution for *Pyrgus serratulae*.

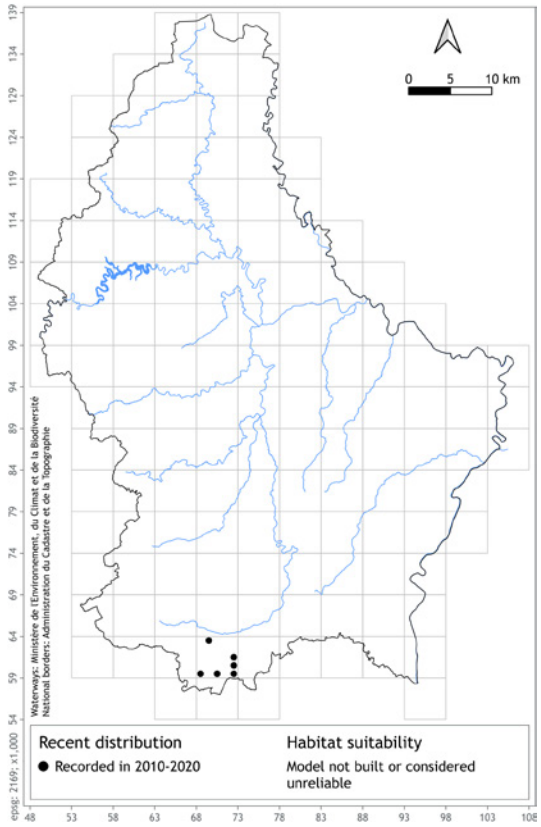


Fig. 4.35: Distribution map at 1-km spatial resolution for *Pyrgus serratulae*.

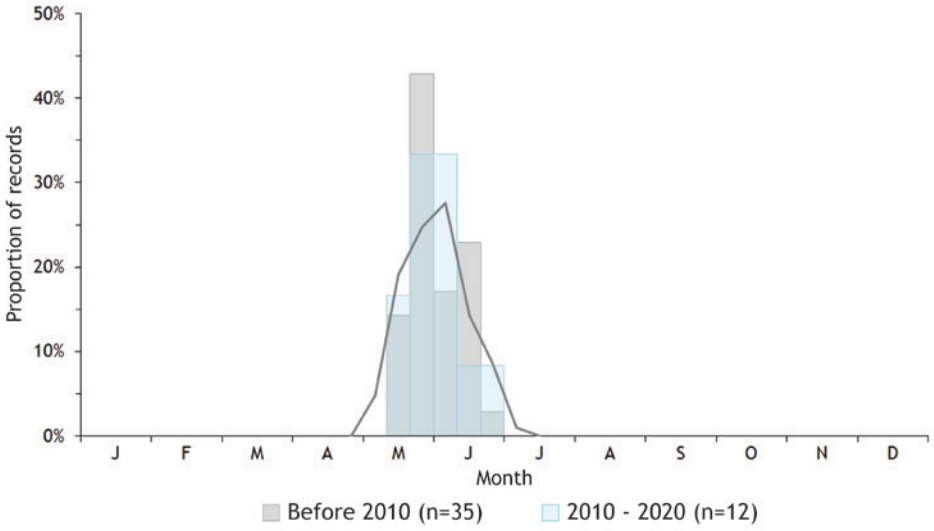


Fig. 4.36: Flight season of *Pyrgus serratulae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Carterocephalus palaemon
(Pallas, 1771)

L: Gescheckten Déckkapp
E: Chequered skipper
G: Gelbwürfliger Dickkopffalter
F: Hespérie du brome

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Near Threatened	Least Concern

This skipper displays yellow patches on a brown background in the upper side of the wings. It is usually observed in low population density and males are highly territorial.

Lifecycle

Univoltine. Flies mostly from May to June, with a peak in late May. Overwinters as final-stage caterpillar.

Habitat

Wet or dry forest-related biotopes, such as forest edges, forest clearings, and lightly wooded areas.

Nectar resources – Typically feeds on blue and purple flowers, such as *Ajuga reptans*, *Cirsium palustre*, and Hyacinthoides non-scriptus.

Fig. 4.37: *Carterocephalus palaemon* (Photo: Martin Heyeres).

Fig. 4.38: *Carterocephalus palaemon* (Photo: Hubert Baltus).

Larval host plants – Lays single eggs on the underside of various species from the Poaceae family, such as *Calamagrostis canescens*, *Bromus* spp., and *Molinia caerulea*.

Distribution

Luxembourg – Exclusively and patchily distributed in the Minette and the eastern half of the Gutland to the Moselle.

Worldwide – Holarctic species distributed across most of central and northern Europe but absent from Iberian Peninsula and the Mediterranean Basin.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -31%

Relative change in extent of occurrence (geographical range): -44%

Moderately decreasing. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Promoting open oak and birch forests, particularly in valley bottoms. Maintaining well-structured forest edges with extensive management of the herbaceous layer. Avoiding the asphalting of forest paths.

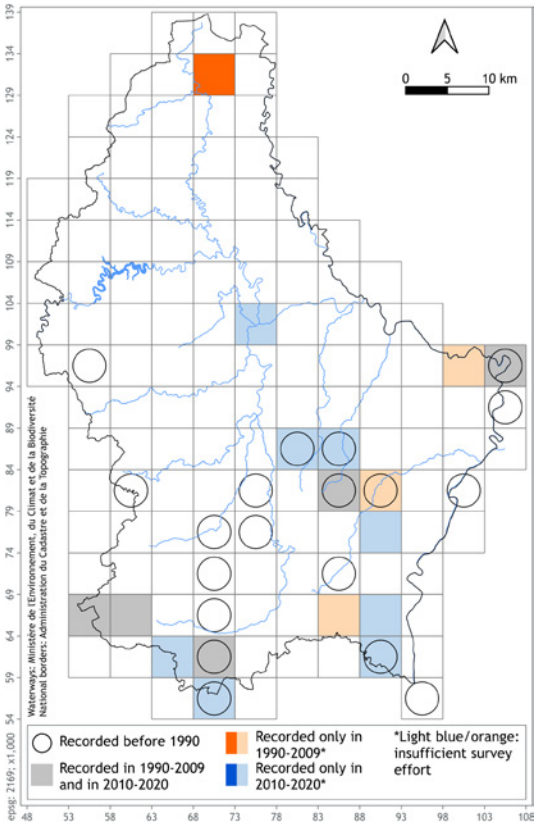


Fig. 4.39: Distribution change map at 5-km spatial resolution for *Carterocephalus palaemon*.

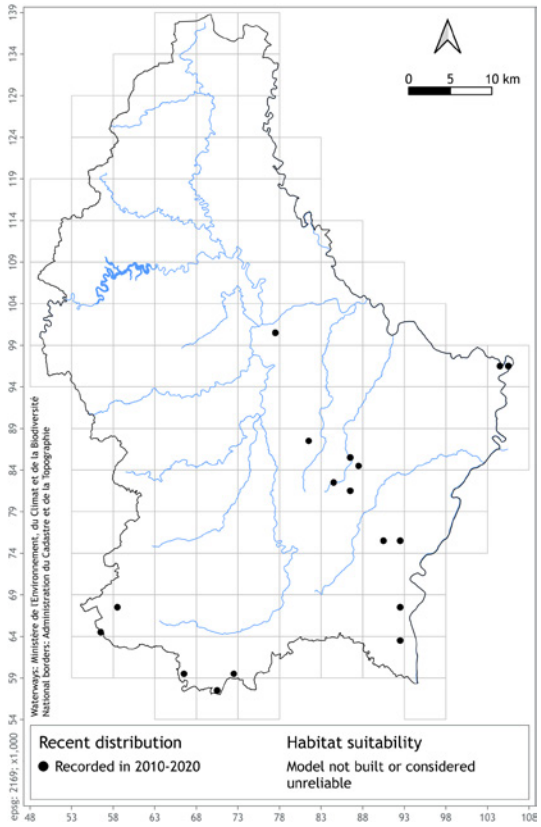


Fig. 4.40: Distribution map at 1-km spatial resolution for *Carterocephalus palaemon*.

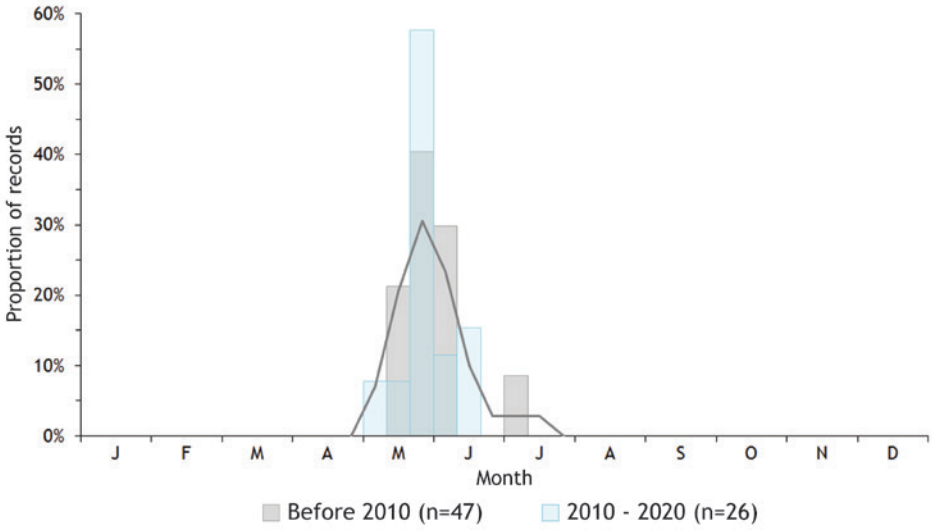


Fig. 4.41: Flight season of *Carterocephalus palaemon* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Thymelicus sylvestris
(Poda, 1761)

L: Brongfühler-Déckkapp

E: Small skipper

G: Braunkolbiger Braun-Dickkopffalter

F: Hespérie de la houlque

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Another of the five golden skippers observed in Luxembourg. The underside of the tip of the antennal club is orange-brown in *Thymelicus sylvestris* and black in *T. lineola*.

Lifecycle

Univoltine. Flies mostly from late May to August with a peak in late-June. Overwinters as caterpillar within a cocoon.

Habitat

Same open biotopes as *T. lineola*, such as flower-rich meadows, wastelands, road verges, and forest edges.

Larval host plants – Lays several eggs inside grass sheaths, primarily on *Holcus lanatus* but also on other species from the Poaceae family, such as *Alopecurus pratensis*, *Brachypodium sylvaticum*, *Dactylis glomerata*, *Holcus mollis*, and *Phleum pratense*.

Fig. 4.42: *Thymelicus sylvestris* (Photo: Hubert Baltus).

Fig. 4.43: *Thymelicus sylvestris* (Photo: Alain Dohet).

Distribution

Luxembourg – Distributed across the whole country with a widespread availability of suitable habitats.

Worldwide – From northern Africa across most parts of Europe to the Middle East.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +1%

Relative change in extent of occurrence (geographical range): +2%

Considered as stable.

Management

Limiting the fertilisation in grasslands, promoting extensive grazing and late mowing.

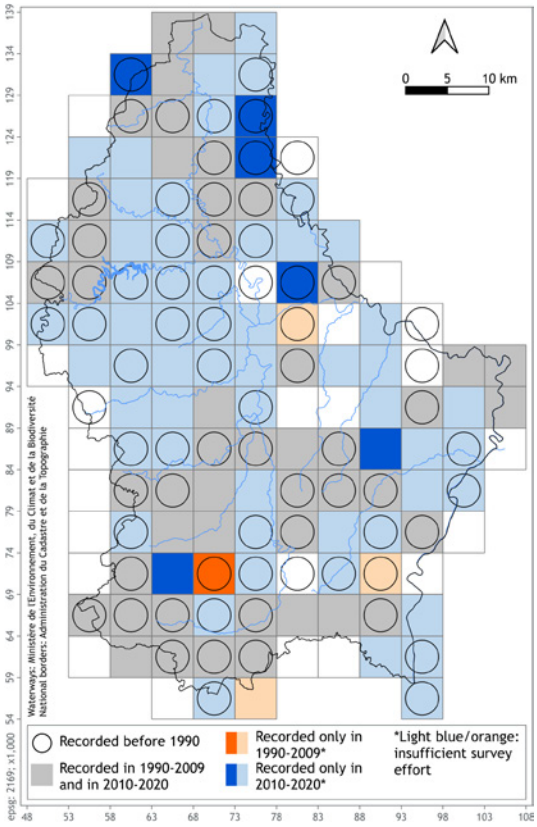


Fig. 4.44: Distribution change map at 5-km spatial resolution for *Thymelicus sylvestris*.

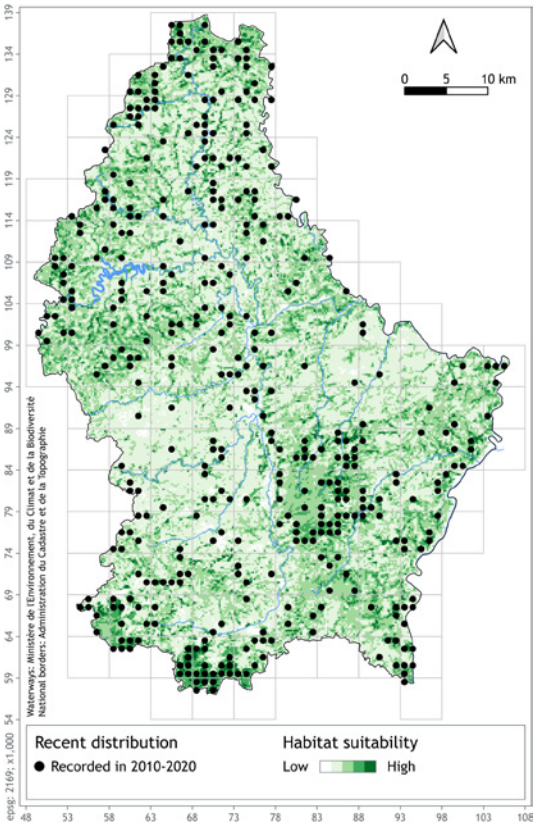


Fig. 4.45: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Thymelicus sylvestris*.

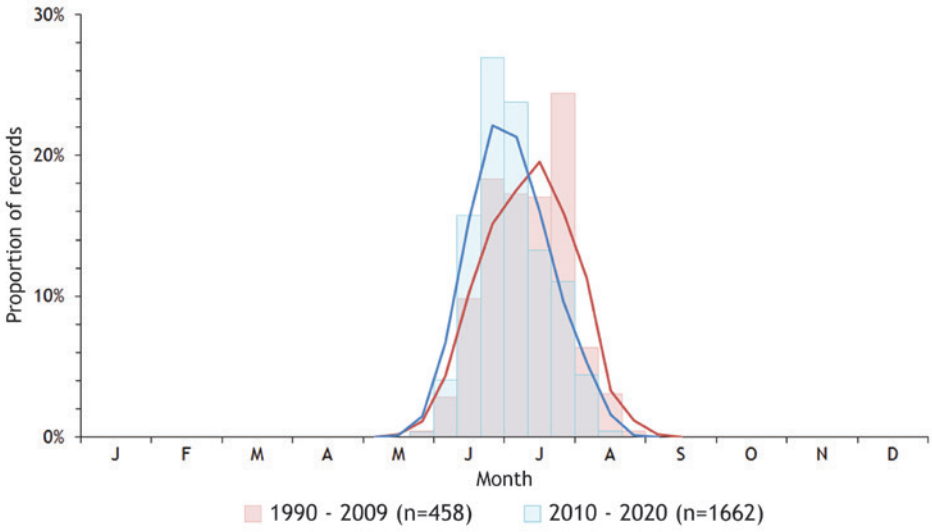


Fig. 4.46: Flight season of *Thymelicus sylvestris* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Thymelicus lineola
(Ochsenheimer, 1808)

L: Schwarzfühler-Déckkapp

E: Essex skipper

G: Schwarzkolbiger Braun-Dickkopffalter

F: Hespérie du dactyle

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Thymelicus lineola is very common but easily confused with *T. sylvestris* as the two species often share the same sites. The underside of the tip of the antennal club is black, while it is orange for *T. sylvestris*.

Lifecycle

Univoltine. Flies mostly from June to August with a peak in July. Overwinters as a fully-developed caterpillar in the egg.

Habitat

Wide range of open biotopes where farming practices are extensive or moderately intensive, such as flower-rich meadows, wastelands, road verges, and forest edges.

Fig. 4.47: *Thymelicus lineola* (Photo: Lionel L'Hoste).

Fig. 4.48: *Thymelicus lineola* (Photo: Xavier Mestdagh).

Larval host plants – Lays eggs in strings on the stems of grasses from the Poaceae family, such as *Agrostis capillaris, Alopecurus pratensis, Anthoxanthum odoratum, Arrhenatherum elatius, Brachypodium sylvaticum, B. pinnatum, Bromus erectus, Dactylis glomerata, Elymus repens, Festuca* spp., and *Phleum pratense*.

Distribution

Luxembourg – Distributed across the whole country with a widespread availability of suitable habitats.

Worldwide – Northern Africa, Europe and large parts of temperate Asia (accidentally introduced in northern America).

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +5%

Relative change in extent of occurrence (geographical range): +2%

Considered as stable.

Management

Limiting the fertilisation in grasslands, promoting extensive grazing and late mowing.

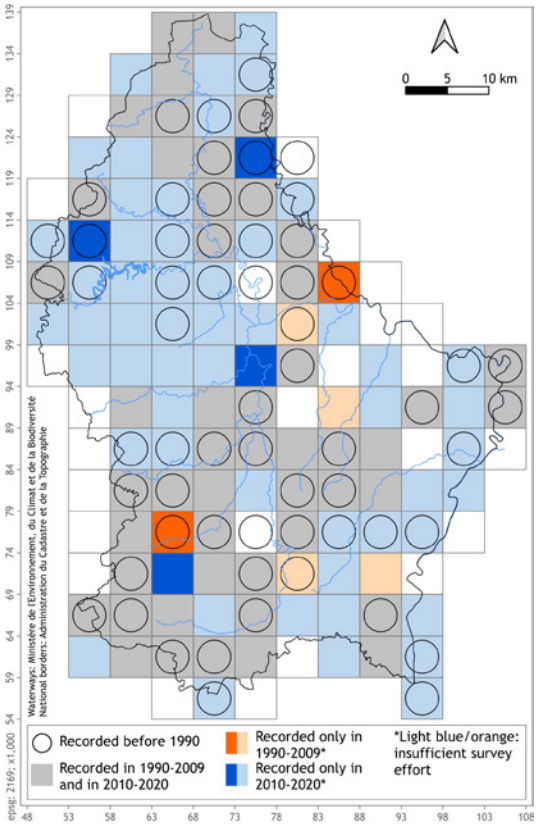


Fig. 4.49: Distribution change map at 5-km spatial resolution for *Thymelicus lineola*.

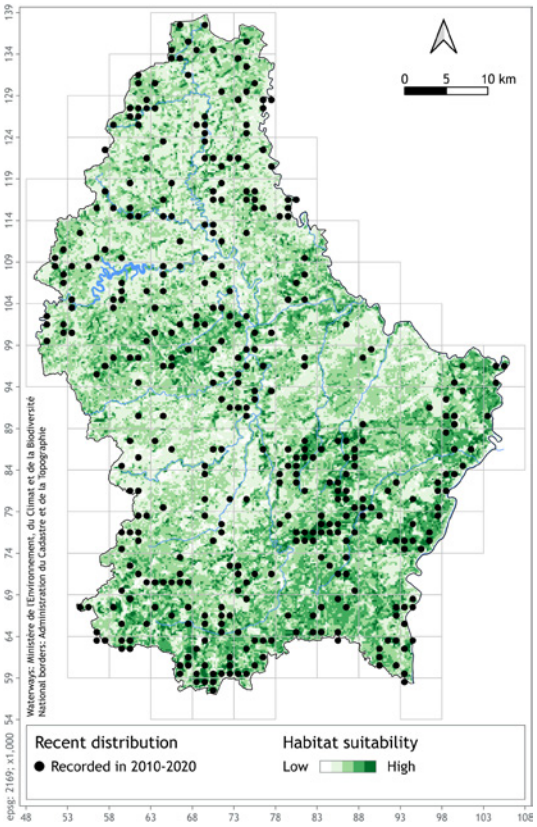


Fig. 4.50: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Thymelicus lineola*.

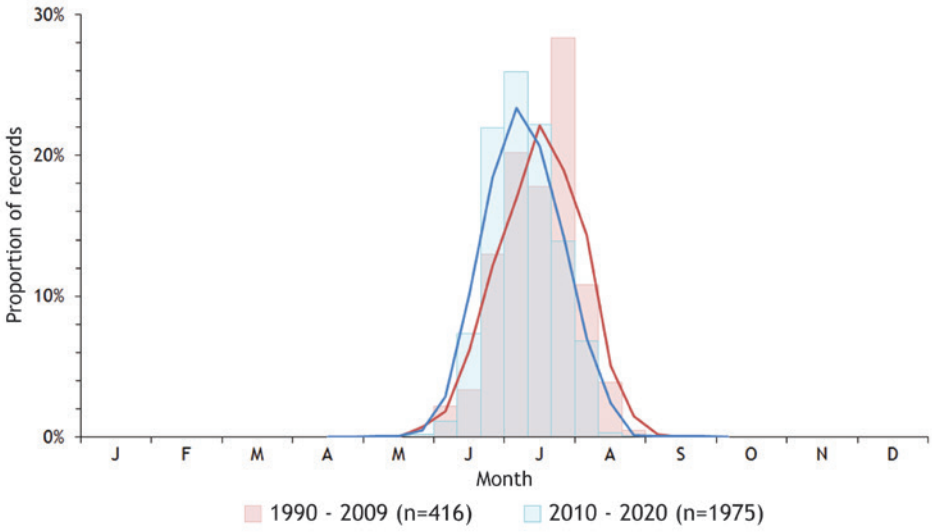


Fig. 4.51: Flight season of *Thymelicus lineola* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Thymelicus acteon

(Rottemburg, 1775)

L: Brongfleckegen Déckkapp

E: Lulworth skipper

G: Mattscheckiger Braun-Dickkopffalter

F: Hespérie du chiendent

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Near Threatened

The smallest species from the *Thymelicus* genus in Europe. *Thymelicus acteon* is known to be strongly sensitive to climate change.

Lifecycle

Univoltine. Flies mostly from late June to August with a peak in late July. Overwinters as first-stage caterpillar in a cocoon.

Habitat

Warm and dry biotopes, such as dry calcareous grasslands and flower-rich meadows on south-facing slopes, with a preference for semi-open areas with patchily distributed shrubs and heterogeneous grass cover.

Nectar resources – Preferentially feeds on *Cirsium* spp. and *Origanum* spp.

Fig. 4.52: *Thymelicus acteon* (Photo: Alain Dohet).

Fig. 4.53: *Thymelicus acteon* (Photo: Lionel L'Hoste).

Larval host plants – Lays eggs on dry grasses from the Poaceae family, such as *Brachypodium pinnatum, B. sylvaticum, Bromus erectus, Carex caryophyllea, Dactylis glomerate, Elymus repens,* and *Festuca* spp.

Distribution

Luxembourg – Distributed with very low population densities in some calcareous grasslands of the eastern half of the Gutland.

Worldwide – Distributed locally across southern and central Europe, Asia Minor, and northern Africa.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -21%

Relative change in extent of occurrence (geographical range): -54%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Promoting extensive grazing in dry grasslands and regular cutting to avoid shrub encroachment. Managing heterogeneous shrub and herbaceous vegetation to diversify microhabitat structures.

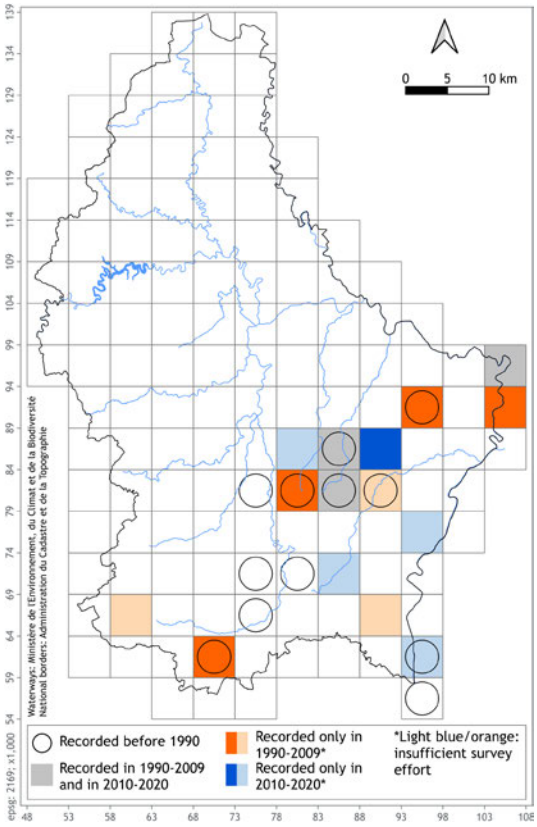


Fig. 4.54: Distribution change map at 5-km spatial resolution for *Thymelicus acteon*.

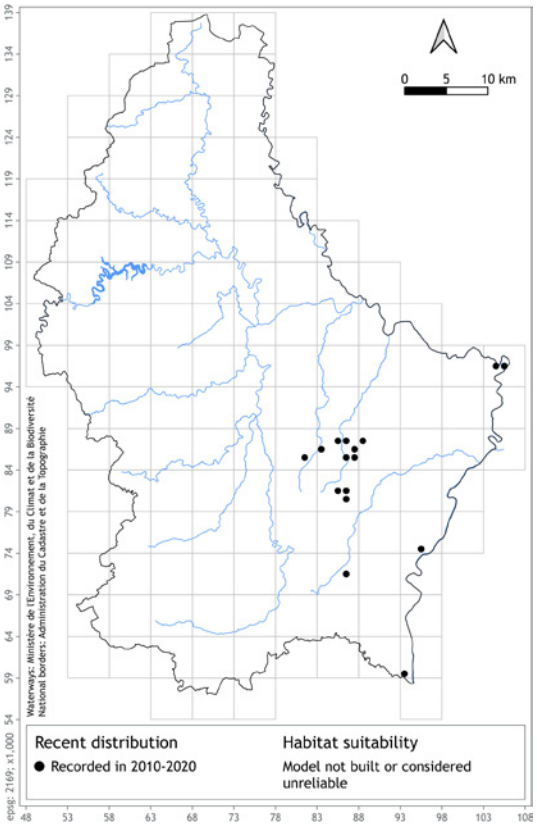


Fig. 4.55: Distribution map at 1-km spatial resolution for *Thymelicus acteon*.

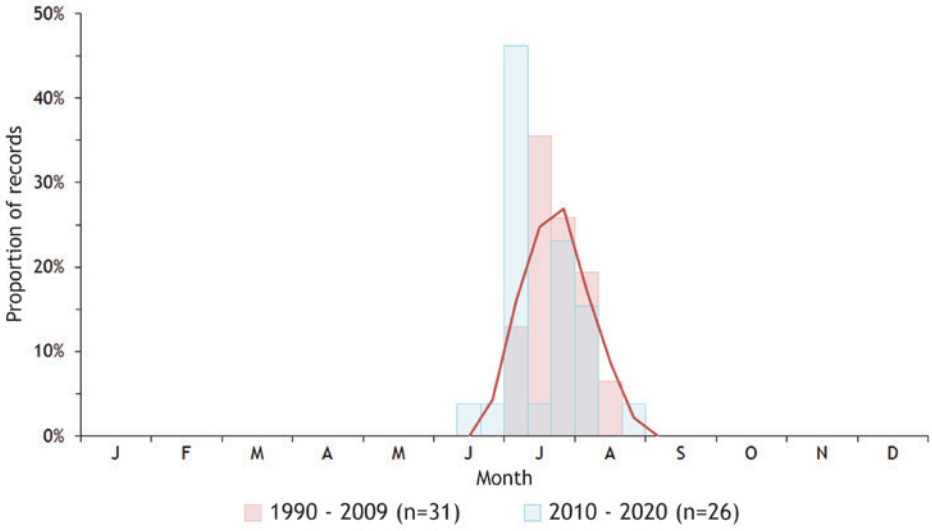


Fig. 4.56: Flight season of *Thymelicus acteon* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Hesperia comma
(Linnaeus, 1758)

L: Komma-Déckkapp
E: Silver-spotted skipper
G: Komma-Dickkopffalter
F: Virgule

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Critically Endangered	Least Concern

Fast-flying species like most skippers, it is characterised by white and contrasted patches on the underside of its wings.

Lifecycle

Univoltine. Flies mostly from July to mid-September, with a peak in mid-August. Overwinters as egg or as unfed caterpillar.

Habitat

Nutrient-poor open biotopes with low vegetation, usually managed by grazing (almost exclusively in calcareous grasslands in Luxembourg).

Nectar resources – Typically feeds on *Centaurea jacea*, *Eupatorium cannabinum*, *Origanum vulgare*, and *Scabiosa columbaria*.

Fig. 4.57: *Hesperia comma* (Photo: Alain Dohet).

Fig. 4.58: *Hesperia comma* (Photo: Lionel L'Hoste).

Larval host plants – Lays single eggs close to the bare ground on *Festuca ovina* and *Nardus stricta*.

Distribution

Luxembourg – Almost exclusively distributed between Esch-sur-Alzette and Dudelange in a network of relatively well-connected sites. Suitable habitats available in this same part of the Minette but also in the south of Pétange (Giele Botter).

Worldwide – Holarctic species, widely distributed in Europe, but absent from northern Britain, lowland regions of Spain and Portugal, southern Italy, and the Mediterranean islands.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -44%

Relative change in extent of occurrence (geographical range): -93%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted to only cover a few sites in the Minette nowadays. The species was already extinct from the Oesling and from many sites in the Gutland before 1990. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Conservation

Limiting the fertilisation and maintaining extensive grazing on nutrient-poor and dry grasslands.

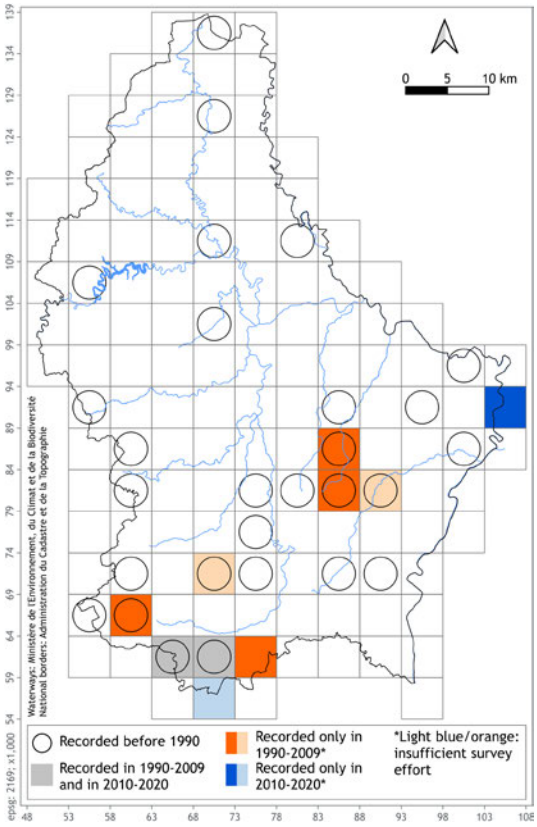


Fig. 4.59: Distribution change map at 5-km spatial resolution for *Hesperia comma*.

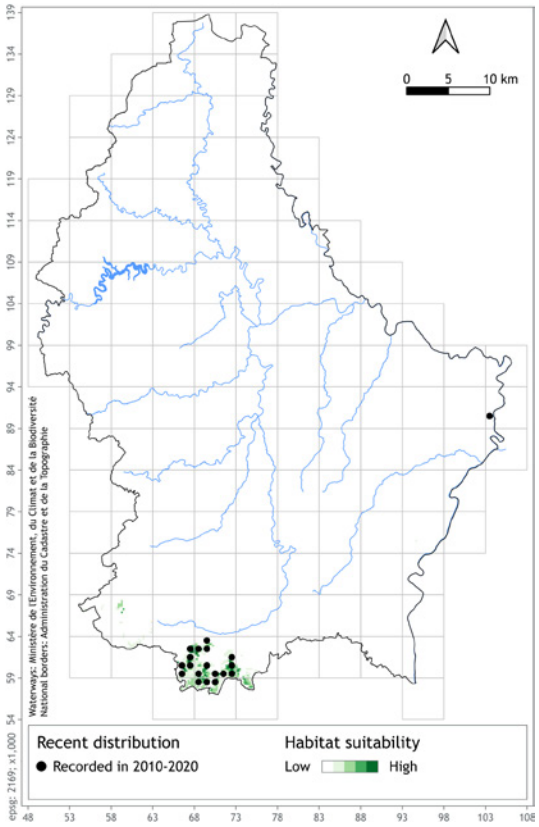


Fig. 4.60: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Hesperia comma*.

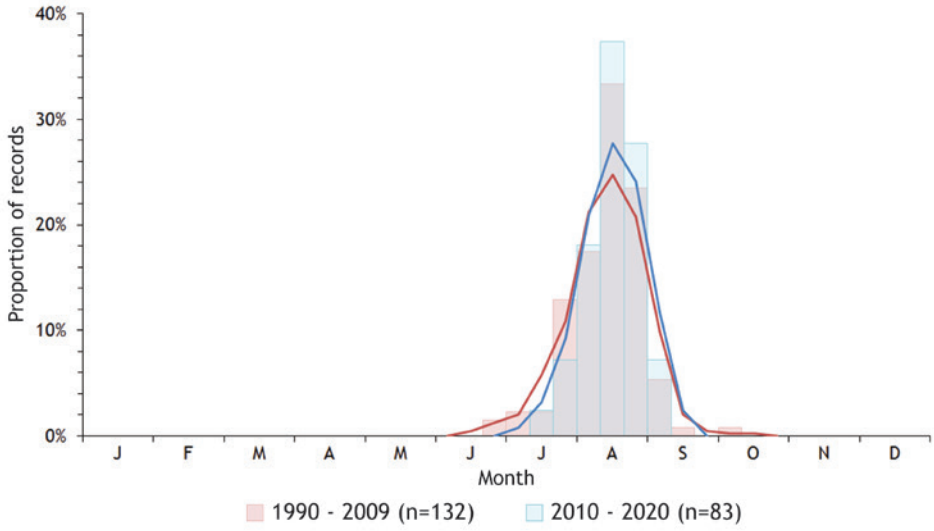


Fig. 4.61: Flight season of *Hesperia comma* representing the frequency distribution of species records over time at a 10-day temporal resolution.

HESPERIIDAE

Ochlodes sylvanus

(Esper, 1777)

Syn.: *Ochlodes venatus*

L: Raschtfarwegen Déckkapp

E: Large skipper

G: Rostfarbiger Dickkopffalter

F: Sylvaine

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

The largest of the "golden" skippers present in Luxembourg, easily distinguished from the others by the presence of a hook at the end of its antennae. Males defend their territories vigorously and chase away any intruder.

Lifecycle

Univoltine. Flies mostly from mid-May to early August, with a peak in mid-June. Overwinters as caterpillar.

Habitat

Various biotopes with tall grasses, along shrubs and forest edges, in wetlands, forest clearings, hay meadows, road verges, hedgerows, and even urban areas.

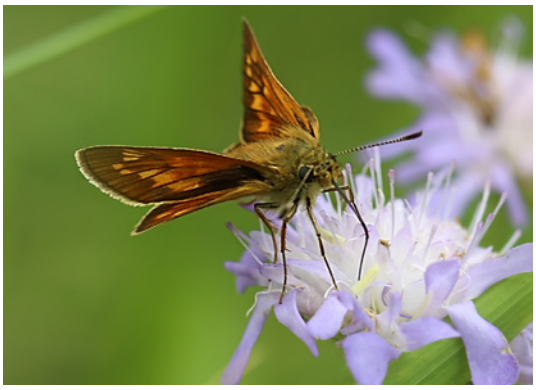


Fig. 4.62: *Ochlodes sylvanus* (Photo: Alain Dohet).

Fig. 4.63: *Ochlodes sylvanus* (Photo: Hubert Baltus).

Nectar resources – Feeds on a large variety of flowers, such as *Ajuga reptans*, *Cirsium* spp., *Lotus corniculatus*, *Rubus fruticosus*, and *Succisa pratensis*.

Larval host plants – Lays single eggs on various species from the Poaceae family, such as *Brachypodium pinnatum*, *B. sylvaticum*, *Bromus erectus*, *Calamagrostis epigejos*, *Dactylis glomerata*, and *Lolium perenne*.

Distribution

Luxembourg – Widely distributed across the whole country with suitable habitats available in every region, especially in forest patches and along riparian forests.

Worldwide – Widespread across Europe and temperate Asia.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -4%

Relative change in extent of occurrence (geographical range): +3%

Considered as stable.

Management

Promoting tall grasses and flower-rich areas with brambles, shrubs, and well-structured forest edges.

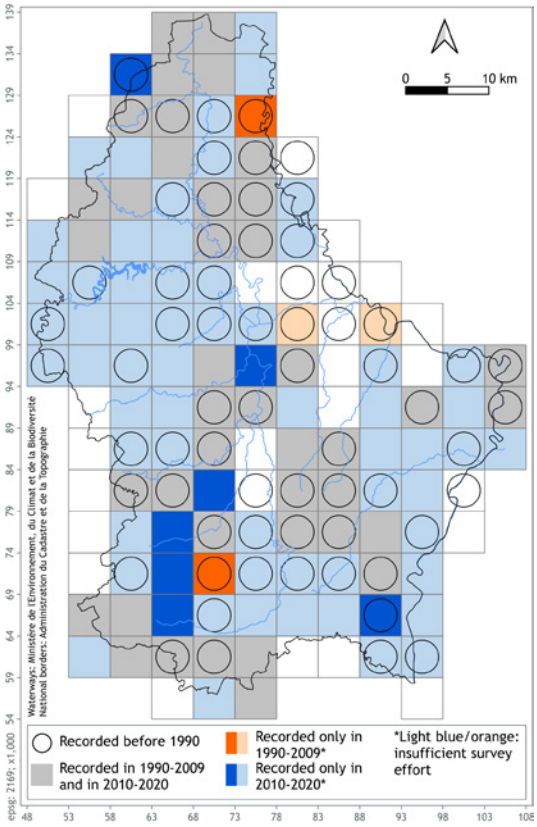


Fig. 4.64: Distribution change map at 5-km spatial resolution for *Ochlodes sylvanus*.

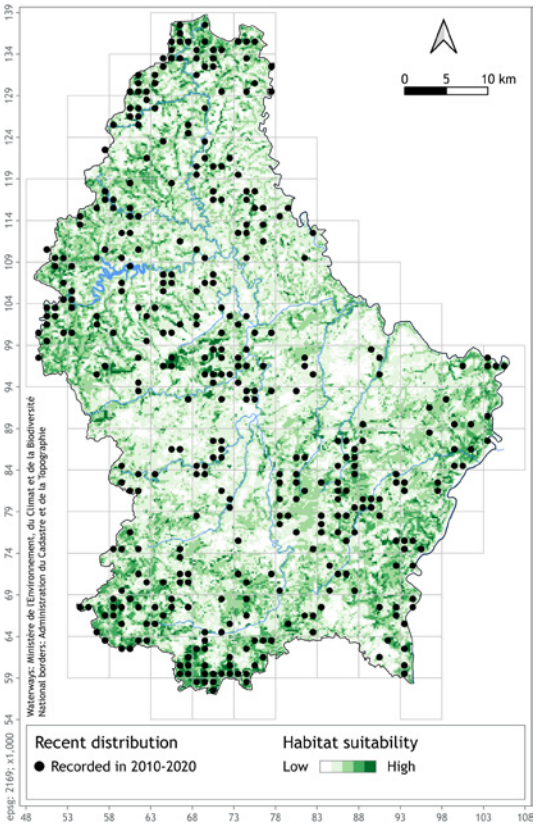


Fig. 4.65: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Ochlodes sylvanus*.

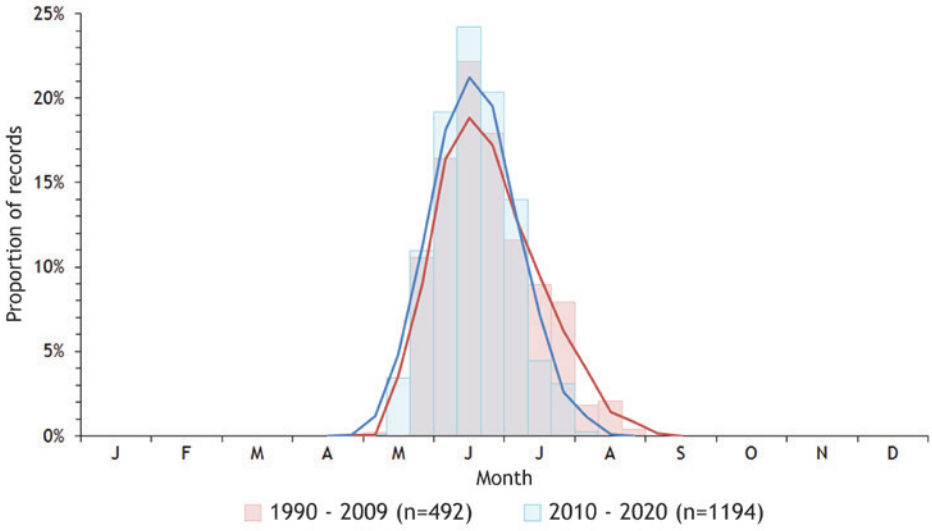


Fig. 4.66: Flight season of *Ochlodes sylvanus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PAPILIONIDAE

Iphiclides podalirius
(Linnaeus, 1758)

L: Segelfalter

E: Scarce swallowtail

G: Segelfalter

F: Flambé

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1992	Least Concern

Iphiclides podalirius is a large, conspicuous, whitish butterfly that is hardly unnoticed, but it has unfortunately not been recorded in Luxembourg for several years. It can be distinguished from *Papilio machaon* by its paler wings, its black stripes, and its longer tails.

Lifecycle

Mostly univoltine in neighbouring regions, sometimes a second generation in hot summers. Flies mostly from April to June, with a peak in May, and in August in the case of a second generation. Overwinters as chrysalis.

Habitat

Warm and dry flower-rich meadows in hilly landscapes, surrounded by forest edges and with scattered *Prunus spinosa* bushes. Males use the hills for "hilltopping" (i.e., they fly around the hilltops in search of females), and like to rest on the bushes that grow at the top.

Fig. 4.67: *Iphiclides podalirius* (Photo: Stéphane Vizthum).

Fig. 4.68: *Iphiclides podalirius* (Photo: Lysandre L'Hoste).

Nectar resources – Typically feeds on flowering shrubs.

Larval host plants – Lays eggs near the ground on the underside of *Prunus spinosa* leaves, on well-exposed bushes not taller than one meter. Larger bushes are ignored because of the colder microclimate they provide. In Lorraine, *P. mahaleb* is also used.

Distribution

Luxembourg – Previously recorded in several regions from the Oesling to the Minette and the Moselle. Last record in 1992 near Esch-sur-Alzette.

Neighbouring countries – Since 2010, occasionally recorded in northern French Lorraine, Belgian Ardennes and eastern Saarland, recorded more frequently close to the Luxembourgish border in the Moselle valley in western Rhineland-Palatinate.

Worldwide – Palearctic species, mainly distributed in southern and central Europe up to western China. Absent from Scandinavia and the British Isles. Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. Its decline was mainly due to the abandonment of agropastoral practices of dry meadows. A comeback from the nearby French and German populations is likely, especially in a context of global warming.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

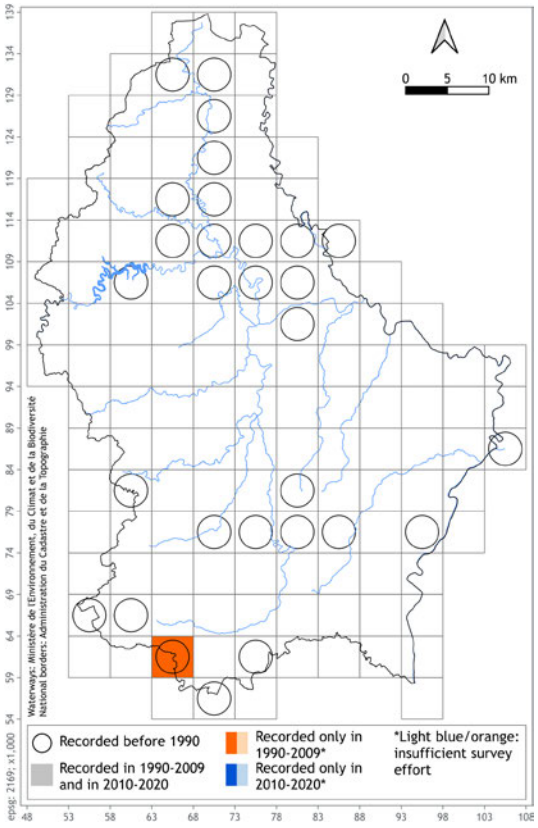


Fig. 4.69: Distribution change map at 5-km spatial resolution for *Iphiclides podalirius*.

Fig. 4.70: *Iphiclides podalirius* (Illustration: Anita Faber).

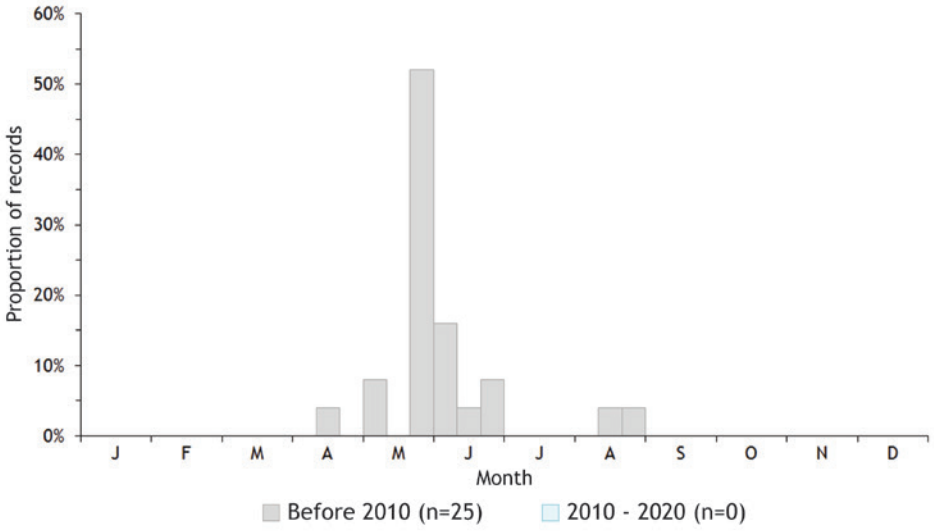


Fig. 4.71: Flight season of *Iphiclides podalirius* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PAPILIONIDAE

Papilio machaon

Linnaeus, 1758

L: Schmuewelschwanz

E: Swallowtail

G: Schwalbenschwanz

F: Machaon

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Papilio machaon is the last representative of the Papilionidae family since *Iphiclides podalirius* went extinct in Luxembourg. It is the largest butterfly in Luxembourg and can fly long distances. It is a relatively widespread species but is rarely observed in high densities in Luxembourg.

Lifecycle

Bivoltine. Flies from April to early October, with a first peak in late May and a second one, steeper, in late July. Overwinters as chrysalis, close to its host plants.

Habitat

Wide variety of open and flower-rich biotopes, such as fallow lands, wastelands, uncultivated strips, gardens, and damp to dry grasslands with relatively extensive management. Males use the hills for "hilltopping" (i.e., they fly around the hilltops in search of females), and like to rest on the bushes that grow at the top.

Fig. 4.72: *Papilio machaon* (Photo: Francis Birlenbach).

Fig. 4.73: *Papilio machaon* (Photo: Roland Proess).

Larval host plants – Lays single eggs on the leaves of many species from the Apiaceae and Rutaceae families, such as *Anethum graveolens*, *Angelica sylvestris*, *Daucus carota*, *Foeniculum vulgare*, *Pastinaca sativa*, *Petroselinum crispum*, *Peucedanum palustre*, *Pimpinella saxifraga*, *Ruta graveolens*, *Selinum carvifolia*, *Seseli libanotis*, and *Silaum silaus*.

Distribution

Luxembourg – Distributed across the whole country, but with low densities in the Oesling where suitable habitats are less available and more patchily distributed.

Worldwide – Holarctic species, distributed in most of Europe, northern Africa, temperate Asia up to Japan, and part of northern America.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -15%

Relative change in extent of occurrence (geographical range): +1%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting extensive management in open biotopes (e.g., grasslands, forest edges, road verges), such as reducing mowing frequency and fertiliser inputs. Since the caterpillar causes no real damage in gardens, citizens can contribute to the conservation of this species by planting some carrots or fennel.

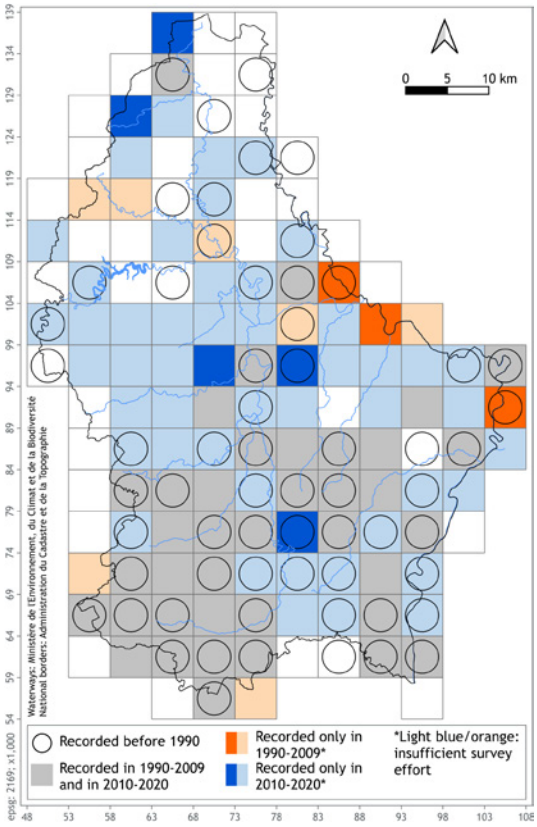


Fig. 4.74: Distribution change map at 5-km spatial resolution for *Papilio machaon*.

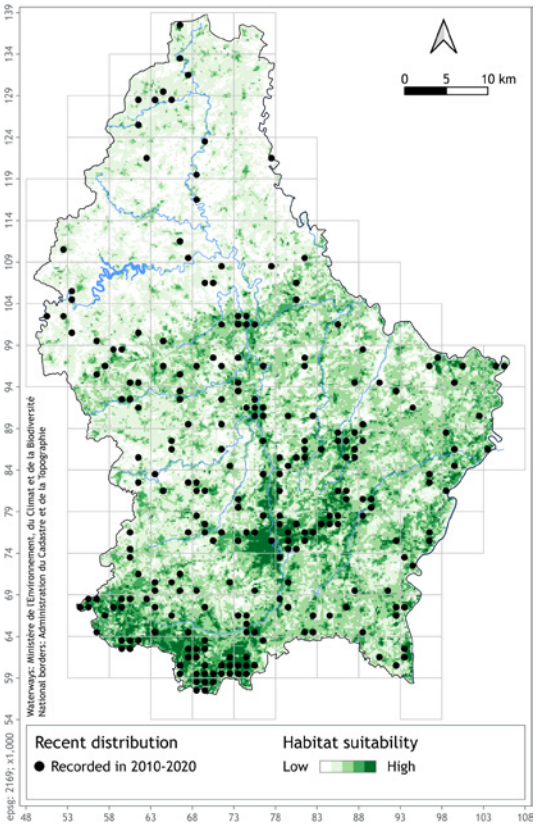


Fig. 4.75: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Papilio machaon*.

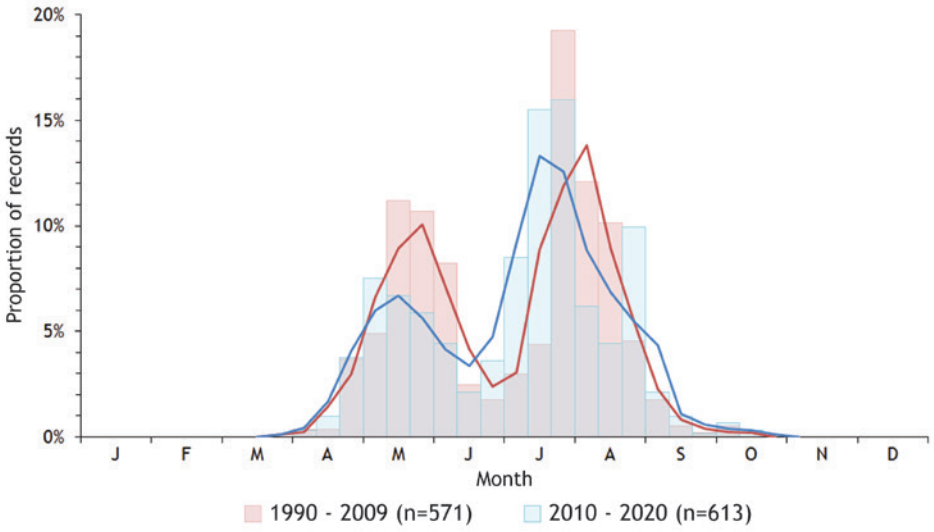


Fig. 4.76: Flight season of *Papilio machaon* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Leptidea sinapis/juvernica

(Linnaeus, 1758)/Williams, 1946

L: Moschter-Wäissleng / Bëschrand-Moschter-W.

E: Wood white / Cryptic wood white

G: Leguminosen-Weißling / Schmalflügel-Weißling

F: Piéride du lotier / Piéride Irlandaise

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Evaluated	Least Concern / -

Leptidea sinapis, *L. juvernica* and *L. reali* form a complex of cryptic species hardly distinguishable in the field, characterised by a light flight close to the ground. *L. reali* is restricted to southern Europe (Mediterranean basin) and *L. juvernica* more northward. *L. sinapis* can be found together with them. Only *L. sinapis* and *L. juvernica* were confirmed present in Luxembourg based on genitalia examination, but further investigations should be undertaken. Both species are therefore considered together here.

Lifecycle

Bivoltine. Fly from April to early September with a first peak in May and a second one in July. Overwinter as chrysalis.

Fig. 4.77: *Leptidea sinapis/juvernica* (Photo: Francis Birlenbach).

Fig. 4.78: *Leptidea sinapis/juvernica* (Photo: Hubert Baltus).

Habitat

Preferentially flower-rich and open forest areas, such as deciduous forest edges and paths, clearings, but also shrubby grasslands, and hedgerows.

Larval host plants – Lay single eggs on the underside of leaves of various sheltered species from the Fabaceae family, such as *Hippocrepis comosa*, *Lathyrus linifolius*, *L. pratensis*, *Lotus corniculatus*, *L. pedunculatus*, *Medicago falcata*, *M. sativa*, *Securigera varia*, and *Vicia cracca*.

Distribution

Luxembourg – Mainly distributed in the southern half of the country, with a few isolated records in the Oesling. Availability of suitable habitats is not shown for this species complex.

Worldwide – Throughout most of Europe and most of temperate western Asia.

Trends (<2010 *vs.* 2010-2020)

Trends were not evaluated for this complex species.

Management

Promoting light forests and wooded grasslands (bocage), refuge strips along hedges in grasslands, as well as rotational mowing of the herbaceous layer along forest paths and road verges.

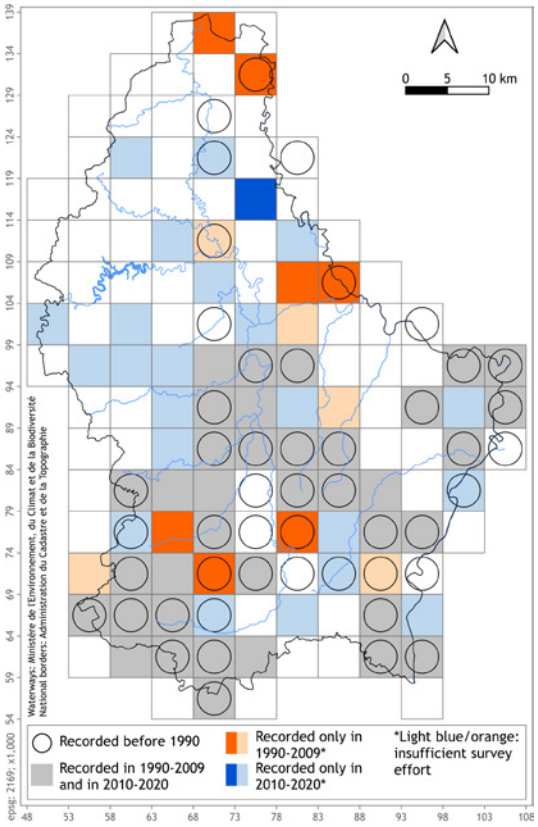


Fig. 4.79: Distribution change map at 5-km spatial resolution for *Leptidea sinapis/juvernica*.

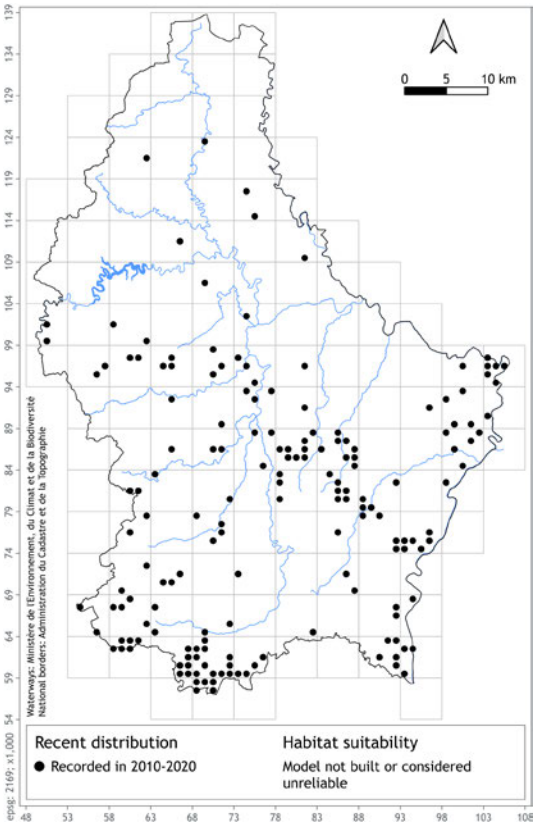


Fig. 4.80: Distribution map at 1-km spatial resolution for *Leptidea sinapis/juvernica*.

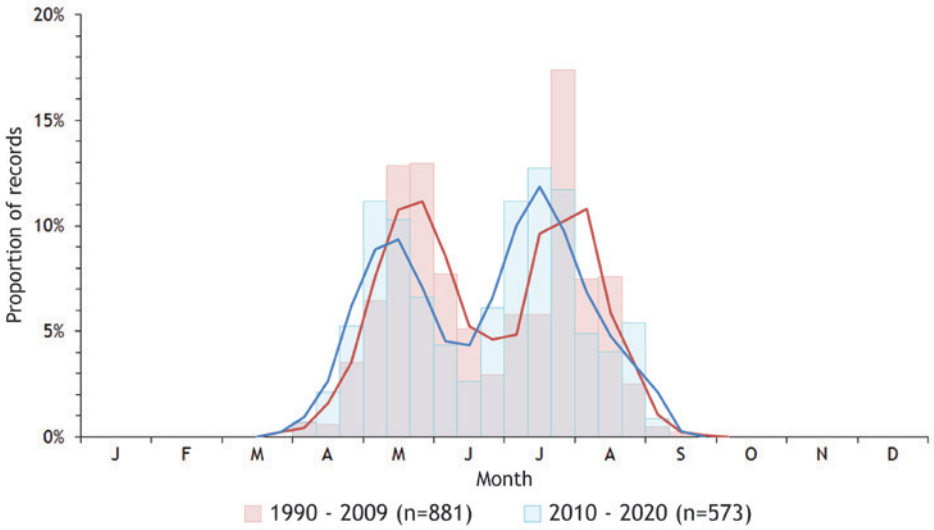


Fig. 4.81: Flight season of *Leptidea sinapis/juvernica* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Aporia crataegi

(Linnaeus, 1758)

L: Bamwäissleng

E: Black-veined white

G: Baum-Weißling

F: Gazé

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Near Threatened	Least Concern

Aporia crataegi is a large white butterfly with contrasted black veins and exhibits a slow and gliding flight, alternating with powerful wing beats.

Lifecycle

Univoltine. Flies from May to July, with a peak in early June. Overwinters as gregarious caterpillar in a nest.

Habitat

Flower-rich areas with shrubs such as hedgerows in extensive grasslands, forest edges, road verges, orchards. Abandoned grasslands are very attractive before shrub encroachment.

Larval host plants – Lays eggs in batches on the underside of leaves of *Crataegus* spp. and *Prunus spinosa*, its main host plants. *Sorbus aucuparia*, *S. torminalis*, *Betula* spp., *Salix caprea*, and fruit trees are also mentioned in the literature.

Fig. 4.82: *Aporia crataegi* (Photo: Hubert Baltus).

Fig. 4.83: *Aporia crataegi* (Photo: Michelle Clemens).

Distribution

Luxembourg – Densely distributed in the valley bottoms of the Oesling and in the lowland areas in the southwest of the country, but patchily distributed in the other regions where suitable habitats are less available.

Worldwide – From northwestern Africa across Europe and temperate Asia to Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -30%

Relative change in extent of occurrence (geographical range): +2%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting the restoration and the plantation of diversified hedges (bocage) in farmland, extensive management such as reduced fertilisation and late mowing, as well as flower-rich areas. Avoiding shrub encroachment with regular cutting and extensive grazing.

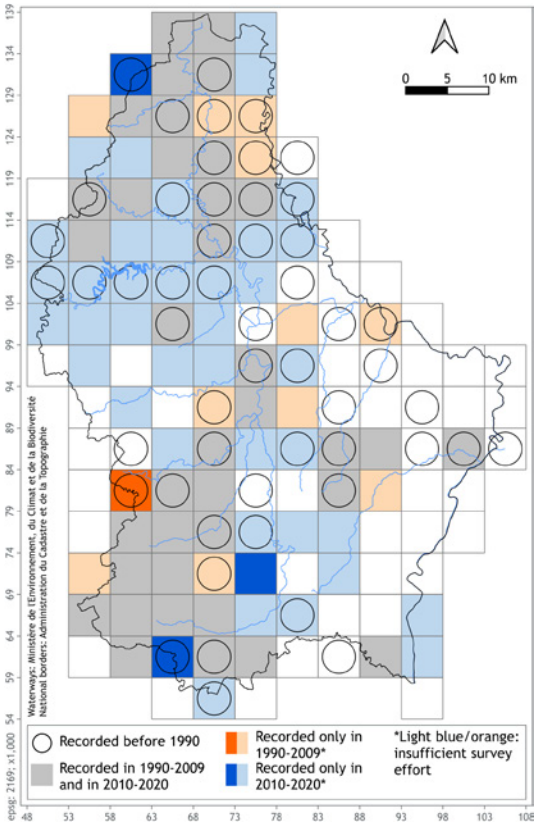


Fig. 4.84: Distribution change map at 5-km spatial resolution for *Aporia crataegi*.

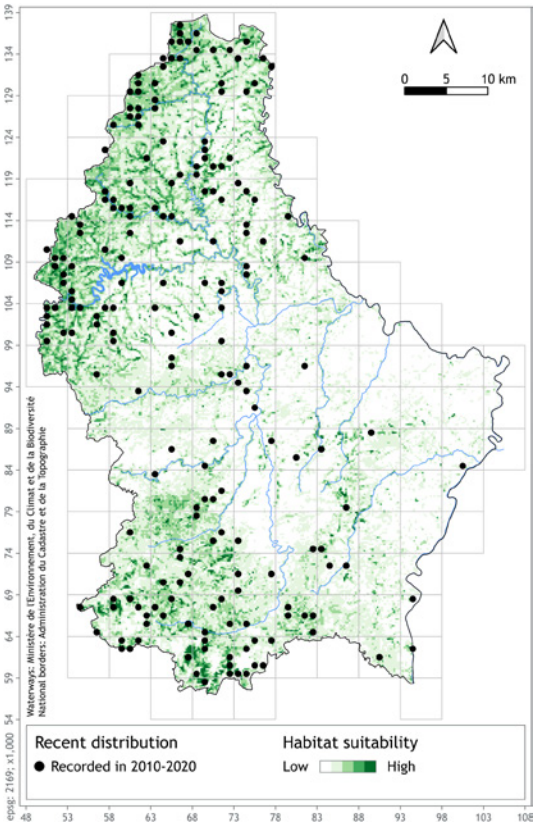


Fig. 4.85: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Aporia crataegi*.

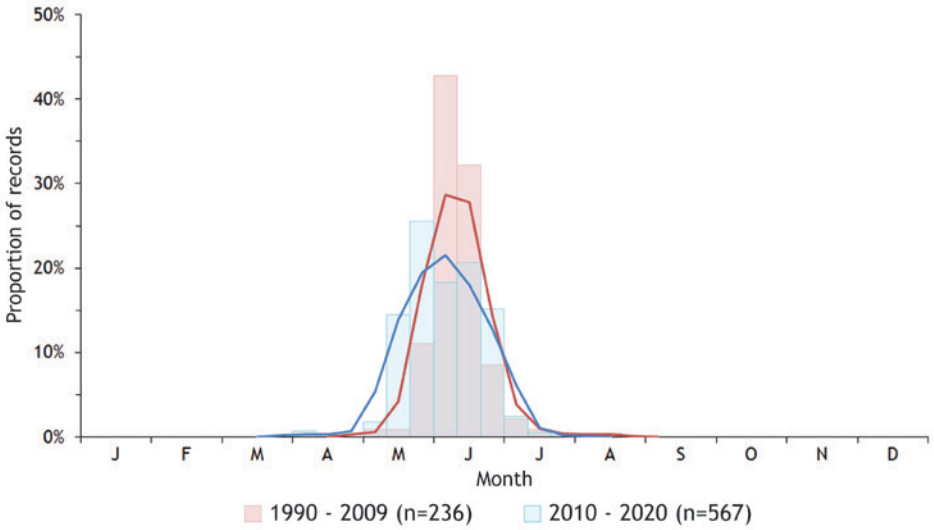


Fig. 4.86: Flight season of *Aporia crataegi* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Pieris brassicae

(Linnaeus, 1758)

L: Kabesfrësser

E: Large white

G: Großer Kohl-Weißling

F: Piéride du chou

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Unprotected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Pieris brassicae is a large and mobile species with a powerful flight. It suffers from severe parasitism due to larva from *Apanteles glomeratus* wasps and, consequently, shows high inter-annual variation in abundance.

Lifecycle

Bivoltine, sometimes three generations in favourable years. Flies mostly from April to early October with a smooth first peak in spring and a second one, steeper, in summer. The resident population is often strengthened by migrants. Overwinters as chrysalis.

Habitat

Gardens, parks, fallow lands, forest edges and clearings, dry to wet grasslands, and along road verges and hedgerows.

Fig. 4.87: *Pieris brassicae* (Photo: Xavier Mestdagh).

Fig. 4.88: *Pieris brassicae* (Photo: Marcel Hellers).

Larval host plants – Lays yellow skittle-shaped eggs in large batches on various species mostly from the Brassicaceae family, such as *Alliaria petiolata*, *Brassica oleracea*, other *Brassica* spp., *Lunaria* spp., *Raphanus raphanistrum*, *Reseda* spp., *Rorippa amphibia*, *Sinapis alba*, *S. arvensis*, and *Tropaeolum majus*.

Distribution

Luxembourg – Homogeneously distributed across the whole country.

Worldwide – From northern Africa across Europe and temperate Asia to the Himalayan mountains. Accidentally introduced in Chile.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -18%

Relative change in extent of occurrence (geographical range): +2%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Often seen as a pest and controlled with insecticides as it can feed on cultivated species from the Brassicaceae family. Avoiding insecticides in gardens and replacing them by alternative solutions such as the manual removal of eggs and larvae, protection with nets, or the use of auxiliary species for biological control.

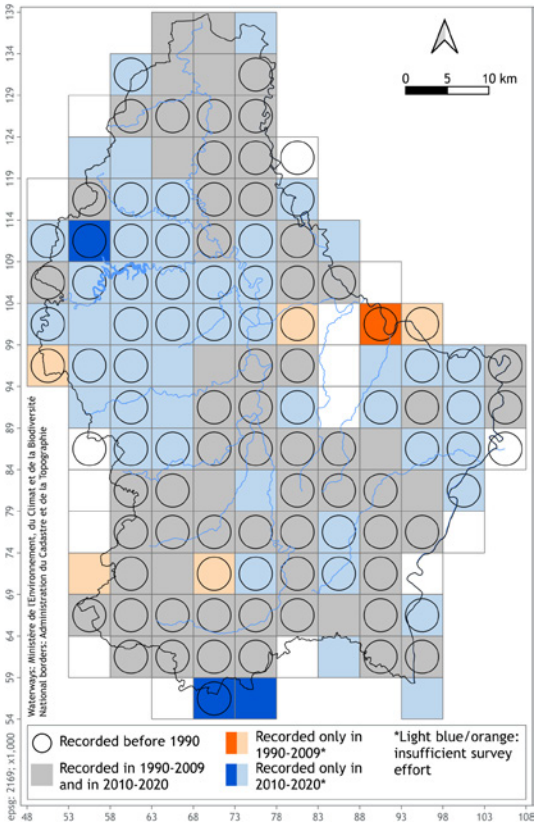


Fig. 4.89 Distribution change map at 5-km spatial resolution for *Pieris brassicae*.

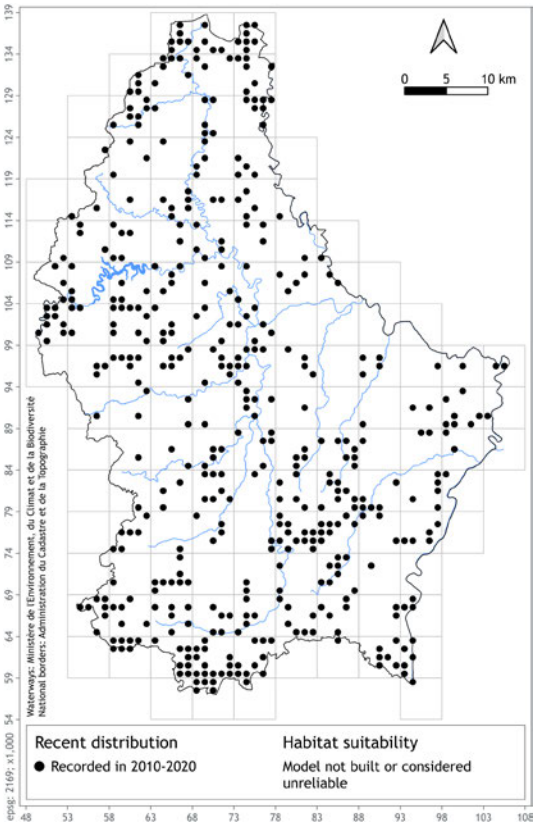


Fig. 4.90: Distribution map at 1-km spatial resolution for *Pieris brassicae*.

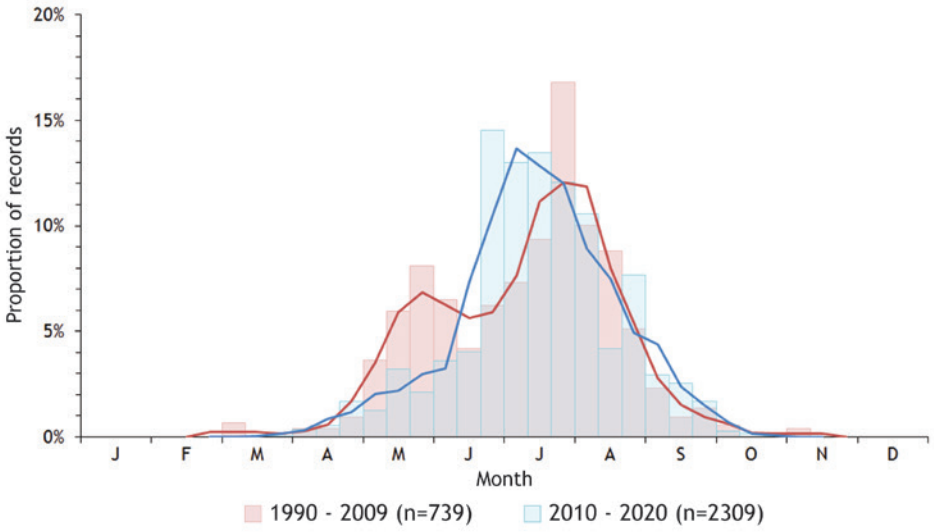


Fig. 4.91: Flight season of *Pieris brassicae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Pieris rapae
(Linnaeus, 1758)

L: Klenge Kabespäiperlek

E: Small white

G: Kleiner Kohl-Weißling

F: Piéride de la rave

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Unprotected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Pieris rapae shows seasonal variation in appearance, specific to the generation. It can be seen mud-puddling on various surfaces rich in nutrients. Confusion with other whites (mainly with *P. napi* and *P. mannii*) may be possible without careful attention.

Lifecycle

Bivoltine, sometimes a third partial generation in favourable years. Flies mostly from April to September. Highly mobile and populations often strengthened by migrants. Overwinters as chrysalis.

Habitat

Wide variety of open biotopes, such as rapeseed crops and gardens.

Fig. 4.92: *Pieris rapae* (Photo: Alain Dohet).

Fig. 4.93: *Pieris rapae* (Photo: Lionel L'Hoste).

Larval host plants – Lays single eggs on the leaves of various species (preferentially cultivated ones), such as *Biscutella laevigata*, *Brassica oleracea*, *B. rapa*, *Cardamine hirsuta*, *Diplotaxis tenuifolia*, *Erucastrum gallicum*, *Lepidium* spp., *Raphanus raphanistrum*, *Reseda lutea*, other *Reseda* spp., *Rorippa amphibia*, *R. sylvestris*, *Sinapis arvensis*, *Sisymbrium officinale*, and *Tropaeolum majus*.

Distribution

Luxembourg – Homogeneously distributed across the whole country. Availability of suitable habitats is not shown because many potential observations of the species are recorded as *Pieris* sp.

Worldwide – From northern Africa across Europe, Asia to Japan. Accidentally introduced in many countries and can nowadays be considered as nearly cosmopolitan.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -7%

Relative change in extent of occurrence (geographical range): +3%

Considered as stable.

Management

Promoting extensive management in farmland, late and/or rotational mowing in herbaceous biotopes (e.g., field margins, forest edges, gardens). Avoiding pesticides in gardens.

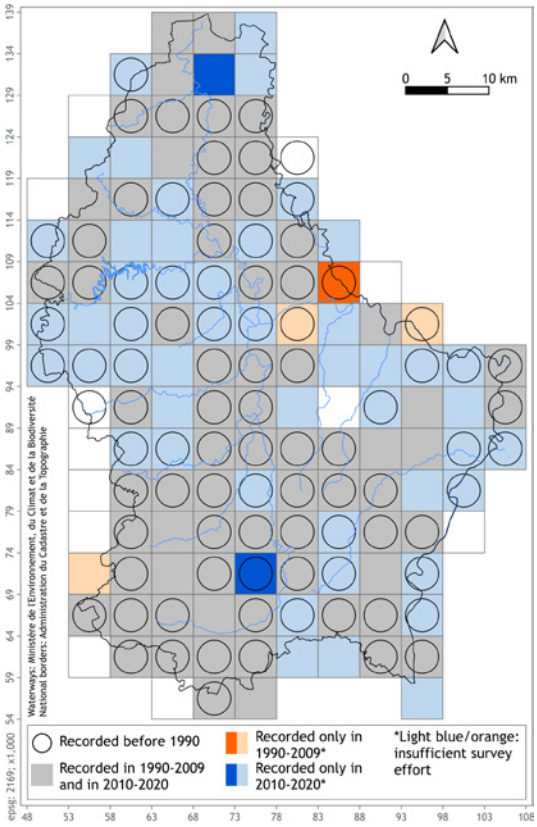


Fig. 4.94: Distribution change map at 5-km spatial resolution for *Pieris rapae*.

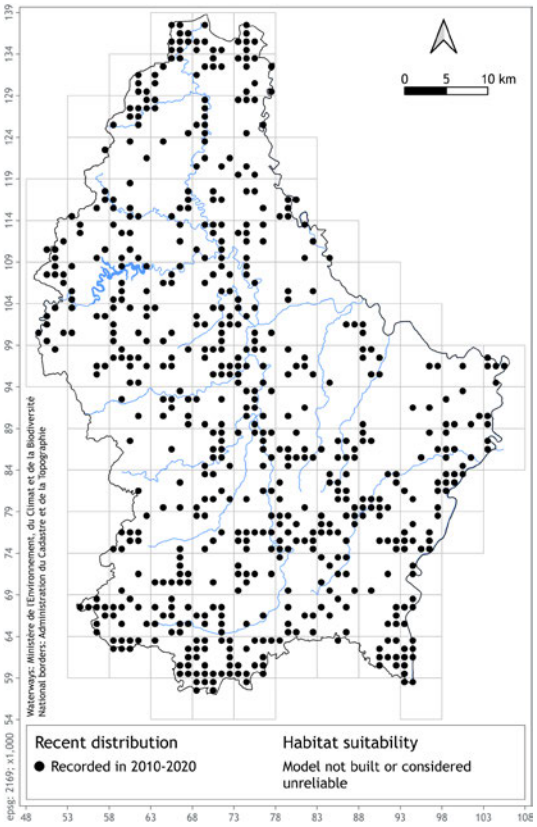


Fig. 4.95: Distribution map at 1-km spatial resolution for *Pieris rapae*.

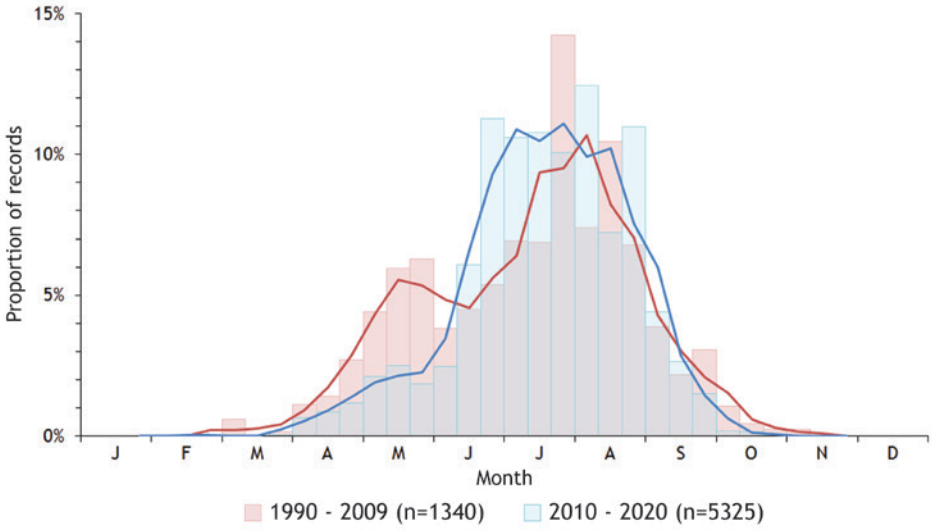


Fig. 4.96: Flight season of *Pieris rapae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Pieris mannii

(Mayer, 1851)

L: Karstwäissleng

E: Southern small white

G: Karst-Weißling

F: Piéride de l'ibéride

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Evaluated	Least Concern

Initially known as a Mediterranean species, the distribution of *Pieris mannii* has been moving northward in recent decades. First records are from 2002 in the Haard (Dudelange), but the species has been mentioned in this area already in the 1970s by Meyer and Cungs (with no record available in the database). The species might have been unnoticed due to its resemblance with *P. rapae*.

Lifecycle

Polyvoltine, with up to five generations per year. Flies from April to late September. Overwinters as chrysalis.

Habitat

Hot, arid and rocky biotopes, but recently colonising other biotopes such as gardens in sunny and warm situations with host plants.

Fig. 4.97: *Pieris mannii* (Photo: Lionel L'Hoste).

Fig. 4.98: *Pieris mannii* (Photo: Lionel L'Hoste).

Larval host plants – Lays single eggs on various species from the Brassicaceae family, mostly *Iberis amara*, *I. sempervirens* and *Aurinia saxatile*.

Distribution

Luxembourg – Patchily distributed in the southern half of the country, mainly in industrial or urban areas. Availability of suitable habitats is not shown because many potential observations of the species are recorded as *Pieris* sp.

Worldwide – Initially distributed from northern Africa across southern and southeastern Europe to Asia Minor and Syria. Due to global warming and the dissemination of horticultural plants from garden centres, it has been expanding northwards, reaching the province of Schleswig-Holstein (Germany) in 2020.

Trends (<2010 vs. 2010-2020)

Although it seems to have strongly increased across the country in 2010-2020, its trends were not estimated as it may have been underdetected before 2010 due to its high resemblance to other withes such as *P. rapae*.

Management

Promoting extensive grazing and limiting the fertilisation in industrial wastelands. Promoting flower-rich and sunny gardens rich in its host plants.

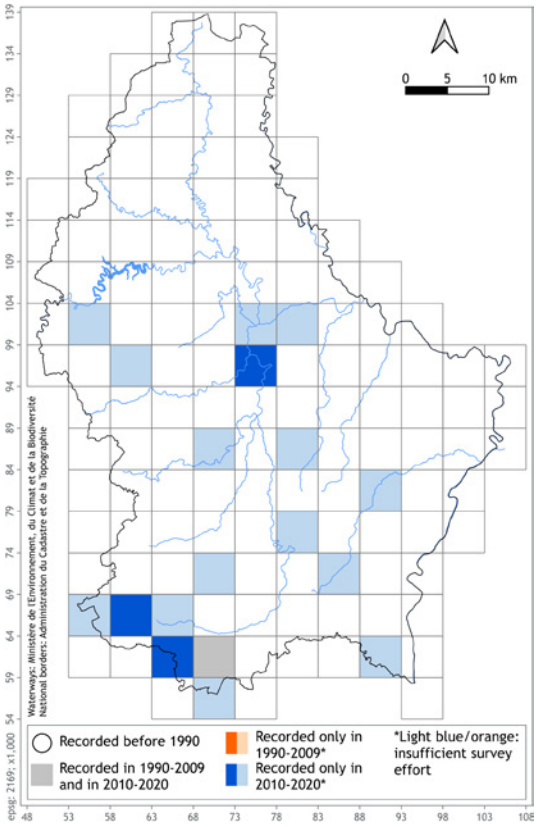


Fig. 4.99: Distribution change map at 5-km spatial resolution for *Pieris mannii*.

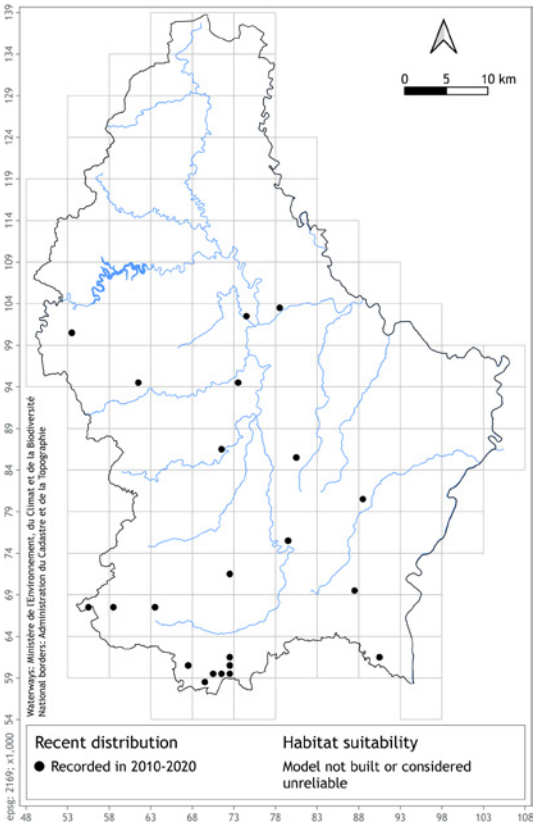


Fig. 4.100: Distribution map at 1-km spatial resolution for *Pieris mannii*.

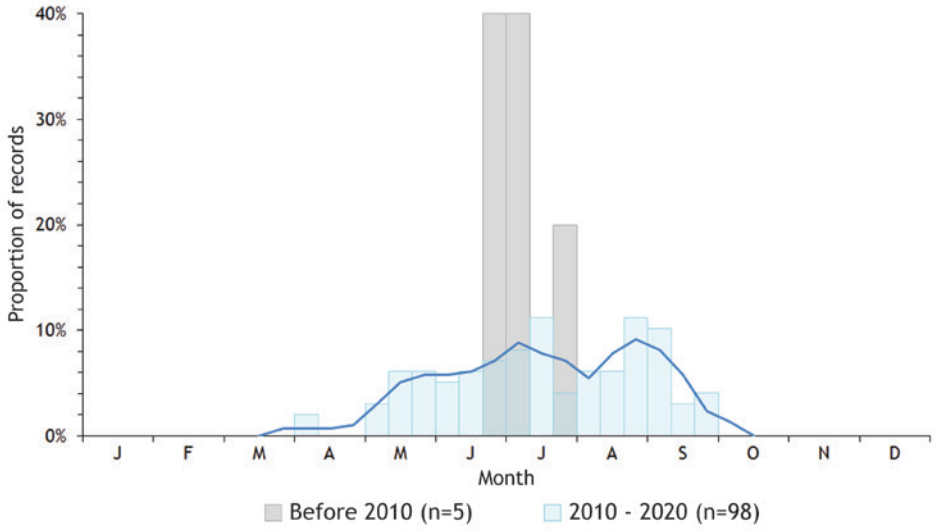


Fig. 4.101: Flight season of *Pieris mannii* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Pieris napi
(Linnaeus, 1758)

L: Rapswäissleng
E: Green-veined white
G: Grünader-Weißling
F: Piéride du navet

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Unprotected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

The English name of *Pieris napi* underlines a reliable criterion to distinguish this species from the other whites. However, the green veins are usually less marked in the summer generation. *P. napi* is often seen mud-puddling on various surfaces rich in nutrients.

Lifecycle

Trivoltine. Flies mostly from April to September, with a first peak in May and a second one in late July (overlapping of the second and third generations). Overwinters as chrysalis.

Habitat

Mainly forest paths and edges, clearings, hedgerows, riparian forests, and wet meadows, but also gardens and farmland.

Fig. 4.102: *Pieris napi* (Photo: Marcel Hellers).

Fig. 4.103: *Pieris napi* (Photo: Francis Birlenbach).

Larval host plants – Lays single eggs on the underside of leaves of many species from the Brassicaceae family (preferably small wild plants), such as *Alliaria petiolata*, *Arabis* spp., *Barbarea vulgaris*, *Biscutella laevigata*, *Brassica* spp., *Cardamine* spp., *Erysimum cheiri*, *Lepidium campestre*, *Lunaria rediviva*, *Nasturtium* spp., *Reseda* spp., *Rorippa* spp., and *Sinapis arvensis*.

Distribution

Luxembourg – Homogeneously distributed across the whole country. Availability of suitable habitats is not shown because many potential observations of the species are recorded as *Pieris* sp.

Worldwide – Holarctic species distributed in northern Africa, Europe, Asia, and northern America.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -8%

Relative change in extent of occurrence (geographical range): +1%

Considered as stable.

Management

Promoting extensive management in farmland, as well as late and/or rotational mowing of the herbaceous layer along wooded biotopes (e.g., clearings, forest paths, hedges).

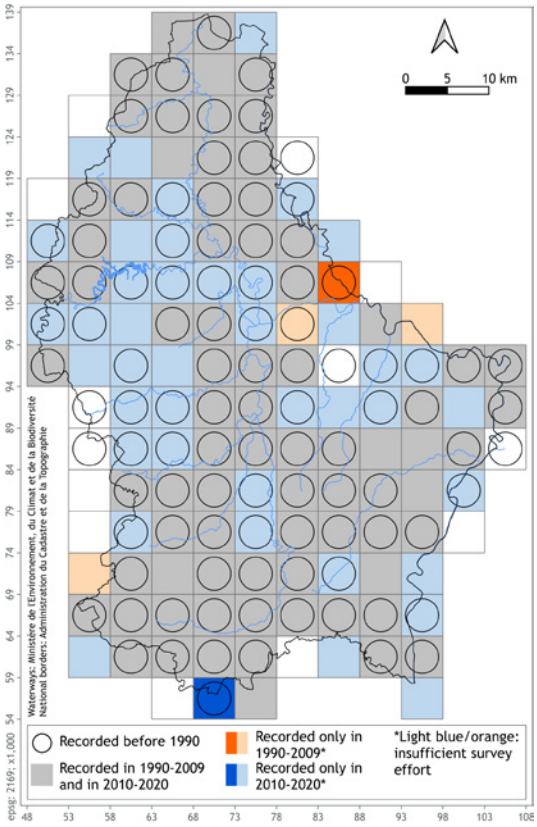


Fig. 4.104: Distribution change map at 5-km spatial resolution for *Pieris napi*.

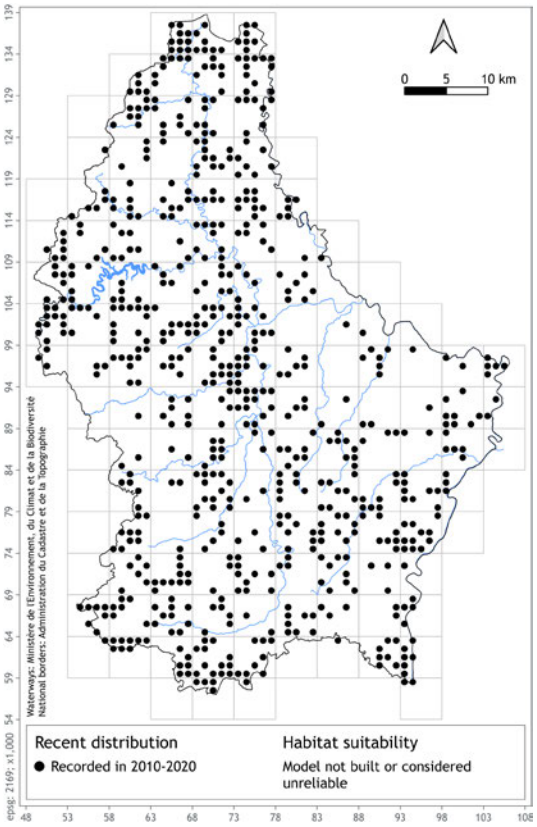


Fig. 4.105: Distribution map at 1-km spatial resolution for *Pieris napi*.

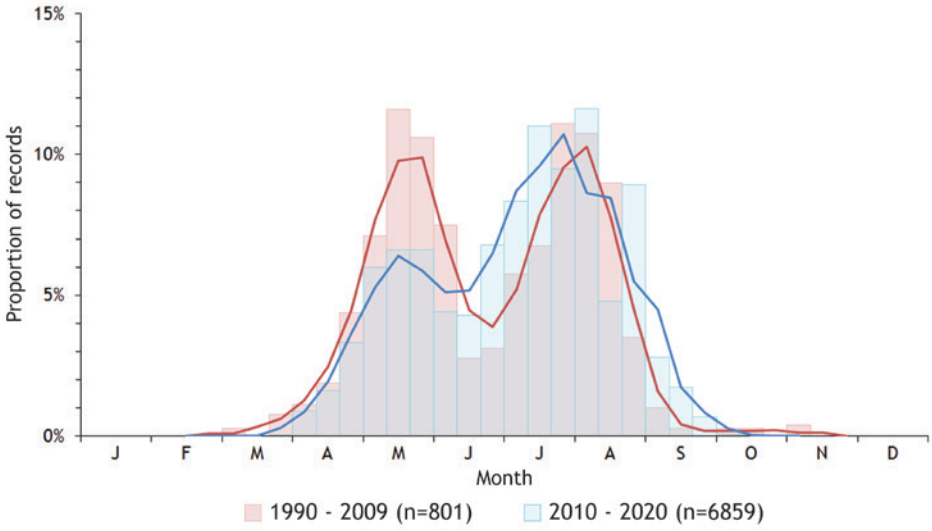


Fig. 4.106: Flight season of *Pieris napi* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Pontia daplidice/edusa

(Linnaeus, 1758)/(Fabricius, 1777)

L: Resedafalter / Südleche Resedafalter

E: Bath white / Eastern bath white

G: Resedaweißling

F: Marbré-de-vert / Marbré de Fabricius

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Evaluated	Least Concern / Least Concern

Pontia daplidice and *P. edusa* are two nearly identical species (or subspecies according to some authors) and are considered here as the complex *P. daplidice/edusa*, although all records in Luxembourg are related to *P. daplidice*. As their French name suggests, the underside of their wings is marbled white with dark green.

Lifecycle

Polyvoltine in neighbouring regions, but no more than two generations at our latitudes. Fly mainly from March to October (but only one record with a precise date in our dataset). Overwinter as chrysalis. Migrate northward every summer.

Habitat

Open warm and dry biotopes, such as dry meadows and wastelands with bare ground.

Fig. 4.107: *Pontia daplidice/edusa* (Photo: Sarah Vray).

Fig. 4.108: *Pontia daplidice/edusa* (Photo: Stéphane Vizthum).

Larval host plants – Lays single eggs on leaves and flowers of various plants from the Resedaceae (mainly *Reseda lutea*) and Brassicaceae families.

Distribution

Luxembourg – Previously recorded sporadically in every region. Last record in 1979 near Luxembourg city.

Neighbouring countries – Since 2010, no record in French Lorraine, only occasional records in north-eastern Wallonia (*P. daplidice*) or in Rhineland-Palatinate and Saarland (*P. edusa*).

Worldwide – From northern Africa, Canaries and southwestern Europe to west Germany and northwestern Italy for *P. daplidice* and from central Europe and much of Italy to eastern Asia for *P. edusa*. *P. daplidice* and *P. edusa* reach in Luxembourg the northern and western margins of their global range, respectively.

Trends (<2010 vs. 2010-2020)

Trends were not estimated for this complex species.

Management

Specific conservation measures are currently not needed as the the complex P. daplidice/edusa is not recorded in Luxembourg anymore.

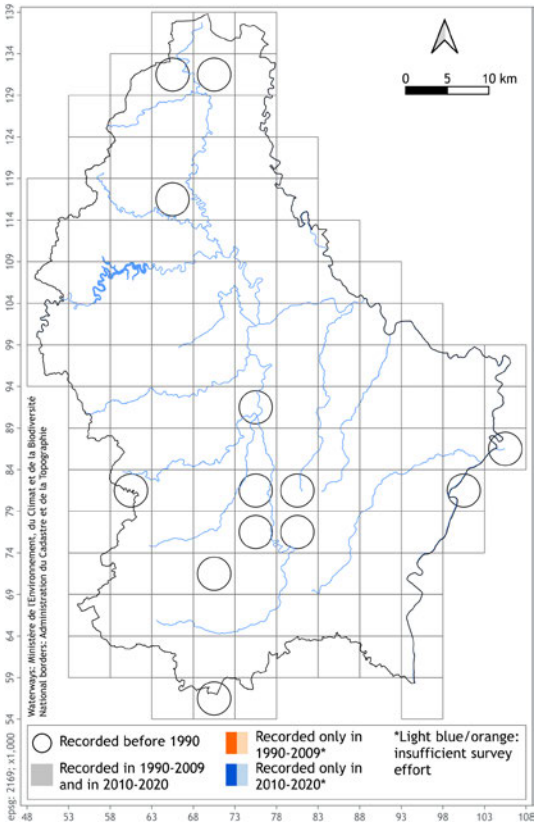


Fig. 4.109: Distribution change map at 5-km spatial resolution for *Pontia daplidice/edusa*.

Fig. 4.110: *Pontia daplidice/edusa* (Illustration: Anita Faber).

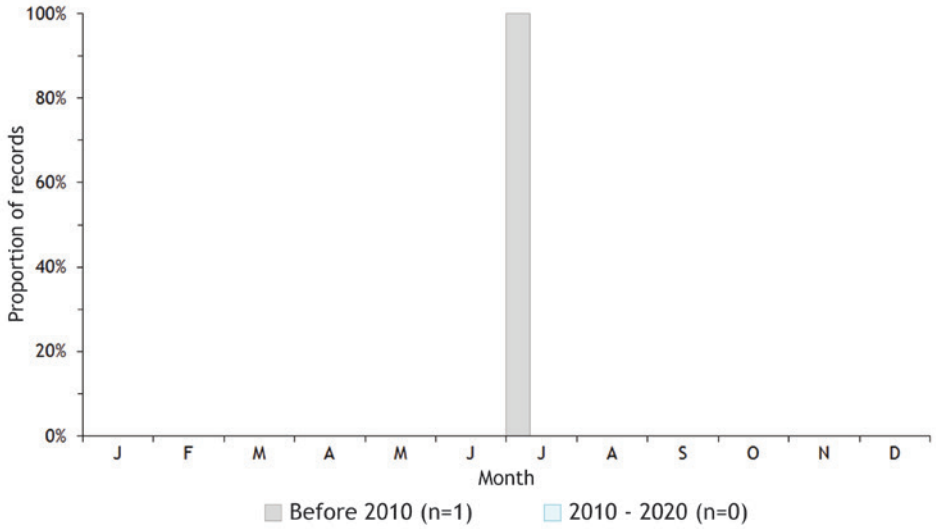


Fig. 4.111: Flight season of *Pontia daplidice/edusa* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Anthocharis cardamines

(Linnaeus, 1758)

L: Aurorafalter

E: Orange tip

G: Aurorafalter

F: Aurore

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Males are easy to identify whereas females, at first glance, might be confused with other whites. The underside of the wings provides the most reliable identification criteria.

Lifecycle

Univoltine. Flies from late March to late June with a peak in early May. Overwinters as chrysalis.

Habitat

Mainly wet to dry meadows, forest edges and clearings, gardens and road verges.

Nectar resources – Preferentially feeds on flowers of Brassicaceae and dandelion (*Taraxacum* spp.).

Larval host plants – Lays single eggs on various species from the Brassicaceae family, such as *Cardamine pratensis, Alliaria petiolata, Arabis hirsuta, A. glabra, Cardaminopsis arenosa, Barbarea vulgaris, Lepidium campestre,* and *Rorippa sylvestris*.

Fig. 4.112: *Anthocharis cardamines* (Photo: Francis Birlenbach).

Fig. 4.113: *Anthocharis cardamines* (Photo: Marcel Hellers).

Distribution

Luxembourg – Homogeneously distributed across the whole country with suitable habitats available in every region, especially in valley bottoms and in the Minette.

Worldwide – Distributed across most of Europe and temperate Asia to Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -8%

Relative change in extent of occurrence (geographical range): +1%

Considered as stable.

Management

Promoting extensive grazing, unmown refuge areas and strips, and rotational mowing, especially along forest paths and road verges. Avoiding the drainage of grasslands.

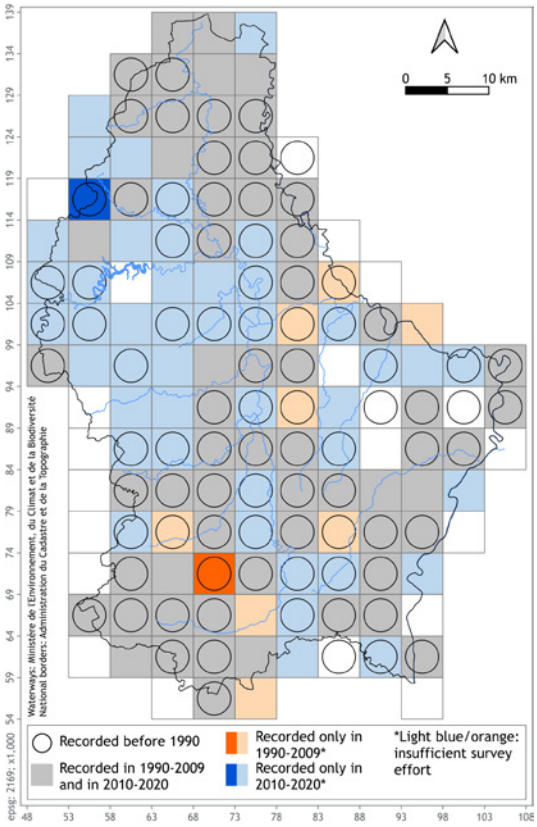


Fig. 4.114: Distribution change map at 5-km spatial resolution for *Anthocharis cardamines*.

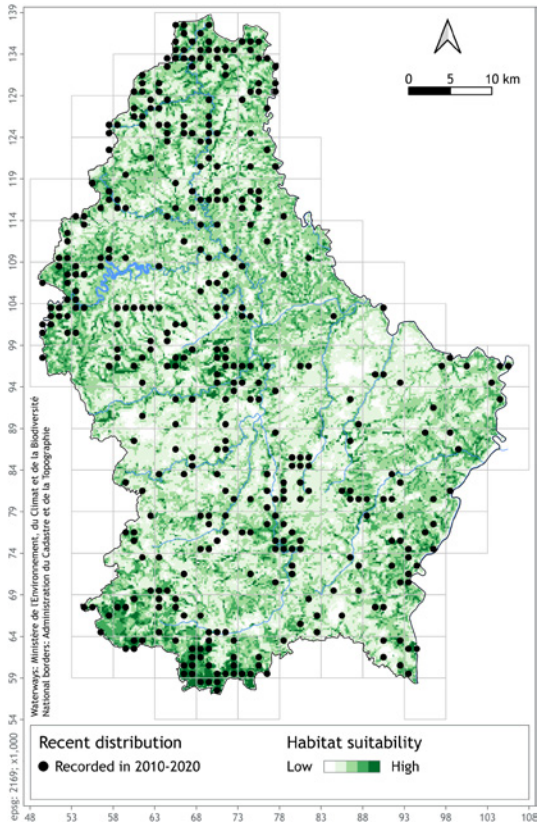


Fig. 4.115: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Anthocharis cardamines*.

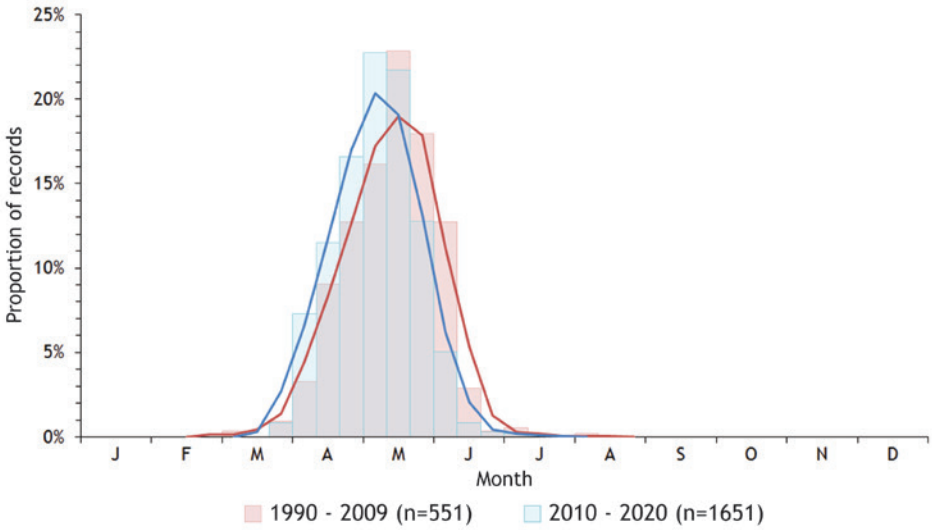


Fig. 4.116: Flight season of *Anthocharis cardamines* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Colias hyale/alfacariensis

(Linnaeus, 1758)/Ribbe, 1905

L: Gëllen Aacht / Dréchewues-Gëllen Aacht

E: Pale clouded yellow / Berger's clouded yellow

G: Weißklee-Gelbling / Hufeisenklee-Gelbling

F: Soufré / Fluoré

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Evaluated	Least Concern / Least Concern

Colias hyale is a migrant and generalist butterfly coming from the south, while *C. alfacariensis* is highly specialised on calcareous grasslands. Both species are almost impossible to differentiate at the adult stage. Hence, they are addressed here as a species complex.

Lifecycle

Bivoltine, sometimes a third incomplete generation can occur. Fly from late April to October, with a first peak in May (local emergences and migrating individuals in *C. hyale*) and a second one, steeper, in August. Overwinter as caterpillar, although *C. hyale* is less frost-resistant than *C. alfacariensis*.

Fig. 4.117: *Colias hyale/alfacariensis* (Photo: Michelle Clemens).

Fig. 4.118: *Colias hyale/alfacariensis* (Photo: Hubert Baltus).

Habitat

C. alfacariensis: dry calcareous grasslands.

C. hyale: flower-rich meadows, especially in flood plains, as well as red clover and alfalfa crops.

Larval host plants – Lays single eggs on various species from the Fabaceae family, mainly on:

C. alfacariensis: *Hippocrepis comosa* and *Securigera varia*.

C. hyale: *H. comosa*, *Lotus corniculatus*, *Medicago sativa*, *S. varia*, *Trifolium repens*, and *Vicia* spp.

Distribution

Luxembourg – Distributed across the whole country as a species complex. Availability of suitable habitats is not shown for this species complex.

Worldwide – From central and southern Europe across Asia.

Trends (<2010 *vs.* 2010-2020)

Trends were not estimated for this complex species.

Management

Promoting extensive management of grasslands (e.g., late mowing, reduction of fertiliser inputs and livestock densities), especially on calcareous soils for *C. alfacariensis*. Promoting leguminous crops (e.g., alfalfa and clover) for *C. hyale* with multi-annual production and maintenance of refuge strips.

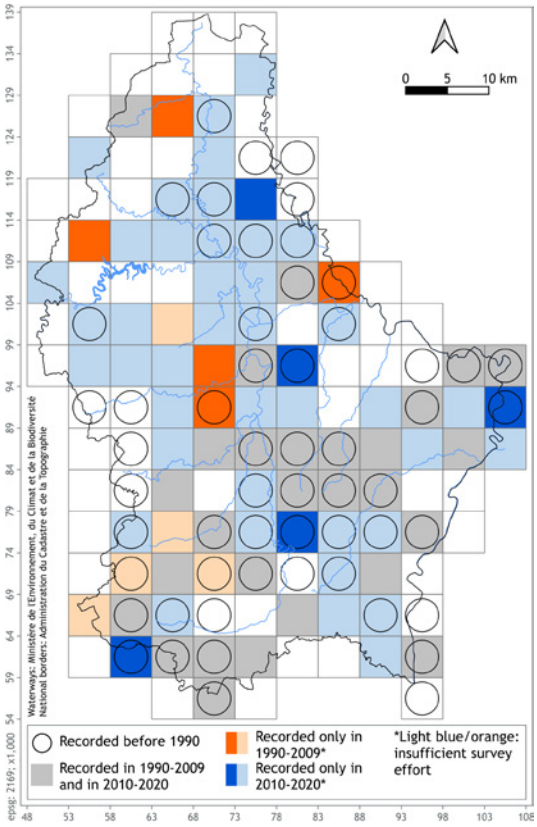


Fig. 4.119: Distribution change map at 5-km spatial resolution for *Colias hyale/alfacariensis*.

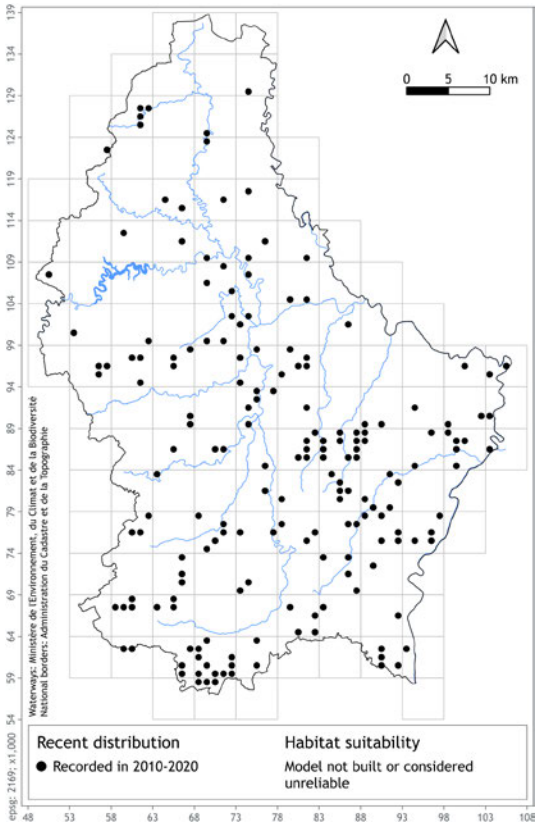


Fig. 4.120: Distribution map at 1-km spatial resolution for *Colias hyale/alfacariensis*.

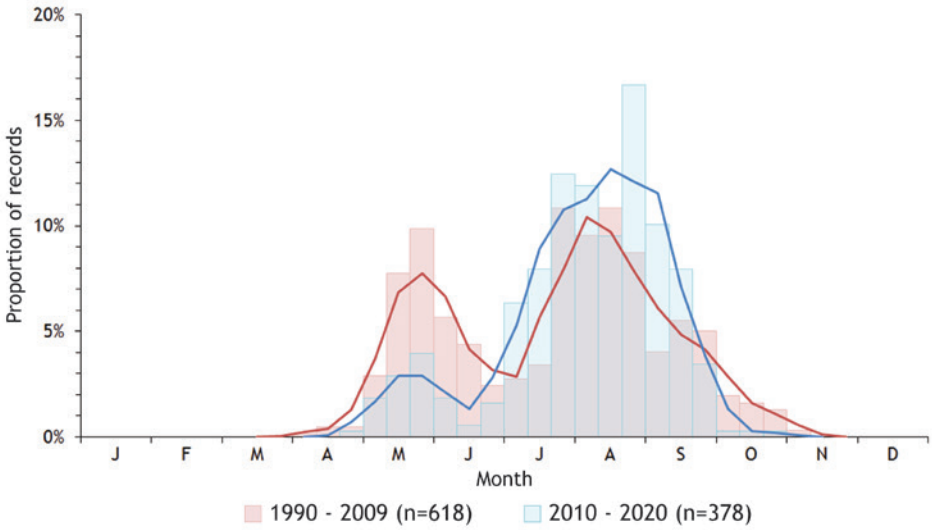


Fig. 4.121: Flight season of *Colias hyale/alfacariensis* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Colias crocea

(Geoffroy, 1785)

Syn.: *Colias croceus*

L: Postillon

E: Clouded yellow

G: Wander-Gelbling

F: Souci

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Colias crocea is a migrant butterfly coming from the south that does not tolerate damp and frost. In most cases, the distinctive upper side of the wings in both sexes are coloured in orange-yellow with broad black margins. However, in a few cases, females can exhibit paler colours (*helice* and *helicina* forms) making them similar to *C. hyale*/*alfacariensis*.

Lifecycle

Bivoltine, sometimes three generations in favourable years. The first wave of migrants usually reaches Luxembourg in May, where they produce a new generation that flies from July, mixing with a second wave of migrants and reaching a peak in mid-August.

Fig. 4.122: *Colias crocea* (Photo: Marcel Hellers).

Fig. 4.123: *Colias crocea* (Photo: Francis Birlenbach).

Habitat

Almost any open and sunny biotope, such as red clover and alfalfa fields, flower-rich meadows, wastelands, road verges and rail embankments.

Larval host plants – Lays single eggs on various species from the Fabaceae family, such as *Astragalus glycyphyllos*, *Colutea arborescens*, *Hippocrepis comosa*, *Lotus corniculatus*, *Medicago sativa*, *Melilotus* spp., *Securigera varia*, *Trifolium* spp., and *Vicia* spp.

Distribution

Luxembourg – Homogeneously distributed across the whole country. Availability of suitable habitats is not shown for this migrant species.

Worldwide – From northern Africa across southern and central Europe to central Asia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +37%

Relative change in extent of occurrence (geographical range): +10%

Although recorded in a moderately increasing number of 1-km grid cells, its range was considered as stable.

Management

Implementing agri-environmental schemes (e.g., reduction of agricultural inputs or livestock densities, late mowing) and promoting leguminous crops (e.g., alfalfa and clover).

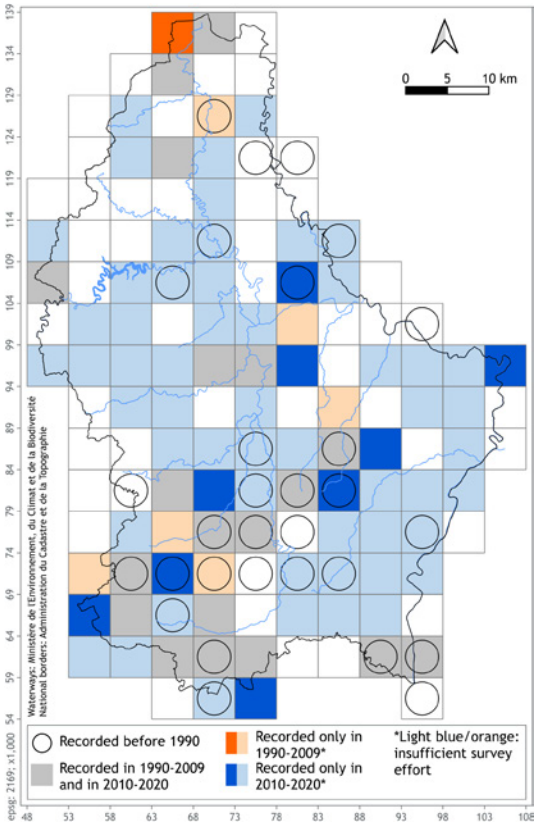


Fig. 4.124: Distribution change map at 5-km spatial resolution for *Colias crocea*.

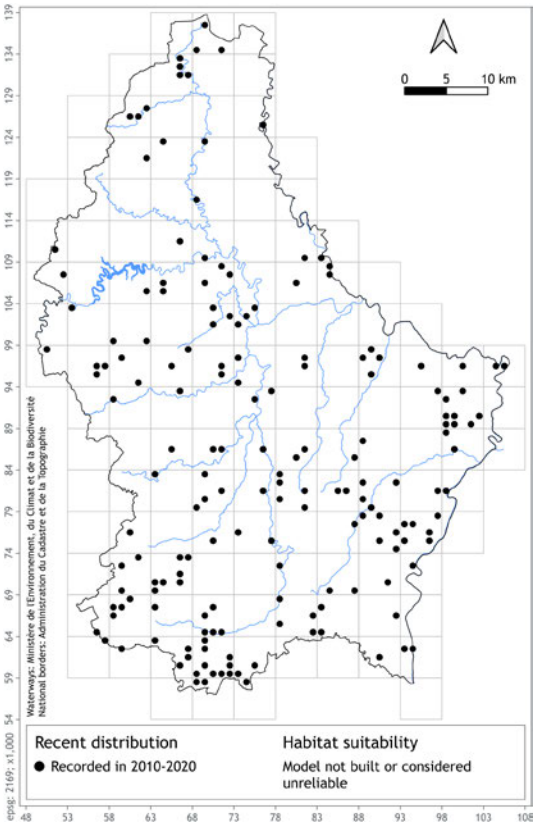


Fig. 4.125: Distribution map at 1-km spatial resolution for *Colias crocea*.

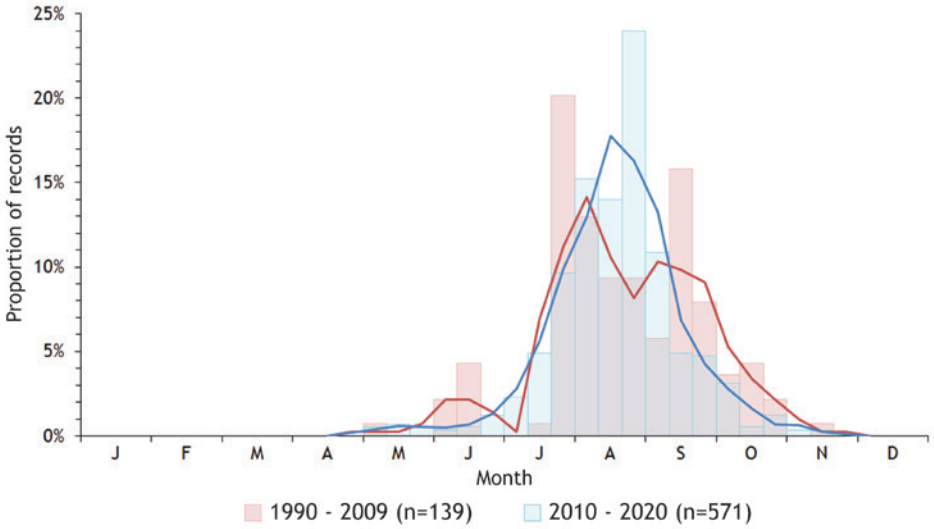


Fig. 4.126: Flight season of *Colias crocea* representing the frequency distribution of species records over time at a 10-day temporal resolution.

PIERIDAE

Gonepteryx rhamni
(Linnaeus, 1758)

L: Zitrouneblat

E: Common brimstone

G: Zitronenfalter

F: Citron

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Gonepteryx rhamni is often the only butterfly seen flying in the earliest and latest sunny days of the year. The adult has an extraordinary long-life span, up to one year, thanks to a double diapause (winter and summer). Its frost-resistance comes from its faculty to dehydrate. Males are unmistakable with their yellow colour, while some females are more whitish and can be mistaken with other whites. In such cases, the shape of the wings is the most reliable identification criterion.

Lifecycle

Univoltine but with a flight season potentially covering the whole year, with a first peak in spring (overwintering individuals) and a second peak in summer (offspring and overwintering individuals). Overwinters as adult within the foliage.

Fig. 4.127: *Gonepteryx rhamni* (Photo: Alain Dohet).

Fig. 4.128: *Gonepteryx rhamni* (Photo: Hubert Baltus).

Habitat

Mostly light forests, forest edges and clearings, hedgerows, urban parks, and gardens.

Larval host plants – Lays single eggs on the buds or young leaves of *Frangula alnus* and *Rhamnus cathartica*.

Distribution

Luxembourg – Homogeneously distributed across the whole country with suitable habitats available in every region, especially in valley bottoms and the Minette.

Worldwide – Across Europe (except northernmost regions), Asia, and northern Africa, closely following the distribution of the larval host plants.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -4%

Relative change in extent of occurrence (geographical range): +3%

Considered as stable.

Management

Promoting and restoring the bocage in farmland areas with diversified hedgerows, including host plants and nectar resources. Implementing rotational management of hedgerows and forest edges over multiple years to create structural heterogeneity.

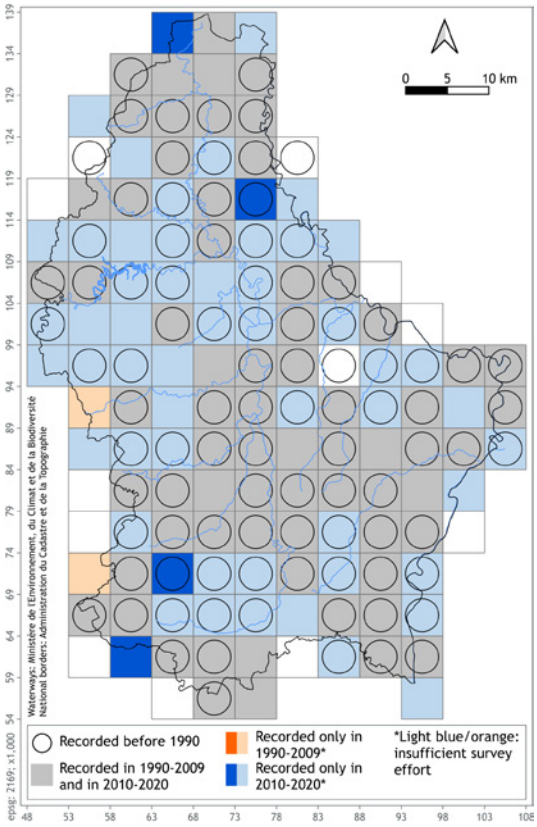


Fig. 4.129: Distribution change map at 5-km spatial resolution for *Gonepteryx rhamni*.

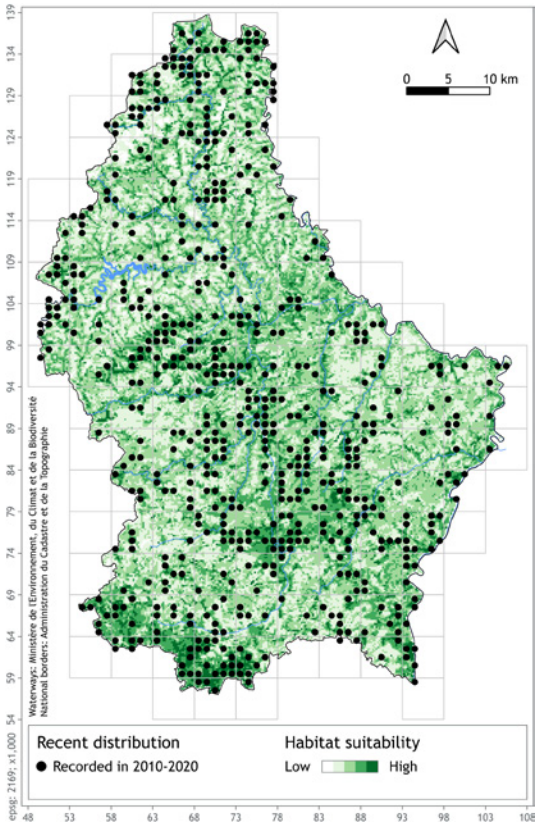


Fig. 4.130: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Gonepteryx rhamni*.

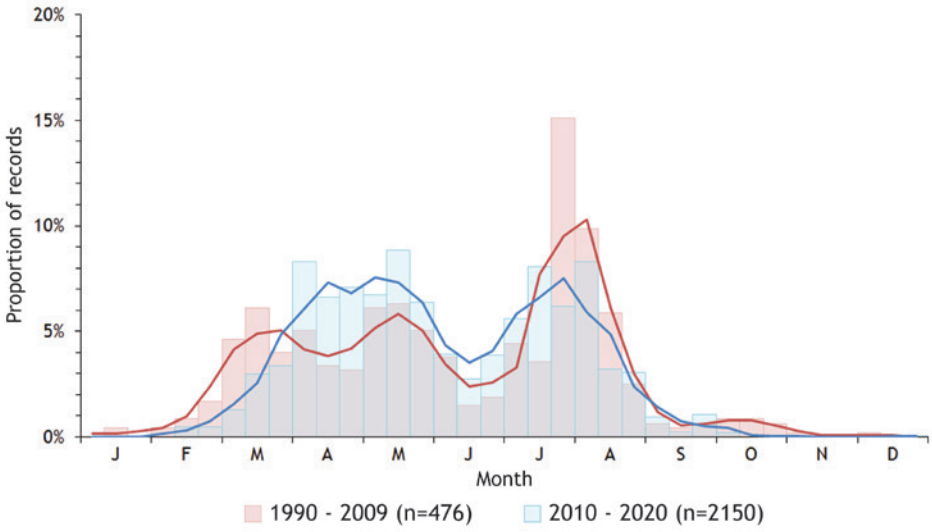


Fig. 4.131: Flight season of *Gonepteryx rhamni* representing the frequency distribution of species records over time at a 10-day temporal resolution.

RIODINIDAE

Hamearis lucina
(Linnaeus, 1758)

L: Fréijoers-Scheckefalter

E: Duke of burgundy fritillary

G: Schlüsselblumen-Würfelfalter

F: Lucine

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1996	Least Concern

Although its English name highlights the resemblance of its wings to the "true" fritillary butterflies, *Hamearis lucina* is assigned to the Riodinidae family, of which it is the only representative in Europe. Often perched on a twig, males defend their territories vigorously and chase away any intruder.

Lifecycle

Univoltine in neighbouring regions. Flies mostly from late April to June, with a peak in late-May. Overwinters as chrysalis. Caterpillars hide during the day and feed only at night.

Habitat

Sunny forest clearings and edges, forest paths, moderately wet flower-rich meadows with bushes, also dry bushy meadows but with wetter spots rich in its host plants.

Larval host plants – Lays eggs on the underside of the leaves of *Primula elatior* and *P. veris*.

Fig. 4.132: *Hamearis lucina* (Photo: Stéphane Vizthum).

Fig. 4.133: *Hamearis lucina* (Photo: Stéphane Vizthum).

Distribution

Luxembourg – Previously patchily recorded across most of the country. Last record in 1996 near Moersdorf.

Neighbouring countries – Since 2010, recorded in western French Lorraine, in French and Belgian Fagne-Fammene, and after 2001, very close to the Luxembourgish border along the Moselle valley in Saarland.

Worldwide – Western palearctic species, mainly distributed in southern and central Europe, from central Spain to the Balkans, including the south of British Isles, up to southern Sweden.

Trends (<2010 vs. 2010-2020)

Considered as extinct. Although *H. lucina* was recorded very close to the Luxembourgish border (Saarland) after 2001, a comeback is unlikely in the short term.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

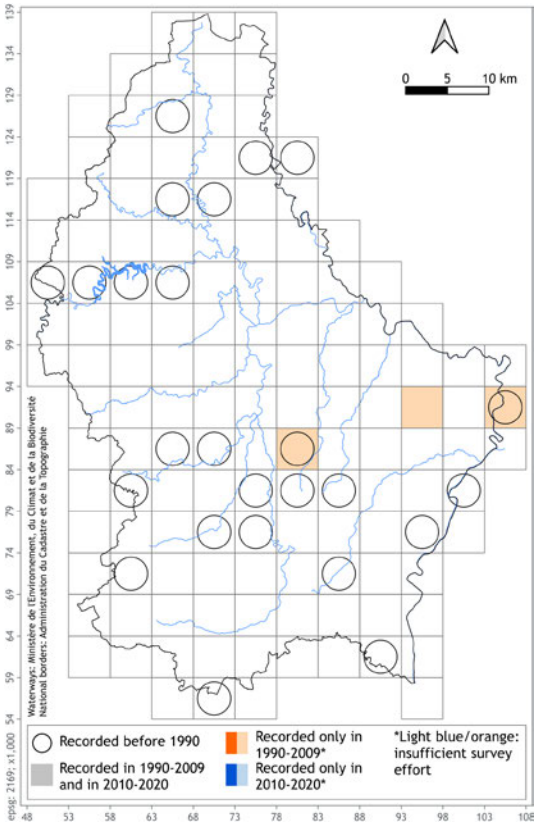


Fig. 4.134: Distribution change map at 5-km spatial resolution for *Hamearis lucina*.

Fig. 4.135: *Hamearis lucina* (Illustration: Anita Faber).

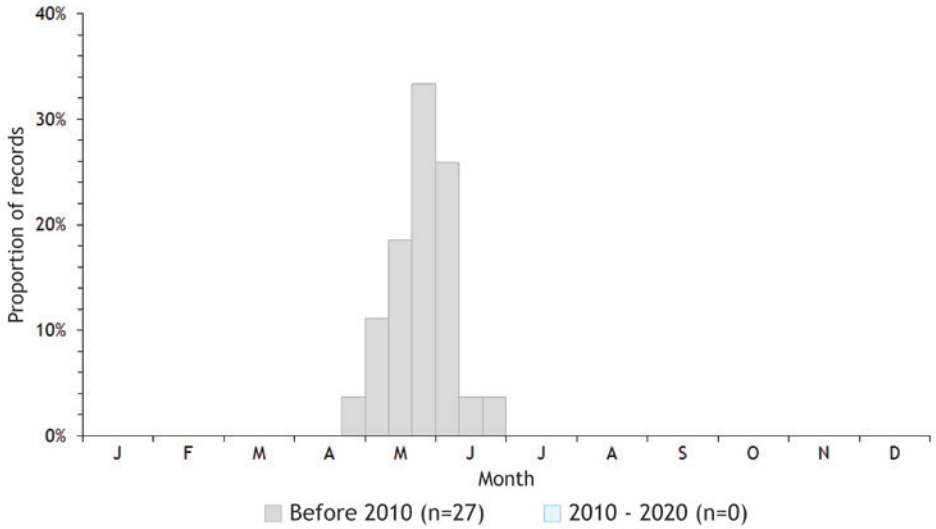


Fig. 4.136: Flight season of *Hamearis lucina* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Thecla betulae

(Linnaeus, 1758)

L: Nierefleck

E: Brown hairstreak

G: Nierenfleck-Zipfelfalter

F: Thécla du bouleau

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

Thecla betulae spends much of its time hidden high up in shrubs and hedgerows, which makes its detection difficult. Males are observed less often than females. Its French name is related to its resting place (birch), not its larval host plants. *T. betulae* has also a frequent but optional relationship with ants such as *Lasius niger*. This family is often perceived as one of the most complicated. Special attention should be paid to the underside of the wings where most criteria are displayed to identify the different species.

Lifecycle

Univoltine. Flies mostly from mid-July to September with a peak in late August. Overwinters as caterpillar within the egg.

Fig. 4.137: *Thecla betulae* (Photo: Nicolas Titeux).

Fig. 4.138: *Thecla betulae* (Photo: Alain Dohet).

Habitat

Hedgerows, forest edges, clearings in deciduous forests, orchards, and even gardens where its host plants are well exposed to the sun.

Nectar resources – Rarely observed on flowers as adults mainly feed on honeydew.

Larval host plants – Lays single white eggs on a fork of *Prunus spinosa* twigs (main host plant). Other *Prunus* spp. shrubs are sometimes used.

Distribution

Luxembourg – Very patchily distributed across most of the country, at least partly due to inconspicuousness and low detectability.

Worldwide – From northern Spain to the southern half of the British Isles and Fennoscandia, and in temperate Asia to Korea.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -57%

Relative change in extent of occurrence (geographical range): -12%

Although recorded in a strongly decreasing number of 1-km grid cells, its range slightly contracted in 2010-2020.

Management

Promoting rotational hedge and shrub pruning over multiple years to maintain structural heterogeneity. Promoting the plantation of *Prunus* spp. in gardens and around houses.

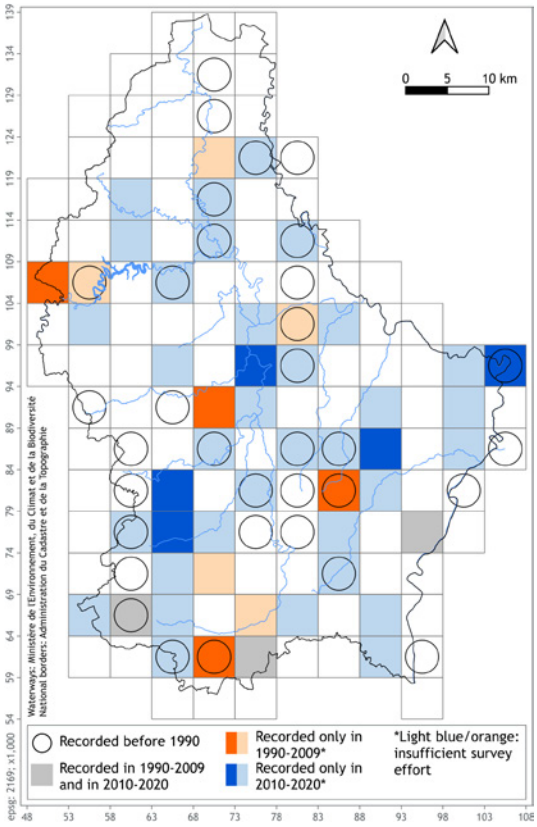


Fig. 4.139: Distribution change map at 5-km spatial resolution for *Thecla betulae*.

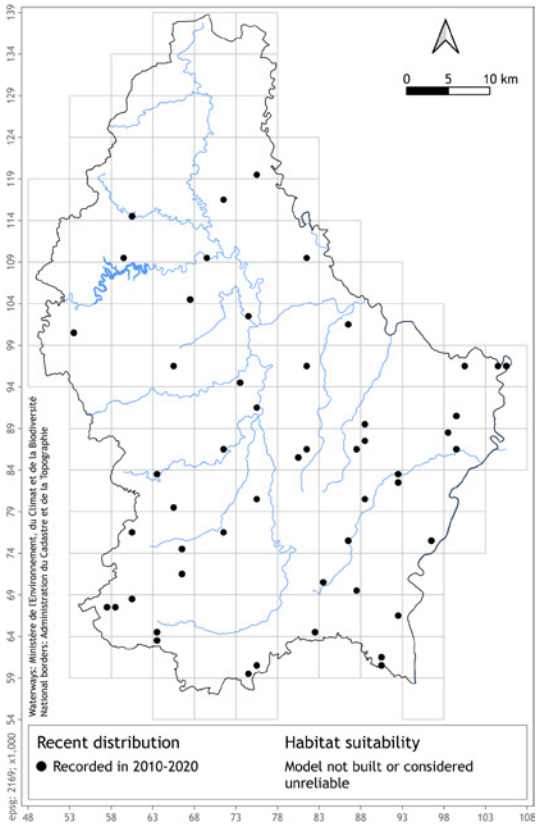


Fig. 4.140: Distribution map at 1-km spatial resolution for *Thecla betulae*.

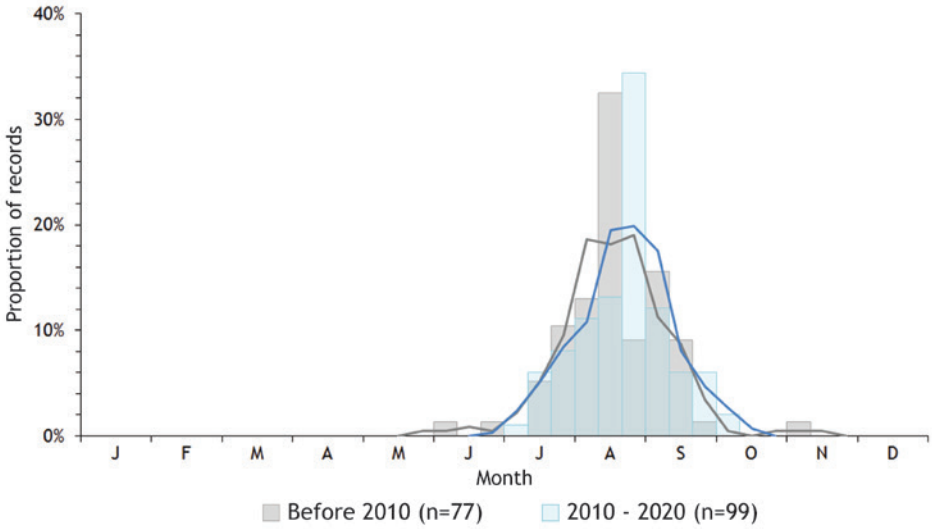


Fig. 4.141: Flight season of *Thecla betulae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Favonius quercus

(Linnaeus, 1758)

Syn.: *Neozephyrus quercus*

L: Eechen-Zipfelfalter

E: Purple hairstreak

G: Blauer Eichen-Zipfelfalter

F: Thécla du chêne

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Often under-detected due to its habit of flying in the tree canopy (oaks, apple trees), even during sunset. Males are quite territorial. *Favonius quercus* is occasionally seen basking on small trees closer to the ground or mud puddling. Eggs can be observed on fallen oak branches.

Lifecycle

Univoltine. Flies mostly from late June to late August, with a peak in July. Overwinters as caterpillar within the egg.

Habitat

Forests with oak trees and more widely in any place with oak trees, such as gardens, parks, and farmland.

Fig. 4.142: *Favonius quercus* (Photo: Alain Dohet).

Fig. 4.143: *Favonius quercus* (Photo: Martin Heyeres).

Nectar resources – feeds primarily on honeydew, tree sap, as well as *Rubus fruticosus* and *Eupatorium cannabinum* flowers.

Larval host plants – Lays single eggs looking like sea urchins on oak buds in late summer.

Distribution

Luxembourg – Patchily distributed across the whole country.

Worldwide – Across northern Africa, much of Europe to wide parts of temperate Asia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -12%

Relative change in extent of occurrence (geographical range): +14%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range slightly expanded in 2010-2020.

Adapting surveying methods (e.g., looking for adults in canopy or eggs on branches) could increase its field detection.

Management

Promoting diversified deciduous forests with native oak species. Maintaining old oak trees along forest edges and in parks, gardens, and farmland.

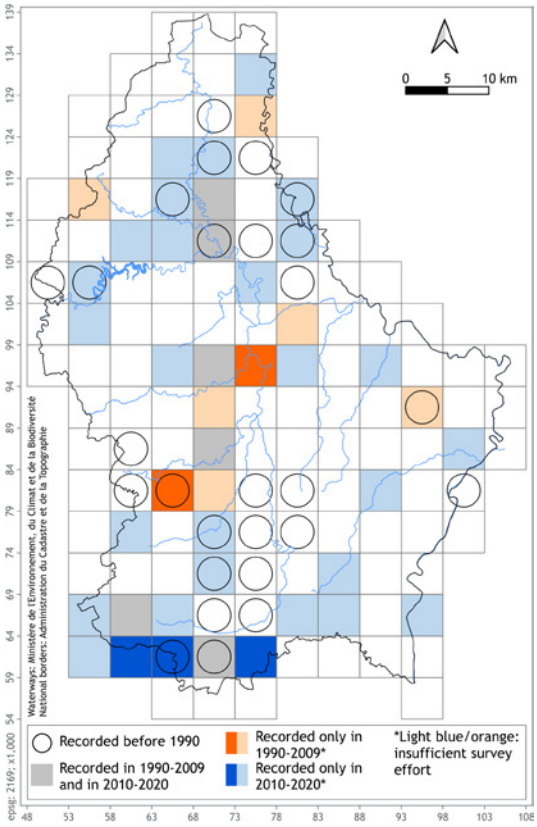


Fig. 4.144: Distribution change map at 5-km spatial resolution for *Favonius quercus*.

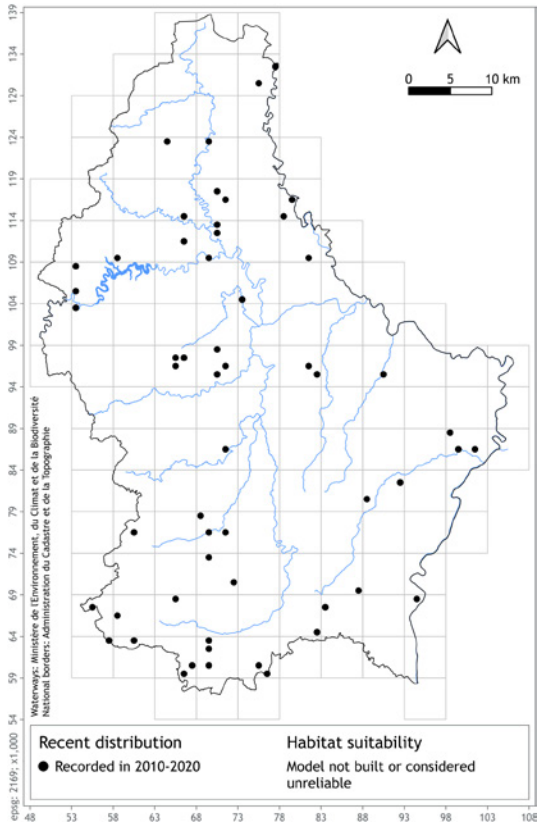


Fig. 4.145: Distribution map at 1-km spatial resolution for *Favonius quercus*.

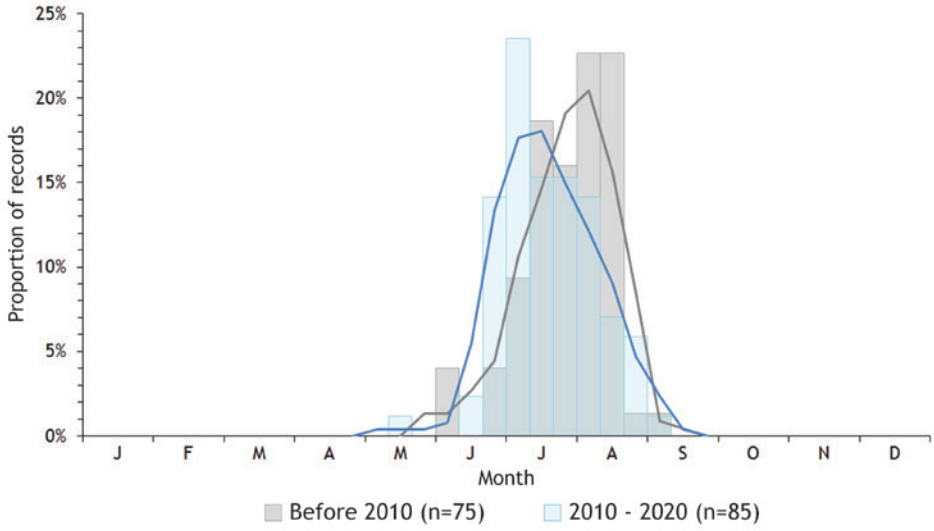


Fig. 4.146: Flight season of *Favonius quercus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Satyrium acaciae
(Fabricius, 1787)

L: Akazien-Zipfelfalter
E: Sloe hairstreak
G: Kleiner Schlehen-Zipfelfalter
F: Thécla de l'acacia

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1854	Least Concern

Satyrium acaciae might be confused with *S. ilicis* but differs by a straight white line on the underside of its hindwings. It spends much of its time hidden in shrubs and hedgerows making its detection difficult.

Lifecycle

Univoltine in neighbouring regions. Flies mostly from end June to July. Overwinters as caterpillar within the egg.

Habitat

Warm, dry, and scrubby biotopes such as calcareous dry grasslands, rocky slopes, and shrub covered areas.

Nectar resources – Feeds preferentially on yellow and white flowers from the Asteraceae family, such as *Achillea millefolium* and *Senecio jacobeae*, but also on *Rubus* spp. and *Thymus* spp.

Fig. 4.147: *Satyrium acaciae* (Photo: Stéphane Vizthum).

Fig. 4.148: *Satyrium acaciae* (Photo: Stéphane Vizthum).

Larval host plants – Lays mostly single eggs on the forks of *Prunus spinosa* stems (only on short bushes in high xerothermic conditions). *Prunus mahaleb* is also mentioned in the literature.

Distribution

Luxembourg – Previously recorded only once in 1854 near Grevenmacher.

Neighbouring countries – Since 2010, recorded close to the Luxembourgish border in northern French Lorraine, southern Belgian Lorraine (Gaume), western Rhineland-Palatinate, and Saarland (Moselle valley).

Worldwide – From northern Spain through central, southern and southeastern Europe, to Asia Minor and even southern Russia. Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. A comeback may still be possible especially in the context of global warming.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

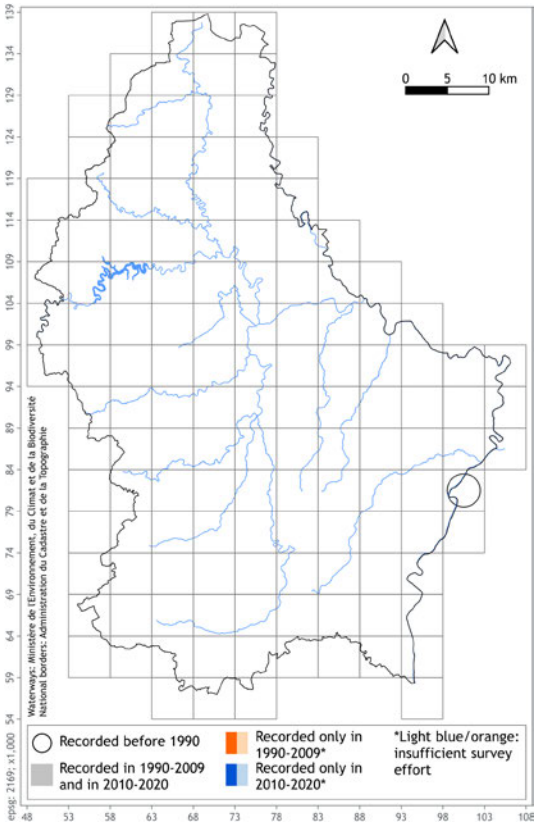


Fig. 4.149: Distribution change map at 5-km spatial resolution for *Satyrium acaciae*.

Fig. 4.150: *Satyrium acaciae* (Illustration: Anita Faber).

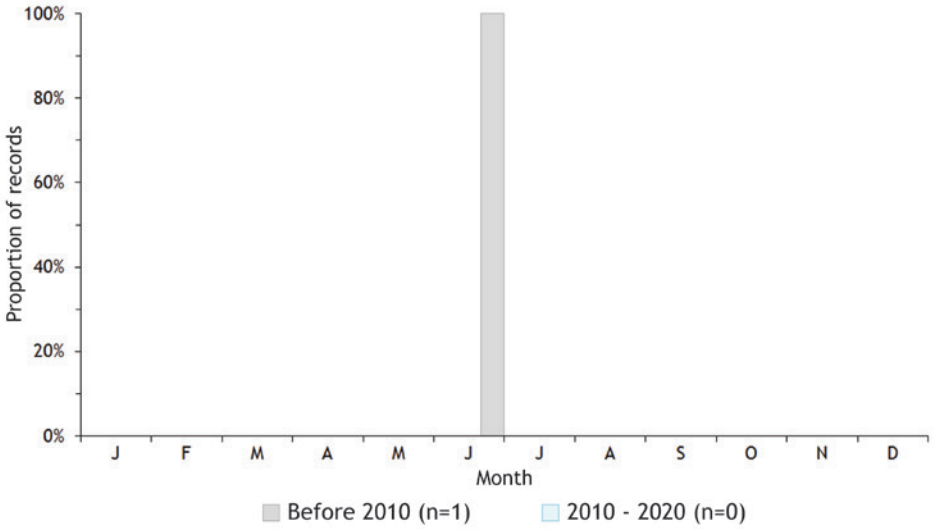


Fig. 4.151: Flight season of *Satyrium acaciae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Satyrium ilicis
(Esper, 1779)

L: Brongen Eechen-Zipfelfalter

E: Ilex hairstreak

G: Brauner Eichen-Zipfelfalter

F: Thécla de l'yeuse

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Endangered	Least Concern

As an inconspicuous species often difficult to detect, its genuine distribution is likely underestimated. Myrmecophile species, the association with ants provides it with some protection against parasites and predators.

Lifecycle

Univoltine. Flies mostly from late May to August with a peak in July. Overwinters as egg on small oak branches.

Habitat

Flower-rich ecotones with scattered oaks (heterogeneous age structure), such as forest edges, forest clearings, forest paths, and heathlands.

Nectar resources – Feeds on many different flowering species such as *Rubus* spp., *Sambucus ebulus*, and *Cirsium* spp.

Fig. 4.152: *Satyrium ilicis* (Photo: Hubert Baltus).

Fig. 4.153: *Satyrium ilicis* (Photo: Hubert Baltus).

Larval host plants – Lays mostly single eggs on or near the buds of young oaks (*Quercus robur*, *Q. petraea* and *Q. pubescens*).

Distribution

Luxembourg – Very patchily distributed across the country, at least partly due to inconspicuousness and low detectability, but not recorded in the Moselle.

Worldwide – Across central and southern Europe to Asia Minor.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -70%

Relative change in extent of occurrence (geographical range): -9%

Although recorded in a strongly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting well-structured and flower-rich forest edges (inner and outer, clearings, forest paths) in deciduous forests with native oak species. Implementing rotational mowing/trimming over multiple years for the management of forest paths and shrubby areas.

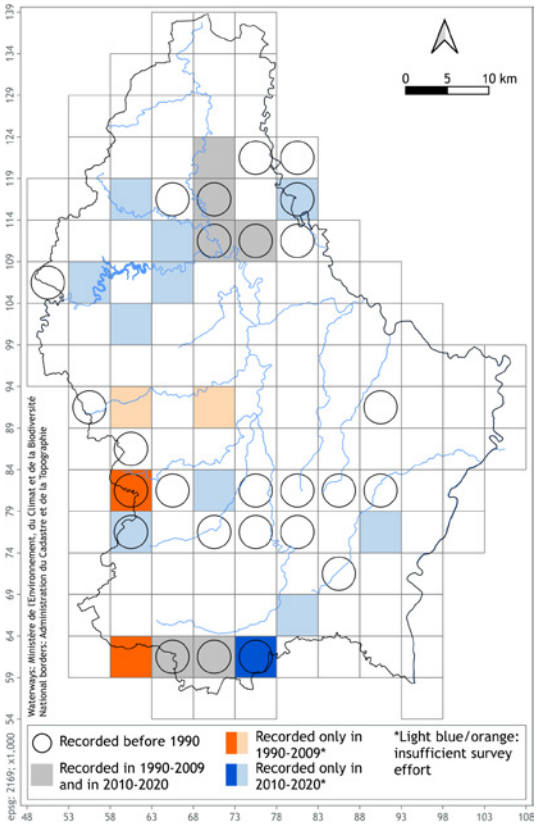


Fig. 4.154: Distribution change map at 5-km spatial resolution for *Satyrium ilicis*.

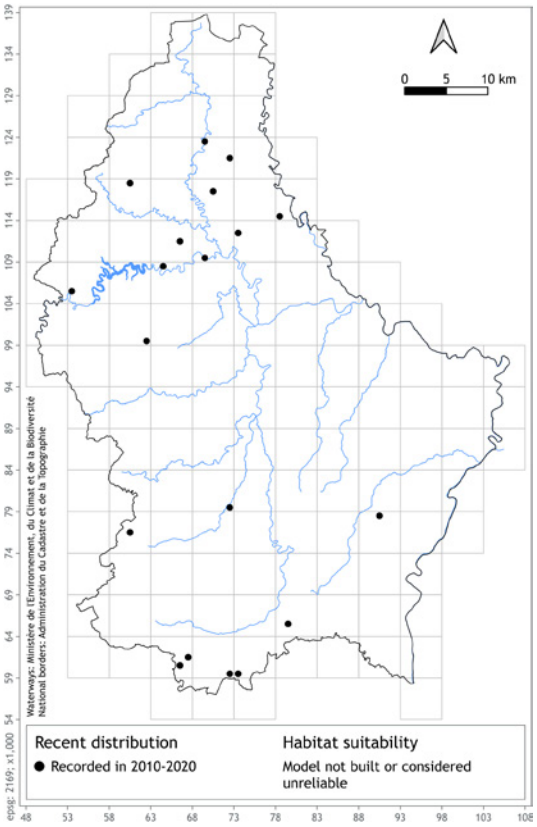


Fig. 4.155: Distribution map at 1-km spatial resolution for *Satyrium ilicis*.

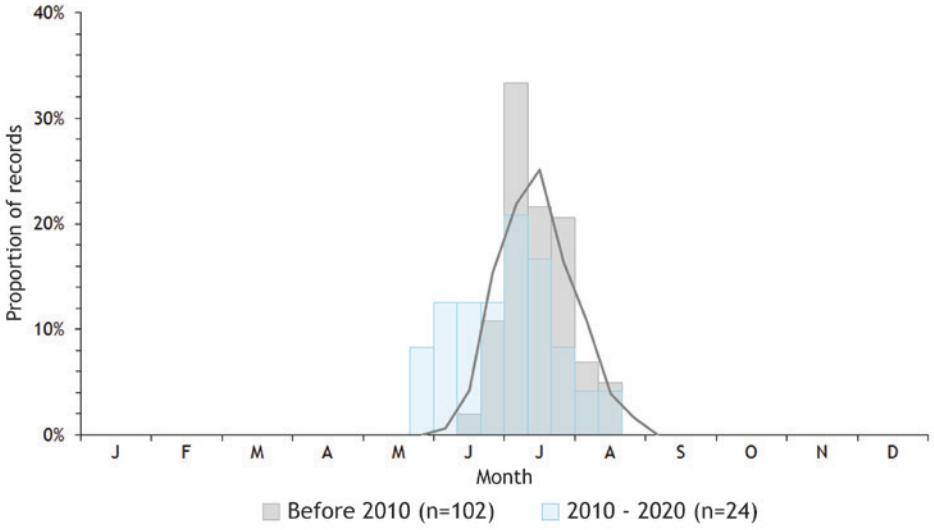


Fig. 4.156: Flight season of *Satyrium ilicis* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Satyrium w-album
(Knoch, 1782)

L: Ulmen-Zipfelfalter
E: White-letter hairstreak
G: Ulmen-Zipfelfalter
F: Thécla de l'orme

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Near Threatened	Least Concern

Like most other hairstreak species, *Satyrium w-album* spends most of its time in the shrub and tree canopy, which makes its detection difficult. However, once on a flower, it can be easily observed from close-up. In the 1970s, it suffered indirectly from the Dutch elm disease, which devastated most of its host plants.

Lifecycle

Univoltine. Flies mostly from mid-June to early August with a peak in July. Overwinters as caterpillar within the egg.

Habitat

Always found near its larval host plant (*Ulmus* spp.). Parks, open biotopes and edges of deciduous forest with mature elm trees are favourite sites.

Fig. 4.157: *Satyrium w-album* (Photo: Francis Birlenbach).

Fig. 4.158: *Satyrium w-album* (Photo: Xavier Mestdagh).

Nectar resources – Feeds on honeydew and flowers such as *Sambucus ebulus*, *Rubus* spp., *Cirsium* spp. and *Eupatorium cannabinum*.

Larval host plants – Lays mostly single eggs on buds of *Ulmus minor* and *U. glabra*.

Distribution

Luxembourg – Almost exclusively and patchily distributed in the Minette, with a few isolated records in the Gutland and the Moselle.

Worldwide – Palearctic species distributed from Europe (from northern Spain to the south of Fennoscandia and the British Isles) to Japan in the East.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -45%

Relative change in extent of occurrence (geographical range): -30%

Moderately decreasing. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Promoting mature elm trees in forests, forest edges and hedgerows as ecological corridors in the landscape.

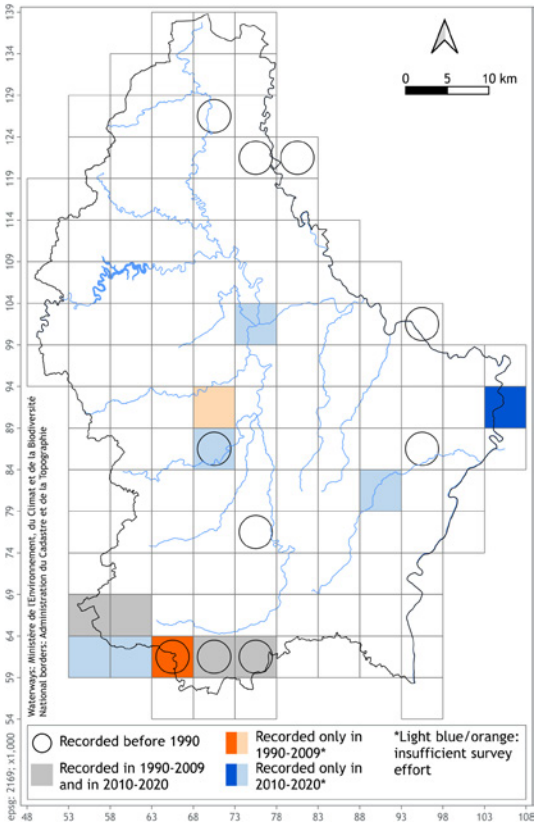


Fig. 4.159: Distribution change map at 5-km spatial resolution for *Satyrium w-album*.

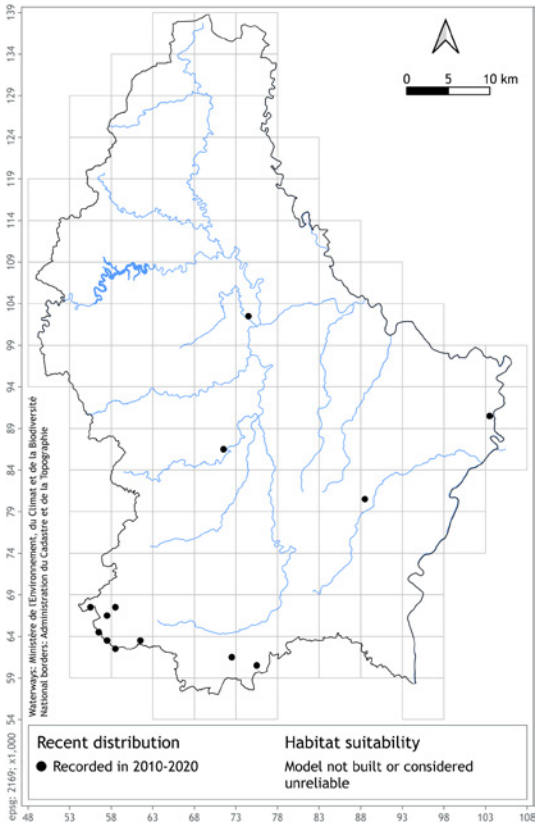


Fig. 4.160: Distribution map at 1-km spatial resolution for *Satyrium w-album*.

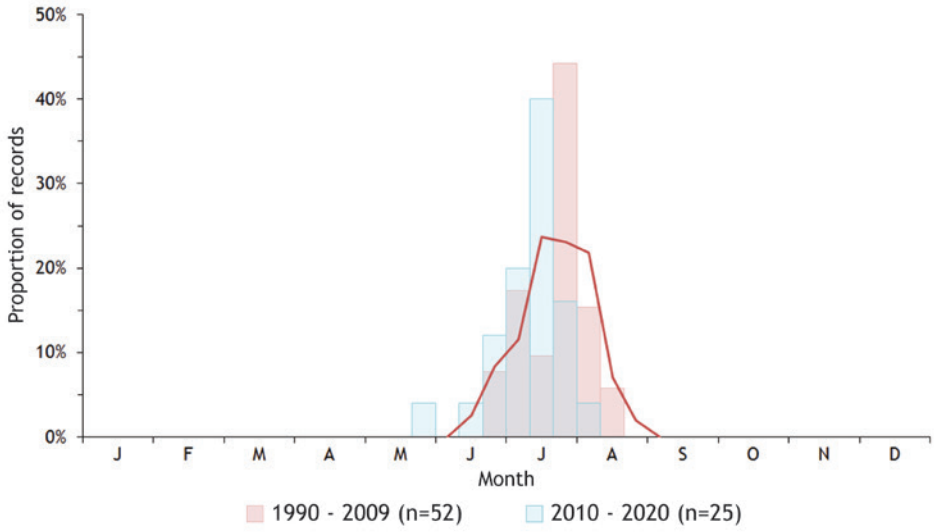


Fig. 4.161: Flight season of *Satyrium w-album* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Satyrium pruni
(Linnaeus, 1758)

L: Schléiwen-Zipfelfalter
E: Black hairstreak
G: Pflaumen-Zipfelfalter
F: Thécla du prunier

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Satyrium pruni is mainly observed close to the ground on flowers in the morning but it flies in the canopy once the sun is shining. Despite the abundance of its host plants, *S. pruni* requires adequate habitat management to colonise and breed in new areas.

Lifecycle

Univoltine. Flies mostly from mid-May to June. Overwinters as caterpillar within the egg.

Habitat

Hedgerows, forest edges, shrubs, coppice forests, and even sometimes gardens where its host plants grow and where flowers are available.

Nectar resources – Feeds on honeydew and flowers such as *Rubus* spp. and *Ligustrum vulgare*.

Fig. 4.162: *Satyrium pruni* (Photo: Roland Proess).

Fig. 4.163: *Satyrium pruni* (Photo: Alain Dohet).

Larval host plants – Lays single eggs close to a fork of *Prunus spinosa* twigs, and sometimes on other *Prunus* spp., such as plum trees.

Distribution

Luxembourg – Very patchily distributed across the whole country, at least partly due to inconspicuousness and low detectability.

Worldwide – Palearctic species distributed from northern Spain and Italy to southern England and Finland up to Japan to the East.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): data deficient.

Relative change in extent of occurrence (geographical range): +21%

Its range slightly expanded in 2010-2020, but changes in the estimated number of occupied 1-km grid cells could not be assessed.

Management

Promoting the restoration and the plantation of heterogeneous hedges in farmland with several native shrub species including host plants and nectar sources. Promoting diversified and well-structured forest edges, hedges as well as open areas in forests.

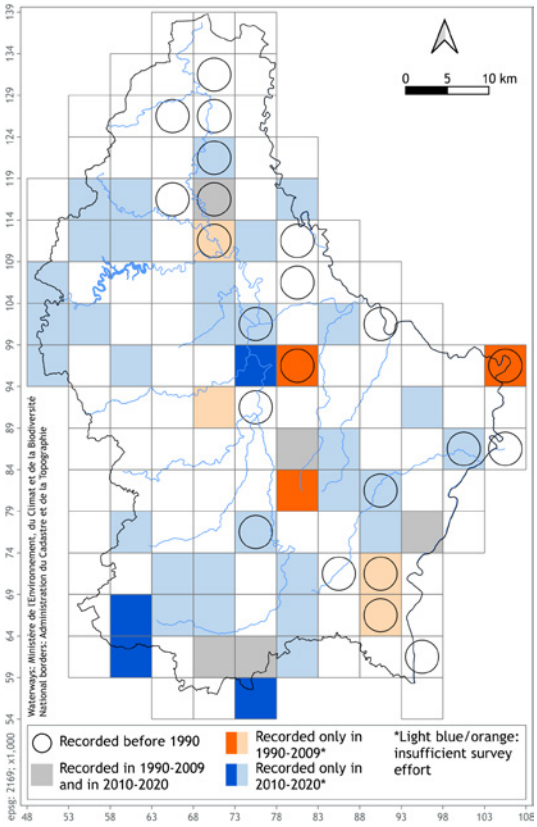


Fig. 4.164: Distribution change map at 5-km spatial resolution for *Satyrium pruni*.

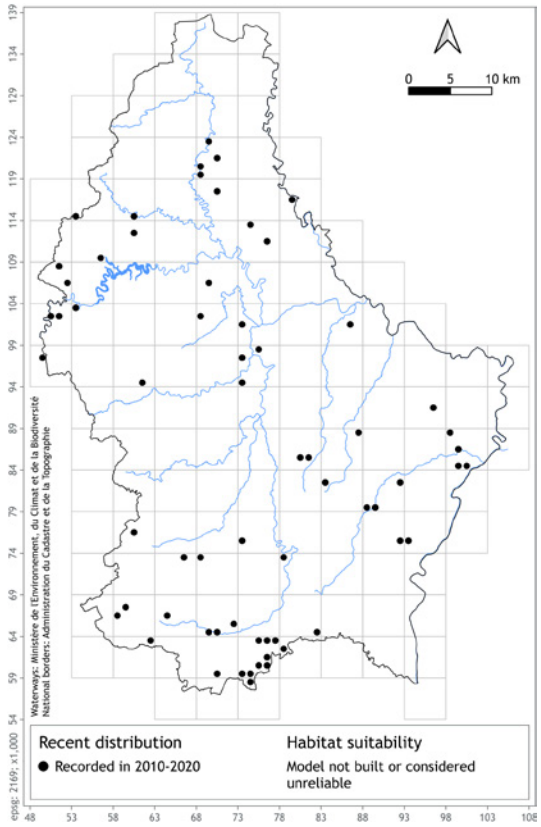


Fig. 4.165: Distribution map at 1-km spatial resolution for *Satyrium pruni*.

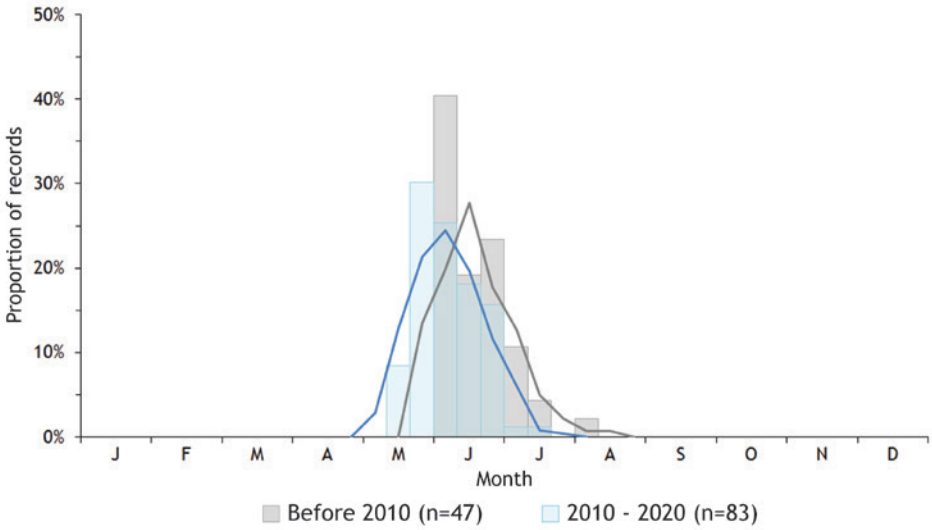


Fig. 4.166: Flight season of *Satyrium pruni* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Satyrium spini

([Denis & Schiffermüller], 1775)

L: Kräizdar-Zipfelfalter

E: Blue-spot hairstreak

G: Kreuzdorn-Zipfelfalter

F: Thécla des nerpruns

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1984	Least Concern

Myrmecophile species, *Satyrium spini* is characterised by an optional and rare association with ants (*Formica* spp.). It looks like *S. acaciae*, except for a larger blue spot on the underside of the hindwings.

Lifecycle

Univoltine in neighbouring regions. Flies mostly from June to August. Overwinters as caterpillar within the egg.

Habitat

Warm and dry biotopes with rocky and scrubby areas, such as calcareous dry grasslands, rocky slopes, shrub covered areas, and forest edges.

Nectar resources – Feeds on a wide variety of flowering species, such as *Achillea millefolium*, *Rubus* spp., *Sedum* spp., and *Thymus* spp.

Fig. 4.167: *Satyrium spini* (Photo: Stéphane Vizthum).

Fig. 4.168: *Satyrium spini* (Photo: Stéphane Vizthum).

Larval host plants – Lays whitish eggs in cluster (up to 5 eggs) on the twigs of young *Rhamnus cathartica*, usually at 1.5 meter high and close to a fork. *Frangula alnus* and other *Rhamnus* spp. are also mentioned in the literature.

Distribution

Luxembourg – Previously recorded in the southern half of the country, with a last record in 1984 near Wasserbillig.

Neighbouring countries – Since 2010, recorded quite far from the Luxembourgish border in Fagne-Famenne in Wallonia and southern French Lorraine, and close to the border in western Rhineland-Palatinate (Moselle valley).

Worldwide – From southwestern and central Europe to western Asia (Iran). Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. A comeback may still be possible especially in the context of global warming.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

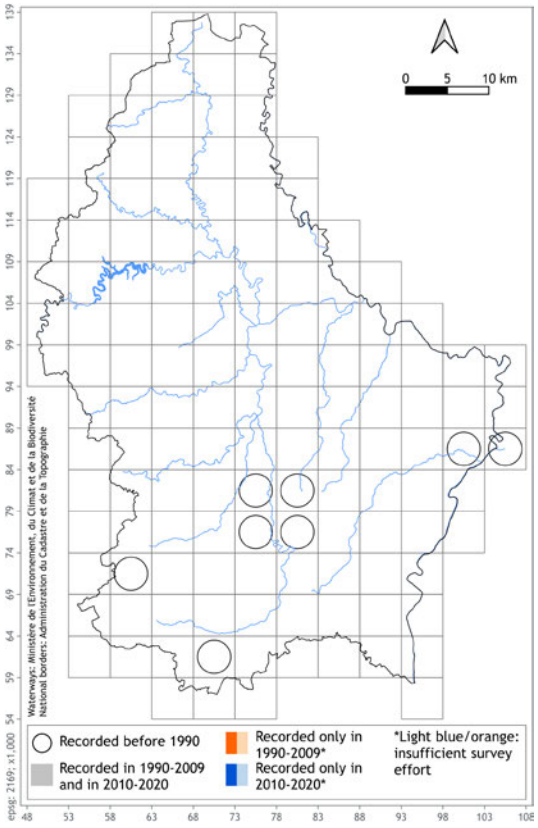


Fig. 4.169: Distribution change map at 5-km spatial resolution for *Satyrium spini*.

Fig. 4.170: *Satyrium spini* (Illustration: Anita Faber).

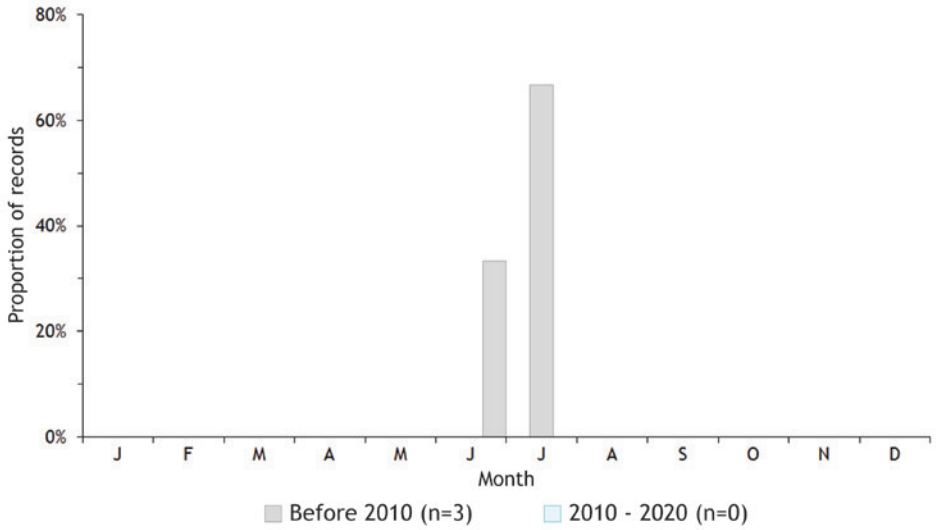


Fig. 4.171: Flight season of *Satyrium spini* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Callophrys rubi

(Linnaeus, 1758)

L: Päerdsbier-Zipfelfalter

E: Green hairstreak

G: Grüner Zipfelfalter

F: Thécla de la ronce

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Near Threatened	Least Concern

The metallic green underside of the wings makes it easily identifiable when flying and provides it with a good camouflage while staying on green leaves.

Lifecycle

Univoltine. Flies mostly from April to late June with a peak in late May. Overwinters as chrysalis.

Habitat

Various biotopes with shrubs, such as nutrient-poor grasslands, forest edges and clearings, hedgerows, wastelands, and shrub-covered areas (e.g., with *Cytisus scoparius* and *Rubus* spp.).

Larval host plants – Lays single eggs on a variety of plants such as *Anthyllis vulneraria*, *Calluna vulgaris*, *Cornus sanguinea*, *Cytisus scoparius*, *Erica tetralix*, *Frangula alnus*, *Genista* spp., *Helianthemum nummularium*, *Lotus corniculatus*, *Medicago sativa*, *Onobrychis viciifolia*, *Rhamnus cathartica*, *Rubus* spp., *Vaccinium* spp., *Vicia cracca*, and *Ulex europaeus*.

Fig. 4.172: *Callophrys rubi* (Photo: Marcel Hellers).

Fig. 4.173: *Callophrys rubi* (Photo: Michelle Clemens).

Distribution

Luxembourg – Patchily distributed across most of the country except in the Minette and some valleys of the Oesling where availability of suitable habitats and population densities are higher.

Worldwide – Palearctic species, from western Europe and northern Africa across Asia Minor to central Asia.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -21%

Relative change in extent of occurrence (geographical range): +4%

Even though recorded in a moderately decreasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting extensive management of grasslands and bocage with a rotational management of hedgerows over multiple years, maintaining mosaic of shrub and herbaceous vegetation.

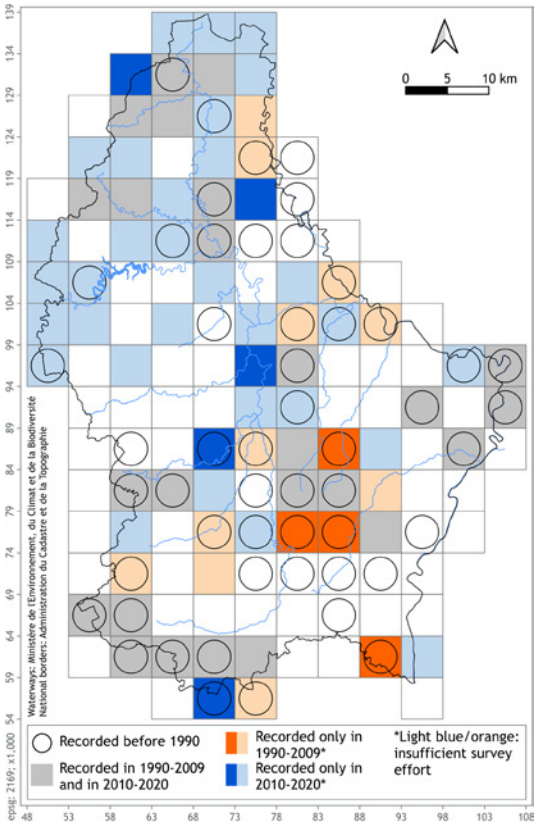


Fig. 4.174: Distribution change map at 5-km spatial resolution for *Callophrys rubi*.

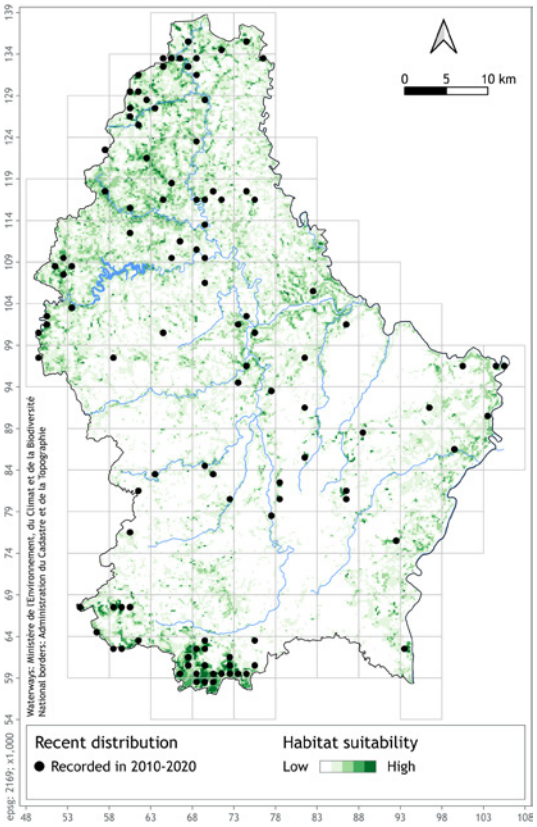


Fig. 4.175: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Callophrys rubi*.

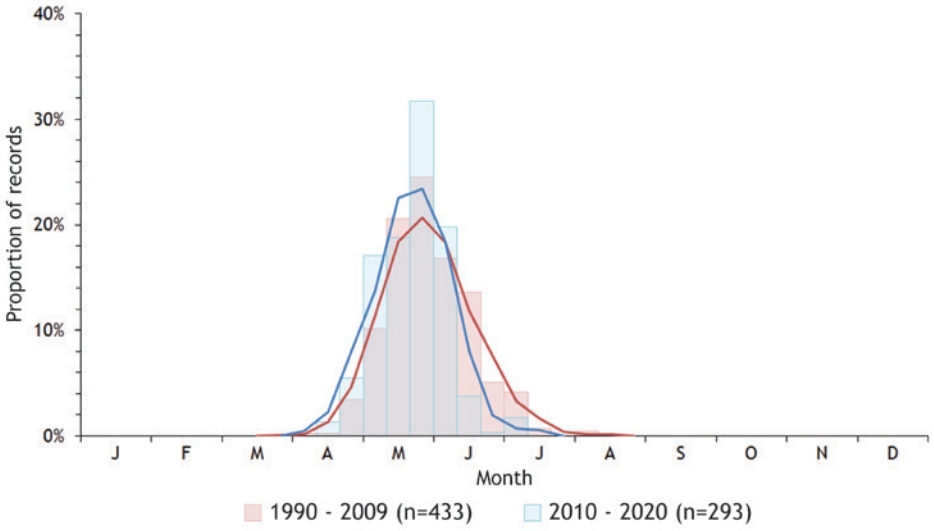


Fig. 4.176: Flight season of *Callophrys rubi* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lycaena helle

([Denis & Schiffermüller], 1775)

L: Bloschillernde Feierfalter

E: Violet copper

G: Blauschillernder Feuerfalter

F: Cuivré de la bistorte

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC Annexes II and IV
Red List category	Vulnerable	Least Concern

Boreomontane and typical postglacial relict species, *Lycaena helle* is considered as one of the rarest butterfly species in western Europe and has shown a continued decline throughout its range.

Lifecycle

Univoltine. Adults fly from late April to early July, with a peak in late May. Overwinters as a chrysalis in the leaf litter.

Habitat

Wetlands with shelters (shrubs) where its host plant grows, such as bogs and wet meadows.

Nectar resources – Feeds on many different plant species.

Larval host plants – Lays eggs exclusively on the underside of leaves of *Bistorta officinalis*.

Fig. 4.177: *Lycaena helle* (Photo: Mireille Molitor).

Fig. 4.178: *Lycaena helle* (Photo: Hubert Baltus).

Distribution

Luxembourg – Almost exclusively distributed in northern and western Oesling where suitable habitats are mostly located in valley bottoms.

Worldwide – Paleartic species with a patchy distribution in Europe restricted to areas over 400 m in altitude.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -27%

Relative change in extent of occurrence (geographical range): -35%

Moderately decreasing. The species is no longer recorded around Weiswampach, in the north-eastern part of the country, despite targeted surveys conducted during the LIFE Eislek project.

Management

Promoting low intensity grazing (sheep/cattle) and mowing of wetlands followed by periods of being set aside. Limiting the grazing or mowing during the flight season. Supporting the restoration of key sites both inside and outside Natura 2000 areas.

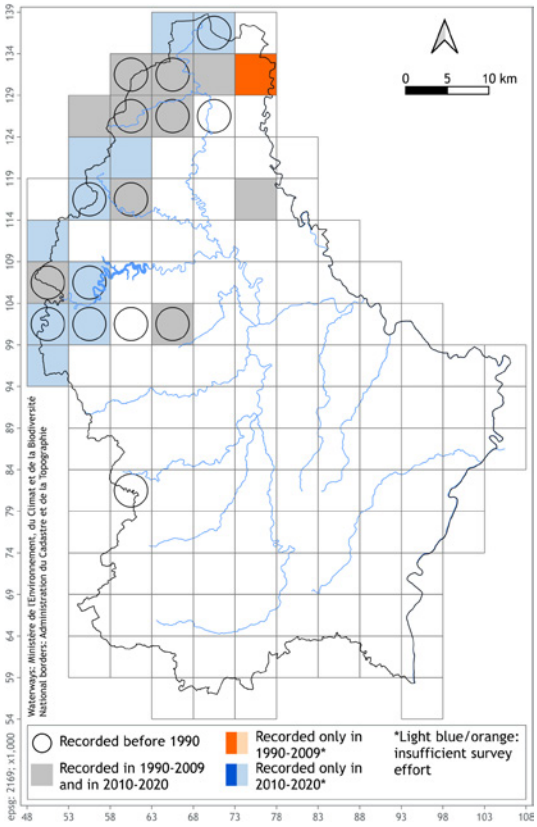


Fig. 4.179: Distribution change map at 5-km spatial resolution for *Lycaena helle*.

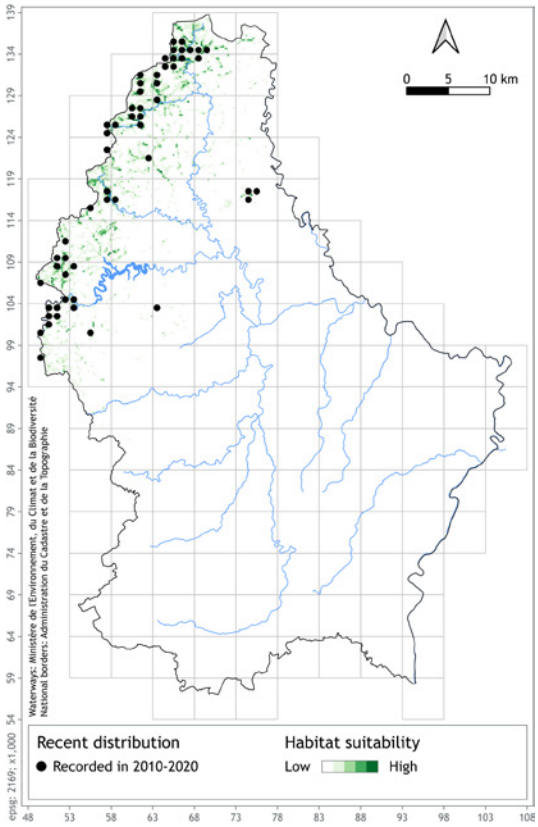


Fig. 4.180: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Lycaena helle*.

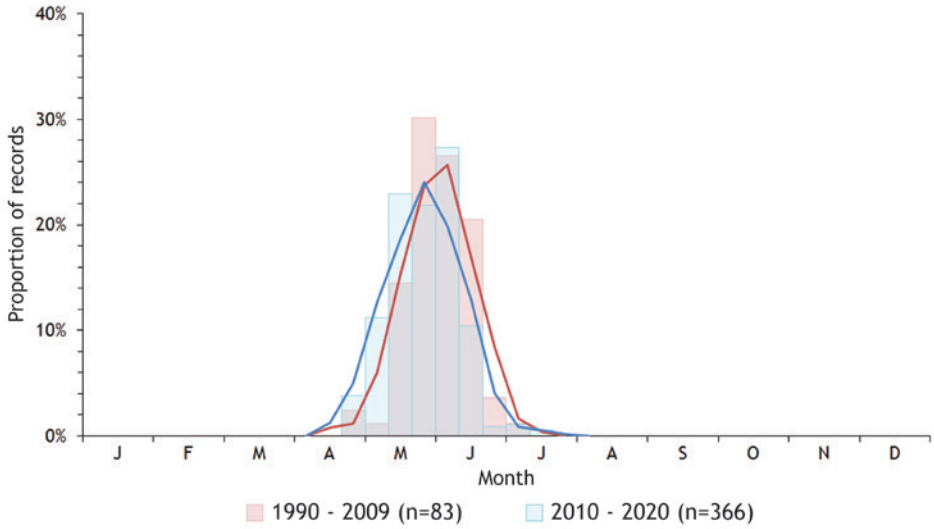


Fig. 4.181: Flight season of *Lycaena helle* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lycaena virgaureae
(Linnaeus, 1758)

L: Dukatefalter
E: Scarce copper
G: Dukaten-Feuerfalter
F: Cuivré de la verge-d'or

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1994	Least Concern

This copper is in considerable decline in several regions of Europe, especially in lowland areas. The underside of its wings displays the most reliable identification criteria.

Lifecycle

Univoltine. Flies mostly from late June to August with a peak in late July. Overwinters mainly as caterpillar in the egg, usually attached to dry parts of plants in the vicinity of the larval host plants.

Habitat

Wet to dry, cool and sheltered biotopes rich in flowering species, such as nutrient-poor meadows along forests, grassy forest clearings, and forest edges.

Fig. 4.182: *Lycaena virgaureae* (Photo: Stéphane Vizthum).

Fig. 4.183: *Lycaena virgaureae* (Photo: Stéphane Vizthum).

Nectar resources – Preferentially feeds on *Origanum vulgare* and flowers from the Asteraceae family.

Larval host plants – Lays single dome-shaped eggs, or in groups of two or three, primarily on *Rumex acetosa* and *R. acetosella*.

Distribution

Luxembourg – Previously recorded mostly in the Oesling and in central Gutland until the 1980s, with the latest record in 1994 near Hosingen.

Neighbouring countries – Since 2010, recorded in eastern French Lorraine, in Belgian Ardennes and Belgian Lorraine, as well as in central Rhineland-Palatinate (mainly in Hunsrück mountains).

Worldwide – Holarctic species, mostly distributed locally in mountains of Europe (mainly France, Spain, the Balkans, and Scandinavia).

Trends (<2010 *vs.* 2010-2020)

Considered as extinct.

The Oesling may still provide suitable habitat for the species but, as it is declining in the Greater Region, its comeback seems currently unlikely.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

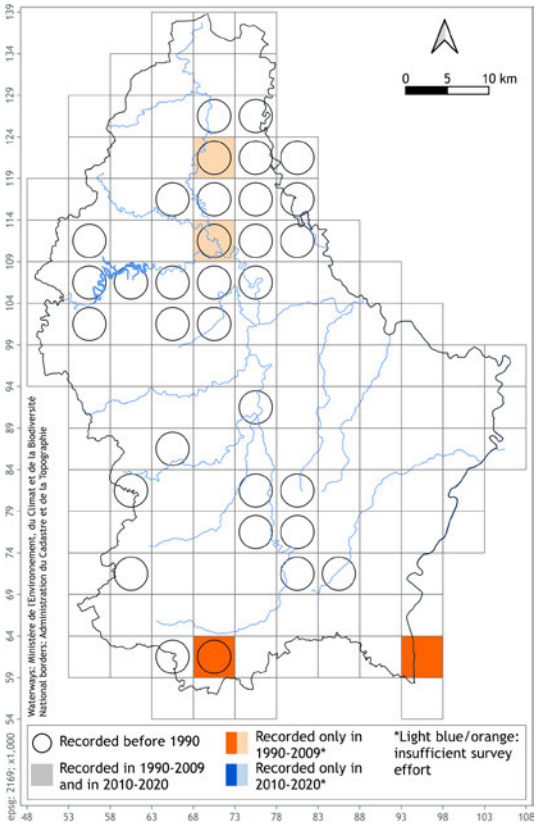


Fig. 4.184: Distribution change map at 5-km spatial resolution for *Lycaena virgaureae*.

Fig. 4.185: *Lycaena virgaureae* (Illustration: Anita Faber).

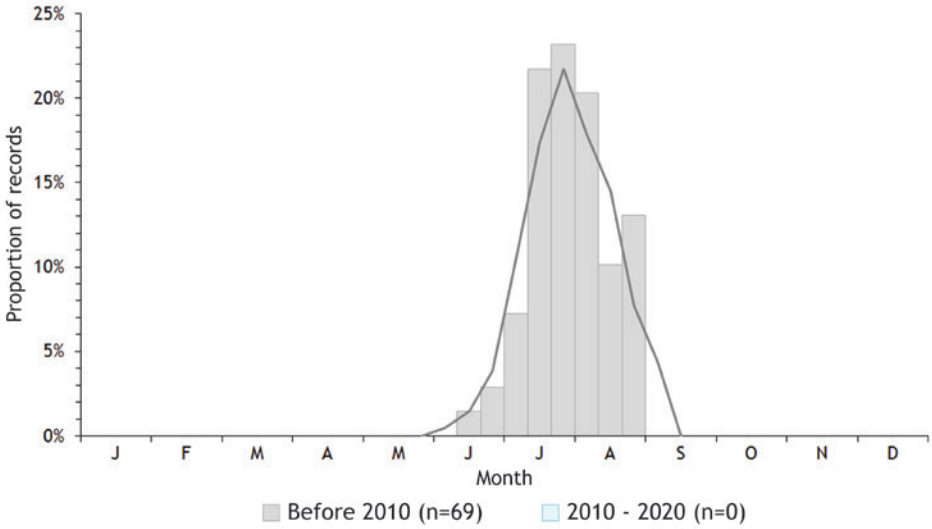


Fig. 4.186: Flight season of *Lycaena virgaureae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lycaena tityrus
(Poda, 1761)

L: Bronge Feierfalter

E: Sooty copper

G: Brauner Feuerfalter

F: Cuivré fuligineux

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Unlike other copper species, males are less colourful than females on the upper side of the wings.

Lifecycle

Bivoltine. Flies mostly from May to early September with a first peak in late May and a second one in late July. Overwinters as caterpillar on the host plant close to the ground.

Habitat

Nutrient-poor, wet to moderately dry, open biotopes, such as flower-rich meadows, forest clearings, forest paths, and fallows with shrubs.

Nectar resources – Feeds on a variety of flowering plants without any preference to colour.

Fig. 4.187: *Lycaena tityrus* (Photo: Alain Dohet).

Fig. 4.188: *Lycaena tityrus* (Photo: Hubert Baltus).

Larval host plants – Lays eggs on *Rumex* spp., primarily *Rumex acetosa*.

Distribution

Luxembourg – Distributed across the whole country, but with higher densities and availability of suitable habitats in the Minette, in central Gutland and in the Oesling, especially in valley bottoms.

Worldwide – From northern Spain across large parts of Europe up to the Altai Mountains in Asia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -9%

Relative change in extent of occurrence (geographical range): +12%

Even though recorded in a stable number of 1-km grid cells, its range slightly expanded in 2010-2020.

Management

Promoting extensive management of grasslands such as reduced fertilisation and late mowing. Implementing biodiversity contracts and agri-environmental schemes, especially in areas with moderate humidity and nutrient levels.

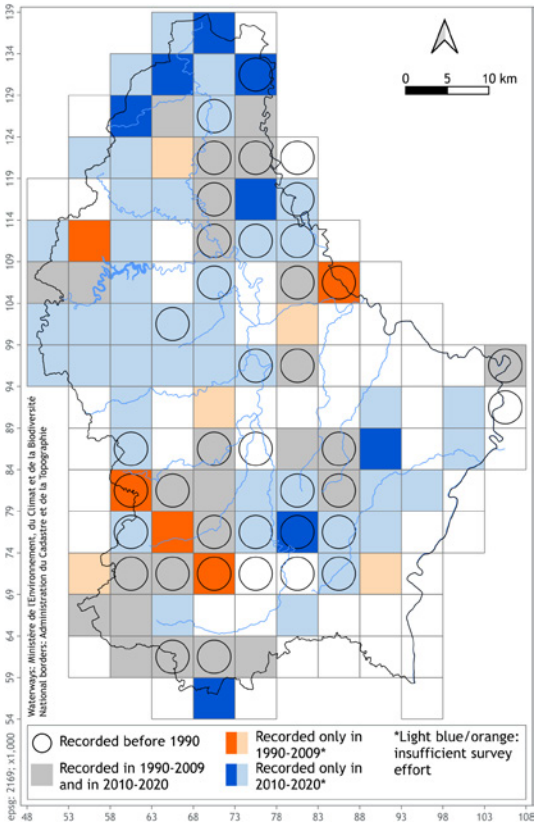


Fig. 4.189: Distribution change map at 5-km spatial resolution for *Lycaena tityrus*.

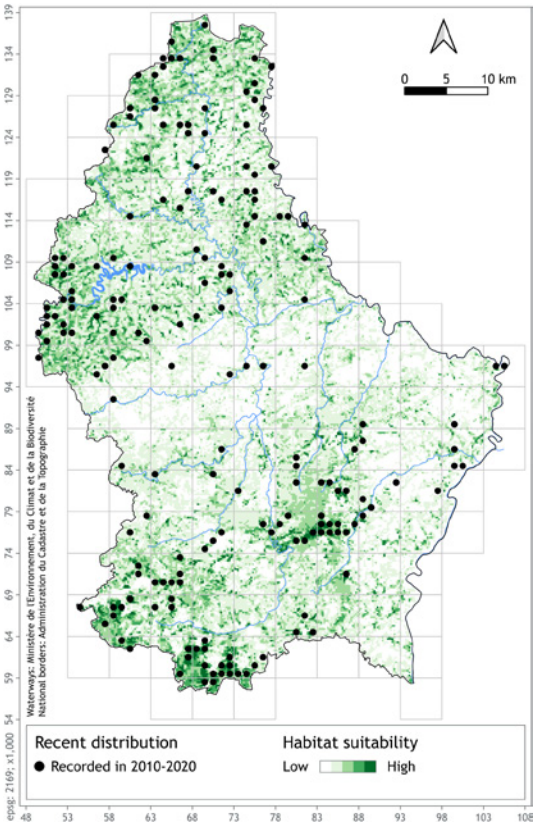


Fig. 4.190: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Lycaena tityrus*.

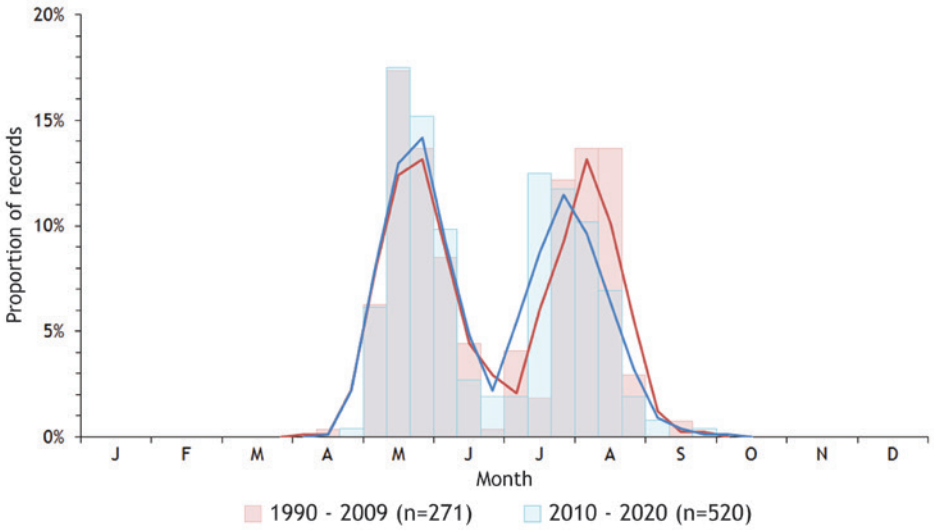


Fig. 4.191: Flight season of *Lycaena tityrus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lycaena dispar

([Haworth], 1802)

L: Grousse Feierfalter

E: Large copper

G: Großer Feuerfalter

F: Cuivré des marais

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC Annexes II and IV
Red List category	Least Concern	Least Concern

As reflected in its English name, *Lycaena dispar* is larger than the other coppers. Highly mobile, the beautiful and distinctive orange colour of the male makes it visible from afar.

Lifecycle

Bivoltine. Flies mostly from mid-May to June and from late July to early September, with a steeper peak in August. Overwinters as caterpillar, often wrapped in dead leaves on the stem of the host plant.

Habitat

Wide variety of wet biotopes where its host plants grow, such as mesophilic meadows, fallows, and along river sides. Strongly linked to wetlands with a high exposure to sunlight.

Fig. 4.192: *Lycaena dispar* (Photo: Michelle Clemens).

Fig. 4.193: *Lycaena dispar* (Photo: Hubert Baltus).

Nectar resources – Feeds on many different plants, mostly linked to wetlands with a preference for yellow and violet flowers such as *Lythrum salicaria*.

Larval host plants – Lays eggs on non-acidic *Rumex* spp., especially on *R. crispus* and *R. obtusifolius*.

Distribution

Luxembourg – Almost exclusively distributed in the Gutland where suitable habitats are mostly located in the valley bottoms and in the lowland areas.

Worldwide – Europe from France to Ukraine and from the north of Greece to Estonia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -24%

Relative change in extent of occurrence (geographical range): +6%

Even though recorded in a moderately decreasing number of 1-km grid cells, its range was considered as stable. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Targeted surveys (SIAS, SICONA, and LIST), especially in the northern half of the Gutland, have contributed to improving our knowledge on its recent distribution.

Management

Promoting extensive management of grasslands such as reduced fertilisation and late mowing. Avoiding the drainage of wetlands.

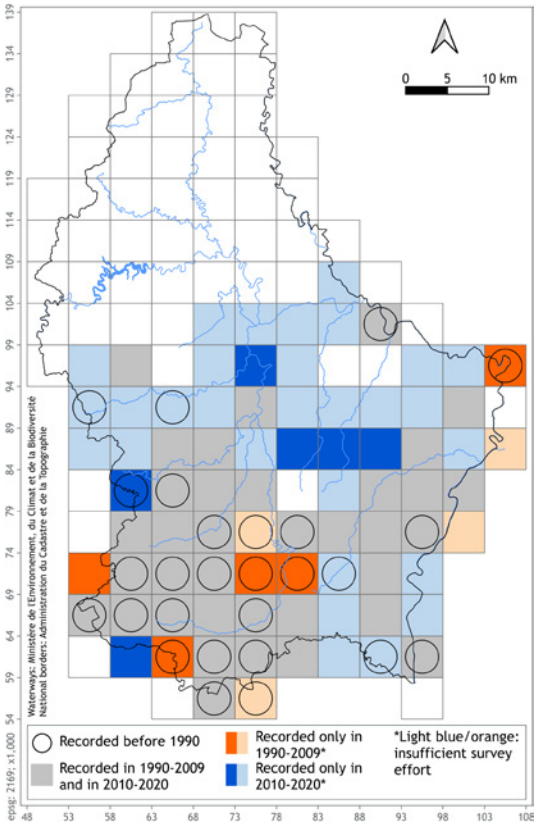


Fig. 4.194: Distribution change map at 5-km spatial resolution for *Lycaena dispar*.

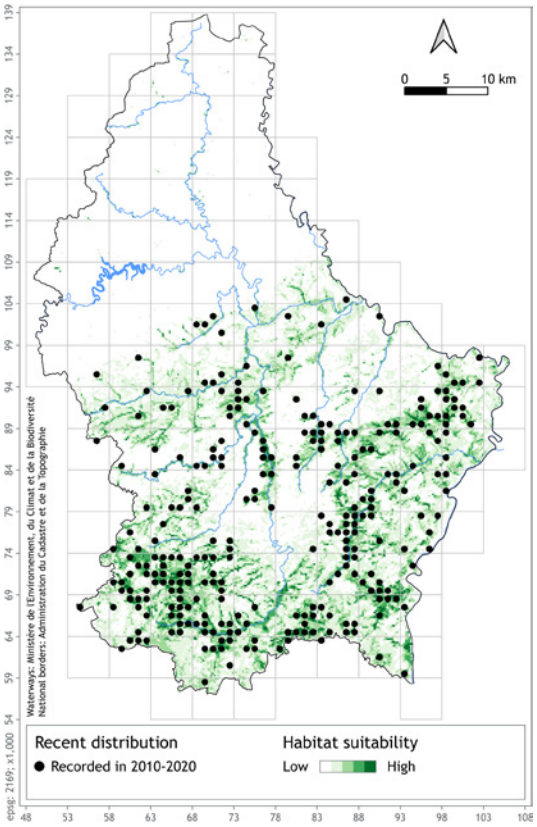


Fig. 4.195: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Lycaena dispar*.

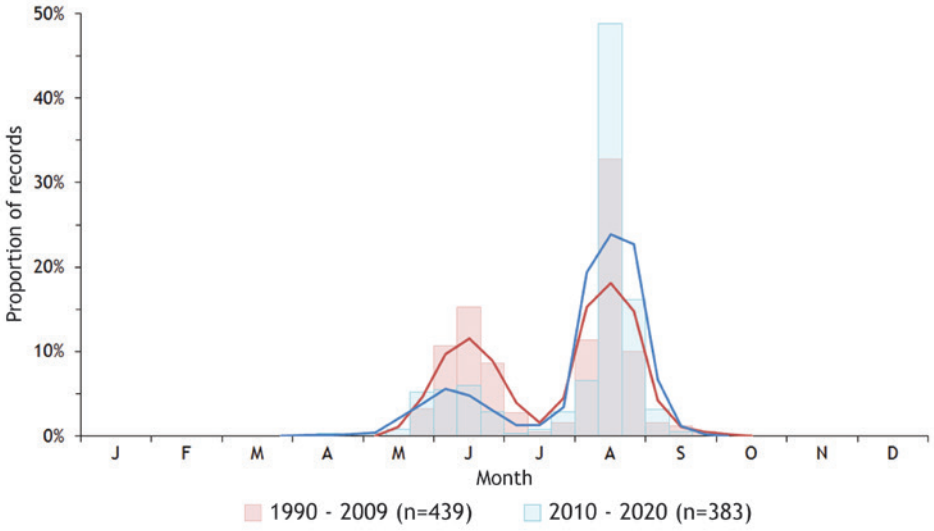


Fig. 4.196: Flight season of *Lycaena dispar* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lycaena phlaeas
(Linnaeus, 1760)

L: Klenge Feierfalter
E: Small copper
G: Kleiner Feuerfalter
F: Cuivré commun

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Lycaena phlaeas is frequently observed resting on the ground, vegetation, and flowers. Its wings often display aberrations. It is therefore advised to look closely at any specimen observed in the field.

Lifecycle

Mostly bivoltine, up to four generations in favourable years. Flies mostly from April to mid-October, with a first peak in May and a second one, steeper, in August. Overwinters at different developmental stages.

Habitat

Wide variety of open biotopes, such as flower-rich meadows, from wet to dry grasslands, wastelands, forest edges, forest clearings, field margins, and road verges.

Fig. 4.197: *Lycaena phlaeas* (Photo: Mireille Molitor).

Fig. 4.198: *Lycaena phlaeas* (Photo: Hubert Baltus).

Larval host plants – Lays single eggs on the leaves or on the stems of different species of the *Rumex* genus, preferentially *R. acetosella* and *R. acetosa*.

Distribution

Luxembourg – Homogeneously distributed across the whole country with suitable habitats available in every region.

Worldwide – Holarctic species, common across Europe, Asia, northern America, and northern Africa.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -12%

Relative change in extent of occurrence (geographical range): +4%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Implementing agri-environmental schemes (e.g., reduction of agricultural inputs and late mowing).

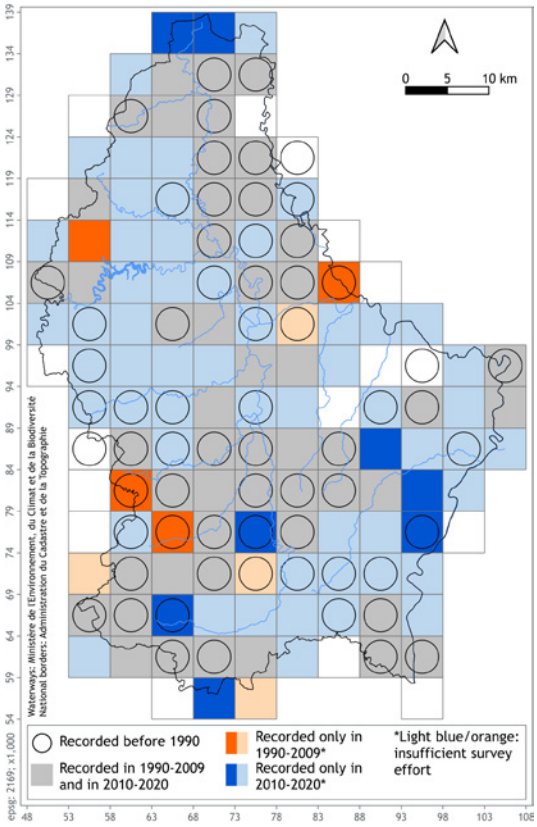


Fig. 4.199: Distribution change map at 5-km spatial resolution for *Lycaena phlaeas*.

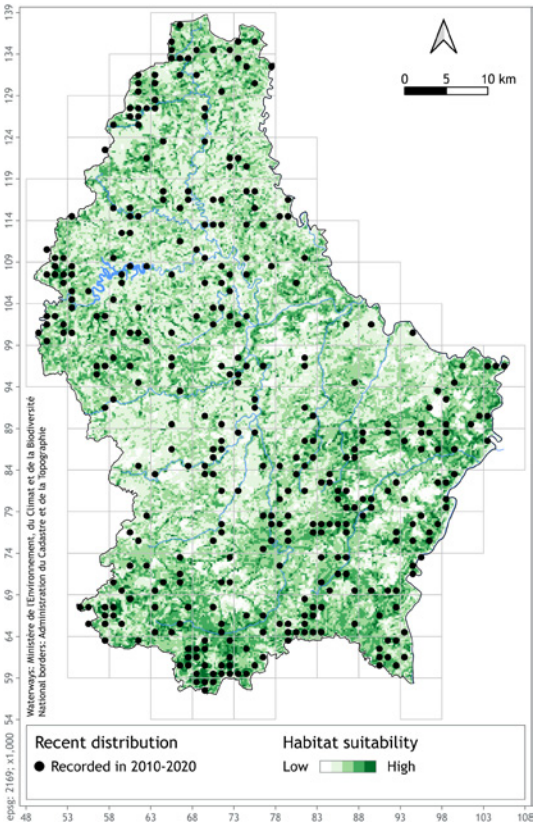


Fig. 4.200: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Lycaena phlaeas*.

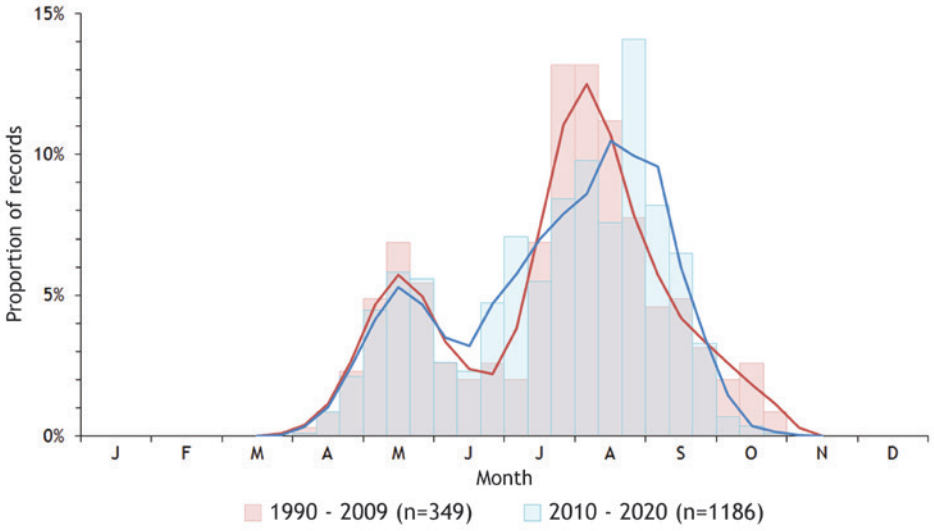


Fig. 4.201: Flight season of *Lycaena phlaeas* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lycaena hippothoe
(Linnaeus, 1760)

L: Lilagold Feierfalter
E: Purple-edged copper
G: Lilagold-Feuerfalter
F: Cuivré écarlate

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Critically Endangered	Near Threatened

Males of this relatively large species display a red copper colour on the upper side of the wings, a large dark strip along the abdomen and some violet reflections on the margins of the wings.

Lifecycle

Univoltine. Flies mostly from mid-May to early July. Overwinters as caterpillar on the ground and pupates in the litter layer in spring.

Habitat

Mainly wet and flower-rich meadows, but also other biotopes such as moors, dry forest clearings, calcareous dry grasslands, and *Nardus* grasslands.

Nectar resources – Feeds on a large variety of flowering plants with a preference for violet flowers.

Fig. 4.202: *Lycaena hippothoe* (Photo: Xavier Mestdagh).

Fig. 4.203: *Lycaena hippothoe* (Photo: Hubert Baltus).

Larval host plants – Lays single eggs on the leaves or stalks of *Rumex* spp., mainly *R. acetosa* and *R. acetosella*.

Distribution

Luxembourg – Almost exclusively distributed in the Upper Sûre valley along the Belgian border, with a few highly isolated records in northern Oesling (Berlé, Brachtenbach, and Troisvierges).

Worldwide – Across most of eastern and northern Europe to Siberia, usually restricted to areas over 400 m in altitude.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -87%

Relative change in extent of occurrence (geographical range): -91%

Strongly decreasing. It went extinct in the Minette and eastern Oesling, which strongly reduced its range.

Management

Promoting low intensity grazing (sheep/cattle) and mowing of wetlands followed by periods of being set aside. Limiting the grazing or mowing during the flight season. Supporting the restoration of key sites both inside and outside Natura 2000 areas. Creating corridors between remaining populations.

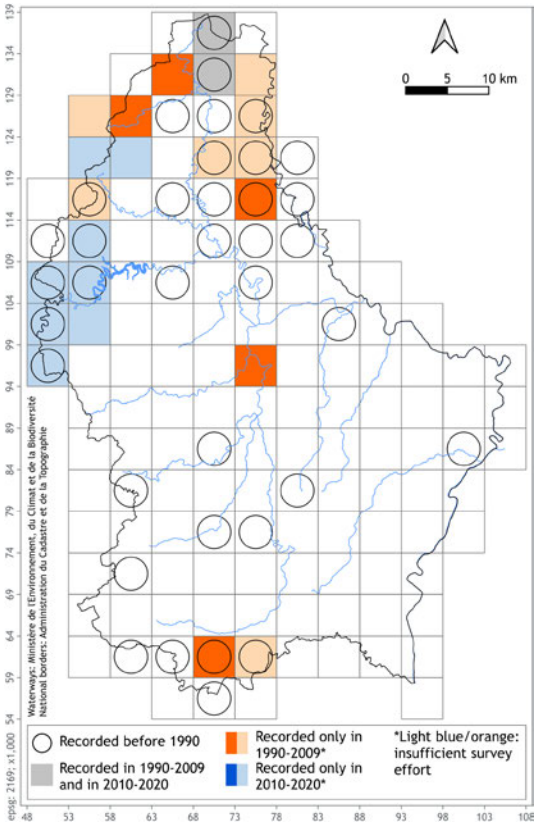


Fig. 4.204: Distribution change map at 5-km spatial resolution for *Lycaena hippothoe*.

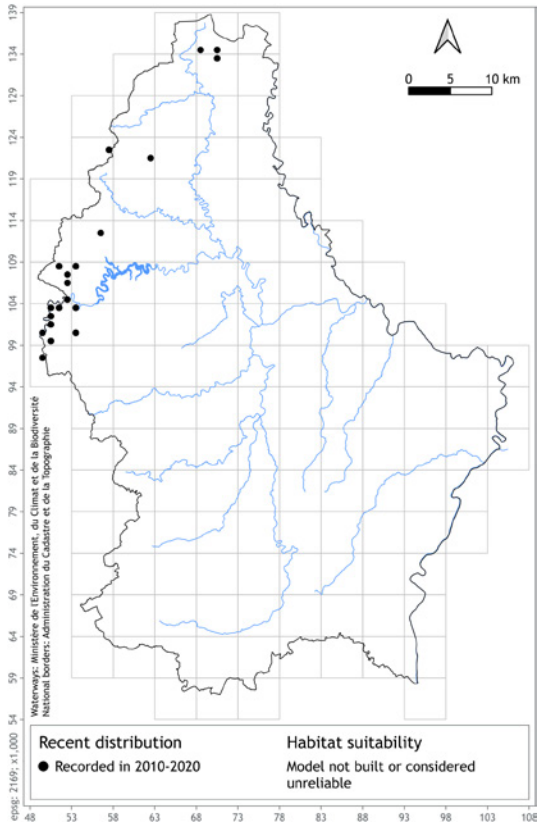


Fig. 4.205: Distribution map at 1-km spatial resolution for *Lycaena hippothoe*.

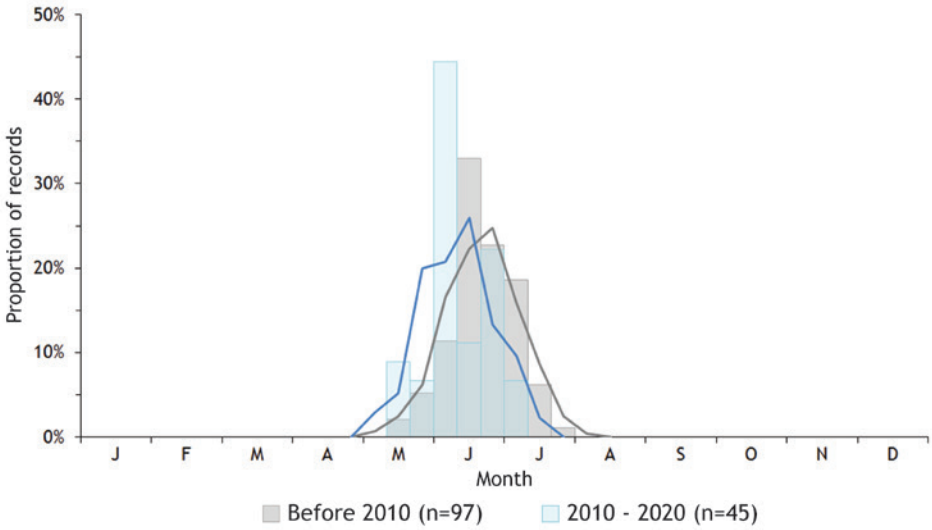


Fig. 4.206: Flight season of *Lycaena hippothoe* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lampides boeticus

(Linnaeus, 1767)

L: Grousse Wanderbläuling

E: Long-tailed blue

G: Großer Wanderbläuling

F: Azuré porte-queue

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Applicable	Least Concern

Strongly migratory, its presence in Luxembourg is considered as accidental. *Lampides boeticus* has two eyespots in the hindwings, extended by two thin, long tails. This feature mimics a head and diverts the attention of birds away from the rest of the body.

Lifecycle

Not breeding at our latitudes but in frost-free areas of southern Europe where it is multivoltine. Further north, migrants reproduce only rarely. Few records in summer and early autumn in the neighbouring countries.

Habitat

Hot and dry flower-rich patches mostly on calcareous substrates, such as gardens, forest edges, and shrub-covered areas.

Fig. 4.207: *Lampides boeticus* (Photo: Hubert Baltus).

Fig. 4.208: *Lampides boeticus* (Photo: Stéphane Vizthum).

Larval host plants – Lays small single eggs on the flowers, sepals and stems of various species from the Fabaceae family, especially *Colutea arborescens, Lathyrus latifolius, and Medicago sativa.*

Distribution

Luxembourg – Previously recorded only twice near Echternach in 1962 but without clear evidence on its local breeding status.

Neighbouring countries – Since 2010, recorded in northeastern French Lorraine, close to the Luxembourgish border in Belgian Lorraine, as well as in several locations in eastern and southern Rhineland-Palatinate.

Worldwide – From northern Africa, Mediterranean regions to large parts of Asia, Australia and even New Zealand (one of the most widely distributed Lycaenids in the world).

Trends (<2010 *vs.* 2010-2020)

Trends were not estimated for this vagrant species. Might become a more frequent visitor due to climate change, as in Wallonia and French Lorraine.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

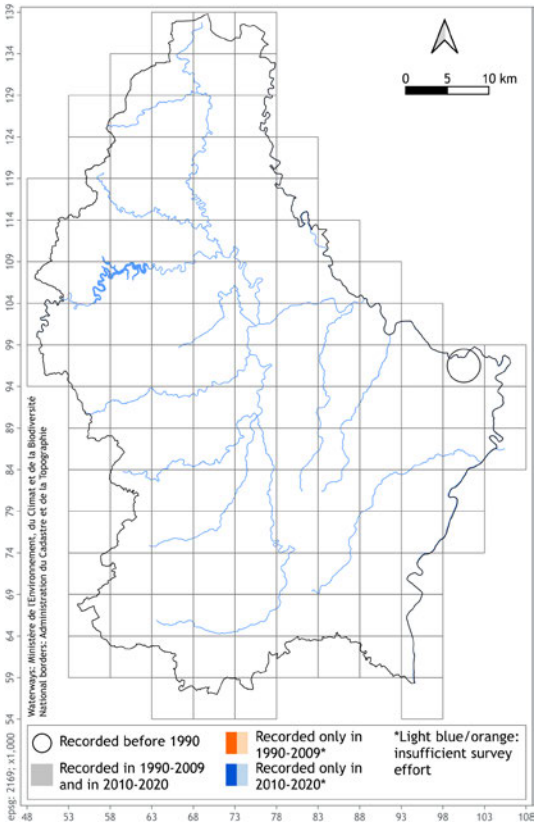


Fig. 4.209: Distribution change map at 5-km spatial resolution for *Lampides boeticus*.

Fig. 4.210: *Lampides boeticus* (Illustration: Anita Faber).

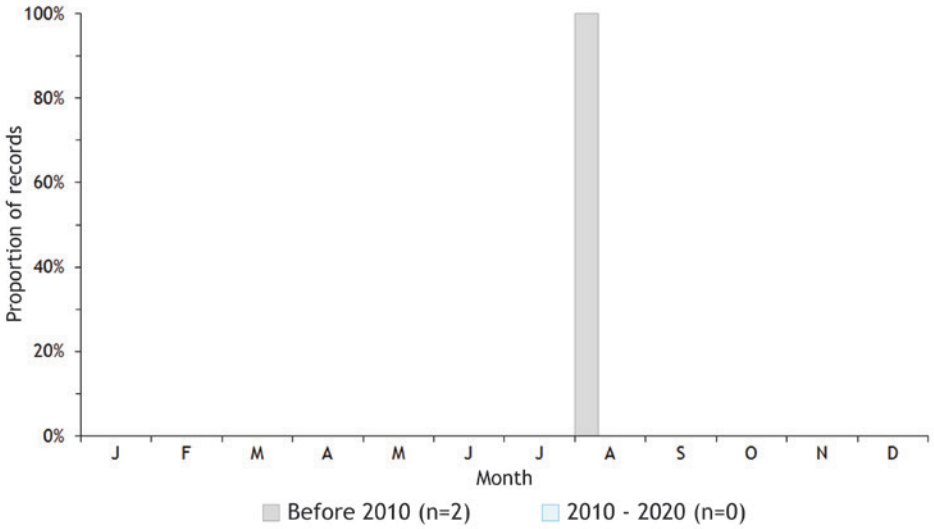


Fig. 4.211: Flight season of *Lampides boeticus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Cupido argiades
(Pallas, 1771)

L: Kuerzschwänzege Bläuling

E: Short-tailed blue

G: Kurzschwänziger Bläuling

F: Azuré du trèfle

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Evaluated	Least Concern

Migrant and known to be shifting northward due to global warming, its annual abundance can be extremely influenced by weather conditions.

Lifecycle

Up to three generations per year. Flies mostly from April to late September in favourable years, the spring generation being usually very inconspicuous due to low densities. Overwinters as caterpillar.

Habitat

Wide variety of flowery biotopes where its host plants are present, such as dry grasslands, wastelands, flower-rich and wet meadows, and forest edges. Individuals can be observed in unsuitable habitats (e.g., nutrient-rich grassland without host plant), which suggests good dispersal abilities.

Fig. 4.212: *Cupido argiades* (Photo: Alain Dohet).

Fig. 4.213: *Cupido argiades* (Photo: Nicolas Titeux).

Larval host plants – Lays single eggs on various species from the Fabaceae family, such as *Lotus corniculatus*, *Medicago sativa*, *Trifolium pratense*, *T. repens*, and *Vicia cracca*.

Distribution

Luxembourg – Nowadays, almost exclusively distributed in the Gutland, with a few isolated records in the Oesling maybe indicating a further northward expansion of this mobile species in the next years.

Worldwide – From continental Europe to Japan. Luxembourg is currently at the northern margin of its global range.

Trends (<2010 vs. 2010-2020)

Trends not estimated but strongly increasing during the period 2010-2020.

Management

Implementing agri-environmental schemes (e.g., reduction of agricultural inputs and livestock densities). Promoting alfalfa and clover crops.

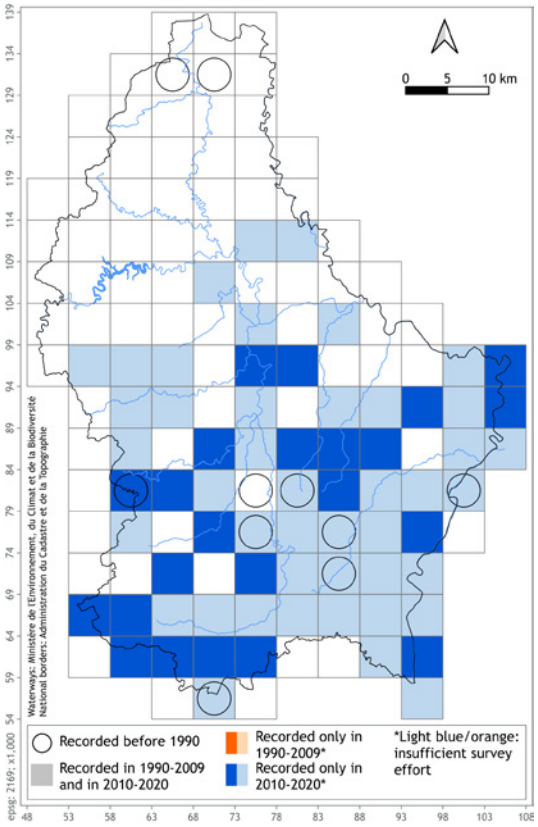


Fig. 4.214: Distribution change map at 5-km spatial resolution for *Cupido argiades*.

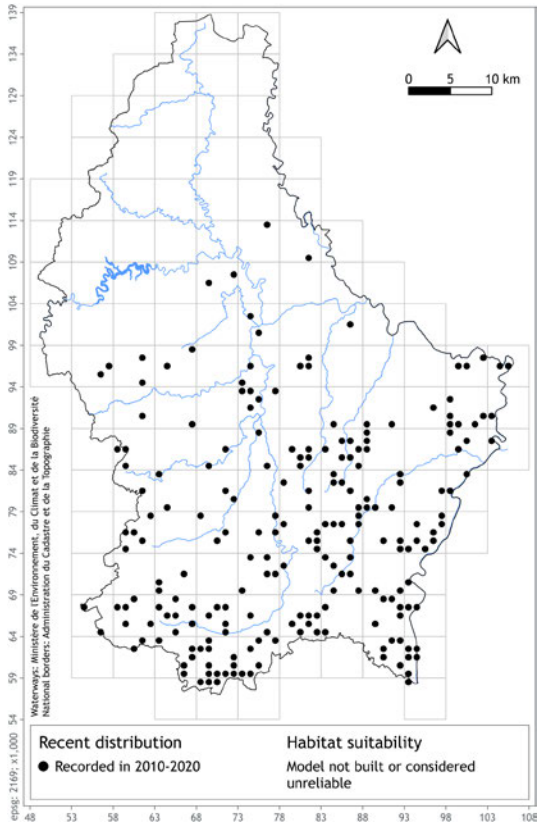


Fig. 4.215: Distribution map at 1-km spatial resolution for *Cupido argiades*.

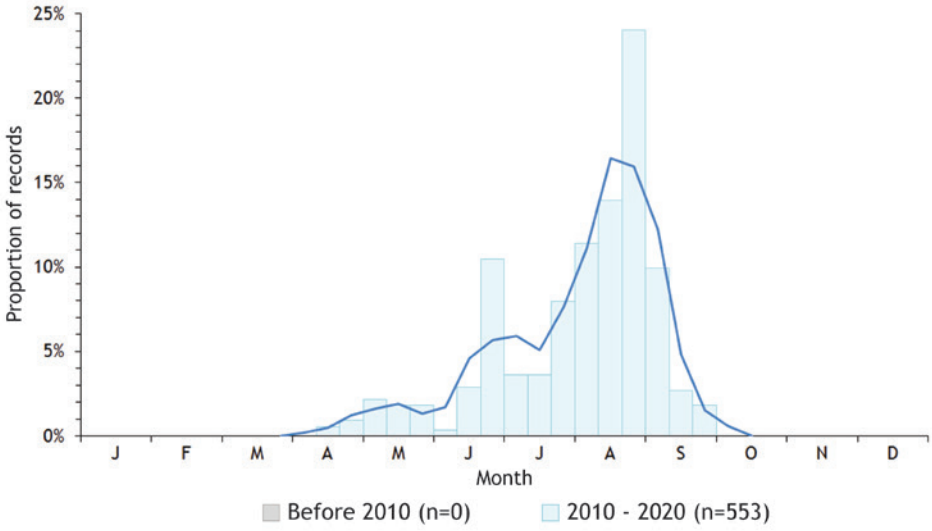


Fig. 4.216: Flight season of *Cupido argiades* representing the frequency distribution of species records over time at a 10-day temporal resolution. No record associated with a precise date was available before 2010.

LYCAENIDAE

Cupido minimus
(Fuessly, 1775)

L: Zwergbläuling
E: Small blue
G: Zwerg-Bläuling
F: Argus frêle

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

Despite its very active flight in sunshine, *Cupido minimus* is not easy to detect due to its small size and grey colour. It is characterised by an optional but frequent association with ants, which provides it with some protection against parasites and predators.

Lifecycle

Mainly univoltine, sometimes two generations per year. Flies mostly from May to August. Overwinters as final-stage caterpillar.

Habitat

Warm and dry biotopes with shrubs where its host plants grow, such as dry grasslands, quarries, wastelands, flower-rich meadows, and road verges.

Fig. 4.217: *Cupido minimus* (Photo: Lionel L'Hoste).

Fig. 4.218: *Cupido minimus* (Photo: Hubert Baltus).

Larval host plants – Lays single eggs on the inflorescence of *Anthyllis vulneraria* (preferentially). *Astragalus* spp., *Colutea arborescens*, *Melilotus* spp., and *Securigera varia* are also mentioned in the literature.

Distribution

Luxembourg – Almost exclusively distributed in the Minette, with a few isolated records in the central Gutland where patches of suitable habitats are very small and highly scattered.

Worldwide – Palearctic species, from western Europe across Asia Minor and central Asia to the Amur region.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -30%

Relative change in extent of occurrence (geographical range): -53%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted in 2010-2020. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Limiting the fertilisation and mowing to maintain large areas of *Anthyllis vulneraria*. Maintaining patches of shrubs to diversify microhabitat structures.

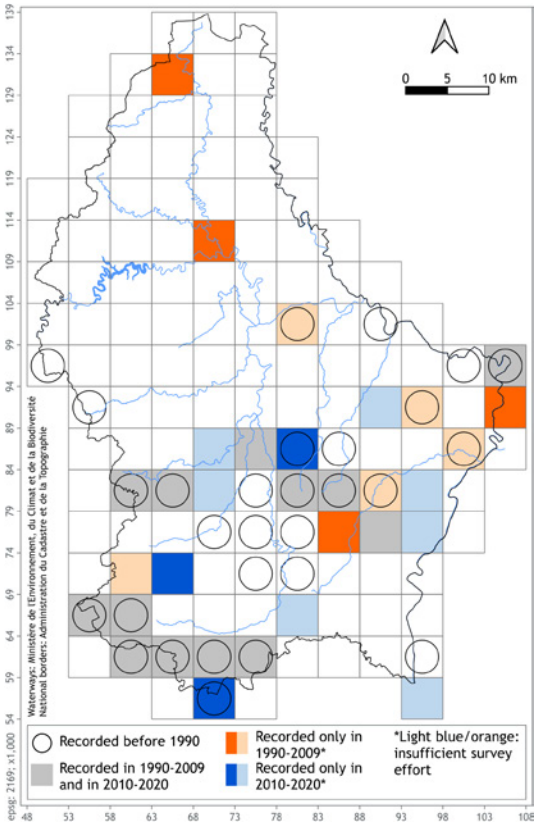


Fig. 4.219: Distribution change map at 5-km spatial resolution for *Cupido minimus*.

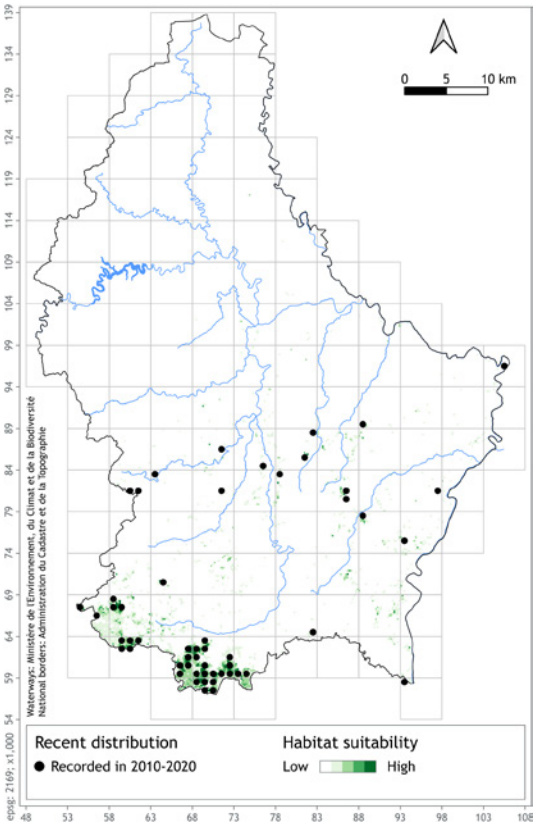


Fig. 4.220: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Cupido minimus*.

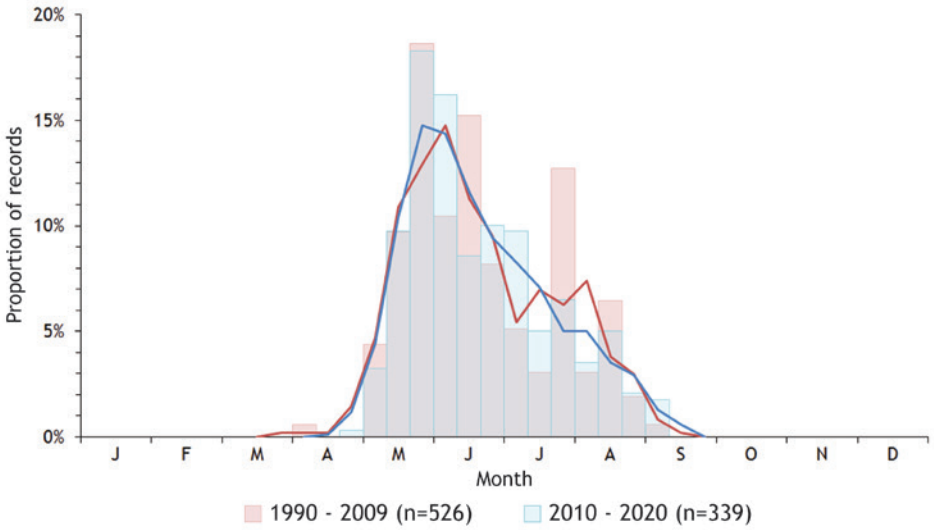


Fig. 4.221: Flight season of *Cupido minimus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Celastrina argiolus

(Linnaeus, 1758)

L: Faulbambläuling

E: Holly blue

G: Faulbaum-Bläuling

F: Azuré des nerpruns

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Among all the blue butterflies from Luxembourg, *Celastrina argiolus* is the earliest one that can be observed in spring, often flying around the tree canopy or along hedges.

Lifecycle

Mostly bivoltine, sometimes three generations in favourable years. Flies mostly from April to early September with a first peak in late April and a second one, steeper, in late July. Overwinters as chrysalis.

Habitat

Various biotopes with shrubs, such as forest edges, forest clearings, hedgerows, wastelands, gardens, and parks.

Fig. 4.222: *Celastrina argiolus* (Photo: Francis Birlenbach).

Fig. 4.223: *Celastrina argiolus* (Photo: Marcel Hellers).

Larval host plants – Has a distinct seasonal preference: lays eggs generally on *Cornus sanguinea*, *Ilex aquifolium* and *Rhamnus* spp. in spring, whereas *Hedera helix* is mainly used in summer. *Buddleja davidii* (an invasive alien species), *Buxus sepervirens*, *Calluna vulgaris* and *Ulex europaeus* are also mentioned in the literature.

Distribution

Luxembourg – Mainly distributed in the southern half of the country, with a few isolated records in the Oesling where availability of suitable habitats is much lower.

Worldwide – Holarctic species with high dispersal abilities. Expanding its range northwards in northern Europe, likely due to climate change.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +17%

Relative change in extent of occurrence (geographical range): +11%

Slightly increasing.

Management

Promoting the restoration and/or replantation of hedgerows in farmland including native host plants. Promoting diversified and well-structured forest edges as well as open areas in forests.

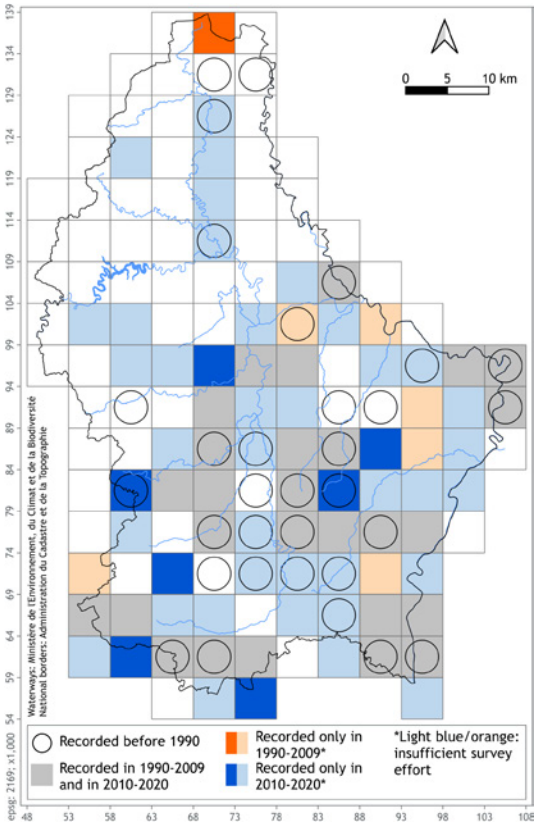


Fig. 4.224: Distribution change map at 5-km spatial resolution for *Celastrina argiolus*.

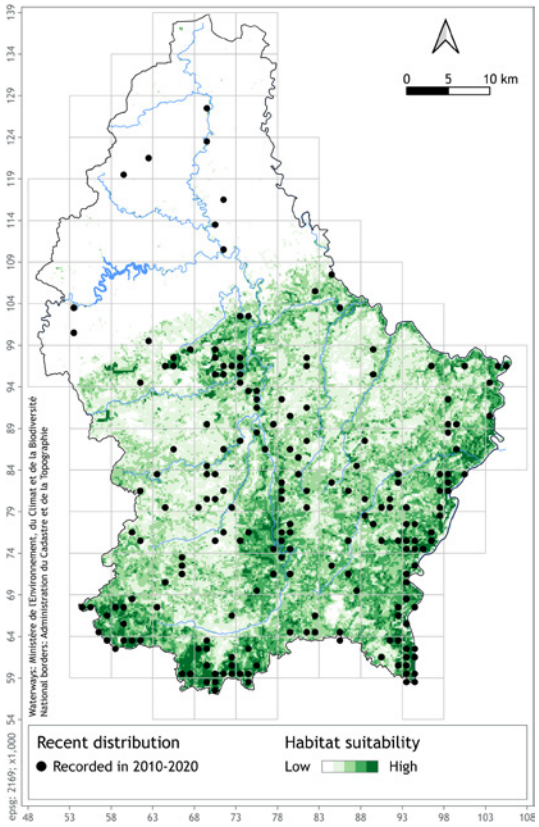


Fig. 4.225: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Celastrina argiolus*.

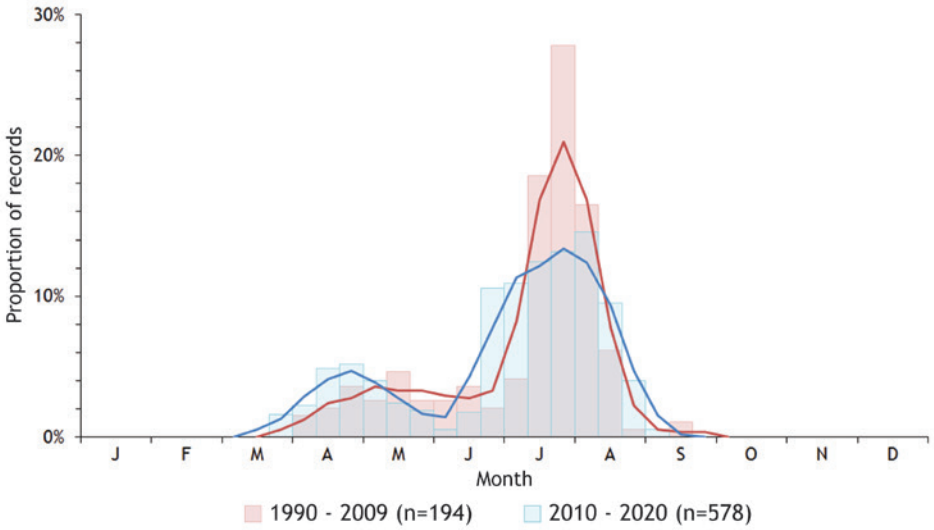


Fig. 4.226: Flight season of *Celastrina argiolus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Glaucopsyche alexis
(Poda, 1761)

L: Alexis-Bläuling
E: Green-underside blue
G: Alexis-Bläuling
F: Azuré des cytises

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Near Threatened	Least Concern

Myrmecophile species, *Glaucopsyche alexis* shows an optional but frequent association with ants, which provides it with some protection against parasites and predators. As it is often flying in low density and with other blues, it is essential to check the underside since it displays a large blue area at the bottom of the hindwings and thick black dots on the forewings.

Lifecycle

Univoltine. Flies mostly from May to mid-July with a peak in early June. Overwinters as caterpillar or chrysalis.

Habitat

Warm and dry biotopes, such as dry grasslands, quarries, wastelands, flower-rich meadows, and road verges.

Fig. 4.227: *Glaucopsyche alexis* (Photo: Martin Heyeres).

Fig. 4.228: *Glaucopsyche alexis* (Photo: Hubert Baltus).

Larval host plants – Lays eggs on the inflorescence of various species from the Fabaceae family, such as *Astragalus glycyphyllos*, *Colutea arborescens*, *Galega officinalis*, *Medicago sativa*, *Melilotus* spp., *Onobrychis viciifolia*, *Securigera varia*, *Trifolium* spp., and *Vicia* spp.

Distribution

Luxembourg – Exclusively and patchily distributed in the southern half of the country, but with higher densities in the Minette where availability of suitable habitats is higher.

Worldwide – Throughout most of Europe, northern Africa, and central Asia to the Amur.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -39%

Relative change in extent of occurrence (geographical range): +2%

Even though recorded in a moderately decreasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting late mowing of road verges and extensive grazing of dry grasslands to limit shrub encroachment and invasion by *Bromus* spp.

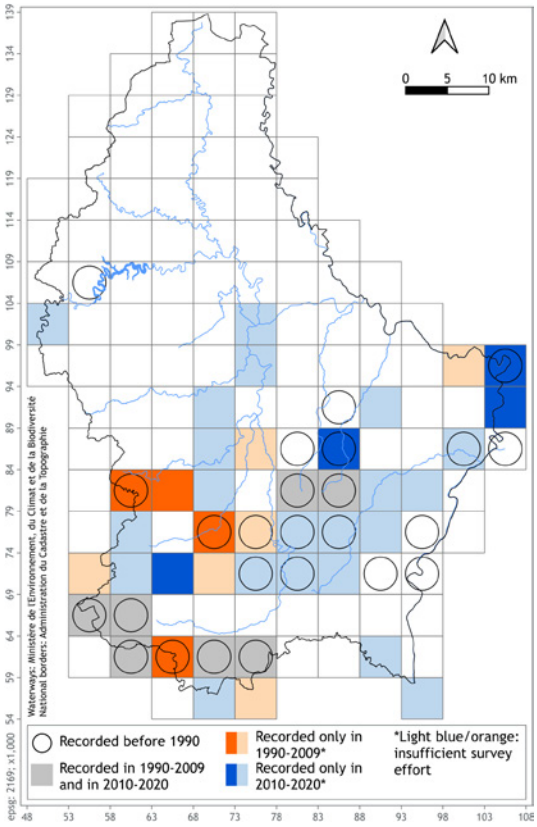


Fig. 4.229: Distribution change map at 5-km spatial resolution for *Glaucopsyche alexis*.

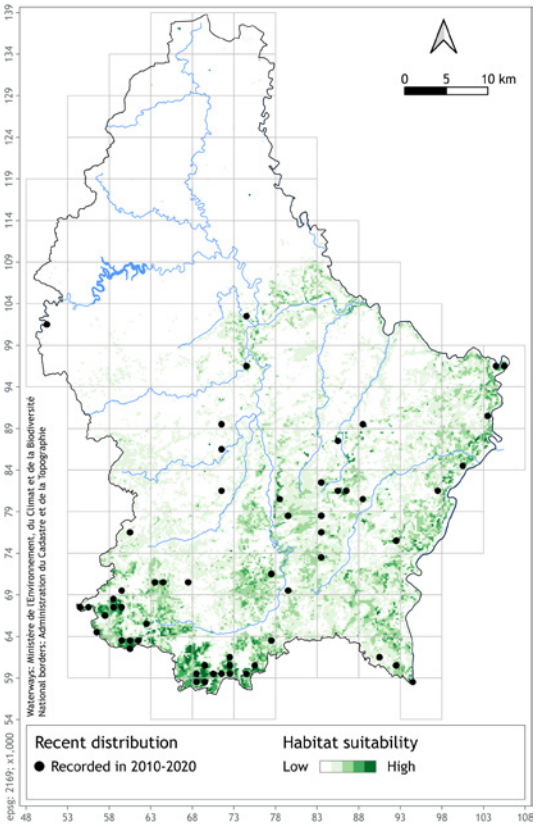


Fig. 4.230: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Glaucopsyche alexis*.

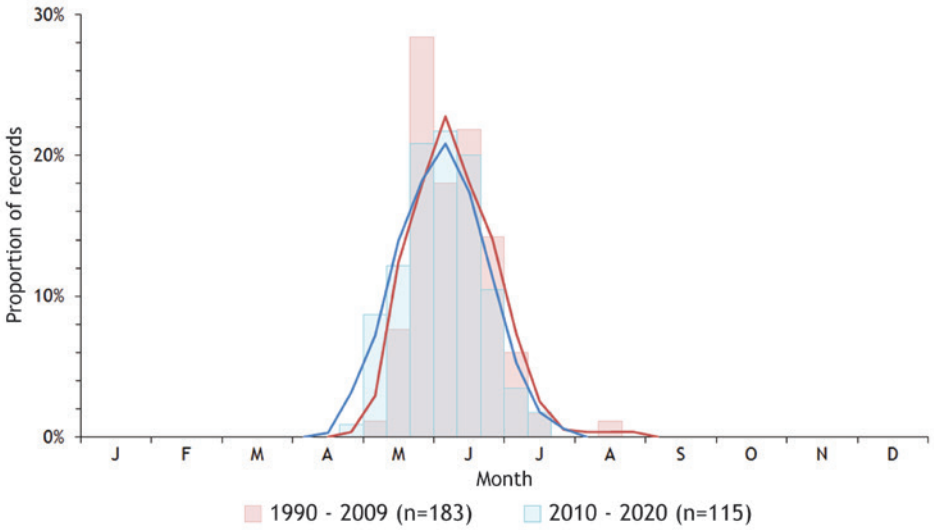


Fig. 4.231: Flight season of *Glaucopsyche alexis* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Phengaris arion

(Linnaeus, 1758)

Syn.: *Maculinea arion*

L: Seejomesse-Bläuling

E: Large blue

G: Thymian-Ameisenbläuling

F: Azuré du serpolet

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC Annex IV
Red List category	Endangered	Endangered

Phengaris arion is the largest blue in Luxembourg and has a unique parasitic relationship with a single species of red ant, *Myrmica sabuleti*.

Lifecycle

Univoltine with a relatively short lifespan. Flies mostly from mid-June to July, with a peak in early July. Overwinters as final-stage caterpillar inside the nest of the ant *M. sabuleti*, where it feeds on the larvae.

Habitat

Dry calcareous grasslands with short vegetation, where its host plants are abundant and where the host ant (*M. sabuleti*) is abundant, such as on south-facing slopes well exposed to the sun.

Fig. 4.232: *Phengaris arion* (Photo: Marcel Hellers).

Fig. 4.233: *Phengaris arion* (Photo: Martin Heyeres).

Larval host plants – Lays whitish, mostly single, eggs in the flower heads of *Thymus* spp. and *Origanum vulgare*. Feeds on these flowers during the first three larval stages before parasitising a colony of *M. sabuleti*.

Distribution

Luxembourg – Almost exclusively distributed in the Minette, with an isolated population in Rosport.

Worldwide – Patchily distributed from western Europe to Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -36%

Relative change in extent of occurrence (geographical range): -74%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted in 2010-2020. It disappeared from several 1-km grid cells in western Minette. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Promoting short and sparse vegetation with *Thymus* spp. and nectariferous plants through extensive grazing (cattle or sheep). Promoting the diversity of microhabitat structures but avoiding shrub encroachment. Creating corridors between remaining populations.

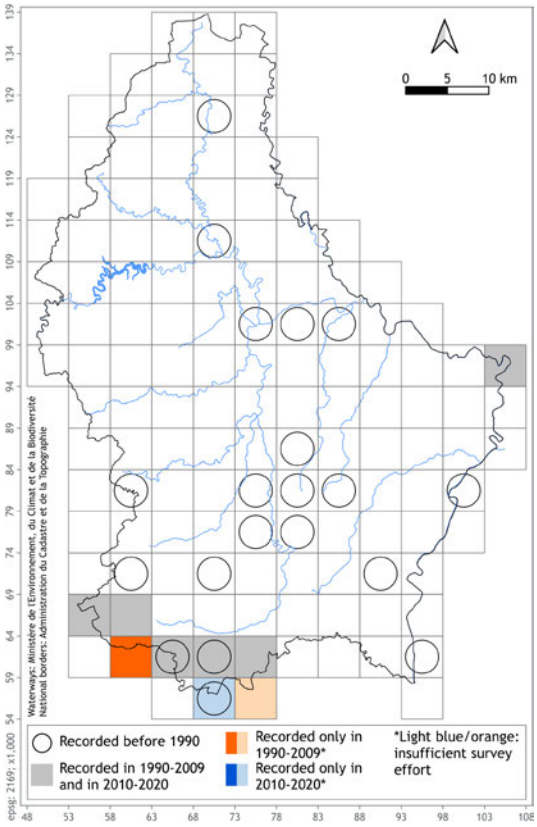


Fig. 4.234: Distribution change map at 5-km spatial resolution for *Phengaris arion*.

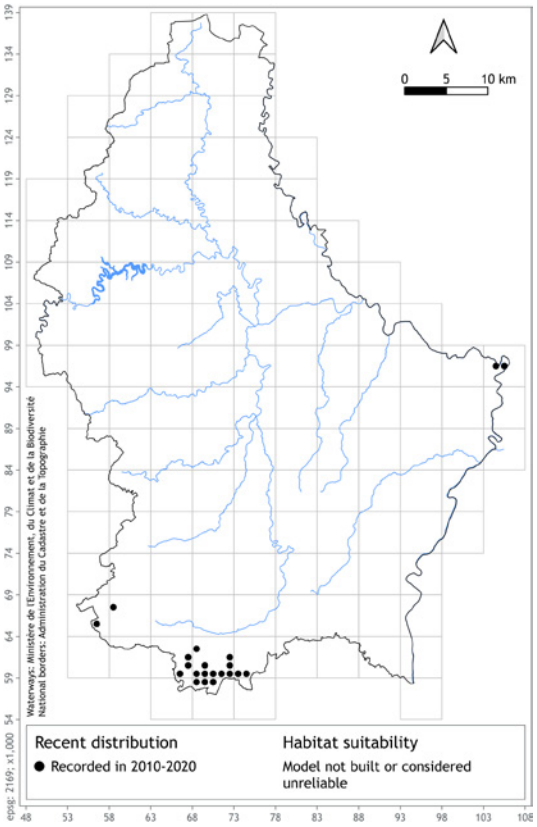


Fig. 4.235: Distribution map at 1-km spatial resolution for *Phengaris arion*.

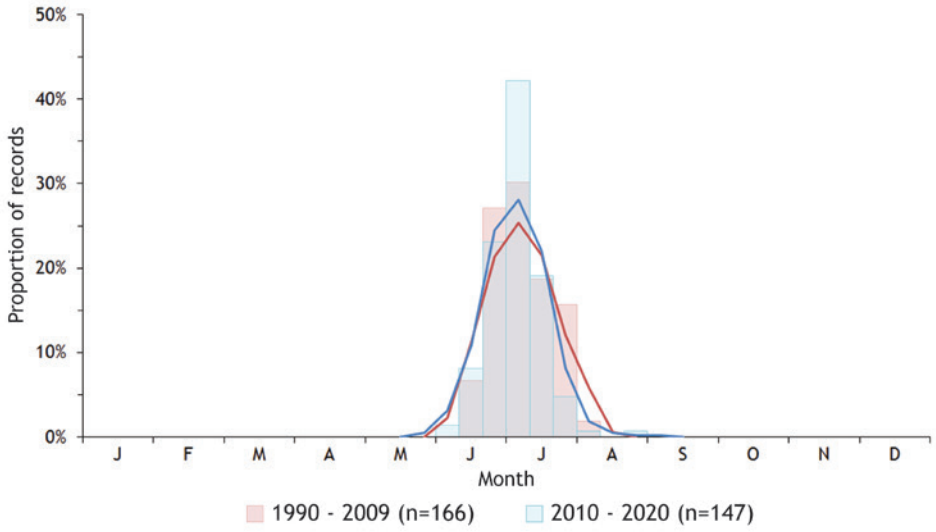


Fig. 4.236: Flight season of *Phengaris arion* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Pseudophilotes baton

(Bergsträsser, 1779)

L: Grobloe Bläuling

E: Baton blue

G: Westlicher Quendel-Bläuling

F: Azuré de la sarriette

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1952	Least Concern

Pseudophilotes baton is a very small species flying above the ground that can be easily unnoticed.

Lifecycle

Bivoltine in neighbouring regions. Flies in higher numbers from late April to June and in low numbers in August. Overwinters as caterpillar.

Habitat

Hot and dry open biotopes with short and sparse vegetation, such as dry calcareous grasslands.

Larval host plants – Lays single eggs in the flower buds of *Thymus* spp.

Fig. 4.237: *Pseudophilotes baton* (Photo: Philippe Mothiron).

Fig. 4.238: *Pseudophilotes baton* (Photo: Philippe Mothiron).

Distribution

Luxembourg – Previously recorded sporadically in the Gutland and the Moselle before 1960. Last record in 1952 near Grevenmacher.

Neighbouring countries – No record since 2010 in the Greater Region (latest records in 1971 in Wallonia, after 2000 in Saarland, and in 2009 in French Lorraine).

Worldwide – Distributed from the Iberian Peninsula to central Europe.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. A comeback is unlikely.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

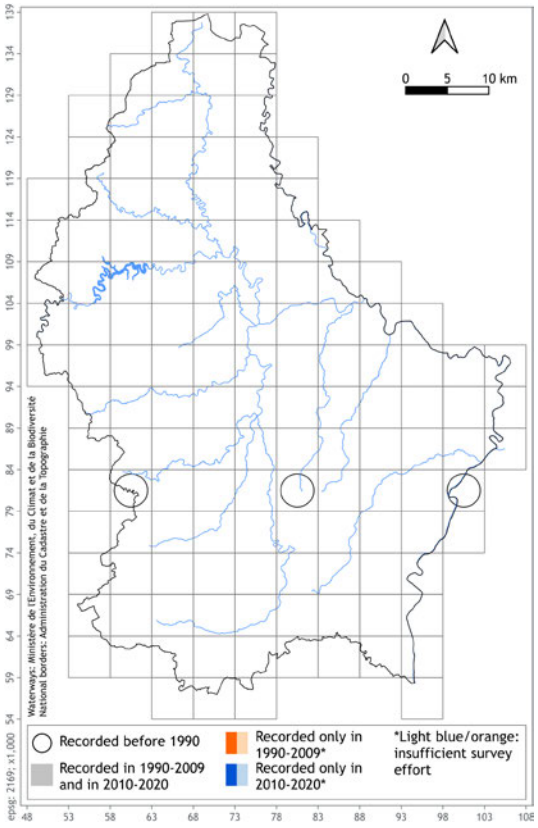


Fig. 4.239: Distribution change map at 5-km spatial resolution for *Pseudophilotes baton*.

Fig. 4.240: *Pseudophilotes baton* (Illustration: Anita Faber).

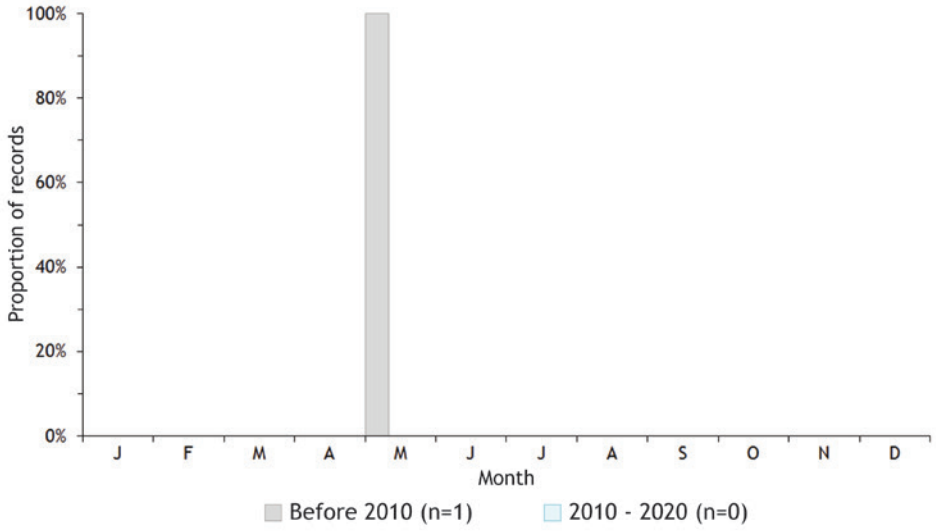


Fig. 4.241: Flight season of *Pseudophilotes baton* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Cyaniris semiargus

(Rottemburg, 1775)

Syn.: *Polyommatus semiargus*

L: Roudkléi-Bläuling

E: Mazarine blue

G: Rotklee-Bläuling

F: Azuré des anthyllides

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Possibly confused with *Cupido minimus*, *Cyaniris semiargus* differs by the black dots on the underside of its forewings, which form a curved line. It is also characterised by an optional but frequent association with ants, which provides it with some protection against parasites and predators.

Lifecycle

Bivoltine, sometimes three generations in favourable years. Flies mostly from May to late-September, with a first peak in late May and a second one in late July. Overwinters as intermediate stage caterpillar.

Habitat

Dry or wet open biotopes, such as flower-rich meadows, bog edges, clover fields, and road verges.

Fig. 4.242: *Cyaniris semiargus* (Photo: Youri Martin).

Fig. 4.243: *Cyaniris semiargus* (Photo: Alain Dohet).

Larval host plants – Lays typically single eggs deep in the flower heads of *Anthyllis vulneraria*, *Genista tinctoria*, *Melilotus officinalis*, *Trifolium pratense*, *Trifolium repens*, and *Ulex europaeus*.

Distribution

Luxembourg – Distributed across the whole country, but with higher population densities and availability of suitable habitats in the southern half of the country.

Worldwide – Palearctic species distributed throughout all Europe, except in the British Isles, and even reaching the Arctic Circle.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -10%

Relative change in extent of occurrence (geographical range): +5%

Considered as stable. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Promoting extensive management of grasslands such as reduced fertilisation and late mowing. Avoiding the drainage of wetlands.

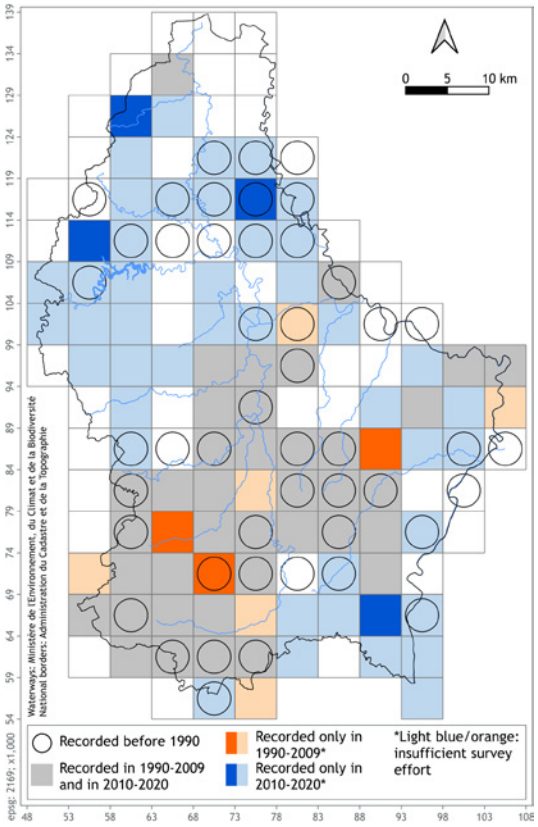


Fig. 4.244: Distribution change map at 5-km spatial resolution for *Cyaniris semiargus*.

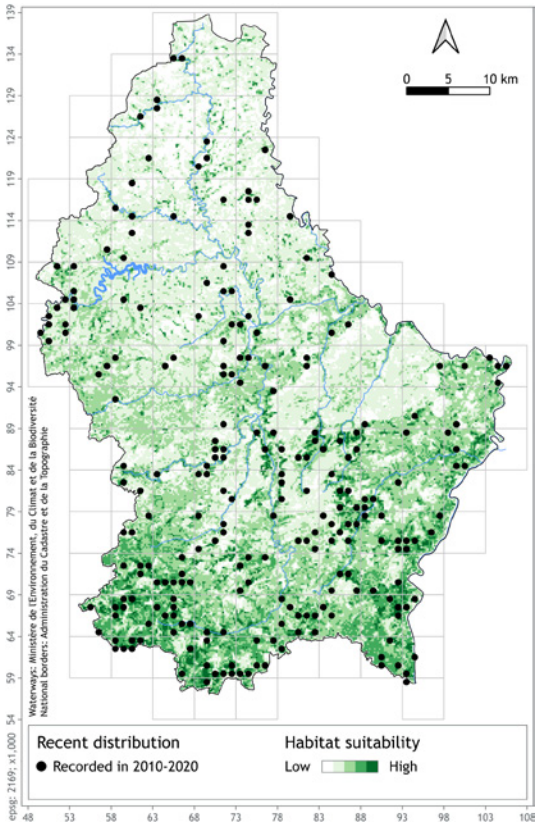


Fig. 4.245: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Cyaniris semiargus*.

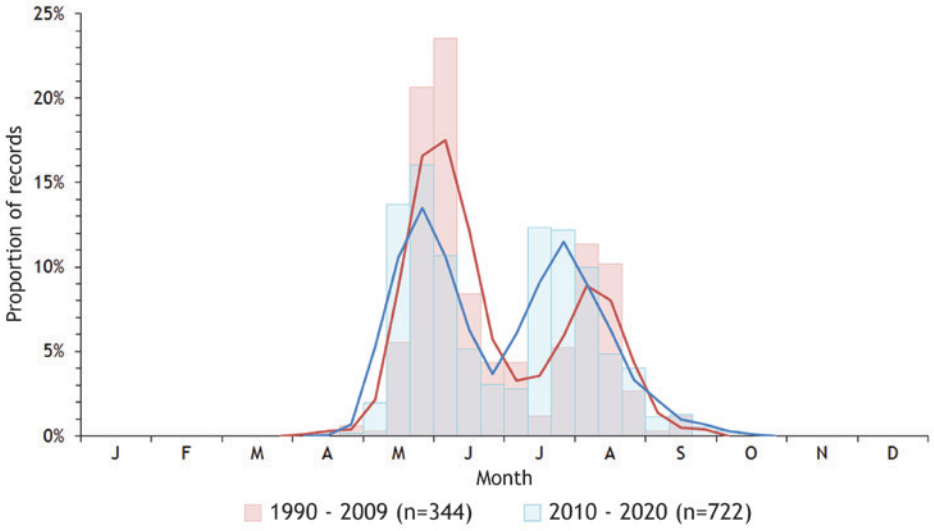


Fig. 4.246: Flight season of *Cyaniris semiargus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Polyommatus dorylas

([Denis & Schiffermüller], 1775)

L: Steekléi-Bläuling

E: Turquoise blue

G: Wundklee-Bläuling

F: Azuré du mélilot

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1950	Near Threatened

Although males are characterised by a dazzling bright blue colour on the upper side of the wings, the heart-shaped orange lunules not delimited by black marks in the internal underside of the hindwings is the most reliable identification criterion for both sexes.

Lifecycle

Bivoltine in neighbouring regions. Flies mostly from May to August. Overwinters as caterpillar.

Habitat

Warm and dry biotopes with short and sparse vegetation and rocky areas, such as flower-rich meadows, rocky slopes, embankments, and dry grasslands.

Fig. 4.247: *Polyommatus dorylas* (Photo: Wolfgang Wagner).

Fig. 4.248: *Polyommatus dorylas* (Photo: Owen Beckett).

Larval host plants – Lays single eggs on the underside of the leaves of *Anthyllis vulneraria*. Association with ants (*Lasius alienus, Myrmica scabrinodis* and *Formica cinereal*) offer some protection to the caterpillar against parasites and predators.

Distribution

Luxembourg – Previously recorded only three times near Leudelange, Niederanven (Gréngewald), and Steinfort in 1950.

Neighbouring countries – Recorded in north-western Rhineland-Palatinate until 2010, no recent record elsewhere in the Greater Region.

Worldwide – Palearctic species, patchily distributed from northern Spain across parts of Europe to western Asia.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. As the species is strongly declining in the north and the west of its native global range, especially in lowlands, its comeback in Luxembourg seems unlikely.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

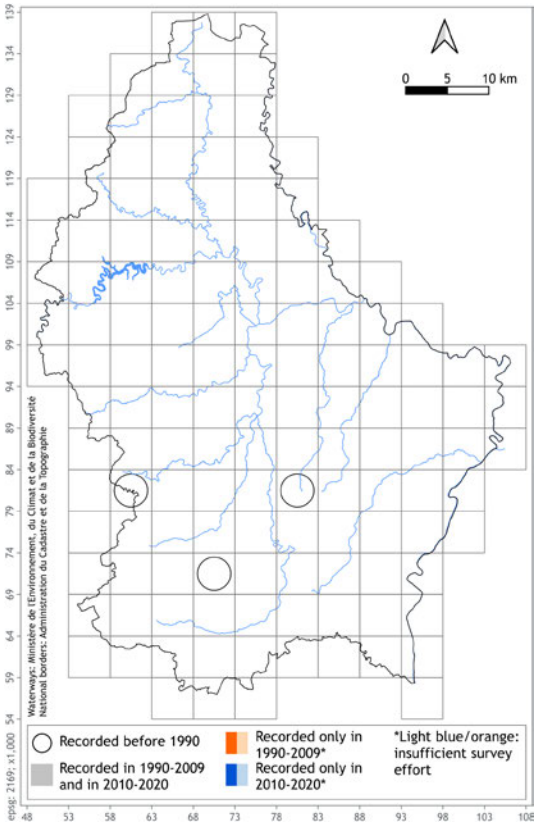


Fig. 4.249: Distribution change map at 5-km spatial resolution for *Polyommatus dorylas*.

Fig. 4.250: *Polyommatus dorylas* (Illustration: Anita Faber).

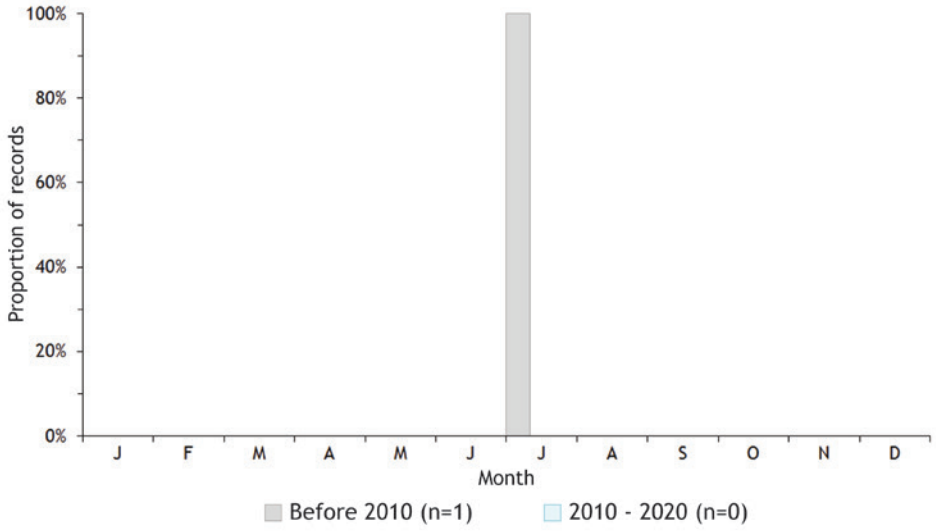


Fig. 4.251: Flight season of *Polyommatus dorylas* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Polyommatus icarus
(Rottemburg, 1775)

L: Dommeldar-Bläuling

E: Common blue

G: Hauhechel-Bläuling

F: Azuré commun

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

One of the most common blues. Myrmecophile species, the association with ants provides it with some protection against parasites and predators.

Lifecycle

Bivoltine, sometimes three generations in favourable years. Flies mostly from May to September, with a first peak in late May and a second one, slightly steeper, in early August. Overwinters at different developmental stages.

Habitat

Wide variety of wet to dry biotopes, such as meadows, grasslands, wastelands, forest clearings, road verges, gardens, and parks.

Larval host plants – Lays single eggs on various species from the Fabaceae family, such as *Anthyllis* spp., *Coronilla* spp., *Genista* spp., *Lotus corniculatus, L. pedunculatus, Medicago lupulina, Melilotus* spp., *Onobrychis viciifolia, Ononis repens, Trifolium spp.*, and *Vicia cracca*.

Fig. 4.252: *Polyommatus icarus* (Photo: Francis Birlenbach).

Fig. 4.253: *Polyommatus icarus* (Photo: Alain Dohet).

Distribution

Luxembourg – Homogeneously distributed across the whole country with suitable habitats available in every region, especially in southeastern part of the country.

Worldwide – From northern Africa across Europe to east Asia. Recently discovered in Canada.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +1%

Relative change in extent of occurrence (geographical range): +5%

Considered as stable.

Management

Promoting extensive management of herbaceous biotopes (e.g., reduction of agricultural inputs or livestock densities, late mowing).

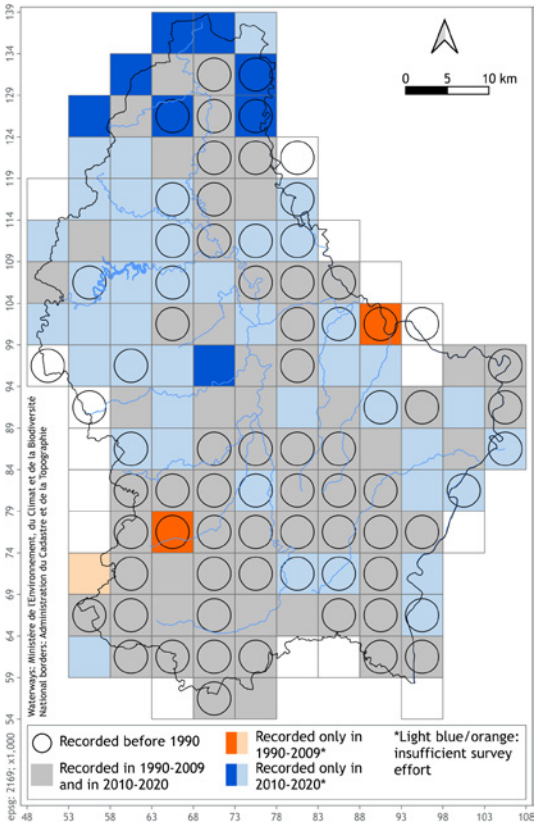


Fig. 4.254 Distribution change map at 5-km spatial resolution for *Polyommatus icarus*.

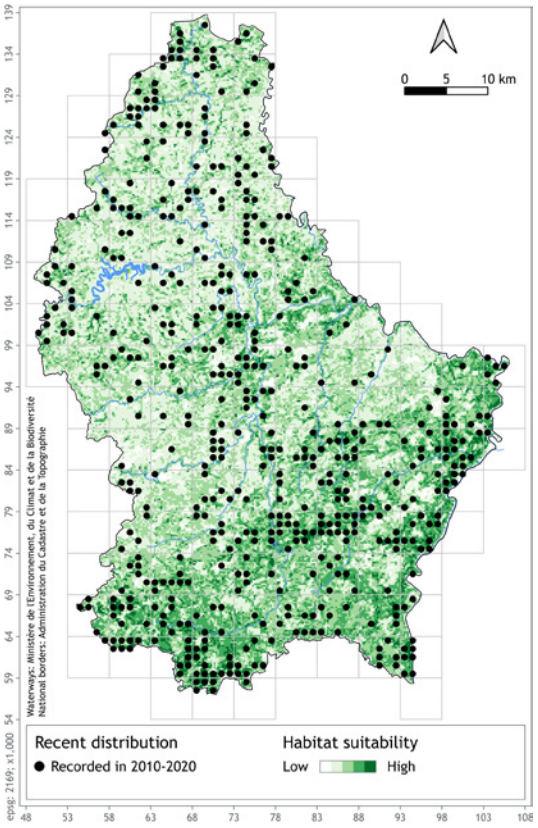


Fig. 4.255: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Polyommatus icarus*.

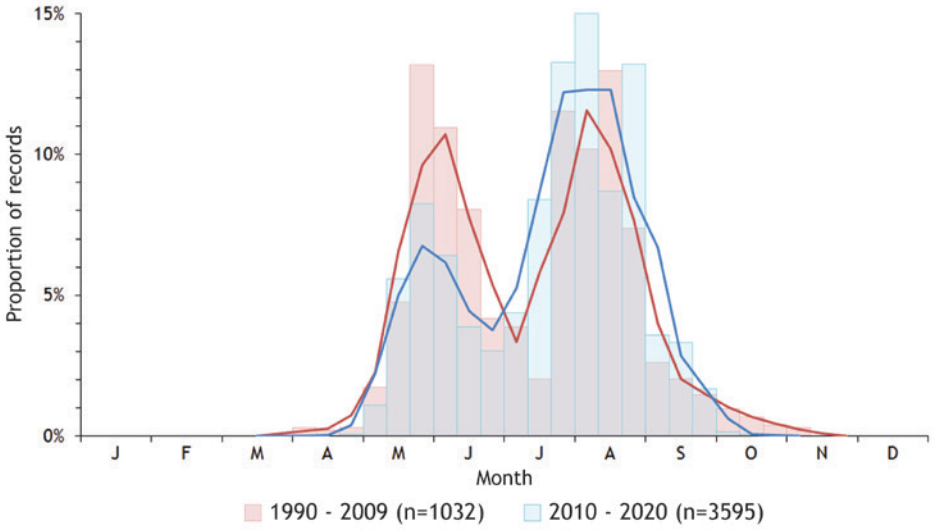


Fig. 4.256: Flight season of *Polyommatus icarus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lysandra coridon

(Poda, 1761)

Syn.: *Polyommatus coridon*

L: Sëlwergrénge Bläuling

E: Chalk-hill blue

G: Silbergrüner Bläuling

F: Argus bleu-nacré

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Near Threatened	Least Concern

Often observed flying in high numbers in favourable sites, *Lysandra coridon* has a frequent but optional relationship with ants. Females of *L. bellargus* and *L. coridon* can be distinguished based on the background colour on the underside of the forewings.

Lifecycle

Univoltine. Flies mostly from July to September. Overwinters as caterpillar.

Habitat

Warm and dry biotopes on calcareous substrates, such as dry calcareous grasslands and nutrient-poor, flower-rich meadows.

Larval host plants – Lays single eggs either on surrounding vegetation or directly on a stem of *Hippocrepis comosa* (main host plant). Other plants such as *Securigera varia*, *Trifolium* spp. and *Vicia* spp. are mentioned in the literature.

Fig. 4.257: *Lysandra coridon* (Photo: Alain Dohet).

Fig. 4.258: *Lysandra coridon* (Photo: Xavier Mestdagh).

Distribution

Luxembourg – Mostly distributed in the eastern part of the Minette where availability of suitable habitats is high, but with several populations established on smaller and more isolated patches of suitable habitats across the eastern part of the Gutland.

Worldwide – Endemic to Europe, follows globally the distribution of its main host plant: from northern Spain to the northern Netherlands, southern British Isles, in Ukraine and the Balkans.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +2%

Relative change in extent of occurrence (geographical range): -45%

Even though recorded in a stable number of 1-km grid cells, its range moderately contracted in 2010-2020.

Management

Avoiding shrub encroachment in dry grasslands and meadows with regular cutting and extensive grazing (cattle or sheep).

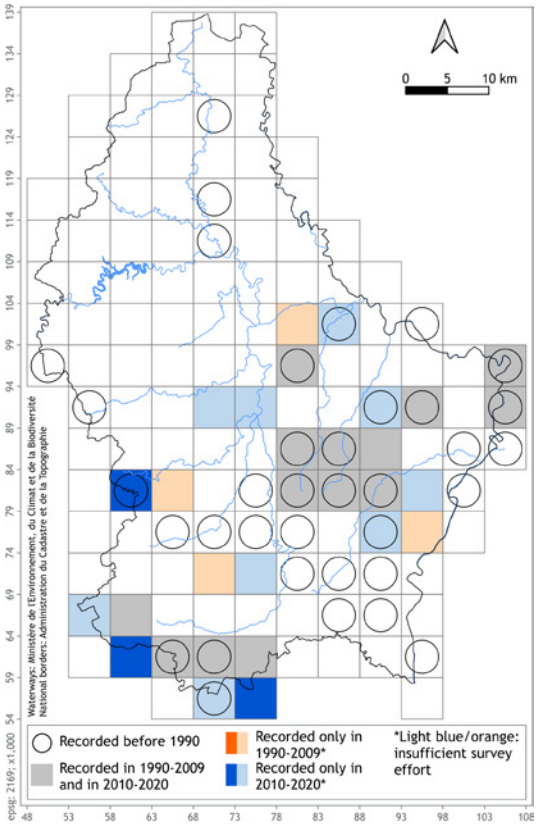


Fig. 4.259: Distribution change map at 5-km spatial resolution for *Lysandra coridon*.

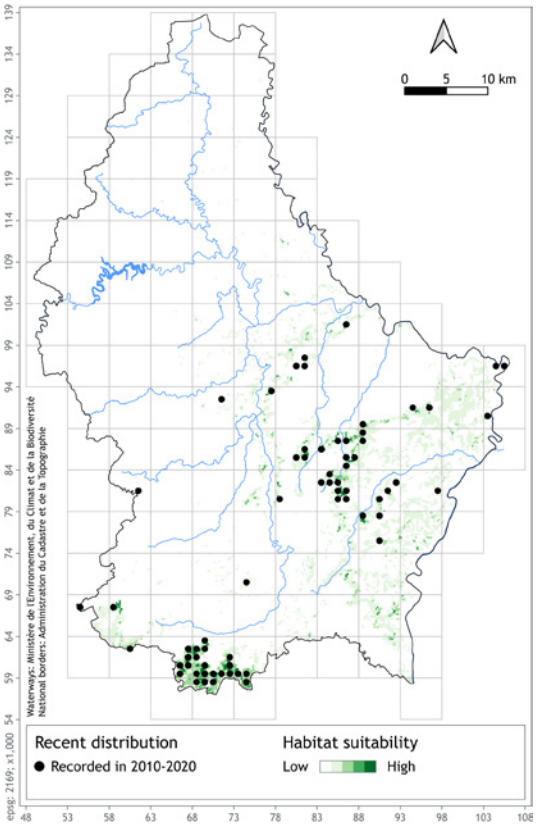


Fig. 4.260: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Lysandra coridon*.

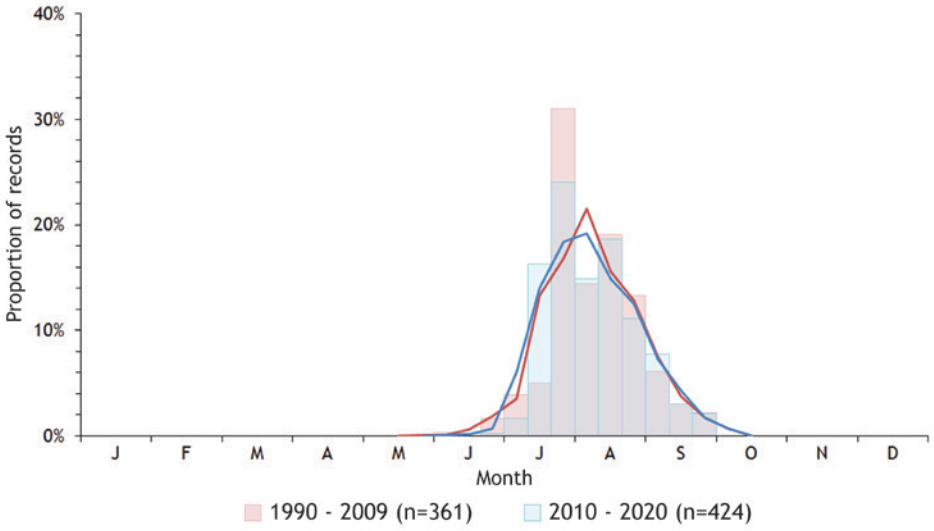


Fig. 4.261: Flight season of *Lysandra coridon* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Lysandra bellargus

(Rottemburg, 1775)

Syn.: *Polyommatus bellargus*

L: Himmelbloe Bläuling

E: Adonis blue

G: Himmelblauer Bläuling

F: Azuré bleu-céleste

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

Association with ants (*Lasius niger*, *L. alienus* or *Myrmica sabuleti*) provides it with some protection against parasites and predators. Fresh flying males are easily identifiable with their typical blue colour. Depending on the wear of its wings, it can be confused with *Polyommatus icarus* or *Lysandra coridon*.

Lifecycle

Bivoltine. Flies mostly from May to June and from late July to September with a first peak in late May and a second one in late August. Overwinters as caterpillar.

Habitat

Open, warm, and south-facing biotopes with short and sparse vegetation on calcareous substrates, such as dry calcareous grasslands, and non-exploited quarries in Luxembourg.

Fig. 4.262 *Lysandra bellargus* (Photo: Alain Dohet).

Fig. 4.263: *Lysandra bellargus* (Photo: Hubert Baltus).

Larval host plants – Lays single eggs on the underside of terminal leaves of *Hippocrepis comosa* and *Securigera varia*.

Distribution

Luxembourg – Mostly distributed in the eastern part of the Minette, with a few isolated populations established on small patches of suitable habitats (dry calcareous grasslands) near Fischbach, Junglinster, Rosport and Mompach.

Worldwide – Palearctic species distributed from southern and central Europe to western Asia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +15%

Relative change in extent of occurrence (geographical range): -64%

Even though recorded in a slightly increasing number of 1-km grid cells, its range strongly contracted in 2010-2020.

Management

Avoiding shrub encroachment and promoting short and sparse vegetation in dry grasslands with regular cutting and grazing (preferentially cattle). Creating corridors between remaining populations.

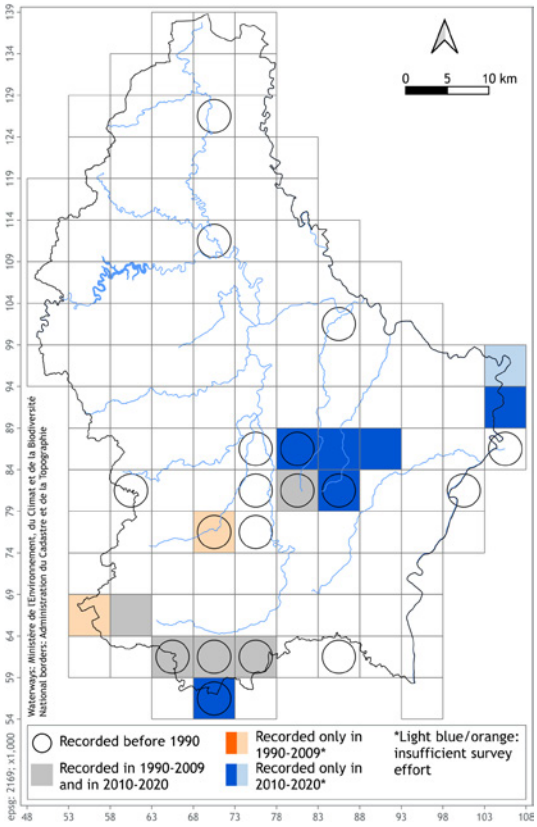


Fig. 4.264: Distribution change map at 5-km spatial resolution for *Lysandra bellargus*.

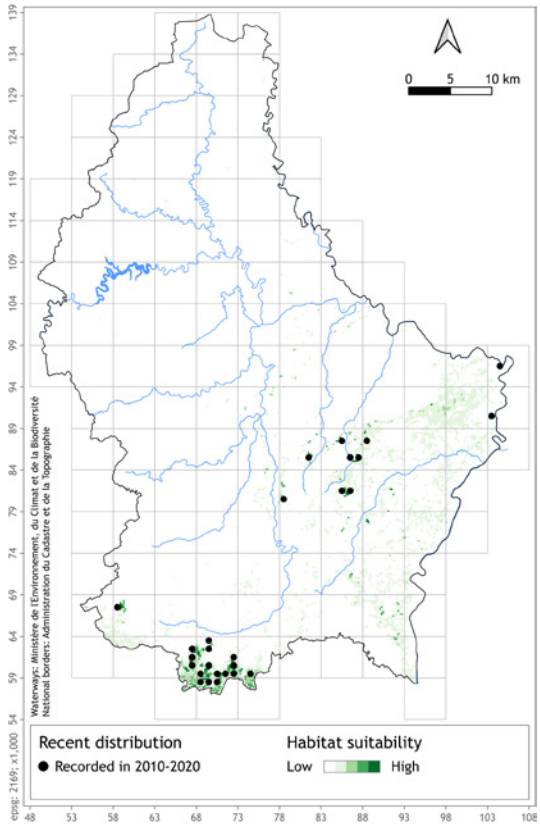


Fig. 4.265: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Lysandra bellargus*.

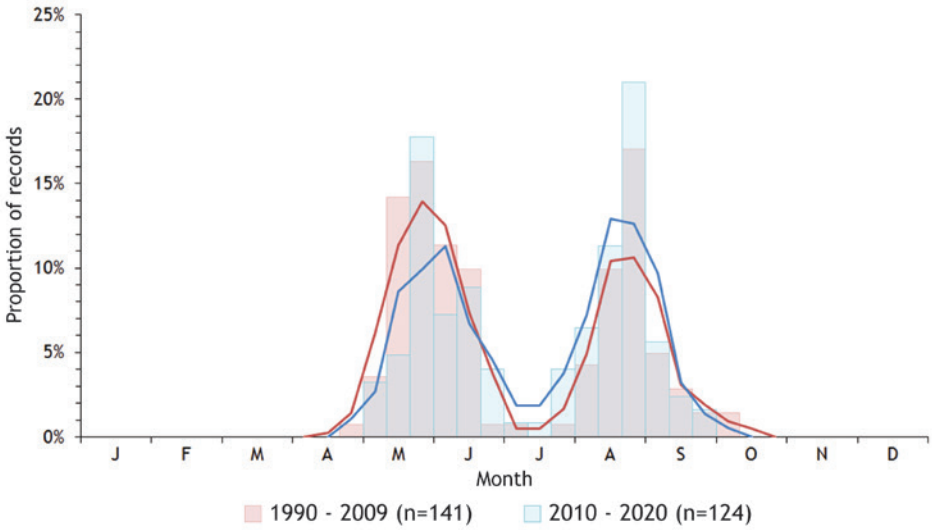


Fig. 4.266: Flight season of *Lysandra bellargus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Aricia agestis

([Denis & Schiffermüller], 1775)

L: Sonneréische-Bläuling

E: Brown argus

G: Kleiner Sonnenröschen-Bläuling

F: Collier-de-corail

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Aricia agestis is characterised by an optional but frequent association with ants, which provides it with some protection against parasites and predators.

Lifecycle

Mostly bivoltine, sometimes three generations in favourable years. Flies mostly from May to late September, with a first peak in late May and a second one, steeper, in August. Overwinters as second- or third-stage caterpillar.

Habitat

Various open and flowery biotopes, such as dry grasslands, wastelands, heathlands, flower-rich meadows, forest edges, and road verges.

Fig. 4.267: *Aricia agestis* (Photo: Roland Proess).

Fig. 4.268: *Aricia agestis* (Photo: Hubert Baltus).

Larval host plants – Lays single eggs, typically on the underside of leaves of *Calluna vulgaris*, *Erodium cicutarium*, *Helianthemum nummularium*, *Geranium* spp., and *Lotus corniculatus*.

Distribution

Luxembourg – Distributed across the whole country, but with lower densities in the Oesling and the northwestern part of the Gutland where suitable habitats are less available.

Worldwide – From northern Africa across southern and central Europe, parts of Asia to the Amur region.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +42%

Relative change in extent of occurrence (geographical range): -2%

Even though recorded in a moderately increasing number of 1-km grid cells (mainly in the Oesling), its range was considered as stable.

Management

Limiting the fertilisation and promoting late mowing and extensive grazing in grasslands and road verges. Promoting diversified herbaceous vegetation, including host plants in heathlands.

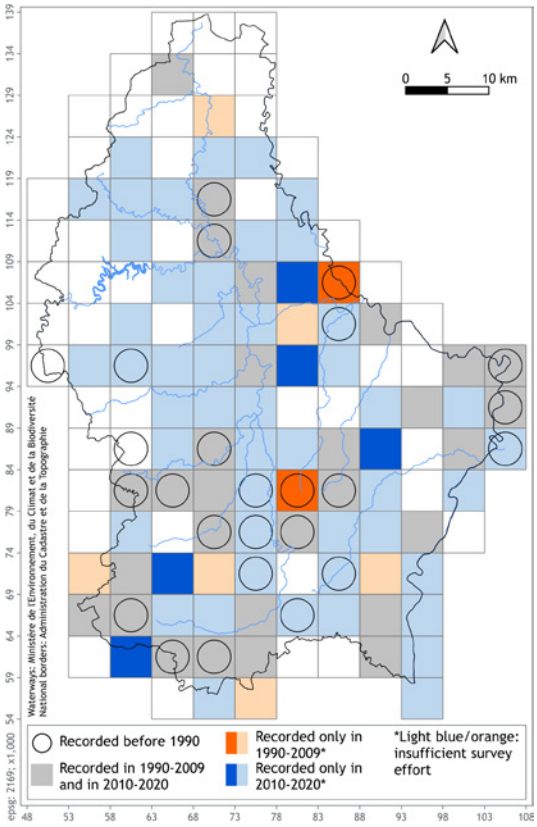


Fig. 4.269: Distribution change map at 5-km spatial resolution for *Aricia agestis*.

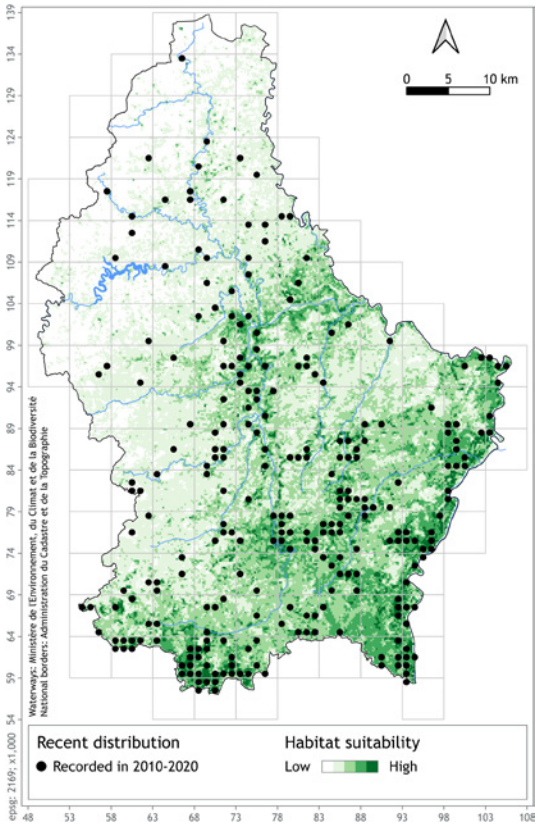


Fig. 4.270: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Aricia agestis*.

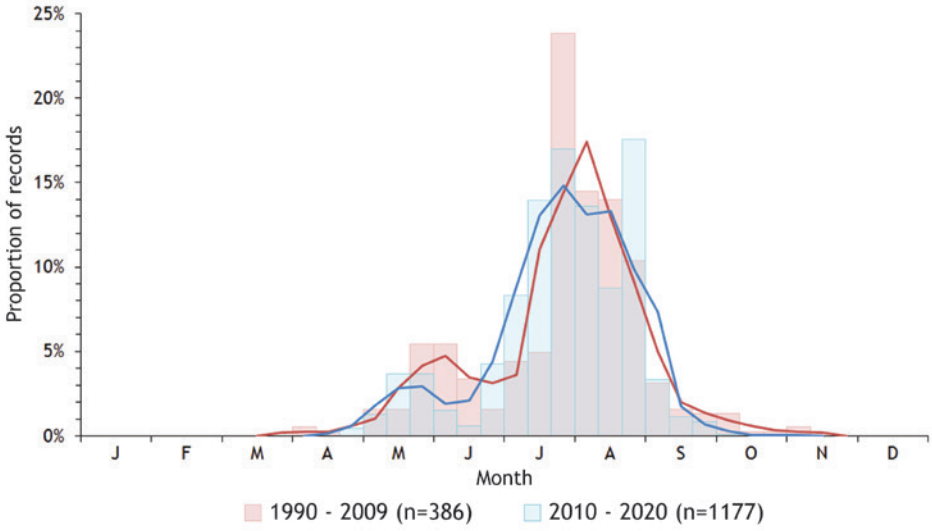


Fig. 4.271: Flight season of *Aricia agestis* representing the frequency distribution of species records over time at a 10-day temporal resolution.

LYCAENIDAE

Plebejus argus

(Linnaeus, 1758)

Syn.: *Plebeius argus*

L: Argus-Bläuling

E: Silver-studded blue

G: Argus-Bläuling

F: Azuré de l'ajonc

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Endangered	Least Concern

Plebejus argus is easily misidentified and confused with *P. idas* and *P. argyrognomon*. The examination of the tibia (presence of a spine on the foreleg tibia of *P. argus* males) and the genitalia are the only reliable criteria.

Lifecycle

Mostly univoltine. Flies mostly from May to mid-September, with a peak around early July. Overwinters as egg.

Habitat

Warm and dry biotopes such as flower-rich meadows and dry grasslands with short and sparse vegetation. Association with ants is mandatory (*Lasius alienus* and *L. niger*) for a successful development of the caterpillars.

Fig. 4.272: *Plebejus argus* (Photo: Xavier Mestdagh).

Fig. 4.273: *Plebejus argus* (Photo: Youri Martin).

Larval host plants – Lays single eggs either on surrounding vegetation or on various species from the Fabaceae and the Cistaceae family, such as *Anthyllis* spp., *Helianthemum nummularium*, *Hippocrepis comosa*, *Lotus corniculatus*, *Medicago* spp., *Trifolium* spp., *Ulex europaeus*, and *Vicia* spp.

Distribution

Luxembourg – Almost exclusively distributed in the Minette, with isolated records or established populations in the western to central Gutland and a few individuals recorded in Esch-sur-Sûre.

Worldwide – Palearctic species patchily distributed from western Europe to Japan.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -39%

Relative change in extent of occurrence (geographical range): -52%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted in 2010-2020. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Limiting the fertilisation and maintaining extensive grazing on nutrient-poor and dry grasslands. Creating corridors between remaining populations.

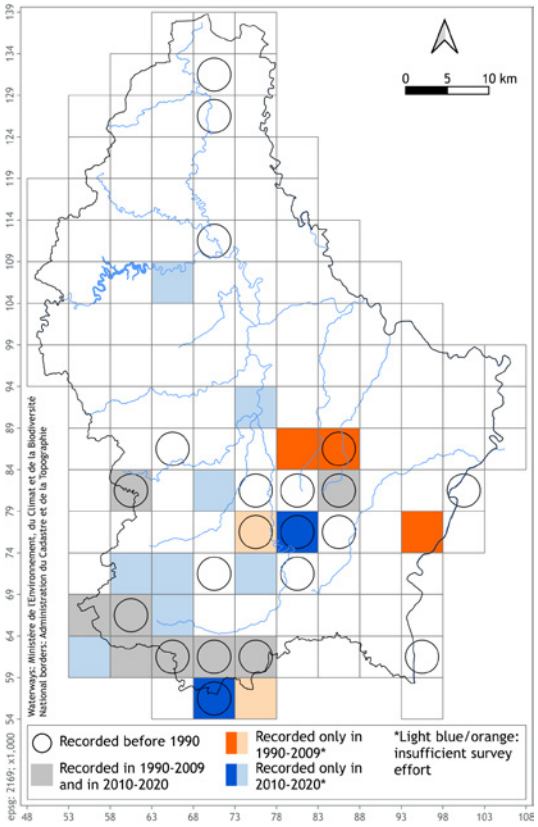


Fig. 4.274: Distribution change map at 5-km spatial resolution for *Plebejus argus*.

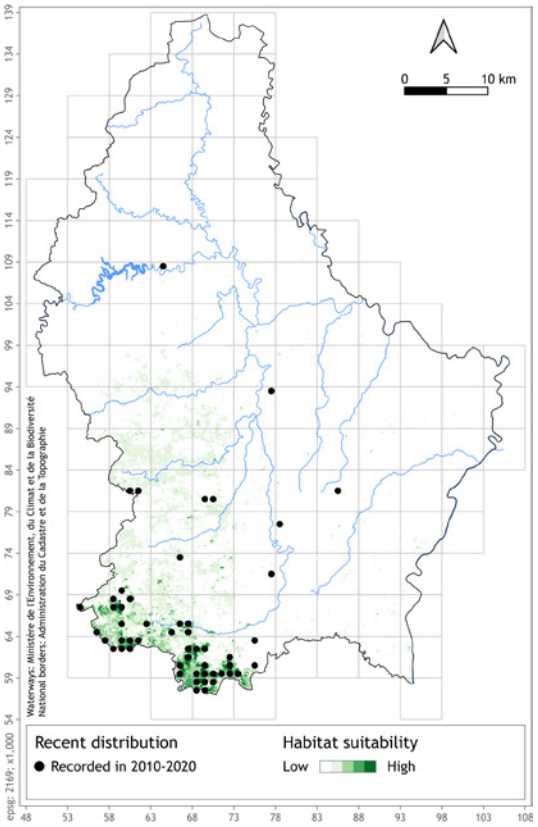


Fig. 4.275: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Plebejus argus*.

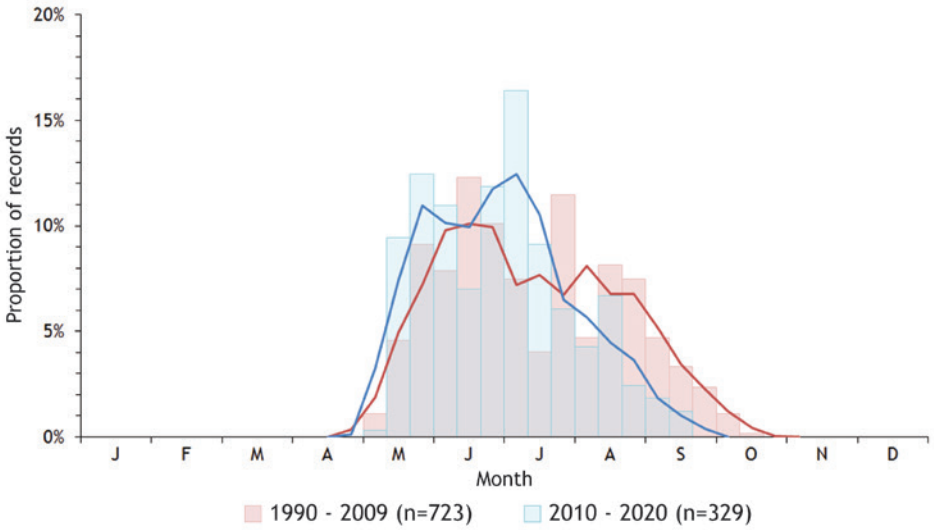


Fig. 4.276: Flight season of *Plebejus argus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Limenitis populi
(Linnaeus, 1758)

L: Groussen Äisvull
E: Poplar admiral
G: Großer Eisvogel
F: Grand sylvain

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Endangered	Near Threatened

Limenitis populi is a mobile forest butterfly spending most of its lifespan high in the canopy, making it difficult to detect. Females are rarely observed but males can be seen mud-puddling on the ground, faeces and even animal carcasses to obtain mineral salts required for their fertility.

Lifecycle

Univoltine. Flies from June to August. Overwinters as young caterpillar within a shelter it builds on a branch with a piece of leaf.

Habitat

Warm and wet deciduous forests rich in poplar trees and open areas, such as unexploited damp forests, fringes of forest ponds, fallows near forest edges, open coppice forests, clearings and forest paths rich in native poplar trees.

Fig. 4.277 *Limenitis populi* (Photo: Stéphane Vizthum).

Fig. 4.278: *Limenitis populi* (Photo: Stéphane Vizthum).

Larval host plants – Lays single eggs on the upper side of poplar leaves (mostly *Populus tremula* but sometimes also *P. nigra*).

Distribution

Luxembourg – Very patchily distributed in the Minette, western half Gutland and eastern Oesling, at least partly due to inconspicuousness and low detectability.

Worldwide – Palearctic species, from continental Europe (in sparse and isolated populations), across temperate Asia to Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -50%

Relative change in extent of occurrence (geographical range): -57%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted in 2010-2020.

Management

Restoring and maintaining riparian and deciduous forests rich in native species including dense patches of poplars and well-structured inner and outer forest edges.

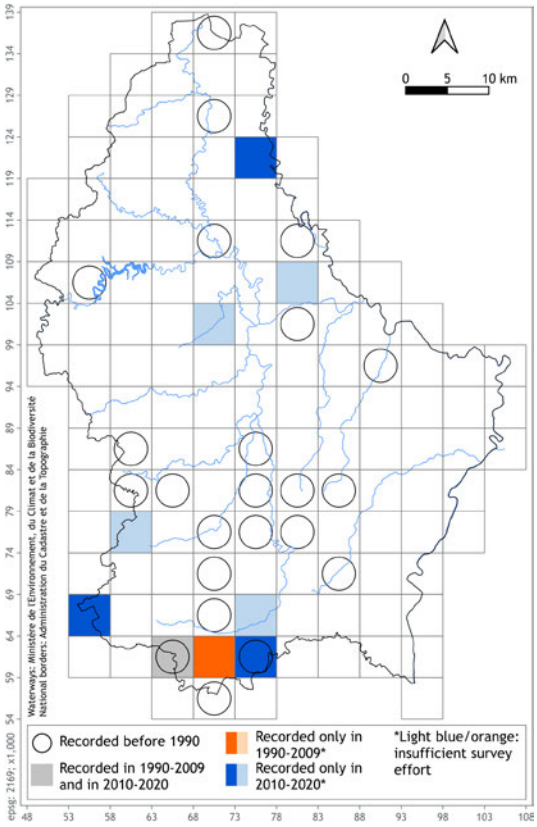


Fig. 4.279: Distribution change map at 5-km spatial resolution for *Limenitis populi*.

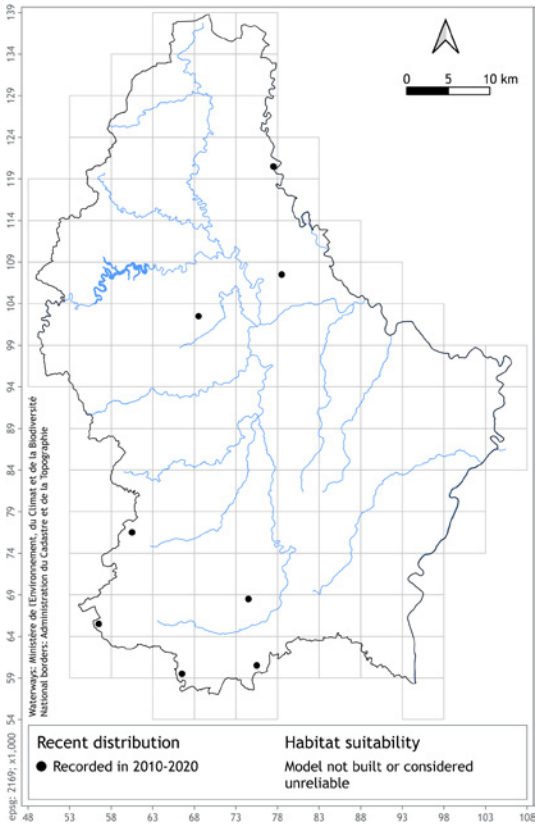


Fig. 4.280: Distribution map at 1-km spatial resolution for *Limenitis populi*.

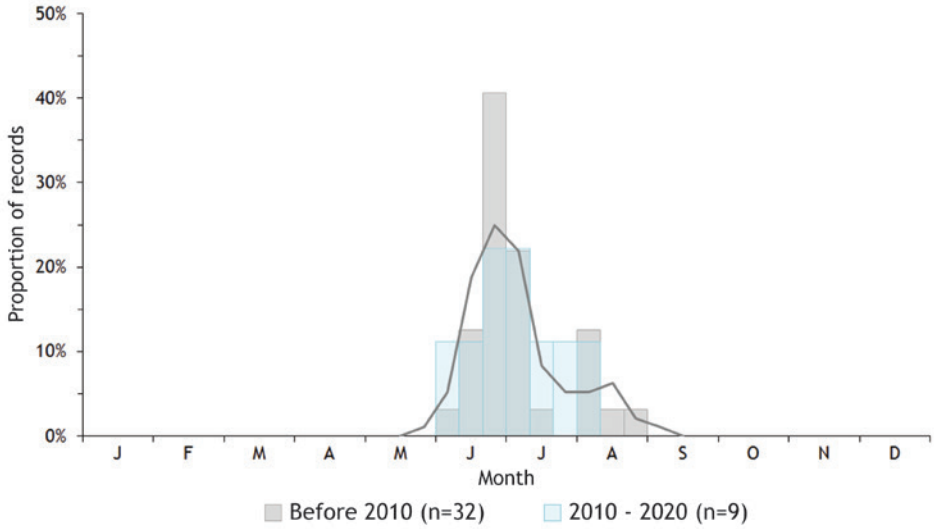


Fig. 4.281: Flight season of *Limenitis populi* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Limenitis camilla

(Linnaeus, 1764)

L: Klengen Äisvull

E: Eurasian white admiral

G: Kleiner Eisvogel

F: Petit sylvain

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Limenitis camilla is a forest butterfly often observed feeding on brambles or sucking minerals from mud, faeces, or carcasses (mud-puddling).

Lifecycle

Univoltine. Few individuals from a second generation are observed in some years. Flies from late May to early August with a peak in early July. Overwinters as young caterpillar within a dry leaf attached to the plant.

Habitat

Shady forests where its host plants grow, typically in coppice forests, well-structured forest edges, sunny clearings, and open forest paths.

Larval host plants – Lays single globular eggs (looking like a miniature sea urchin) on honeysuckle leaves (*Lonicera periclymenum* and *L. xylosteum*), less than two metres above the ground.

Fig. 4.282: *Limenitis camilla* (Photo: Roland Proess).

Fig. 4.283: *Limenitis camilla* (Photo: Lionel L'Hoste).

Distribution

Luxembourg – Patchily distributed across most of the country, with suitable habitats mostly available in the Minette and, to a lower extent, in forested areas of the Oesling and the Gutland.

Worldwide – Widely distributed throughout much of temperate Europe and temperate Asia to Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): 0%

Relative change in extent of occurrence (geographical range): +21%

Although recorded in a stable number of 1-km grid cells, its range moderately expanded in 2010-2020. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Promoting rotational management of hedges and forest (inner and outer) edges over multiple years to create spatial and temporal heterogeneity. Avoiding the asphalting of forest paths.

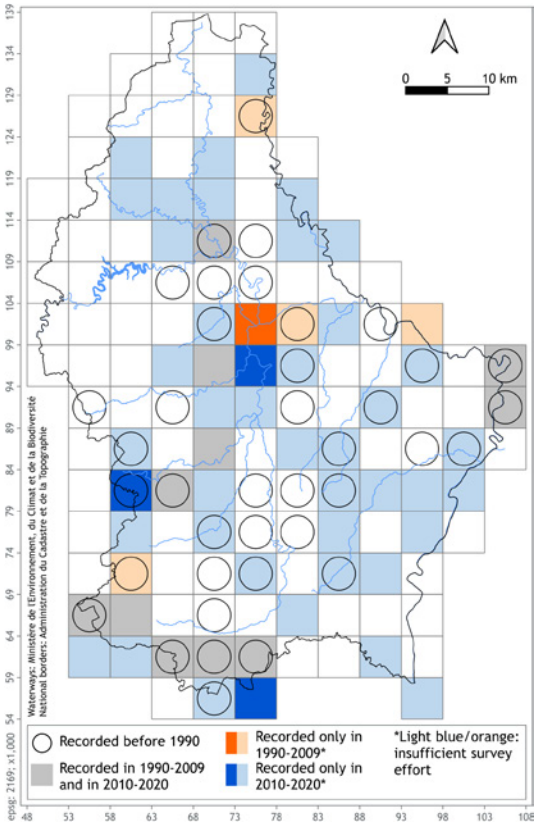


Fig. 4.284: Distribution change map at 5-km spatial resolution for *Limenitis camilla*.

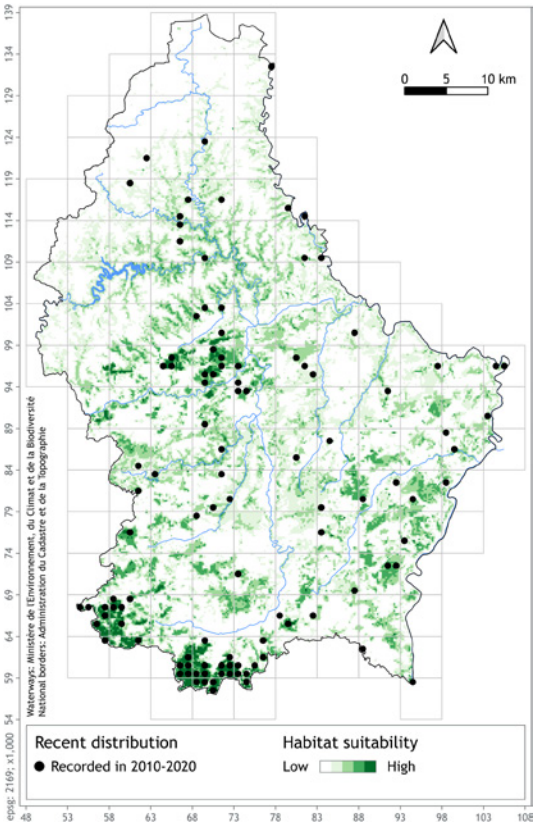


Fig. 4.285: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Limenitis camilla*.

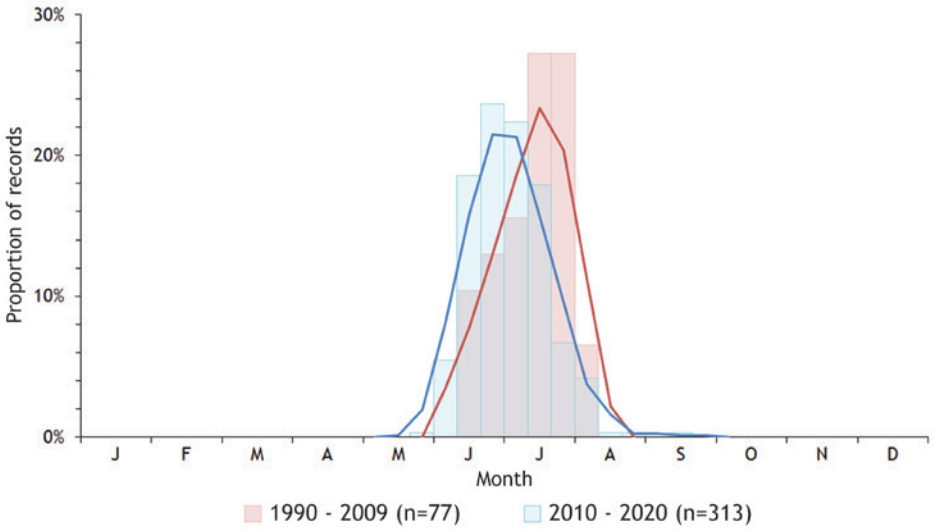


Fig. 4.286: Flight season of *Limenitis camilla* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Apatura iris
(Linnaeus, 1758)

L: Grousse Schillerfalter
E: Purple emperor
G: Großer Schillerfalter
F: Grand mars changeant

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

Apatura iris is a mobile forest butterfly. Males can be seen mud-puddling on the moist ground, faeces and animal carcasses which provide the mineral salts required for their sexual fertility. Females spend much of their time resting high up in the canopy, making their detection difficult.

Lifecycle

Univoltine. Flies mostly from early June to late July with a peak in early July. Overwinters as a young caterpillar on branches.

Habitat

Cool but sunny locations, mainly in wet and open deciduous forests, riparian forests, forest clearings, forest edges, and forest paths.

Fig. 4.287: *Apatura iris* (Photo: Roland Proess).

Fig. 4.288: *Apatura iris* (Photo: Alain Dohet).

Larval host plants – Lays single eggs on the upper side of sallow leaves (mainly *Salix caprea*). *Alnus* spp. and *Populus* spp. can also be used.

Distribution

Luxembourg – Patchily distributed across most of the country.

Worldwide – Across temperate Europe and from temperate Asia to Korea.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -51%

Relative change in extent of occurrence (geographical range): -10%

Although recorded in a strongly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Restoring and maintaining riparian and alluvial deciduous forests with native tree species. Avoiding the asphalting of forest paths.

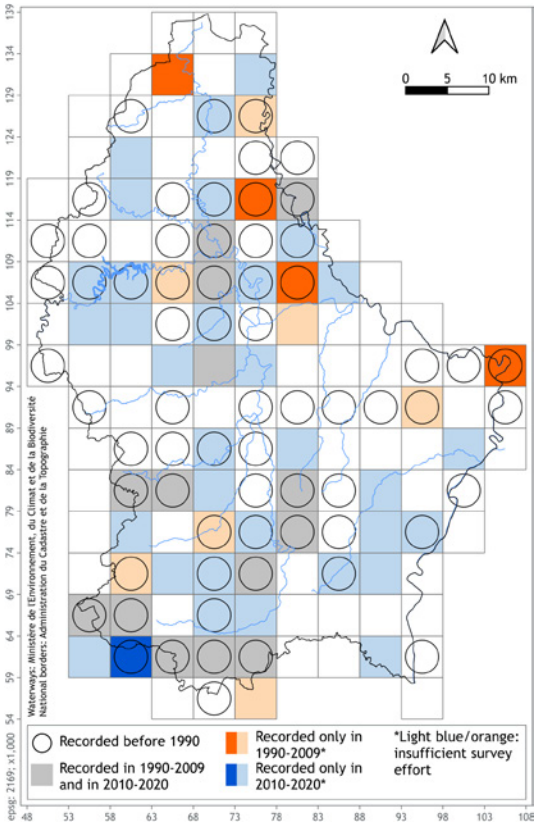


Fig. 4.289: Distribution change map at 5-km spatial resolution for *Apatura iris*.

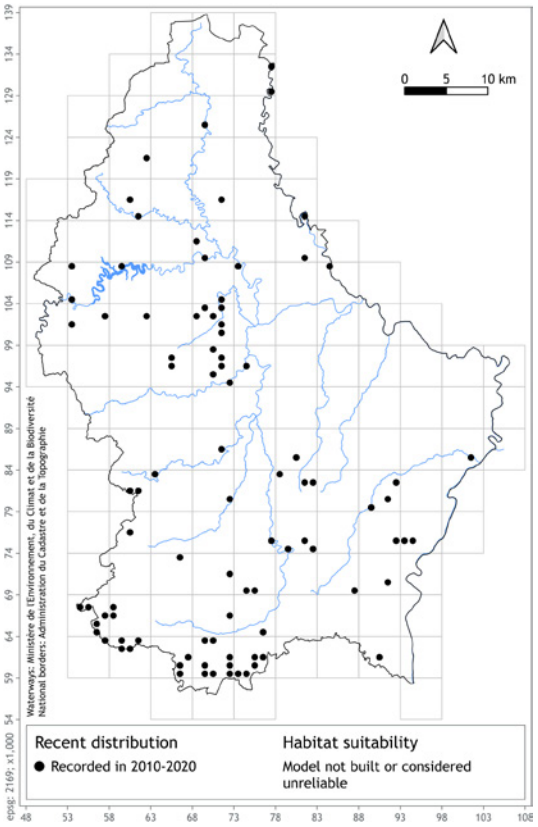


Fig. 4.290: Distribution map at 1-km spatial resolution for *Apatura iris*.

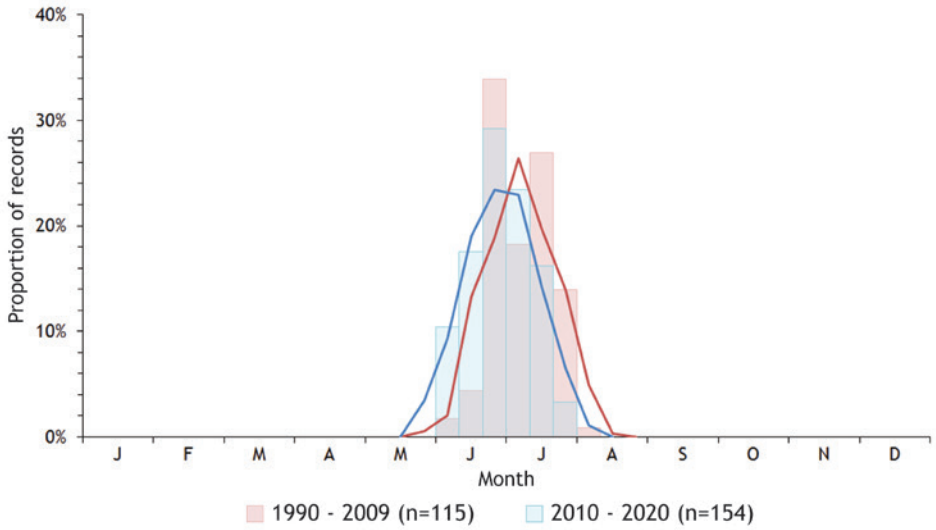


Fig. 4.291: Flight season of *Apatura iris* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Apatura ilia

([Denis & Schiffermüller], 1775)

L: Klenge Schillerfalter

E: Lesser purple emperor

G: Kleiner Schillerfalter

F: Petit mars changeant

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Apatura ilia is a forest butterfly whose males are commonly seen mud-puddling on substrates, faeces and even animal carcasses to obtain mineral salts required for their sexual fertility. Females are rarely observed. *A. ilia* occurs in two distinctive coloured forms often flying together: on the upper side of the wings, the margins and areas that are white on the *ilia* form are orange-coloured on the *clytie* form.

Lifecycle

Univoltine, but exceptionally bivoltine in favourable years. Flies mostly from June to early August with a peak in early July (relatively short flight season). Overwinters as a young caterpillar close to the terminal bud of branches.

Fig. 4.292: *Apatura ilia* (Photo: Francis Birlenbach).

Fig. 4.293: *Apatura ilia* (Photo: Marcel Hellers).

Habitat

Sunny locations mostly in damp and open deciduous forests, riparian forests, forest clearings, forest edges, and forest paths.

Larval host plants – Lays single eggs mostly on the upper side of the leaves of *Populus nigra*, *P. tremula* and *P. italica* at around 5 metres high, often in wet atmospheric conditions but sometimes on isolated and sunny trees. *Alnus glutinosa* and *Salix* spp. are less often used.

Distribution

Luxembourg – Very patchily distributed across the country but not recorded in the northernmost part of the Oesling.

Worldwide – Lowland species distributed in most of Europe across temperate Asia to Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -7%

Relative change in extent of occurrence (geographical range): +47%

Even though recorded in a stable number of 1-km grid cells, its range moderately expanded in 2010-2020.

Management

Restoring and maintaining riparian and alluvial deciduous forests with native tree species. Avoiding the asphalting of forest paths.

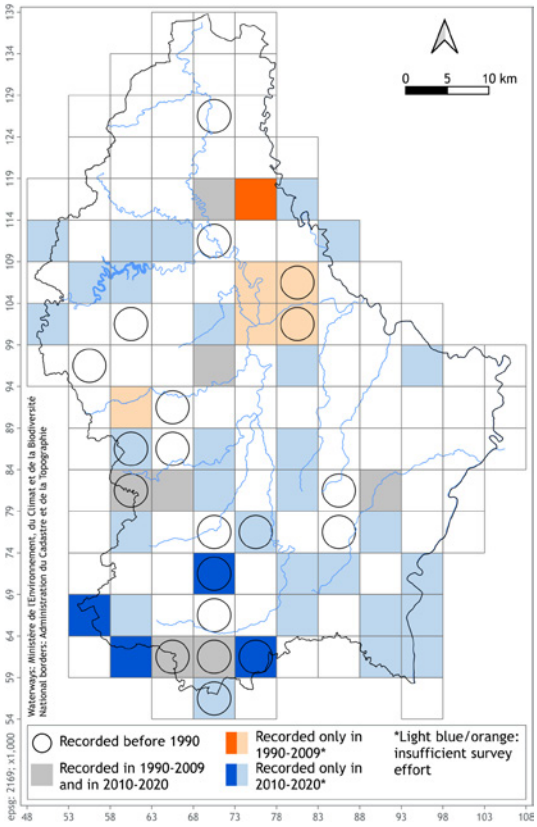


Fig. 4.294: Distribution change map at 5-km spatial resolution for *Apatura ilia*.

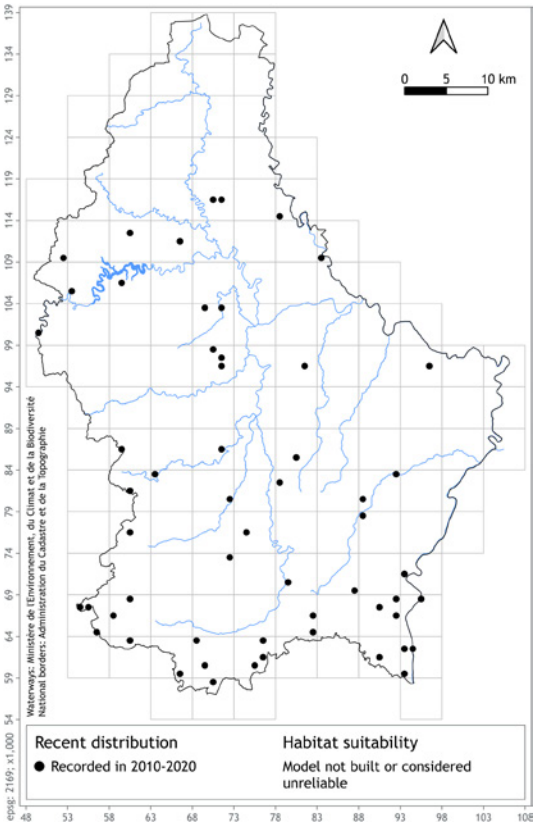


Fig. 4.295: Distribution map at 1-km spatial resolution for *Apatura ilia*.

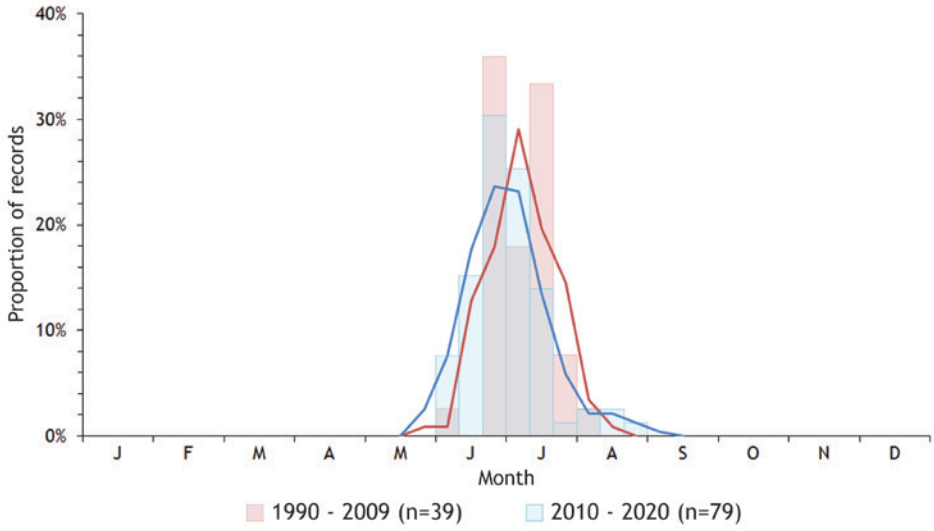


Fig. 4.296: Flight season of *Apatura ilia* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Argynnis paphia
(Linnaeus, 1758)

L: Keesermantel

E: Silver-washed fritillary

G: Kaisermantel

F: Tabac d'Espagne

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

At the beginning of the flight season, individuals fly unceasingly with a powerful flight and start to be quieter after a few days while actively visiting flowers. As a probable result of climate change, *Argynnis paphia* has recently shown northward expansion across Europe.

Lifecycle

Univoltine. Flies mostly from June to early September, with a peak in late July. Overwinters as unfed caterpillar after hatching.

Habitat

Deciduous and coniferous forests where nectar sources and larval host plants are present, such as inner and outer forest edges and clearings. Adults are highly mobile in late summer and are often observed outside forests in search of flowering plants, even in gardens.

Fig. 4.297: *Argynnis paphia* (Photo: Roland Proess).

Fig. 4.298: *Argynnis paphia* (Photo: Michelle Clemens).

Nectar resources – Feeds on *Cirsium* spp., *Eupatorium cannabinum*, *Sambucus ebulus*, *Rubus* spp., *Origanum vulgare*, and even *Buddleja davidii* (an invasive alien species).

Larval host plants – Lays eggs on the bark of trees close to the host plants, violets (*Viola canina*, *V. hirta*, *V. palustris*, *V. reichenbachiana*, *V. riviniana*, and *V. tricolor*), up to several meters high and mostly along forest edges.

Distribution

Luxembourg – Densely distributed in the Minette, in the Moselle and in some valley bottoms of the Gutland, but patchily distributed in the other regions where availability of suitable habitats is lower.

Worldwide – Palearctic species distributed in northern Africa, most of Europe and temperate Asia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +8%

Relative change in extent of occurrence (geographical range): +7%

Considered as stable.

Management

Promoting well-structured forest edges with *Viola* spp. and flower-rich areas in the landscape (e.g., forest edges, forest paths, forest clearings, road verges, pastures).

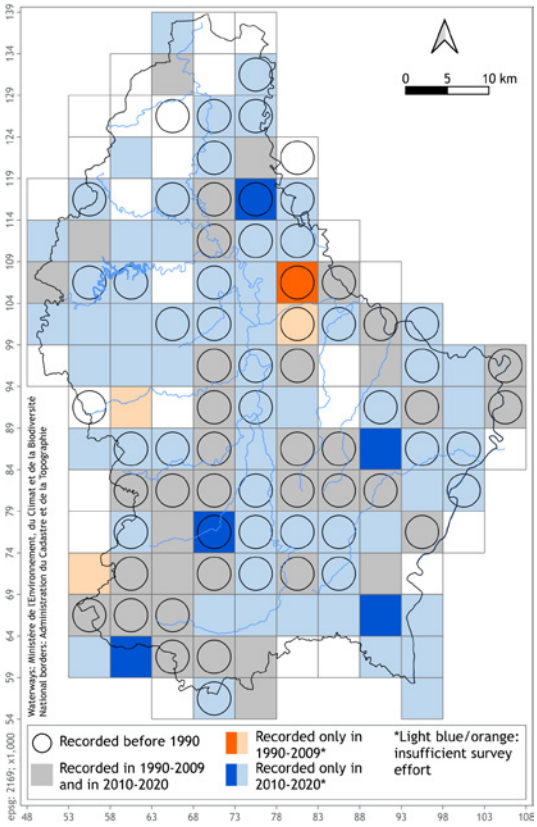


Fig. 4.299: Distribution change map at 5-km spatial resolution for *Argynnis paphia*.

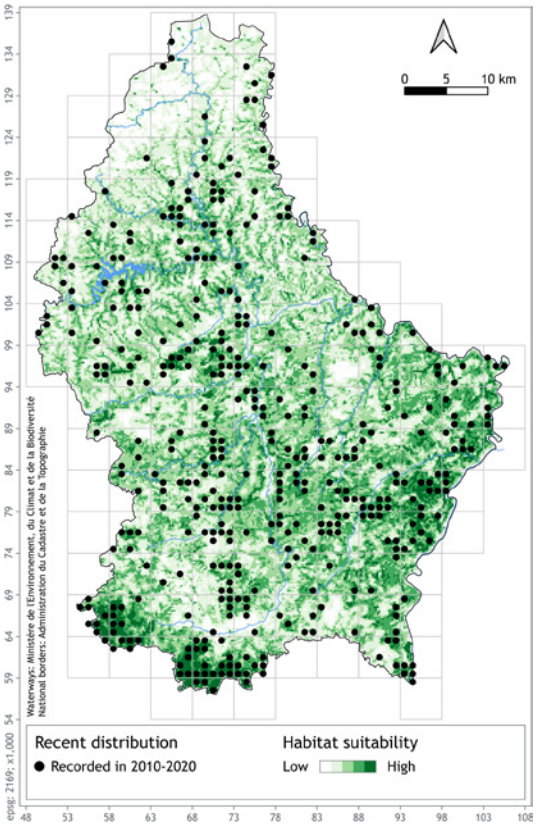


Fig. 4.300: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Argynnis paphia*.

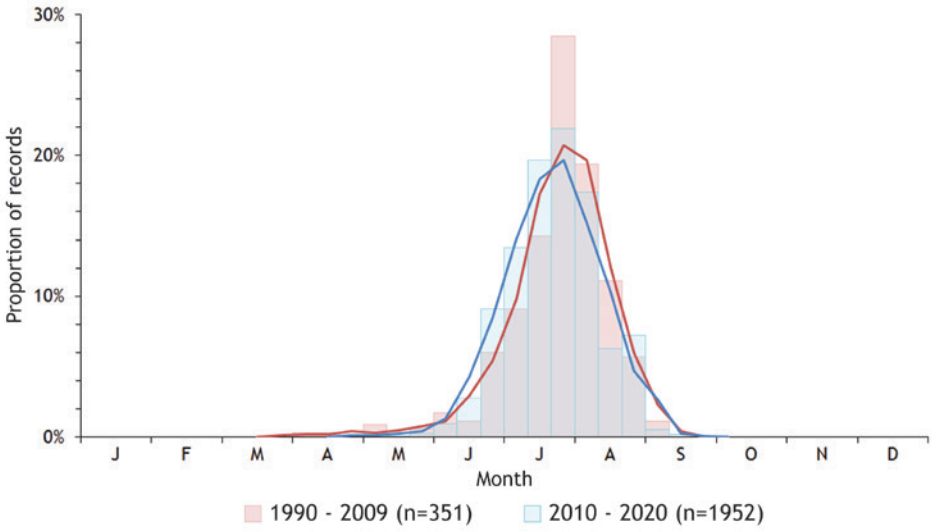


Fig. 4.301: Flight season of *Argynnis paphia* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Speyeria aglaja

(Linnaeus, 1758)

Syn.: *Argynnis aglaja*

L: Groussen Nackerfalter

E: Dark green fritillary

G: Großer Perlmutterfalter

F: Grand nacré

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

Often flying together, *Speyeria aglaja* can be easily mistaken with *Fabriciana adippe* unless the underside of the wings can be observed when foraging or resting on vegetation. Despite its powerful flight, it is not particularly mobile.

Lifecycle

Univoltine. Flies mostly from May to August, with a peak in July. Overwinters as caterpillar in the egg.

Habitat

Wide variety of biotopes such as wet flower-rich meadows that are seldom mown, dry grasslands, forest edges, and forest clearings.

Larval host plants – Lays single eggs usually near the host plants (*Viola hirta*, *V. tricolor*, *V. palustris*, *V. canina*, and *Bistorta officinalis*) that caterpillars look for when emerging in spring.

Fig. 4.302: *Speyeria aglaja* (Photo: Hubert Baltus).

Fig. 4.303: *Speyeria aglaja* (Photo: Alain Dohet).

Distribution

Luxembourg – Nowadays, almost exclusively distributed in the Minette, with a few records in isolated patches of suitable habitats in the rest of the country.

Worldwide – From northern Africa, most of Europe and temperate Asia to China and Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -50%

Relative change in extent of occurrence (geographical range): -6%

Although recorded in a moderately decreasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting light forest undergrowth in deciduous forests and well-structured south-facing forest edges with the host plants (*Viola* spp.) in the direct vicinity of flower-rich areas (brambles and nutrient-poor grasslands) flowering during the flight season of the species.

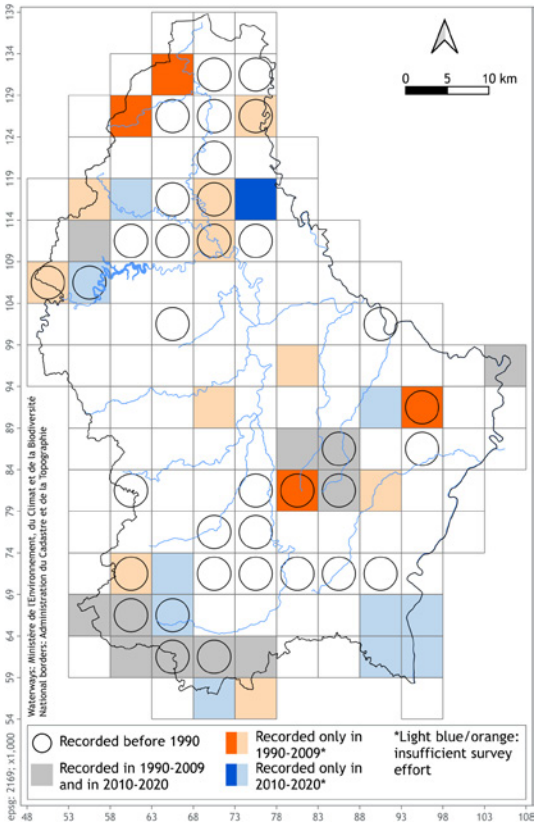


Fig. 4.304: Distribution change map at 5-km spatial resolution for *Speyeria aglaja*.

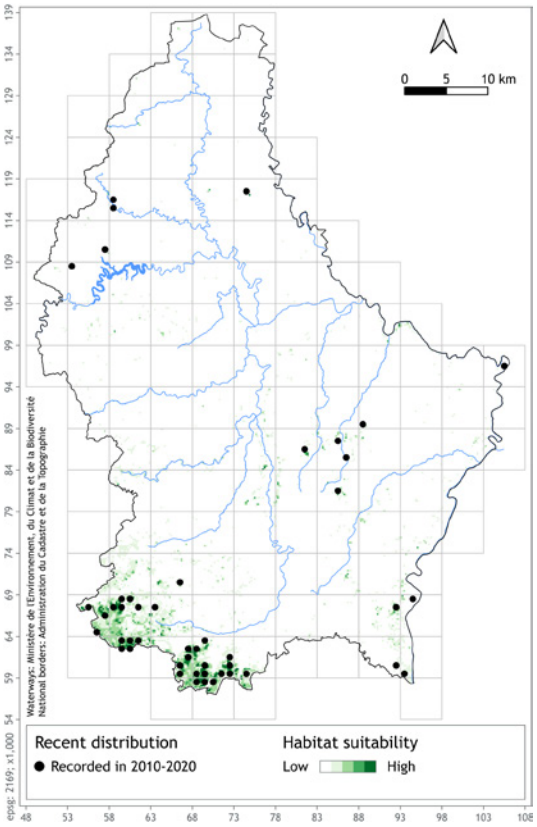


Fig. 4.305: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Speyeria aglaja*.

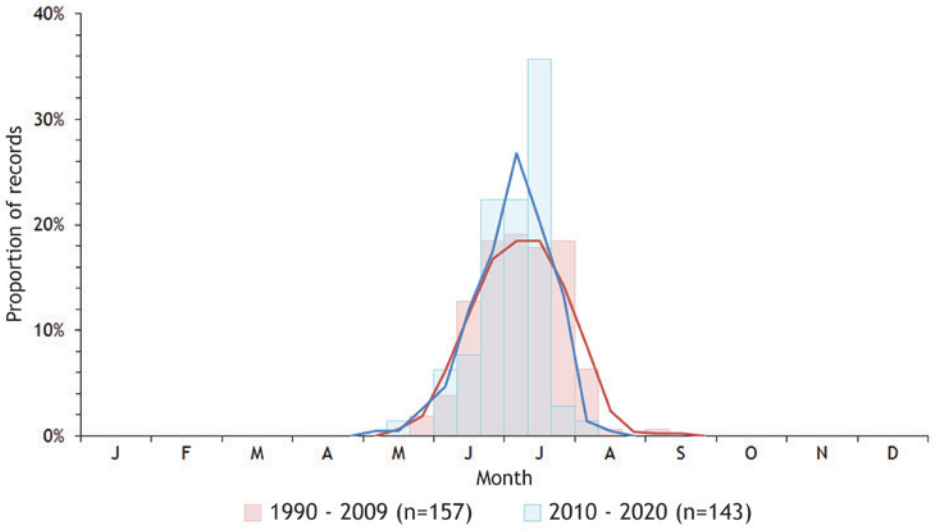


Fig. 4.306: Flight season of *Speyeria aglaja* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Fabriciana adippe

([Denis & Schiffermüller], 1775)

Syn.: *Argynnis adippe*

L: Sëlwer-Nackerfalter

E: High brown fritillary

G: Feuriger Perlmutterfalter

F: Moyen nacré

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Critically Endangered	Least Concern

Often flying together, *Fabriciana adippe* can easily be confused with *Speyeria aglaja* unless the underside of the wings can be distinguished when feeding or resting on vegetation.

Lifecycle

Univoltine. Flies mostly from June to August with a peak in July. Overwinters as caterpillar in the egg.

Habitat

Various open biotopes sufficiently warm and sunny to allow the larval development and the growth of its host plants, often very close to deciduous forest.

Larval host plants – Lays single eggs on or nearby various species of violets, such as *Viola canina, V. palustris, V. odorata, V. reichenbachiana, V. riviniana,* and *V. tricolor*.

Fig. 4.307: *Fabriciana adippe* (Photo: Alain Dohet).

Fig. 4.308: *Fabriciana adippe* (Photo: Alain Dohet).

Distribution

Luxembourg – Nowadays, exclusively distributed close to forested areas in the Minette.

Worldwide – Palearctic species distributed from northwestern Africa across much of Europe to temperate Asia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -57%

Relative change in extent of occurrence (geographical range): -97%

Strongly decreasing.

Management

Promoting light deciduous forest undergrowth and well-structured south-facing forest edges with the host plants (*Viola* spp.) close to flower-rich areas (brambles and nutrient-poor grasslands).

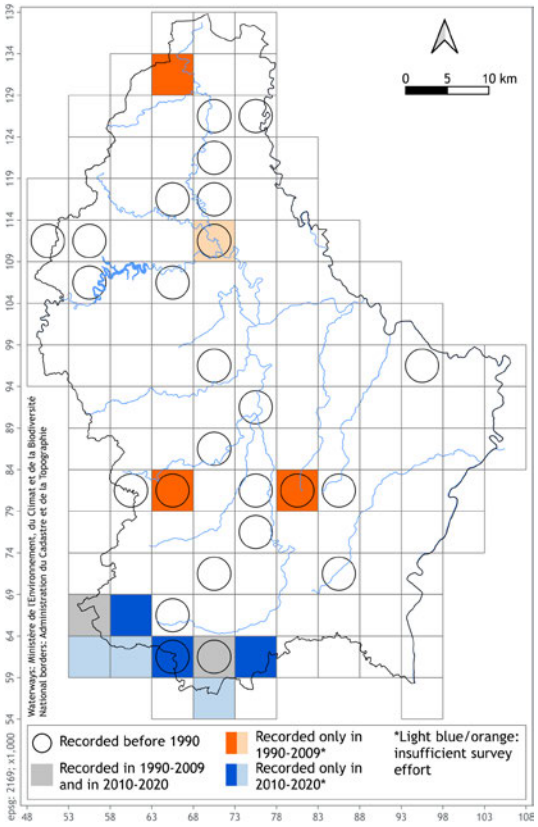


Fig. 4.309: Distribution change map at 5-km spatial resolution for *Fabriciana adippe*.

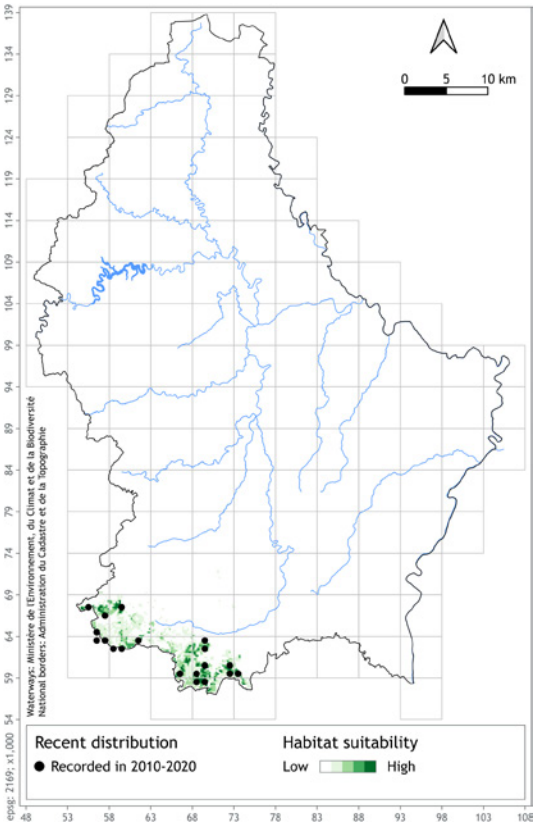


Fig. 4.310: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Fabriciana adippe*.

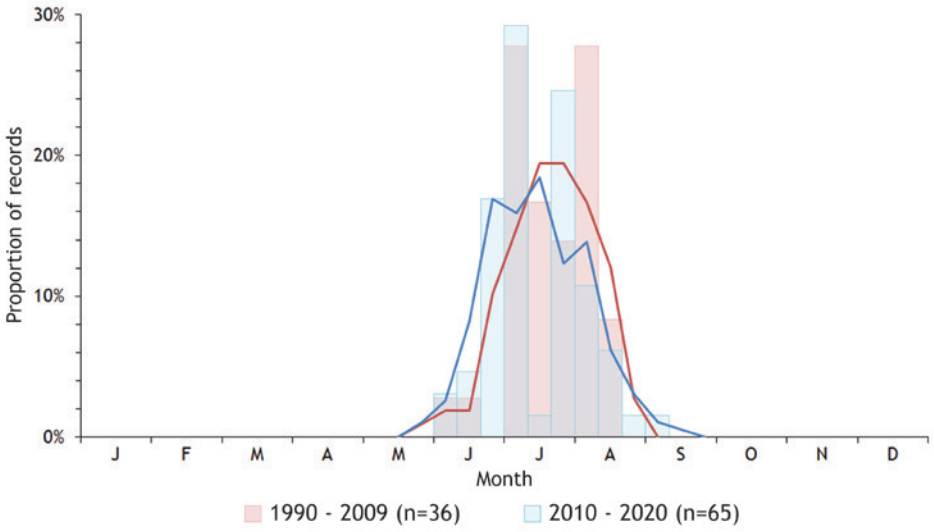


Fig. 4.311: Flight season of *Fabriciana adippe* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Issoria lathonia

(Linnaeus, 1758)

L: Klengen Nackerfalter

E: Queen of Spain fritillary

G: Kleiner Perlmuttfalter

F: Petit nacré

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Issoria lathonia is a migrant butterfly with a powerful flight. When disturbed, it generally flies a short distance and resettles on bare ground a few metres away. The underside of its wings displays the most reliable identification criteria.

Lifecycle

Up to three generations. Flies mostly from April to October (local populations are reinforced annually by migration from the South). The generation from early August is the most abundant. Can overwinter at any stage of its lifecycle (usually at the egg stage or as young larva).

Habitat

Along forest edges, road verges, crop edges and fallows where violet species (*Viola* spp.) are found.

Fig. 4.312: *Issoria lathonia* (Photo: Alain Dohet).

Fig. 4.313: *Issoria lathonia* (Photo: Xavier Mestdagh).

Adults are particularly mobile and active on flowers, often far from their breeding sites.

Larval host plants – Lays single eggs on the underside of violet leaves, such as *Viola arvensis*, *V. calaminaria*, *V. hirta*, and *V. tricolor*.

Distribution

Luxembourg – Distributed across the whole country with suitable habitats available in every region, especially in the Minette, the Moselle and the Oesling.

Worldwide – Palearctic species, from northern Africa across Europe and Asia to India and Mongolia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +33%

Relative change in extent of occurrence (geographical range): +12%

Although recorded in a moderately increasing number of 1-km grid cells, its range slightly expanded in 2010-2020.

Management

Promoting extensive management of nutrient-poor grasslands (e.g., reduced fertilisation and extensive grazing) and the acceptance of some "weeds" used as nectar resources, such as *Dipsacus fullonum*, in crops and small patches of fallows.

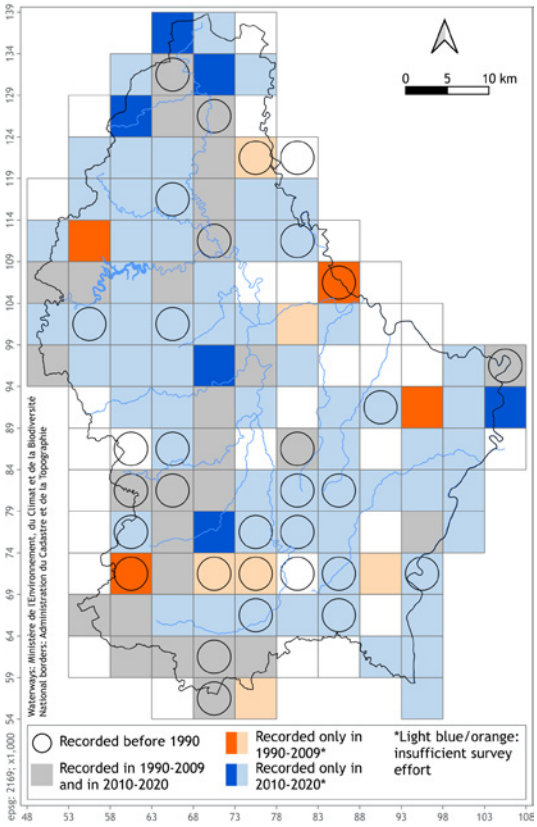


Fig. 4.314: Distribution change map at 5-km spatial resolution for *Issoria lathonia*.

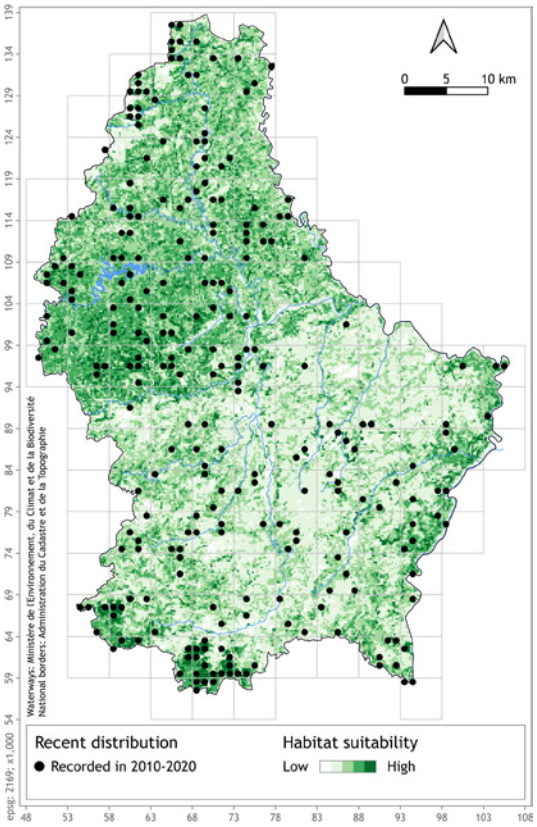


Fig. 4.315: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Issoria lathonia*.

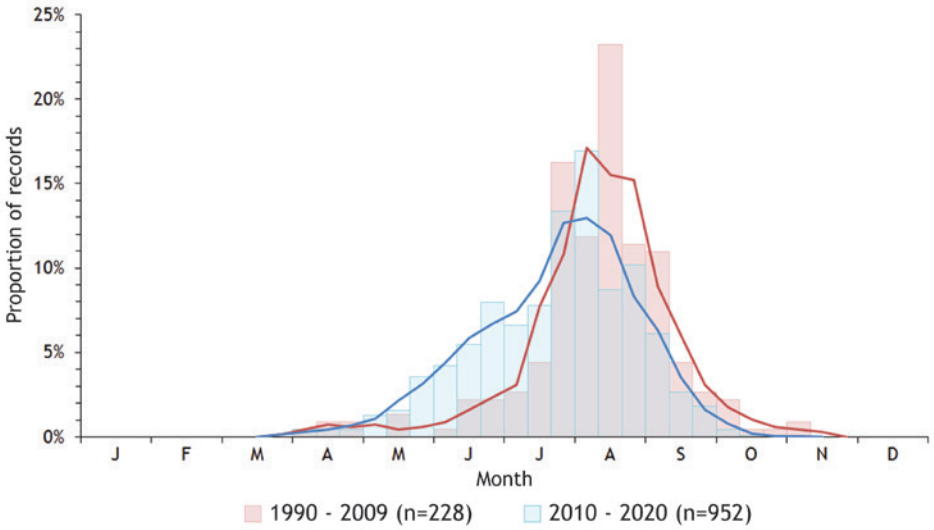


Fig. 4.316: Flight season of *Issoria lathonia* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Brenthis daphne

([Denis & Schiffermüller], 1775)

L: Päerdsbier-Nackerfalter

E: Marbled fritillary

G: Brombeer-Perlmutterfalter

F: Nacré de la ronce

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Recorded for the first time in 2000 in the south of Luxembourg (Dudelange, Haardt on 15/05/2000 by Josy Cungs), *Brenthis daphne* is a southern species known to be shifting northward due to global warming. It can be distinguished from *B. ino* by looking at the underside of the hindwings. Although they inhabit different biotopes, both species can be observed flying together.

Lifecycle

Univoltine. Flies from mid-May to early August, with a peak in late June. Overwinters as a fully-developed caterpillar in the egg.

Habitat

Sunny biotopes with brambles, such as forest edges, deciduous forests, clearings, forest paths, and hedgerows.

Fig. 4.317: *Brenthis daphne* (Photo: Alain Dohet).

Fig. 4.318: *Brenthis daphne* (Photo: Hubert Baltus).

Nectar resources – Preferentially feeds on *Rubus* spp., *Origanum vulgare* and *Cirsium* spp.

Larval host plants – Lays single eggs on the leaves of various bramble species, such as *Rubus canescens*, *R. idaeus*, *R. ulmifolius*, and *R. fruticosus*.

Distribution

Luxembourg – Patchily distributed across the whole country with suitable habitats available in every region, especially close to forests in valleys and lowland areas.

Worldwide – Palearctic species mainly distributed in central and southern Europe, temperate Asia to western Siberia and Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +1900%

Relative change in extent of occurrence (geographical range): not estimated due to insufficient number of records before 2010.

Strongly increasing. From very few records in the Minette before 2010, it has recently colonised the whole country.

Management

Promoting flower-rich areas with brambles and well-structured forest edges, forest clearings, and forest paths.

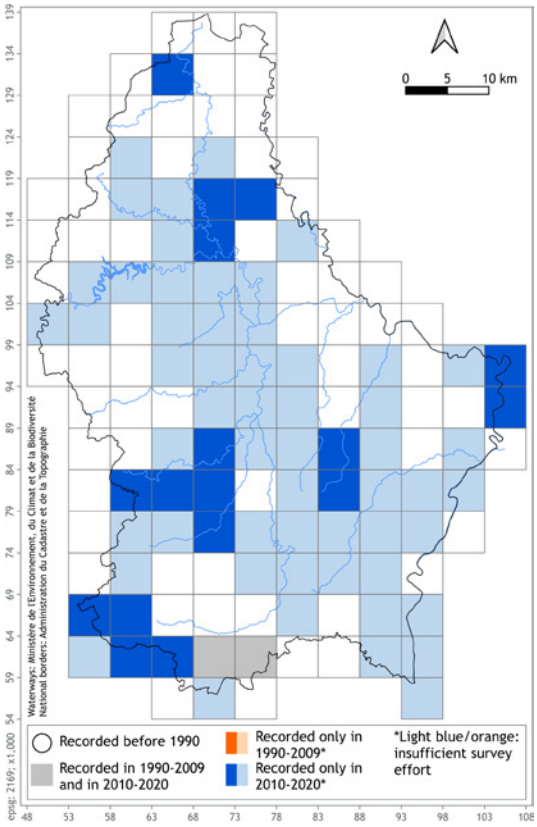


Fig. 4.319: Distribution change map at 5-km spatial resolution for *Brenthis daphne*.

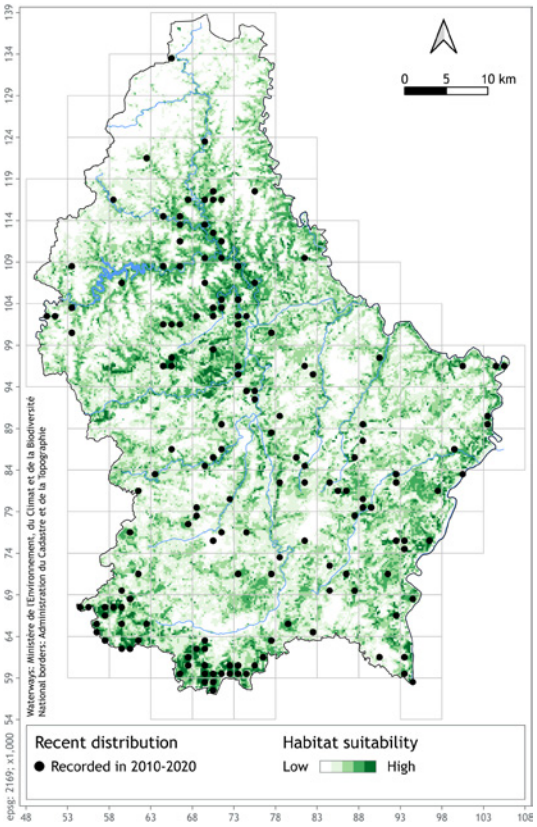


Fig. 4.320 Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Brenthis daphne*.

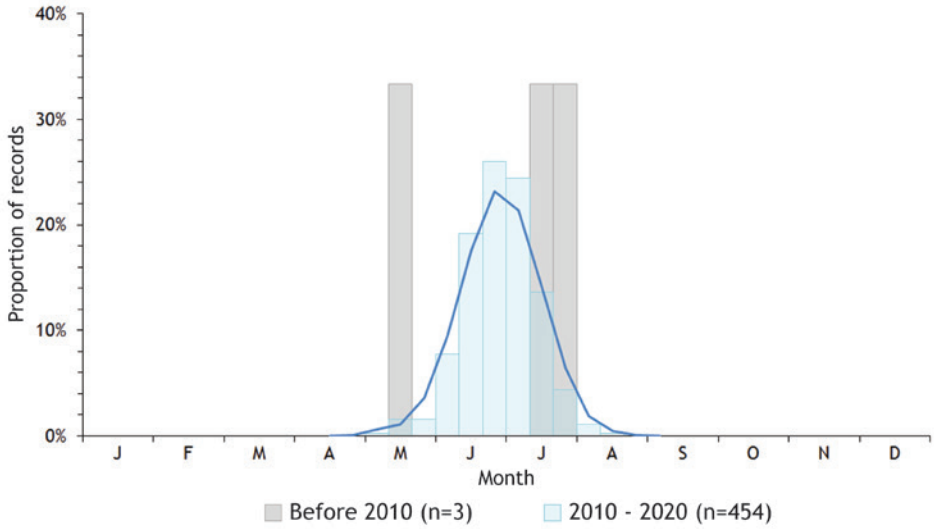


Fig. 4.321: Flight season of *Brenthis daphne* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Brenthis ino

(Rottemburg, 1775)

L: Wisekinniginnen-Nackerfalter

E: Lesser marbled fritillary

G: Mädesüß-Perlmutterfalter

F: Nacré de la sanguisorbe

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Brenthis ino is very similar to *B. daphne*. Although they are found in different biotopes, they can be found flying together. They can be distinguished by checking the pattern on the underside of their hindwings.

Lifecycle

Univoltine. Flies from mid-May to late July, with a peak in late June. Overwinters as egg or caterpillar.

Habitat

Wet biotopes dominated by *Filipendula ulmaria*, such as abandoned wet meadows, megaphorbs, bog margins, river sides, and forest clearings.

Nectar resources – Preferentially feeds on *Cirsium* spp., *Rubus* spp., *Valeriana officinalis*, *Bistorta officinalis*, and *Centaurea jacea*.

Fig. 4.322: *Brenthis ino* (Photo: Hubert Baltus).

Fig. 4.323: *Brenthis ino* (Photo: Youri Martin).

Larval host plants – Lays single eggs on the leaves and flowerheads of *F. ulmaria*. Other species such as *Sanguisorba officinalis*, *S. minor* and *Comarum palustre* are also mentioned in the literature.

Distribution

Luxembourg – Mainly distributed in valley bottoms of the Oesling and in lowland areas of southwestern Gutland (Niederkorn, Dippach, Clémency), with a few isolated records elsewhere.

Worldwide – Palearctic species, mainly distributed in central and northern Europe, across temperate Asia to Siberia, northern China and Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -13%

Relative change in extent of occurrence (geographical range): +5%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Maintaining strips and small areas of *Filipendula ulmaria* along river sides, bogs, wetlands, forest edges and clearings. Promoting rotational management over multiple years by mowing in autumn and exporting the vegetation.

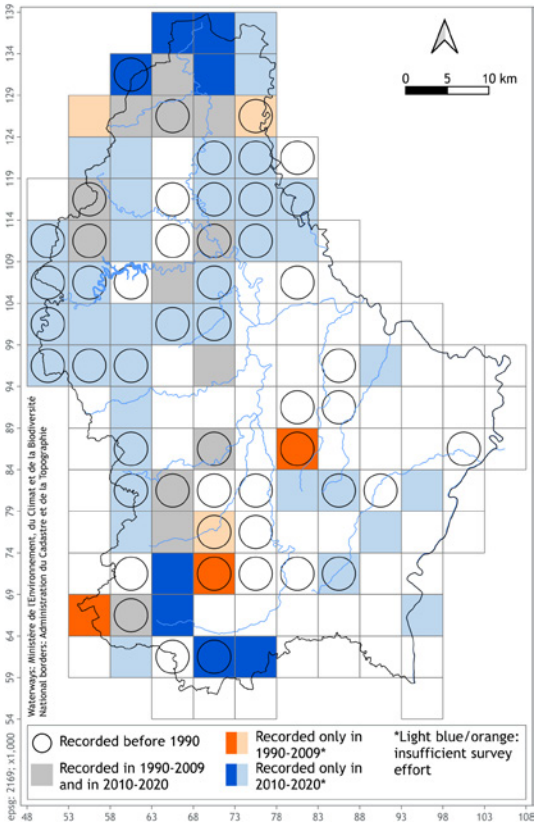


Fig. 4.324: Distribution change map at 5-km spatial resolution for *Brenthis ino*.

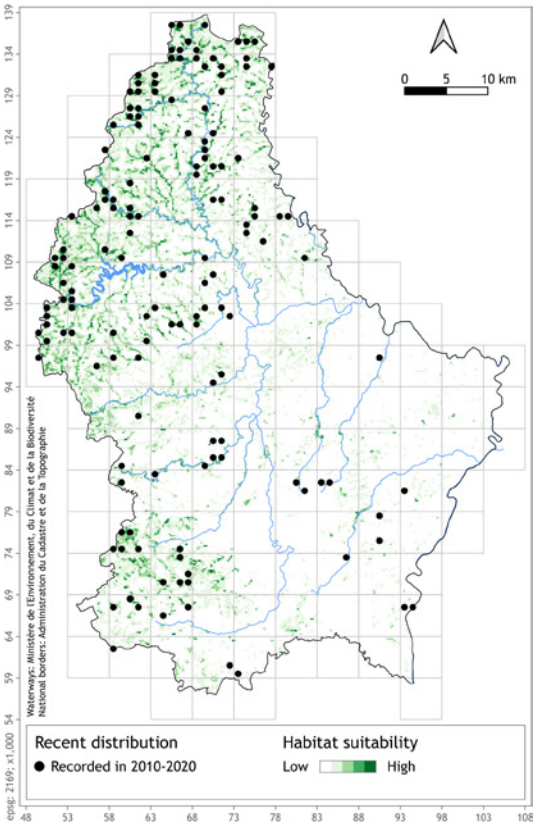


Fig. 4.325: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Brenthis ino*.

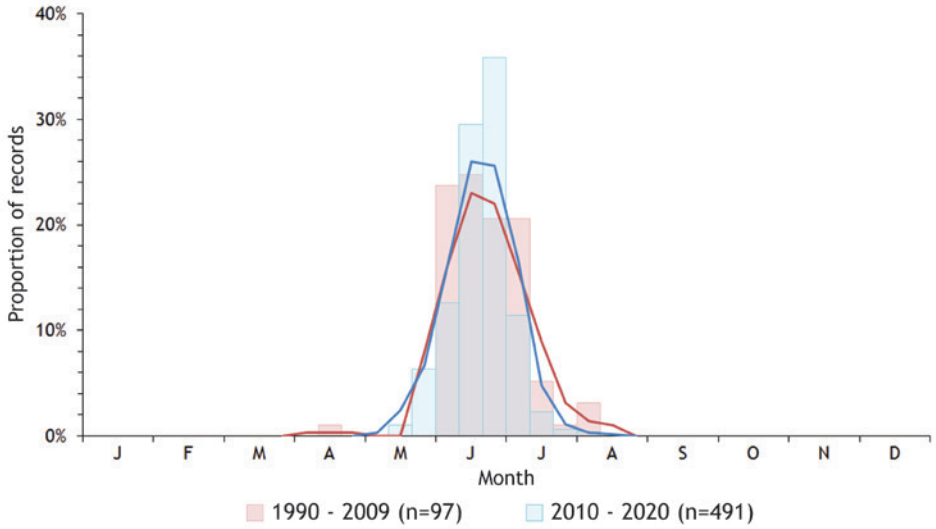


Fig. 4.326: Flight season of *Brenthis ino* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Boloria eunomia
(Esper, 1800)

L: Knuetkraut-Nackerfalter

E: Bog fritillary

G: Randring-Perlmutterfalter

F: Nacré de la bistorte

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

Glacial relict species with high dispersal abilities, *Boloria eunomia* is often flying close to the ground and is strongly linked to the bistort.

Lifecycle

Univoltine. Flies from May to early July, with a peak in June. Overwinters as young caterpillar, which can take up to two years to metamorphose into an adult.

Habitat

Fallow wetlands where its host plant is abundant, such as abandoned wet grasslands, raised bogs, fens, and springs. Caterpillars require tufts of grass for their thermoregulation.

Fig. 4.327: *Boloria eunomia* (Photo: Mireille Molitor).

Fig. 4.328: *Boloria eunomia* (Photo: Alain Dohet).

Nectar resources – Preferentially feeds on *Bistorta officinalis*, sometimes on *Cirsium palustre* and *Myosotis scorpioides*.

Larval host plants – Lays eggs exclusively on the underside of *B. officinalis* leaves.

Distribution

Luxembourg –Almost exclusively distributed in northwestern part of the Oesling, mainly along the Belgian border where suitable habitats are located.

Worldwide – Holarctic species distributed mainly in northern Asia and northern Europe (Baltic States, Belarus, and Fennoscandia), very rare and localised in the rest of Europe (isolated populations in the Pyrenees, Ardennes and upper stream of the Semois River, northeast, central and southern Germany).

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -34%

Relative change in extent of occurrence (geographical range): -26%

Moderately decreasing.

Management

Promoting very extensive management in nutrient-poor wetlands, with grazing after August and exclosure fences to prevent part of the sites from being gazed (refuge area). Promoting fallow strips and low fertiliser inputs in valley bottoms to reconnect the remaining populations.

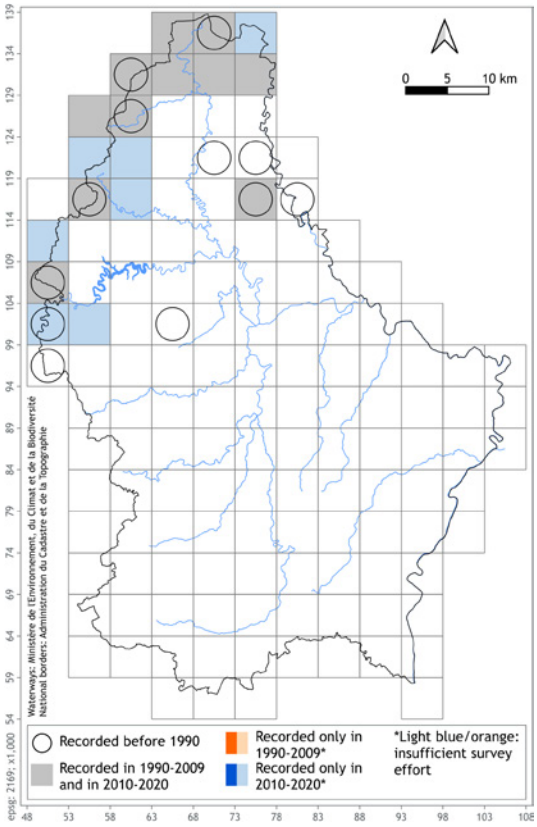


Fig. 4.329: Distribution change map at 5-km spatial resolution for *Boloria eunomia*.

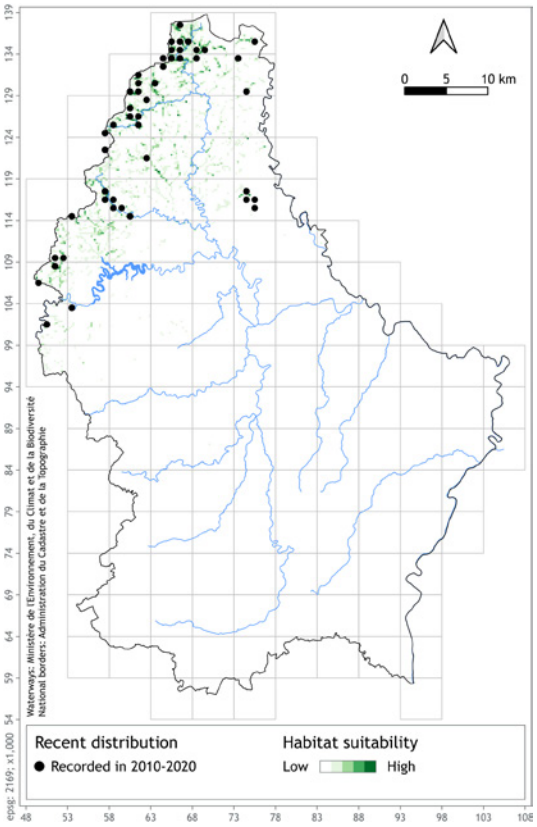


Fig. 4.330: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Boloria eunomia*.

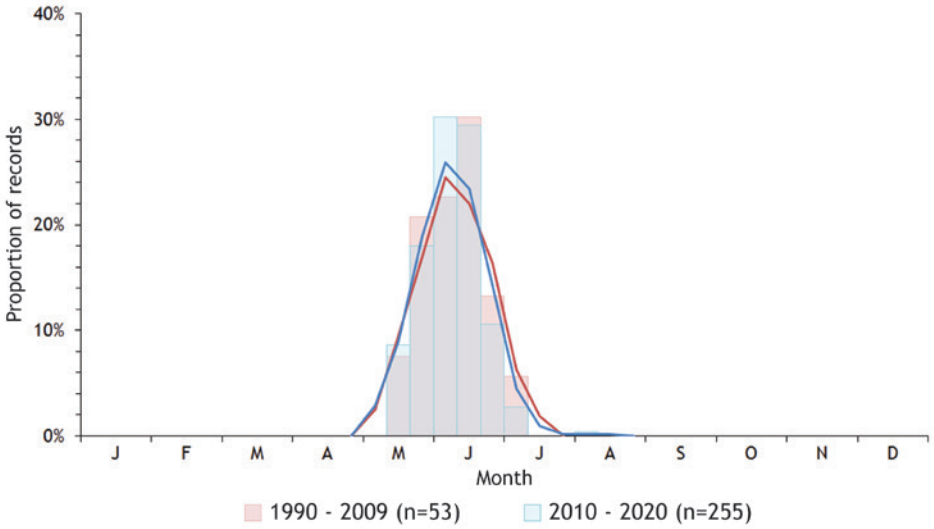


Fig. 4.331: Flight season of *Boloria eunomia* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Boloria selene

([Denis & Schiffermüller], 1775)

L: Brongfleckege Nackerfalter

E: Small pearl-bordered fritillary

G: Braunfleckiger Perlmutterfalter

F: Petit collier argenté

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Endangered	Least Concern

Boloria selene is a medium-sized butterfly often observed in the same biotopes as *B. euphrosyne*. The underside of the wings provides the most reliable criteria to distinguish it from other fritillaries.

Lifecycle

Mostly univoltine, with sometimes a second partial generation. Flies mostly from mid-May to August, with a peak in June. Overwinters as caterpillar.

Habitat

Sheltered, sunny and damp biotopes, such as nutrient-poor grasslands rich in violets, wet and litter meadows, swamps, peat bog margins, heathlands, forest clearings, and forest paths.

Fig. 4.332: *Boloria selene* (Photo: Alain Dohet).

Fig. 4.333: *Boloria selene* (Photo: Hubert Baltus).

Nectar resources – Feeds preferentially on violet flowers and *Potentilla palustris*.

Larval host plants – Lays single eggs on or near *Viola* species (most often *V. palustris*, *V. riviniana*, and *V. canina*), or directly on the ground.

Distribution

Luxembourg – Almost exclusively distributed in the Oesling, mainly in wetlands from the northern and western parts along the Belgian border.

Worldwide – Holarctic species, widespread in central and northern Europe.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -43%

Relative change in extent of occurrence (geographical range): -59%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted in 2010-2020. Almost extinct from the Gutland and the Minette.

Management

Restoring and maintaining nutrient-poor grasslands with extensive grazing along well-structured forest edges, especially in valley bottoms. Limiting shrub encroachment in fallow lands with regular cutting and grazing (preferentially cattle).

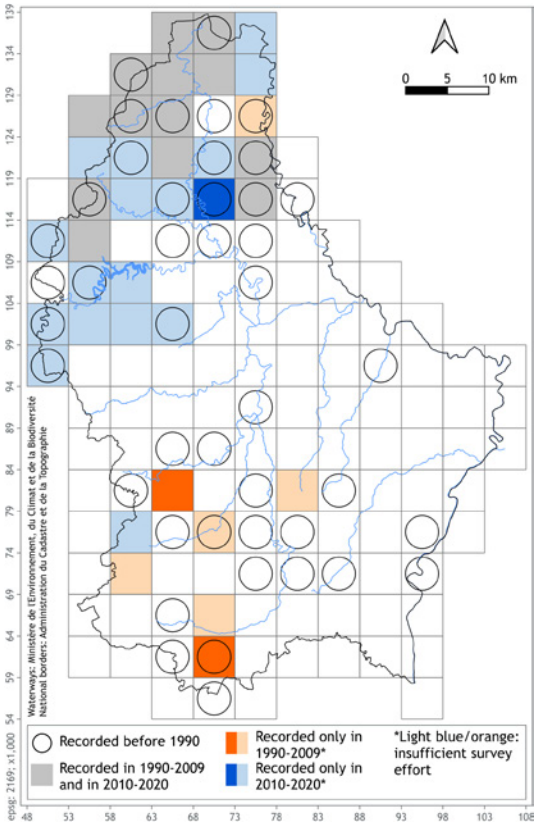


Fig. 4.334: Distribution change map at 5-km spatial resolution for *Boloria selene*.

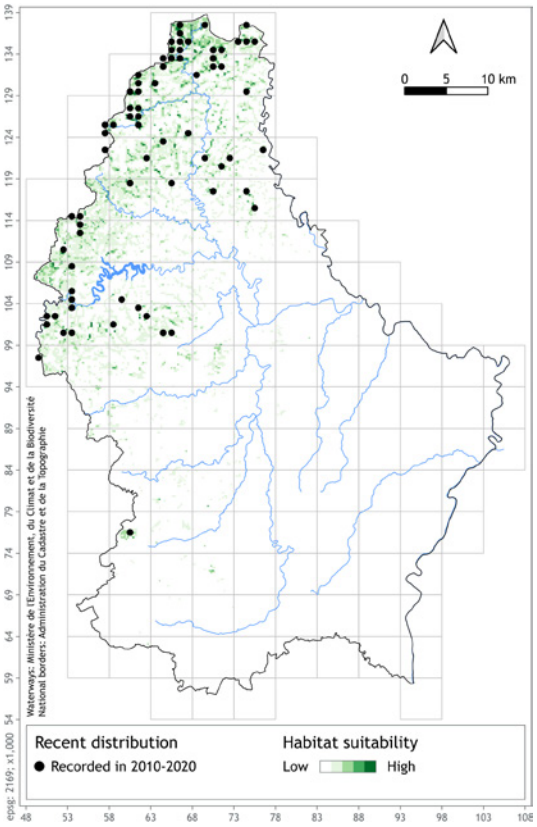


Fig. 4.335: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Boloria selene*.

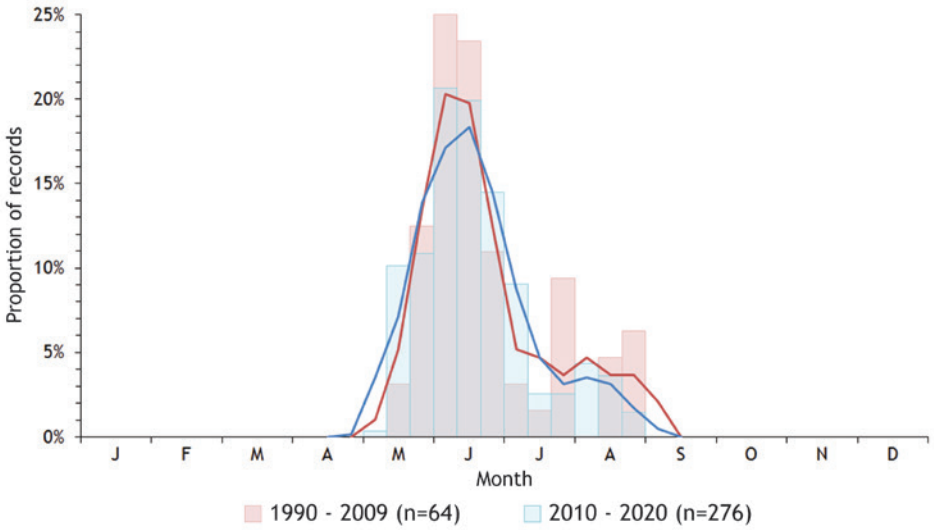


Fig. 4.336: Flight season of *Boloria selene* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Boloria euphrosyne

(Linnaeus, 1758)

Syn.: *Clossiana euphrosyne*

L: Veilchen-Nackerfalter

E: Pearl-bordered fritillary

G: Silberfleck-Perlmutterfalter

F: Grand collier argenté

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 2003	Least Concern

Its English name comes from the row of silver-pearly markings along the edge of the underside of its wings.

Lifecycle

Univoltine in neighbouring regions, sometimes a second generation in hot summers. Flies mostly from late April to early July. Overwinters as caterpillar.

Habitat

Warm, flower-rich forest edges and clearings, typically in forests under coppicing management.

Nectar resources – Feeds preferentially on *Ajuga reptans*.

Fig. 4.337: *Boloria euphrosyne* (Photo: Stéphane Vizthum).

Fig. 4.338: *Boloria euphrosyne* (Photo: Hubert Baltus).

Larval host plants – Lays eggs on the underside of leaves of violet species (*Viola* spp.).

Distribution

Luxembourg – Previously recorded across most of the country. Recorded only near Unterschlinder and the Minette after 1990. Last record in 2003 near Lasauvage.

Neighbouring countries – Since 2010, recorded in French and Belgian Lorraine (Gaume), in Belgian Fagne-Famenne, and in the eastern part of Hunsrück mountains in Rhineland-Palatinate. Extinct from Saarland and from Trier region during the last decade.

Worldwide – Palearctic, from the northern Iberian Peninsula and northern Turkey to northern Scandinavia, including the British Isles.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. As there are still favourable areas for the species in the Minette, its comeback may still be possible.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

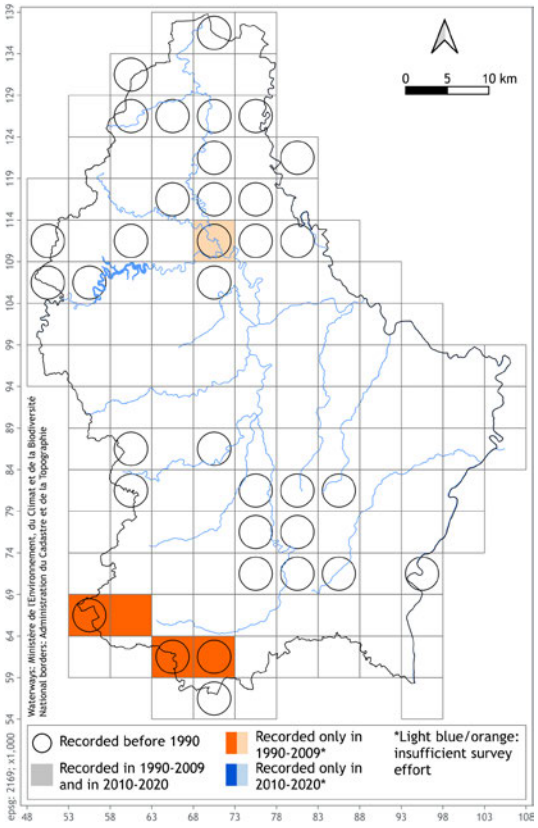


Fig. 4.339: Distribution change map at 5-km spatial resolution for *Boloria euphrosyne*.

Fig. 4.340: *Boloria euphrosyne* (Illustration: Anita Faber).

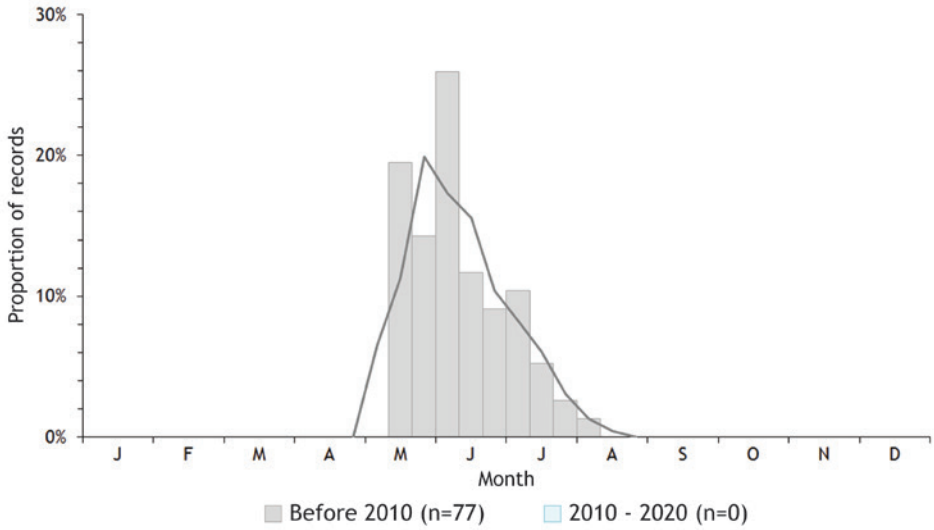


Fig. 4.341: Flight season of *Boloria euphrosyne* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Boloria dia
(Linnaeus, 1767)

L: Dréchewues-Nackerfalter

E: Weaver's fritillary

G: Magerrasen-Perlmutterfalter

F: Petite violette

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Boloria dia is a small butterfly characterised by a very fast flight close to the ground. Misidentification with other fritillaries can be avoided by checking the pattern of the underside of the wings. In Luxembourg, it is usually observed in low densities.

Lifecycle

Mostly bivoltine, but three generations in favourable years. Flies from late April to September. Overwinters as caterpillar.

Habitat

Dry grasslands and flower-rich meadows surrounded by shrubs or deciduous forests.

Larval host plants – Lays single eggs on violet species (e.g., *Viola hirta*, *V. odorata*, *V. riviniana*, and *V. reichenbachiana*), sometimes on nearby vegetation.

Fig. 4.342: *Boloria dia* (Photo: Hubert Baltus).

Fig. 4.343: *Boloria dia* (Photo: Alain Dohet).

Distribution

Luxembourg – Almost exclusively distributed in the Minette and the eastern half of the Gutland until the Moselle, with isolated populations or records of dispersing individuals in other parts of the country.

Worldwide – From western Europe, through northern Spain, northern Italy, northern Greece, the Balkans, Turkey, up to Siberia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -17%

Relative change in extent of occurrence (geographical range): -6%

Although recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Restoring and maintaining nutrient-poor grasslands with extensive grazing along well-structured forest edges.

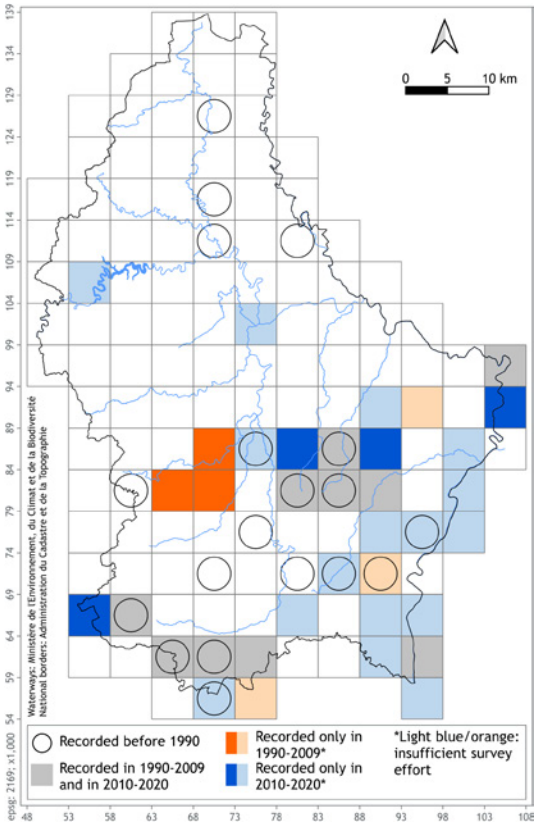


Fig. 4.344: Distribution change map at 5-km spatial resolution for *Boloria dia*.

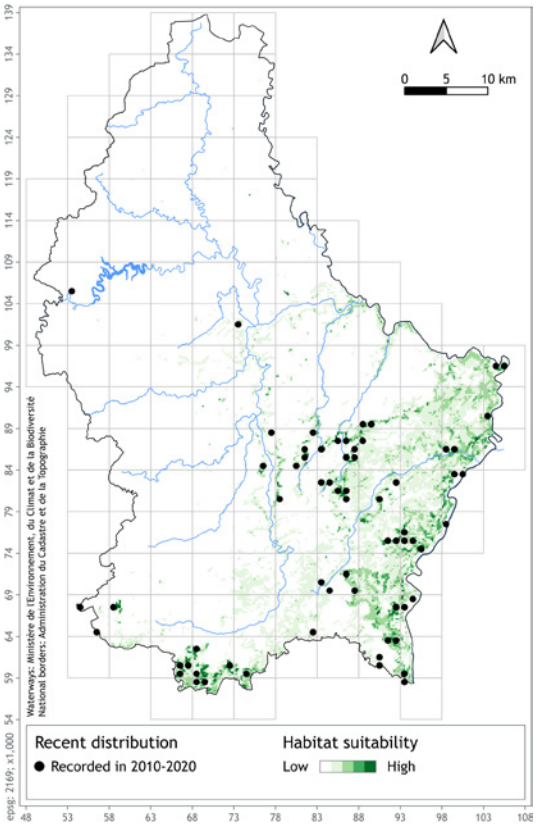


Fig. 4.345: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Boloria dia*.

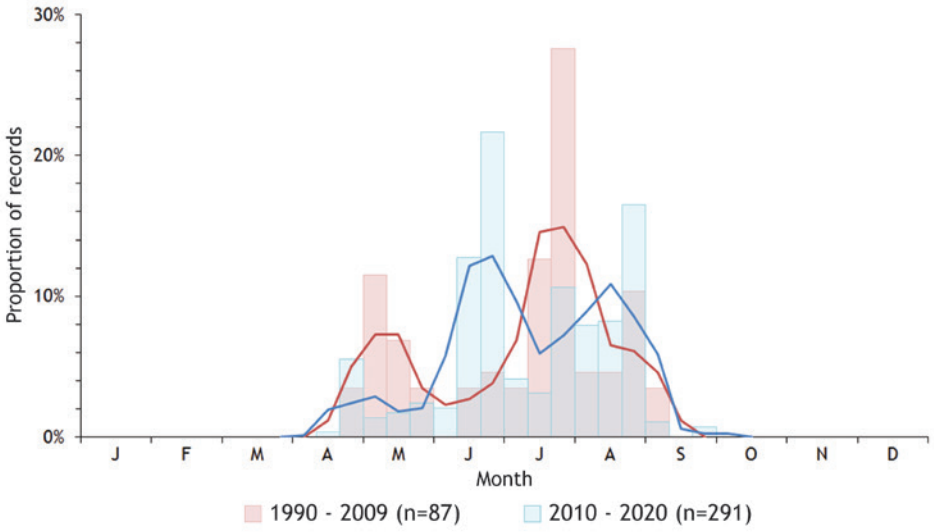


Fig. 4.346: Flight season of *Boloria dia* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Melitaea cinxia

(Linnaeus, 1758)

L: Wegerich-Scheckefalter

E: Glanville fritillary

G: Wegerich-Scheckenfalter

F: Mélitée du plantain

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Melitaea cinxia is quite easy to distinguish from other fritillaries with its black spots on the underside of the wings.

Lifecycle

Mostly univoltine. Flies mostly from mid-April to late June. A second partial generation is possible during summer in the driest and warmest locations. Overwinters as young caterpillar in gregarious sibling groups, in a weaved nest on or near their host plants.

Habitat

Open and nutrient-poor biotopes with short vegetation and bare ground, such as dry calcareous grasslands, often with some bushes, rocks, and near a forest. As the caterpillars are gregarious, quite voracious, and not very mobile, they need large quantities of their host plants to prevent starvation.

Fig. 4.347: *Melitaea cinxia* (Photo: Alain Dohet).

Fig. 4.348: *Melitaea cinxia* (Photo: Hubert Baltus).

Larval host plants – Lays yellow eggs in untidy batches on the underside of leaves of *Plantago lanceolata*, *P. media*, and *Veronica spicata*.

Distribution

Luxembourg – Almost exclusively distributed in the southern half of the country, but with higher densities in the Minette and in central Gutland where availability of suitable habitats is higher.

Worldwide – Palearctic species distributed from northwestern Africa across most of Europe (except northern Scandinavia and south of Iberian Peninsula) and temperate Asia to Mongolia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -6%

Relative change in extent of occurrence (geographical range): +28%

Even though recorded in a stable number of 1-km grid cells, its range moderately expanded in 2010-2020.

Management

Promoting extensive management (e.g., extensive grazing or late mowing) of nutrient-poor grasslands with some sparse vegetation patches and large refuge areas, close to forest edges. Promoting interconnection of suitable biotopes with ecological corridors (e.g., extensively managed road verges, hedges). Limiting mowing to late summer, at a height taller than 20 cm in some patches to preserve the caterpillar nests.

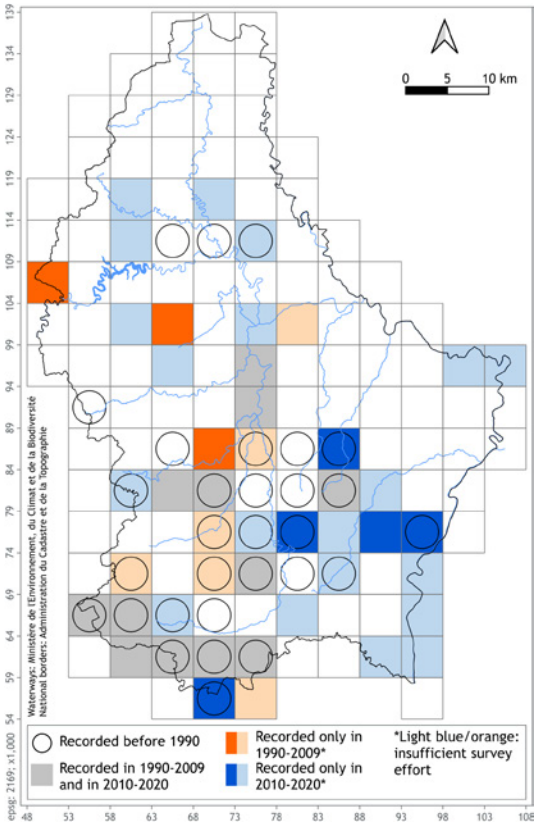


Fig. 4.349: Distribution change map at 5-km spatial resolution for *Melitaea cinxia*.

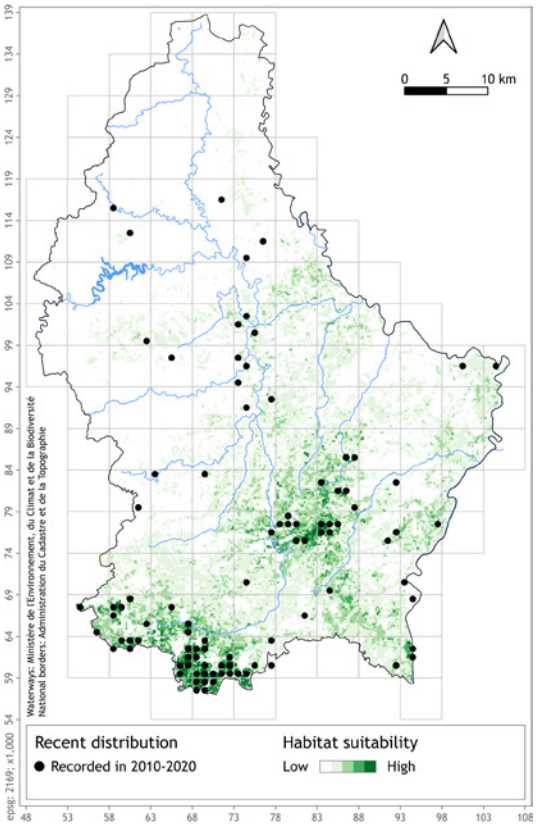


Fig. 4.350: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Melitaea cinxia*.

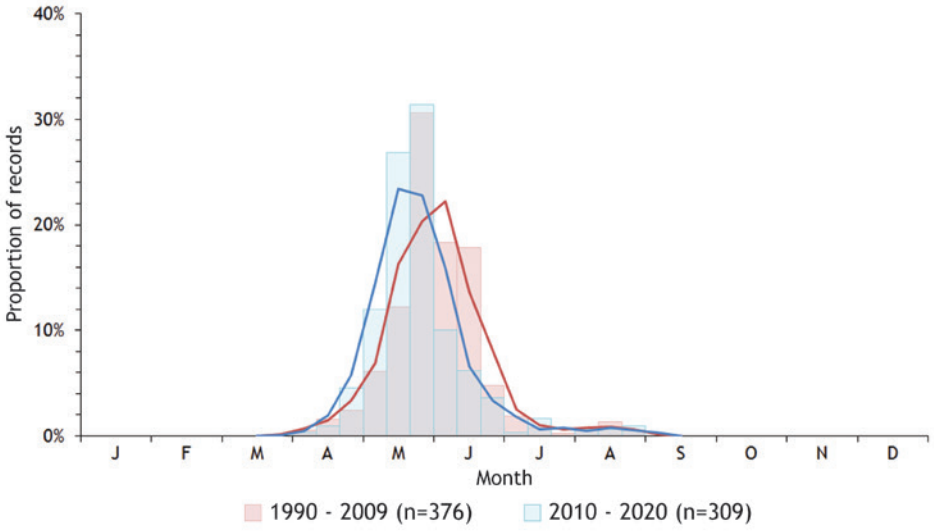


Fig. 4.351: Flight season of *Melitaea cinxia* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Melitaea diamina

(Lang, 1789)

L: Baldrian-Scheckefalter

E: False heath fritillary

G: Baldrian-Scheckenfalter

F: Damier noir

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

Melitaea diamina is a relatively sedentary species with heavy dark markings on the upper side of the hindwings. Confusion is, however, possible with other *Melitaea*: the yellow marginal band on the underside of the hindwings is a reliable identification criterion.

Lifecycle

Univoltine. Flies from mid-May to early July with a peak in June. Overwinters as gregarious caterpillar in a nest.

Habitat

Moist and nutrient-poor open biotopes, typically in bogs, wetlands, litter meadows, flower-rich grasslands along river sides, damp forest edges, and clearings.

Fig. 4.352: *Melitaea diamina* (Photo: Hubert Baltus).

Fig. 4.353: *Melitaea diamina* (Photo: Xavier Mestdagh).

Larval host plants – Lays eggs in clusters, usually on the underside of a leaf of *Valeriana officinalis* or *V. dioica*. *Melampyrum* spp., *Bistorta officinalis*, *Plantago* spp. and *Veronica chamaedrys* are also sometimes used.

Distribution

Luxembourg – Exclusively distributed in the valley bottoms of the northwestern part of the Oesling.

Worldwide – From northern Spain to southern Scandinavia, across central Europe to Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -33%

Relative change in extent of occurrence (geographical range): -73%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted in 2010-2020. The relative change in the extent of occurrence is influenced by a limited number of records and part of them could be dispersing individuals instead of established populations.

Management

Promoting extensive and rotational management of wet and nutrient-poor open biotopes over multiple years (e.g., extensive grazing or late mowing).

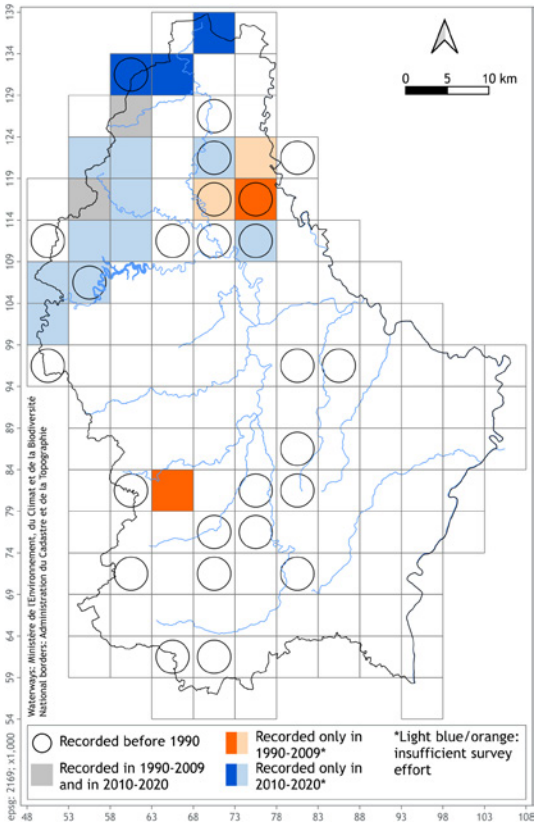


Fig. 4.354: Distribution change map at 5-km spatial resolution for *Melitaea diamina*.

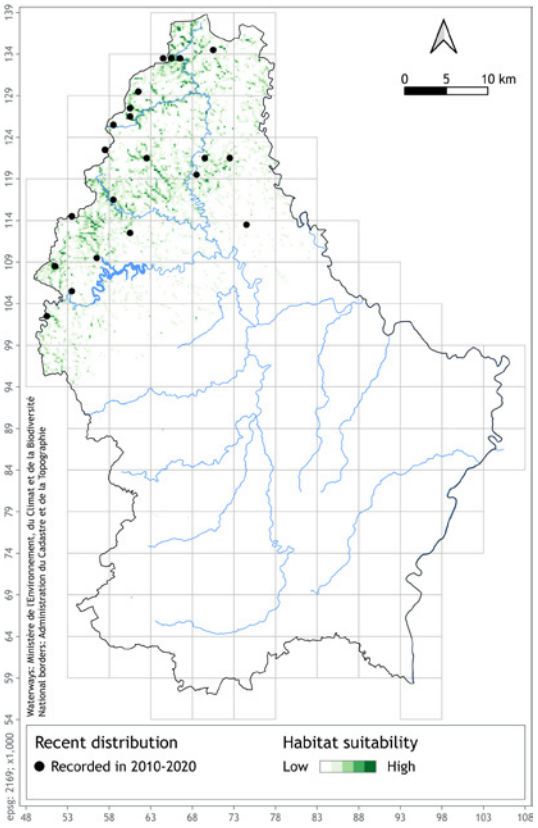


Fig. 4.355: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Melitaea diamina*.

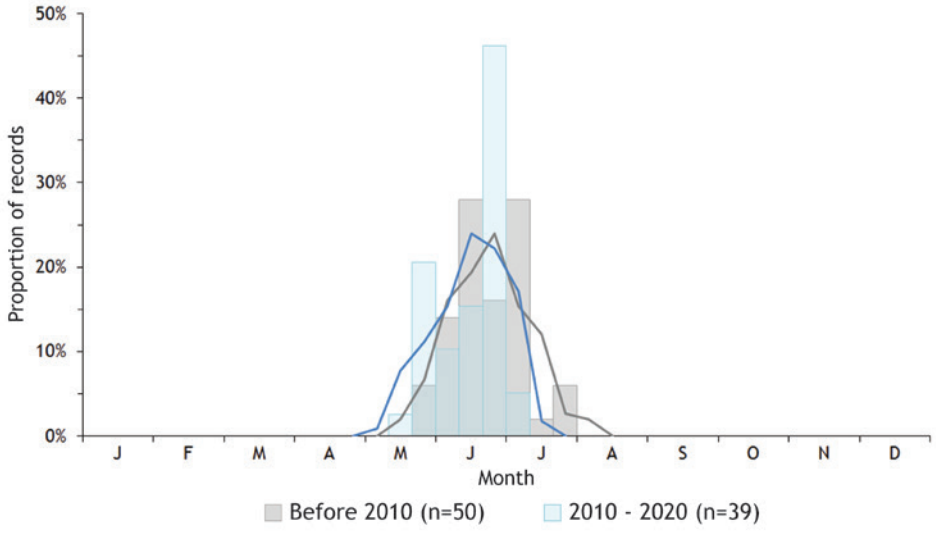


Fig. 4.356: Flight season of *Melitaea diamina* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Melitaea phoebe

([Denis & Schiffermüller], 1775)

L: Flackeblumme-Scheckefalter

E: Knapweed fritillary

G: Flockenblumen-Scheckenfalter

F: Mélitée des centaurées

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1984	Least Concern

Rather similar to *Melitaea cinxia*, *M. phoebe* lacks the small black dots in the submarginal area of the upper side and the underside of the wings.

Lifecycle

Bivoltine in neighbouring regions. Flies mostly from May to August. Overwinters as young caterpillar in small groups on the ground under wilted leaves.

Habitat

Warm, dry to semi-arid, flower-rich meadows, as well as road verges with some bushes, where its host plants are abundant.

Larval host plants – Lays eggs in small clusters on leaves of *Centaurea* spp., mainly *Centaurea scabiosa*, and more rarely on thistles (e.g., *Cirsium arvense*) and *Plantago* spp.

Fig. 4.357: *Melitaea phoebe* (Photo: Stéphane Vizthum).

Fig. 4.358: *Melitaea phoebe* (Photo: Stéphane Vizthum).

Distribution

Luxembourg – Previously recorded sporadically in different regions, with a last record in 1984 at Prenzebierg (Pétange).

Neighbouring countries – Since 2010, recorded in the Moselle valley in French Lorraine. Extinct from Wallonia (last record in 1973 in southern Belgian Lorraine) and from Rhineland-Palatinate.

Worldwide – Northern Africa, southern and central Europe, up to Russia. Absent from northern Europe (UK, northern Germany, and Scandinavia). Luxembourg is at the northern margin of its global range.

Trends (<2010 vs. 2010-2020)

Considered as extinct. A comeback from the French Lorraine population is likely.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

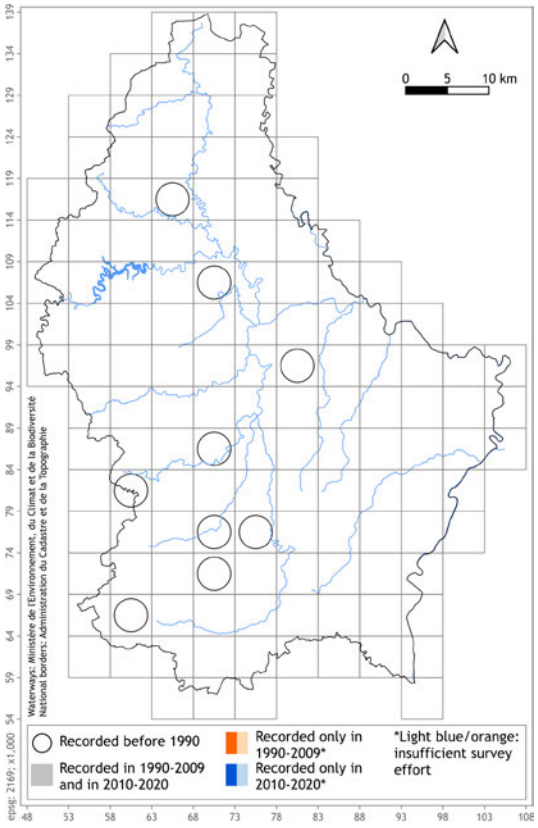


Fig. 4.359: Distribution change map at 5-km spatial resolution for *Melitaea phoebe*.

Fig. 4.360: *Melitaea phoebe* (Illustration: Anita Faber).

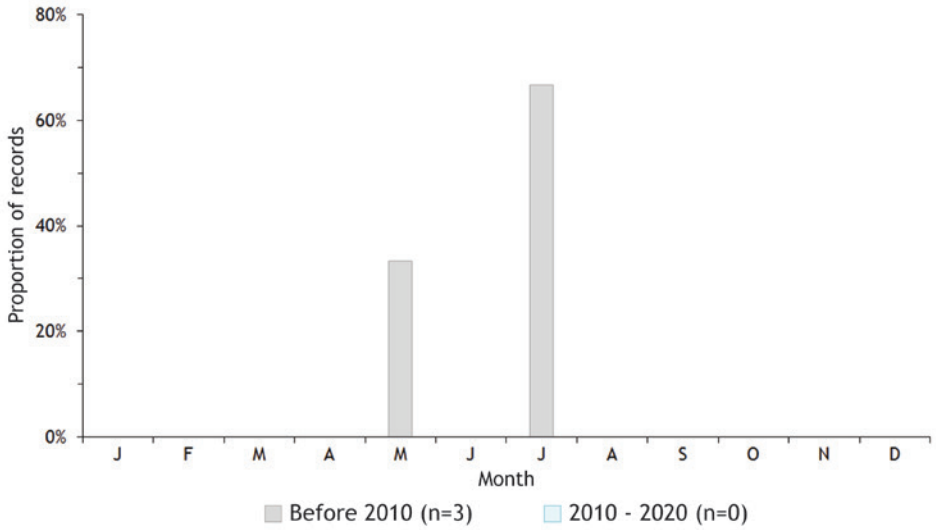


Fig. 4.361: Flight season of *Melitaea phoebe* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Melitaea didyma
(Esper, 1778)

L: Roude Scheckefalter
E: Spotted fritillary
G: Roter Scheckenfalter
F: Melitée orangée

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1977	Least Concern

As its English name suggests, the wings of this fritillary butterfly are spotted and orange-red, although this is subject to some variation.

Lifecycle

Mostly univoltine, but sometimes bivoltine in neighbouring regions. Flies Mostly from June to August. Overwinters as caterpillar. Phenological curves unavailable due to lack of precision on recording dates.

Habitat

Sunny, dry to semi-arid, flower-rich meadows with heterogeneous herbaceous vegetation.

Larval host plants – Lays eggs mainly on the underside of the leaves of *Plantago lanceolata* and *P. media*, and sometimes on *Linaria vulgaris*, *Centaurea scabiosa*, *Rhinanthus angustifolius*, *Stachys recta*, *Veronica teucrium*, and *Digitalis purpurea*.

Fig. 4.362: *Melitaea didyma* (Photo: Stéphane Vizthum).

Fig. 4.363: *Melitaea didyma* (Photo: Stéphane Vizthum).

Distribution

Luxembourg – Previously recorded very sporadically, with a last record in 1977 near Kautenbach.

Neighbouring countries – Since 2010, recorded in the Moselle valley, and more recently close to the Luxembourgish border, in French Lorraine, as well as in several locations in central Rhineland-Palatinate. Only occasionally recorded in Wallonia (last record in 2005 in Belgian Lorraine). Extinct from Saarland since 1972.

Worldwide – Northern Africa, southern and central Europe, up to central Asia and Russia. Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. A comeback from the nearby French population is likely, especially in a context of global warming.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

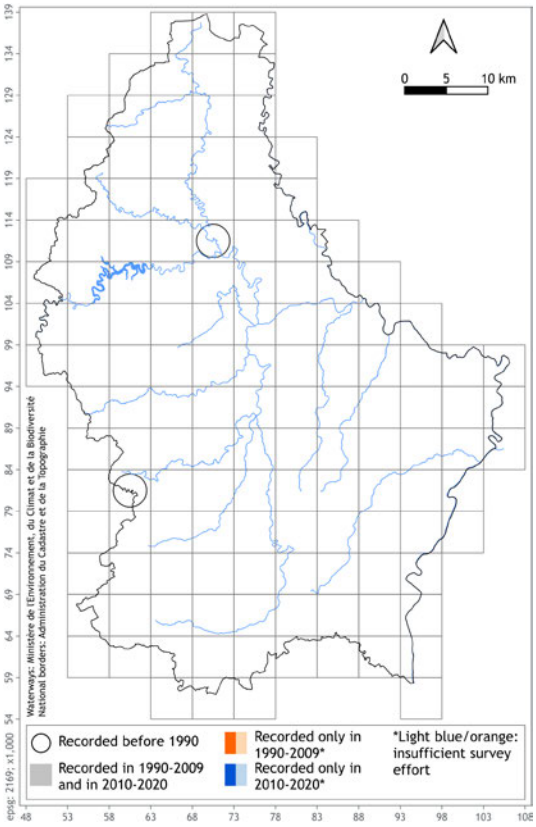


Fig. 4.364: Distribution change map at 5-km spatial resolution for *Melitaea didyma*.

Fig. 4.365: *Melitaea didyma* (Illustration: Anita Faber).

NYMPHALIDAE

Melitaea athalia/aurelia

(Rottemburg, 1775)/Nickerl, 1850

L: Wise-Scheckefalter / Dréchewues-Scheckefalter

E: Heath fritillary / Nickerl's fritillary

G: Wachtelweizen-Scheckenfalter / Ehrenpreis-Sch.

F: Mélitée du mélampyre / Mélitée des digitales

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Evaluated	Least Concern / Least Concern

Based on external morphology, *Melitaea aurelia* and *M. athalia* are extremely similar. The colour of the palpi, formerly considered as a reliable criterion, has been recently re-evaluated as misleading. Examination of the genitalia (possible on living males) is necessary. Further investigations should be done to check the possible presence of another similar species, *M. parthenoides*, in Luxembourg.

Lifecycle

Both species are univoltine. Fly from mid-May to late July, with a peak in mid-June. Overwinter as caterpillars.

Habitat

M. athalia: diverse wet to dry biotopes with herbaceous and woody vegetation, such as forest clearings, coppiced forests, and flower-rich meadows.

Fig. 4.366: *Melitaea athalia/aurelia* (Photo: Hubert Baltus).

Fig. 4.367: *Melitaea athalia/aurelia* (Photo: Lionel L'Hoste).

M. aurelia: calcareous biotopes where its host plants occur, especially in nutrient-poor meadows and extensively grazed dry calcareous grasslands.

Larval host plants – Lay eggs in clusters:

M. athalia: on the underside of a dead leaf or a bramble leaf in the vicinity of (but rarely on) the host plants, most often *Melampyrum pratense*, *Veronica chamaedrys*, and *Plantago lanceolata*.

M. aurelia: under the leaves of *Plantago media* and *P. lanceolata*. *M. arvense*, *Rhinanthus minor* and *Veronica* spp. can also be used.

Distribution

Luxembourg – Distributed as a species complex in all regions. Without clear evidence, *M. aurelia* probably restricted to the southern half of the country and *M. athalia* more widespread in the Oesling. Availability of suitable habitats is not shown as the two species do not have the same habitat requirements.

Worldwide – *M. athalia*: widespread across Europe, temperate Asia and Japan. *M. aurelia*: Eurasian species, from the eastern half of France to the Balkans and Baltic States.

Trends (<2010 *vs.* 2010-2020)

Trends were not estimated for this complex species.

Management

Promoting extensive management of grasslands (e.g., low intensity grazing and reduced fertilisation). Limiting mowing to late summer (September) with vegetation not cut below a height of 15 cm and keeping unmown refuge areas. Promoting light deciduous forests and rotational management of forest edges and clearings over multiple years. Avoiding the drainage of wetlands.

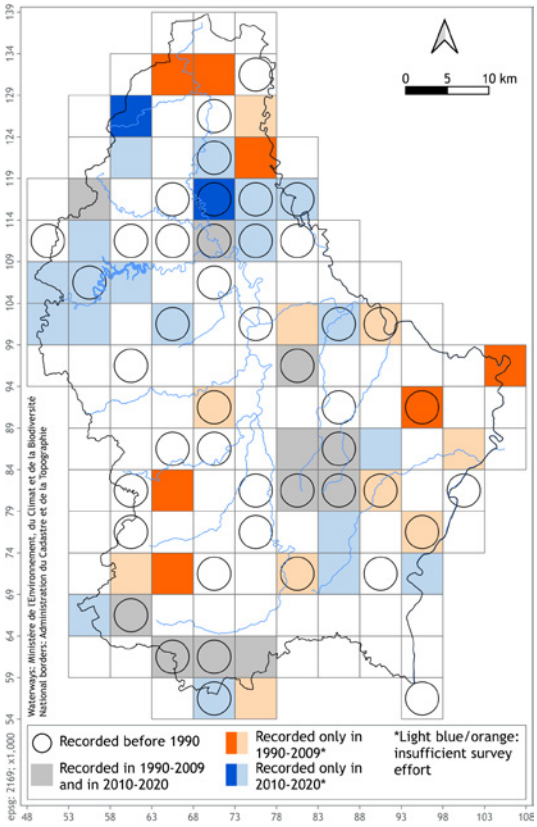


Fig. 4.368: Distribution change map at 5-km spatial resolution for *Melitaea athalia/aurelia*.

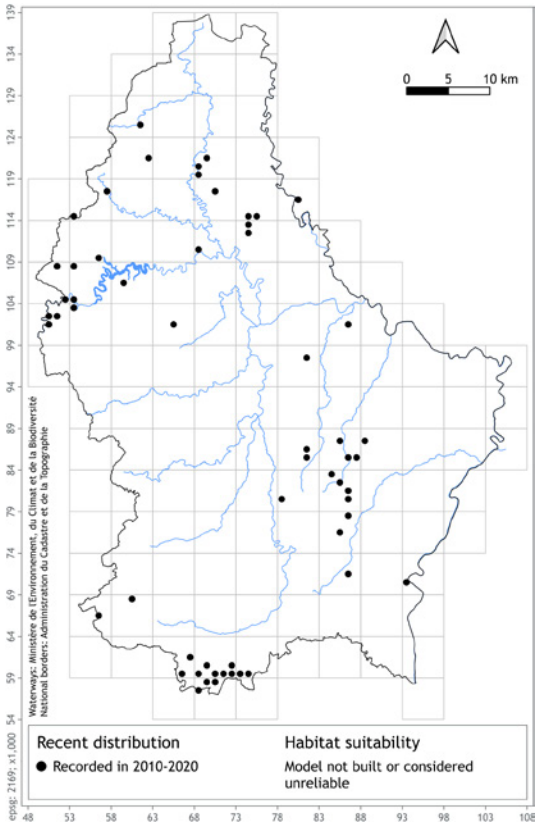


Fig. 4.369: Distribution map at 1-km spatial resolution for *Melitaea athalia/aurelia*.

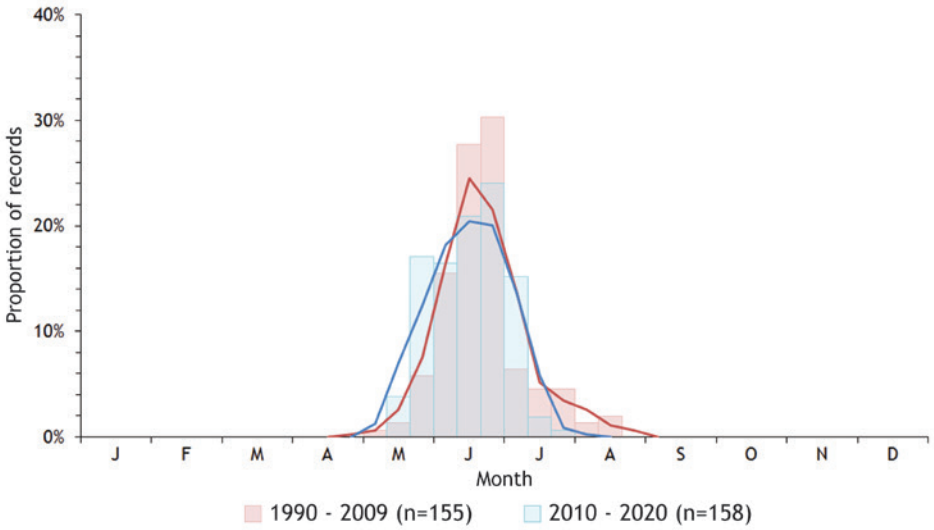


Fig. 4.370: Flight season of *Melitaea athalia/aurelia* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Euphydryas maturna

(Linnaeus, 1758)

L: Gëllene Scheckefalter

E: Scarce fritillary

G: Eschen-Scheckenfalter

F: Damier du frêne

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC Annexes II and IV
Red List category	Regionally Extinct since 1960-80	Least Concern

Euphydryas maturna is a forest species frequently flying at 2-3 meters high along forest edges and in large clearings. Males are often seen mud-puddling on organic matter coming from animal sources.

Lifecycle

Univoltine in neighbouring regions. Flies mainly in June. Overwinters as caterpillar in small groups on the ground in withered leaves. Phenological curves unavailable due to lack of precision on recording dates.

Habitat

Large, wind-protected, warm and humid forest clearings with ash trees at the forest edge and their branches hanging down to the ground. Warmth and a high humidity level are two important conditions for this species as well as an immediate access to a variety of nectar sources.

Fig. 4.371: *Euphydryas maturna* (Photo: Wolfgang Wagner).

Fig. 4.372: *Euphydryas maturna* (Photo: Wolfgang Wagner).

Nectar resources – Preferentially feeds on species from the Apiaceae family and on flowering shrubs such as *Ligustrum vulgare* and *Viburnum lantana*.

Larval host plants – Lays eggs in clusters on the underside of an ash (*Fraxinus excelsior*) leaf at the tip of a branch hanging just above the ground. Caterpillars form a common web and first feed on the ash leaves, then on other host plants such as *Populus tremula*, *Plantago lanceolata*, and *Succisa pratensis* during the next spring.

Distribution

Luxembourg – Previously recorded in all regions. Last record in 1960-80 near Pétange (record with an inaccurate location and therefore not shown on the map).

Neighbouring countries – No recent record in the Greater Region. Last record in 2000 in southeastern French Lorraine, extinct from Wallonia (last record in 1921) and Rhineland-Palatinate, never recorded in Saarland.

Worldwide – Mainly distributed in central and eastern Europe, from northern France, through southern Germany to Bulgaria, the northern part of Poland and the Baltic States, up to Scandinavia.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. Becoming increasingly rare in western and central Europe, its comeback in Luxembourg is unlikely.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

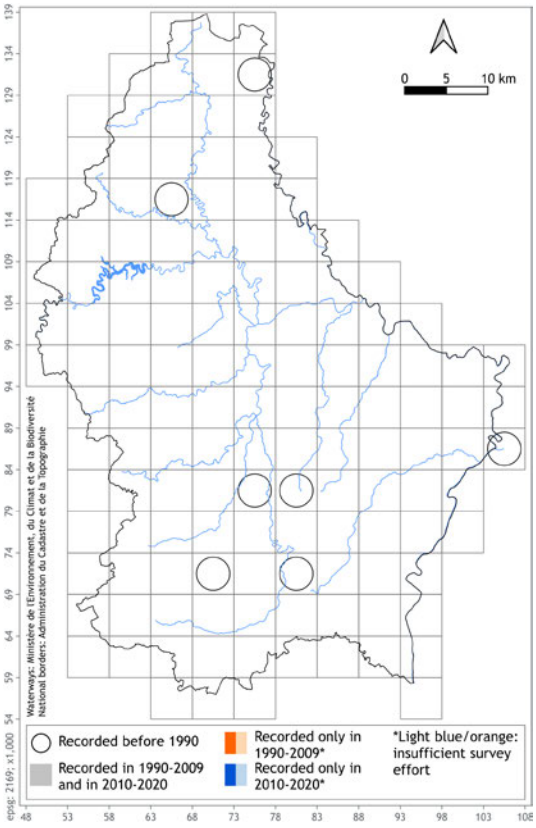


Fig. 4.373: Distribution change map at 5-km spatial resolution for *Euphydryas maturna*.

Fig. 4.374: *Euphydryas maturna* (Illustration: Anita Faber).

NYMPHALIDAE

Euphydryas aurinia
(Rottemburg, 1775)

L: Skabiose-Scheckefalter

E: Marsh fritillary

G: Goldener-Scheckenfalter

F: Damier de la succise

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC Annex II
Red List category	Critically Endangered	Least Concern

Euphydryas aurinia is one of the most threatened species in Luxembourg, in severe decline in most of Europe. It shows considerable inter-annual variations in population size due to weather and parasitism.

Lifecycle

Univoltine. Flies from May to mid-June, with a peak in mid-May. Overwinters as gregarious caterpillars after the third moult, in a nest close to the ground in dense vegetation.

Habitat

Nutrient-poor grasslands along forest edges, large forest paths and clearings, hedgerows, and shrubby areas. In contrast with surrounding regions like Wallonia, the species has been recently restricted to dry grasslands in Luxembourg. In addition to abundant larval food plants and grass height, adults require the vicinity of shelters such as well-structured forest edges or hedgerows.

Fig. 4.375: *Euphydryas aurinia* (Photo: Francis Birlenbach).

Fig. 4.376: *Euphydryas aurinia* (Photo: Hubert Baltus).

Larval host plants – Lays eggs in large batches on the underside of *Succisa pratensis* leaves in wet conditions, or *Scabiosa columbaria* (mostly used in Luxembourg) and *Knautia arvensis* on dry substrates.

Distribution

Luxembourg – Nowadays, almost exclusively distributed with low population densities in the southeastern part of the Minette.

Worldwide – Patchily distributed across most of Europe and temperate Asia to Korea.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -65%

Relative change in extent of occurrence (geographical range): -92%

Strongly decreasing.

Management

Promoting grazing of grasslands by cattle (*S. pratensis* is likely too palatable to sheep and goats) in early spring or in September. Mowing only in late summer (September) when caterpillars are more mobile. Avoiding cutting the vegetation below 15 cm height to preserve the nests. In case of earlier mowing, a large refuge area should be maintained and moved every year within the parcel. Creating corridors between remaining populations via well-structured forest edges or hedgerows.

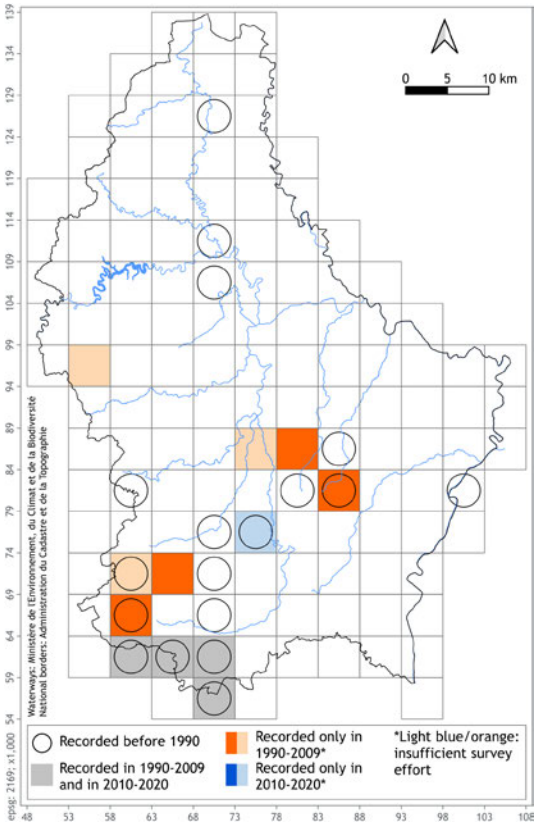


Fig. 4.377: Distribution change map at 5-km spatial resolution for *Euphydryas aurinia*.

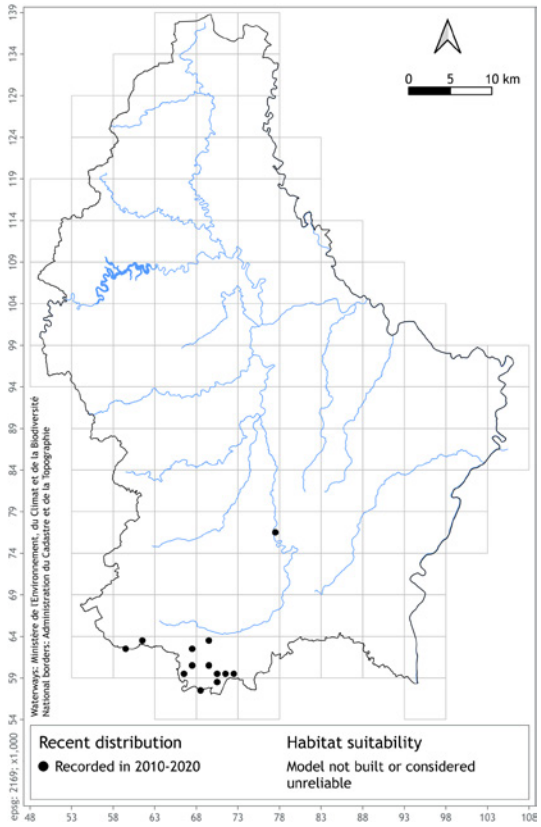


Fig. 4.378: Distribution map at 1-km spatial resolution for *Euphydryas aurinia*.

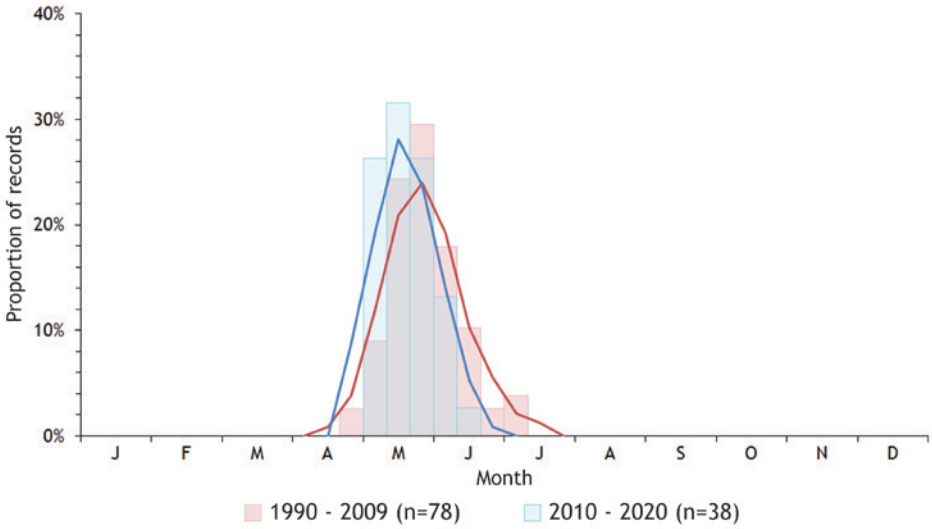


Fig. 4.379: Flight season of *Euphydryas aurinia* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Nymphalis antiopa
(Linnaeus, 1758)

L: Trauermantel

E: Camberwell beauty

G: Trauermantel

F: Morio

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Vulnerable	Least Concern

Nymphalis antiopa is an unmistakable forest butterfly with a powerful flight. Very fearful, it flies away at the slightest movement. Scarce migrant in Luxembourg, adults can fly long distances.

Lifecycle

Univoltine in neighbouring regions. Overwinters as an adult so that one generation produces a first peak in early spring (overwintering adults) and a second one in late summer (offspring).

Habitat

Light deciduous forests with well-exposed open areas, forest edges or coppice management. Typical overwintering sites are woodpiles, dead tree trunks, trunk cavities, cliffs or dry-stone walls, and barns.

Fig. 4.380: *Nymphalis antiopa* (Photo: Stéphane Vizthum).

Fig. 4.381: N*ymphalis antiopa* (Photo: Stéphane Vizthum).

Nectar resources – Feeds on diverse flowers in spring, while in summer it mostly feeds on sap, damaged fruits, faeces or mud.

Larval host plants – Lays eggs in clusters preferentially around a small branch of *Salix* spp. and *Betula* spp. Other tree species are sometimes used, such as *Fraxinus excelsior*, *Populus* spp., *Prunus avium*, or *Ulmus* spp.

Distribution

Luxembourg – Previously mainly recorded in the valleys of central Gutland and the Oesling. Recently recorded near Waldbredimus.

Worldwide – Holarctic species distributed almost all over Europe (from northern Spain to northern Fennoscandia), in temperate Asia and northern America.

Trends (<2010 *vs.* 2010-2020)

Trends were not estimated due to data deficiency but recorded only once during 2010-2020.

Management

Promoting native host plants and maintaining mature trees and dead wood in forest. Avoiding monospecific plantations and dense afforestation.

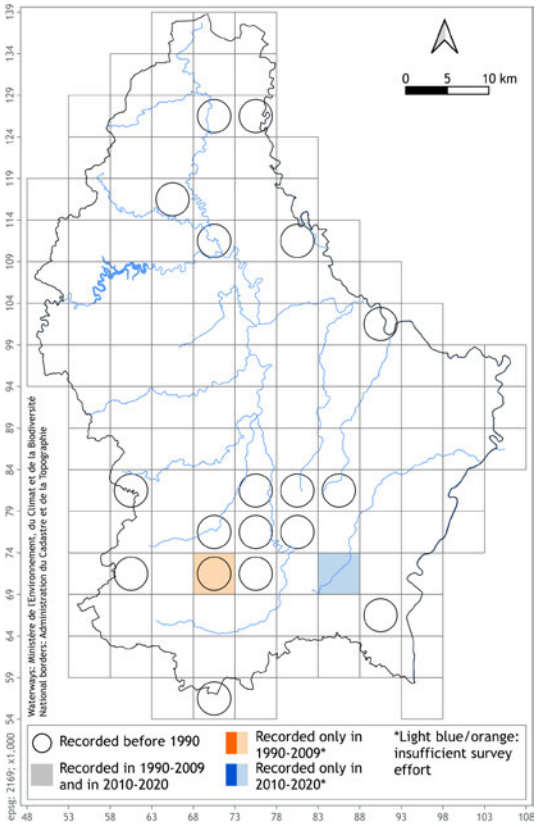


Fig. 4.382: Distribution change map at 5-km spatial resolution for *Nymphalis antiopa*.

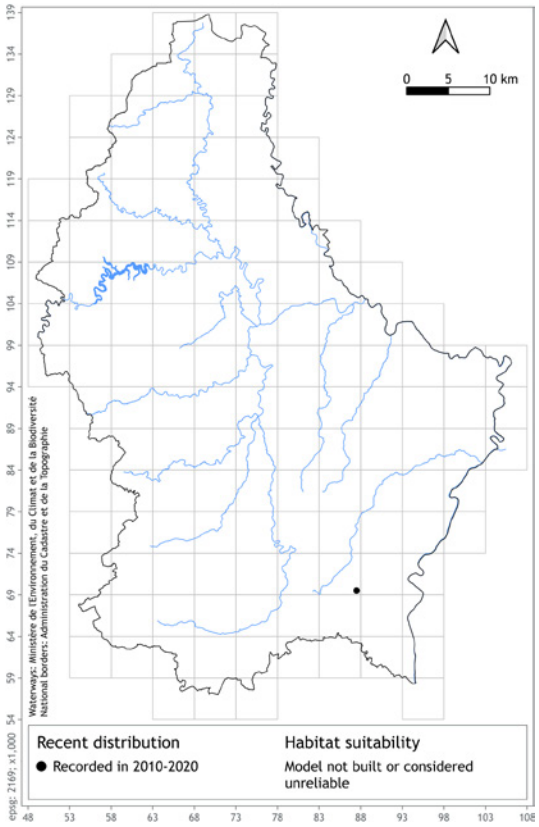


Fig. 4.383: Distribution map at 1-km spatial resolution for *Nymphalis antiopa*.

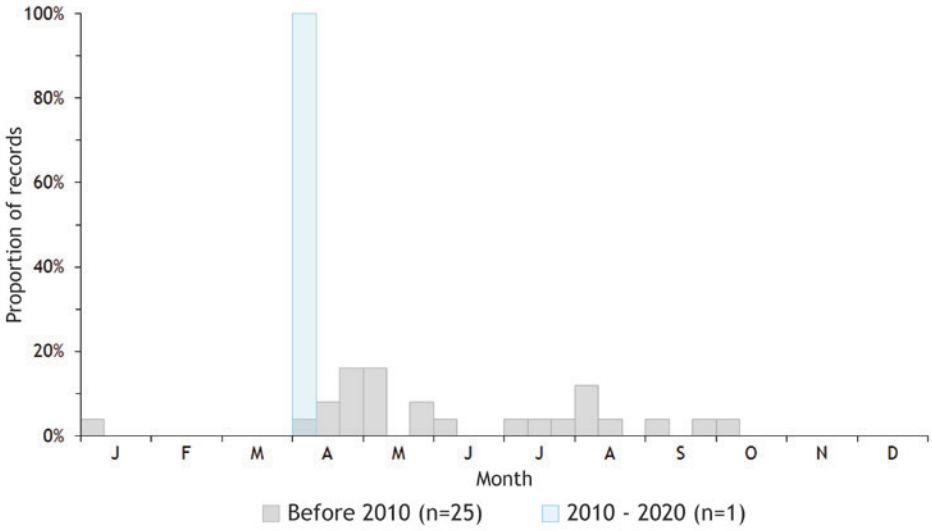


Fig. 4.384: Flight season of *Nymphalis antiopa* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Nymphalis polychloros
(Linnaeus, 1758)

L: Grousse Fox
E: Large tortoiseshell
G: Großer Fuchs
F: Grande tortue

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Vulnerable

Nymphalis polychloros is a forest butterfly showing a strong inter-annual variation in abundance due to parasitism. Confusion with *Aglais urticae* and *N. xanthomelas* may be possible without careful attention, although this latter has not yet been observed in Luxembourg. Males are territorial. When disturbed, they make a short flight and often return to the same place. It can fly over large distances.

Lifecycle

Univoltine. Flies mostly from late February to August, with a first peak in early April (overwintering adults) and a second one, smaller, in mid-June (offspring).

Habitat

Light deciduous forests, riparian forests in valleys, well-exposed forest edges, clearings, shrubby areas, orchards, and even gardens with its host plants. Adults overwinter in trunk cavities, woodpiles, attics, or barns.

Fig. 4.385: *Nymphalis polychloros* (Photo: Marcel Hellers).

Fig. 4.386: *Nymphalis polychloros* (Photo: Alain Dohet).

Nectar resources – Preferentially feeds on willow flowers in spring, and on mud, faeces and damaged fruits during the rest of the time.

Larval host plants – Lays eggs in clusters around a young branch of tree species, such as *Betula* spp., native *Populus* spp. (e.g., *Populus tremula*), *Prunus avium*, *Salix* spp., and *Ulmus* spp. (especially *Ulmus glabra*).

Distribution

Luxembourg – Distributed across the whole country with suitable habitats available in every region, especially in forested areas along the valleys.

Worldwide – From northern Africa across southern and central Europe, temperate Asia to the Himalaya mountains.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -17%

Relative change in extent of occurrence (geographical range): +15%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range slightly expanded in 2010-2020.

Management

Promoting native host plants in forests and wintering sites such as mature trees, woodpiles and dead wood.

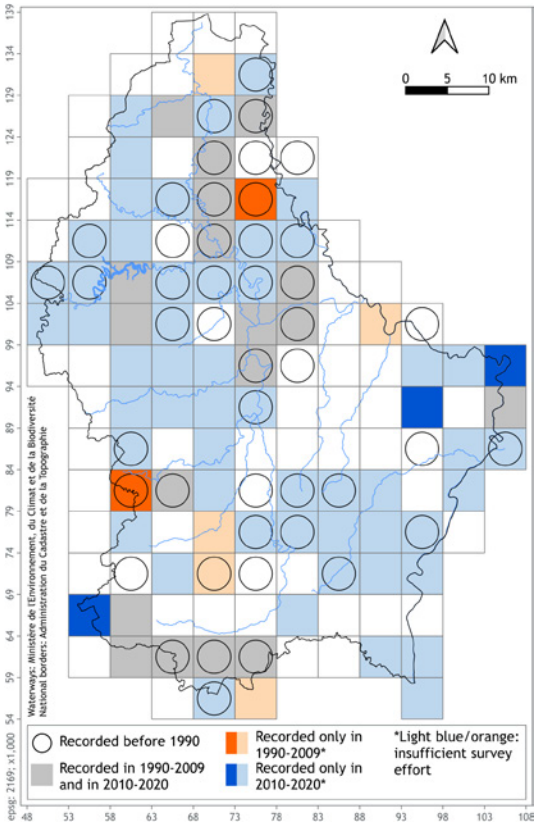


Fig. 4.387: Distribution change map at 5-km spatial resolution for *Nymphalis polychloros*.

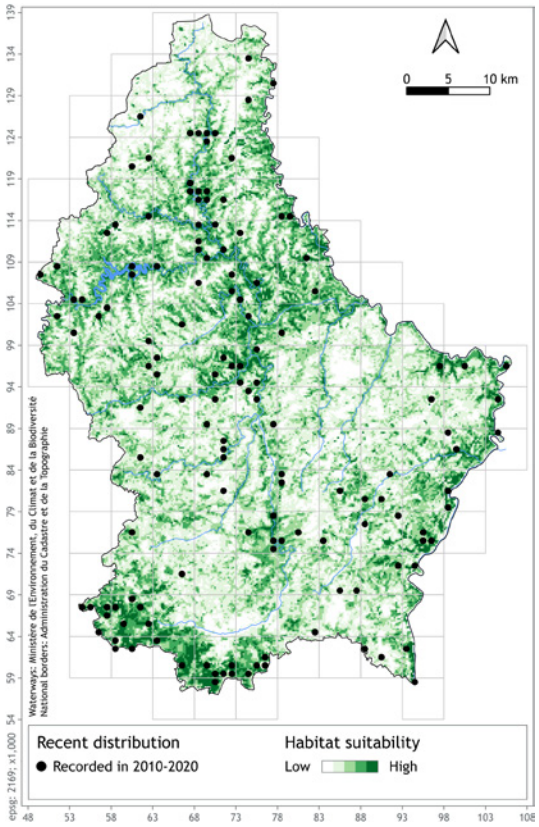


Fig. 4.388: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Nymphalis polychloros*.

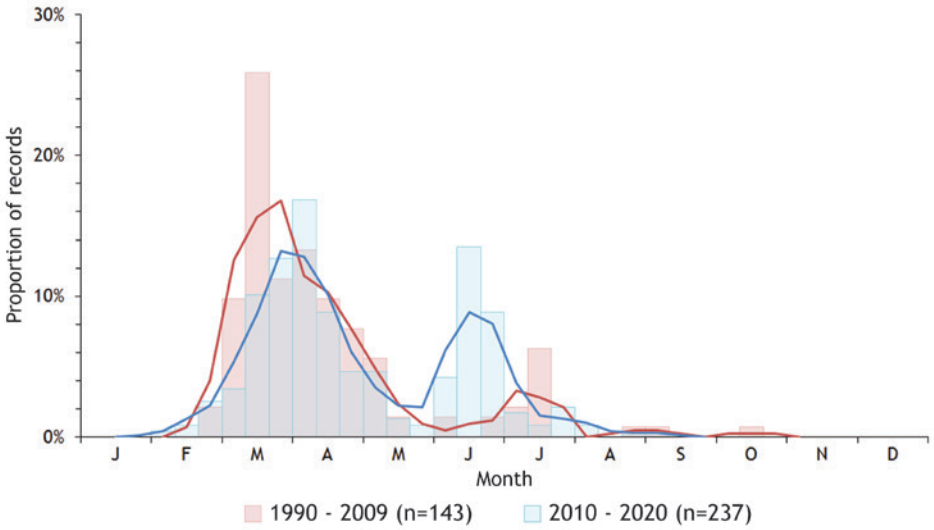


Fig. 4.389: Flight season of *Nymphalis polychloros* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Aglais urticae
(Linnaeus, 1758)

L: Klenge Fox
E: Small tortoiseshell
G: Kleiner Fuchs
F: Petite tortue

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Aglais urticae is a highly mobile butterfly showing strong inter-annual variation in abundance due to parasitism by Tachinid flies.

Lifecycle

Mostly bivoltine, sometimes three generations in favourable years. Flies mostly from March to late September with a main peak in June. Overwinters as adult in buildings, trees or woodpiles. Can be seen at any time of the year as soon as weather conditions become favourable (i.e., above 10°C, sunny, no or little wind).

Habitat

Wide variety of open biotopes where nettles grow in abundance, such as field margins, road verges, forest edges, wet grasslands, gardens, and wastelands.

Fig. 4.390: *Aglais urticae* (Photo: Michelle Clemens).

Fig. 4.391: *Aglais urticae* (Photo: Alain Dohet).

Nectar resources – Feeds on many different flowering species.

Larval host plants – Lays eggs in clusters of 80 to 200 on the underside of *Urtica dioica* leaves. Caterpillars are gregarious until the last moult, spread on the host plant, and then may travel a long distance searching for a place to make their chrysalis.

Distribution

Luxembourg – Homogeneously distributed across the whole country with suitable habitats available in every region.

Worldwide – Throughout temperate Europe, in Asia Minor, central Asia, Siberia, China, Mongolia, Korea, and Japan.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +2%

Relative change in extent of occurrence (geographical range): +2%

Considered as stable.

Management

Maintaining some unmown nettle beds and flower-rich areas in gardens, forest edges, hedgerows, wetlands, or road verges.

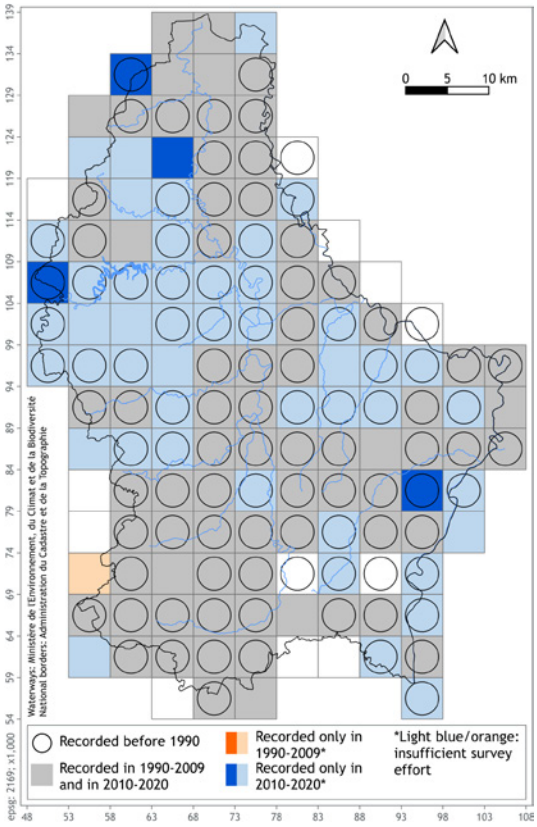


Fig. 4.392: Distribution change map at 5-km spatial resolution for *Aglais urticae*.

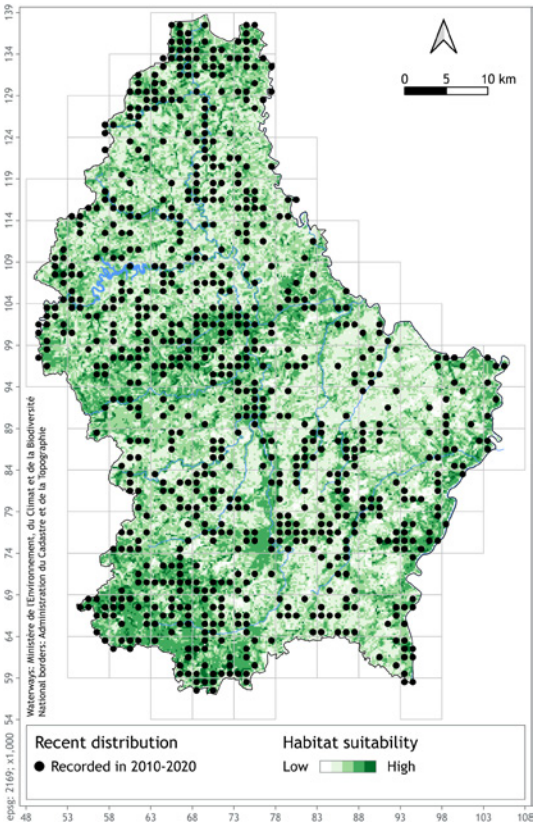


Fig. 4.393: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Aglais urticae*.

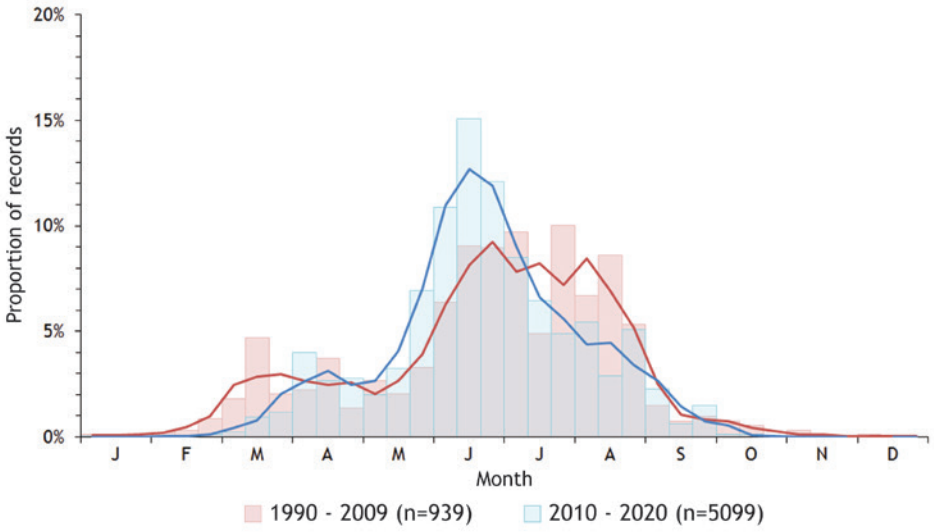


Fig. 4.394: Flight season of *Aglais urticae* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Aglais io

(Linnaeus, 1758)

Syn.: *Inachis io*

L: Pohunn

E: Peacock

G: Tagpfauenauge

F: Paon du jour

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Aglais io is a highly mobile butterfly showing strong inter-annual variation in abundance due to parasitism by Tachinid flies.

Lifecycle

Bivoltine. Flies mostly from mid-March to October with a first peak in April and a second one, steeper, in late July. Overwinters as adult in refuges like attics, cellars, tree bark, and piles of firewood. Can be seen at any time of the year as soon as weather conditions become favourable (i.e., above 10°C, sunny, no or little wind).

Habitat

Wide variety of biotopes with sunny nettle beds and abundant flowers, such as forest edges, forest clearings, gardens, wastelands, field margins, wetlands, and river sides.

Fig. 4.395: *Aglais io* (Photo: Youri Martin).

Fig. 4.396: *Aglais io* (Photo: Roland Proess).

Nectar resources – Feeds on a wide variety of flowers, but willow flowers (*Salix* spp.) are important resource in spring.

Larval host plants – Lays eggs in clusters of 50 to 200 on the underside of *Urtica dioica* leaves (primarily). *Humulus lupulus* and *Urtica urens* are also mentioned in the literature.

Distribution

Luxembourg – Heterogeneously distributed across the whole country with suitable habitats available in almost every region.

Worldwide – From Europe to temperate Asia and even in Japan.

Trends (<2010 vs. 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -10%

Relative change in extent of occurrence (geographical range): +2%

Considered as stable.

Management

Maintaining some unmown and sunny nettle beds and flower-rich areas in gardens, forest edges, hedgerows, wetlands, or road verges.

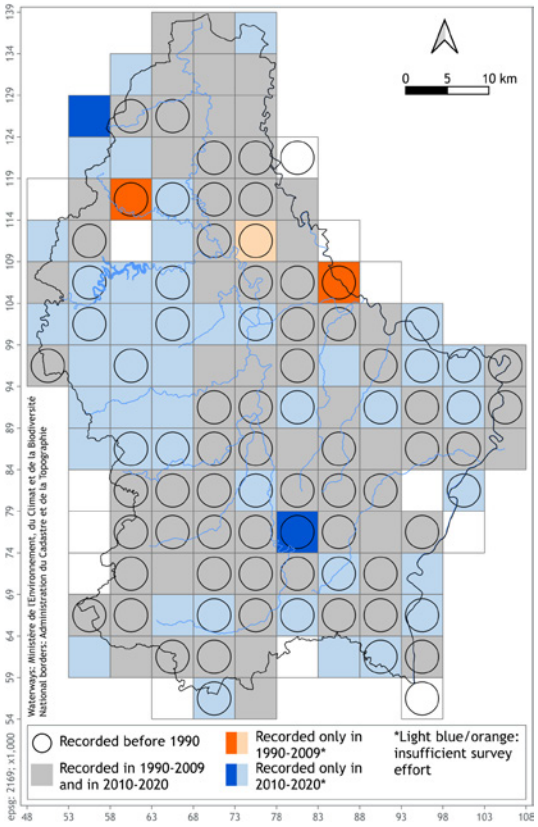


Fig. 4.397: Distribution change map at 5-km spatial resolution for *Aglais io*.

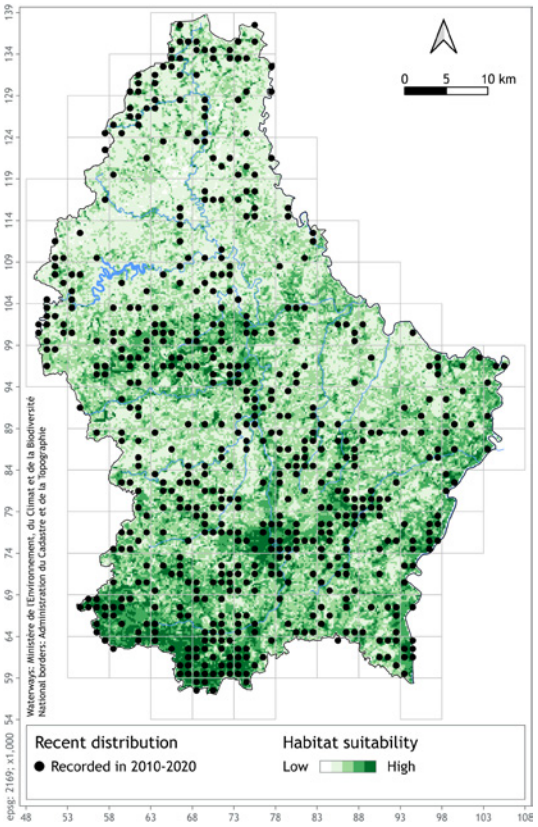


Fig. 4.398: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Aglais io*.

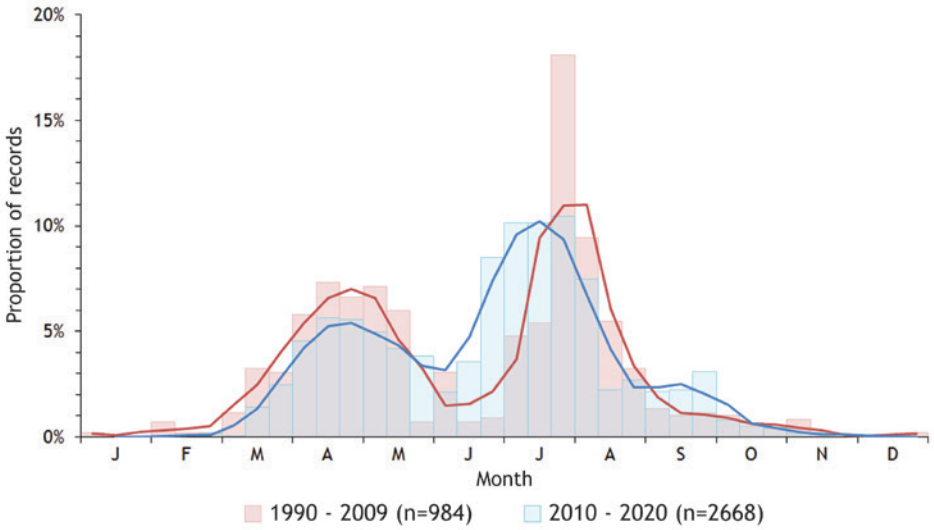


Fig. 4.399: Flight season of *Aglais io* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Vanessa atalanta
(Linnaeus, 1758)

L: Admirol

E: Red admiral

G: Admiral

F: Vulcain

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Vanessa atalanta is a migrant butterfly coming from southern Europe, with few individuals overwintering in Luxembourg. It likes to bask with wide open wings, and suck minerals or sugars from mud, ripe fruits and faeces. Males are territorial with conspecifics but several individuals of other species are frequently observed together while feeding and mud-puddling.

Lifecycle

Mostly univoltine, but two generations in favourable years. Flies from March to November with a peak in late July. Generally, individuals born in Luxembourg migrate in autumn to breed in the Mediterranean regions. In spring, their offspring undertakes the migration back to breed in Luxembourg and surrounding areas.

Fig. 4.400: *Vanessa atalanta* (Photo: Hubert Baltus).

Fig. 4.401: *Vanessa atalanta* (Photo: Marcel Hellers).

Habitat

Wide variety of open biotopes, including gardens. Typical overwintering sites are woodpiles, trunk cavities, attics, and barns.

Nectar resources – Preferentially feeds on flowers such as *Hedera helix* as well as on ripe fruits in late summer and autumn before migration.

Larval host plants – Lays single eggs mostly on *Urtica dioïca* and *U. urens*. *Parietaria officinalis*, *Carduus nutans* and *Humulus lupulus* are also mentioned in the literature.

Distribution

Luxembourg – Distributed across the whole country. Availability of suitable habitats is not shown for this migrant species.

Worldwide – Holarctic species distributed all over Europe.

Trends (1990-2009 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +11%

Relative change in extent of occurrence (geographical range): +3%

Although recorded in a slightly increasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting nettle patches in gardens, open areas in forests, well-structured forest edges and hedgerows, as well as floral resources and ripe fruits (especially in autumn).

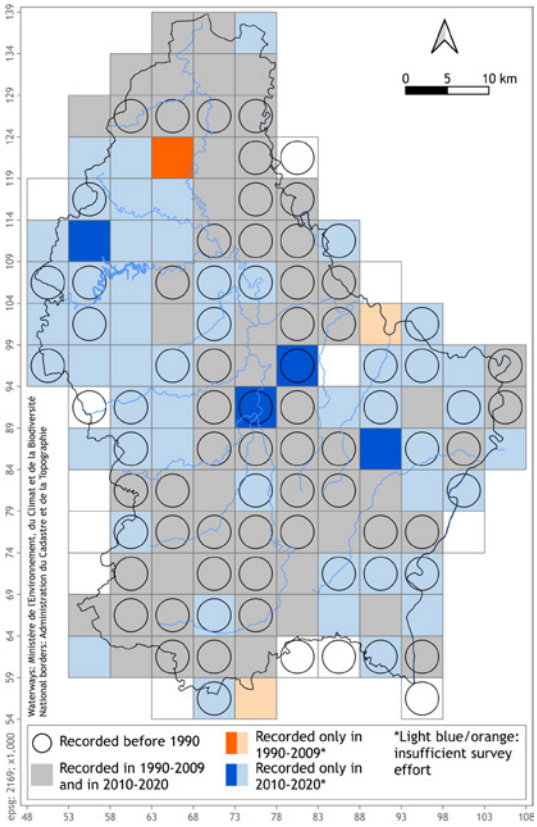


Fig. 4.402: Distribution change map at 5-km spatial resolution for *Vanessa atalanta*.

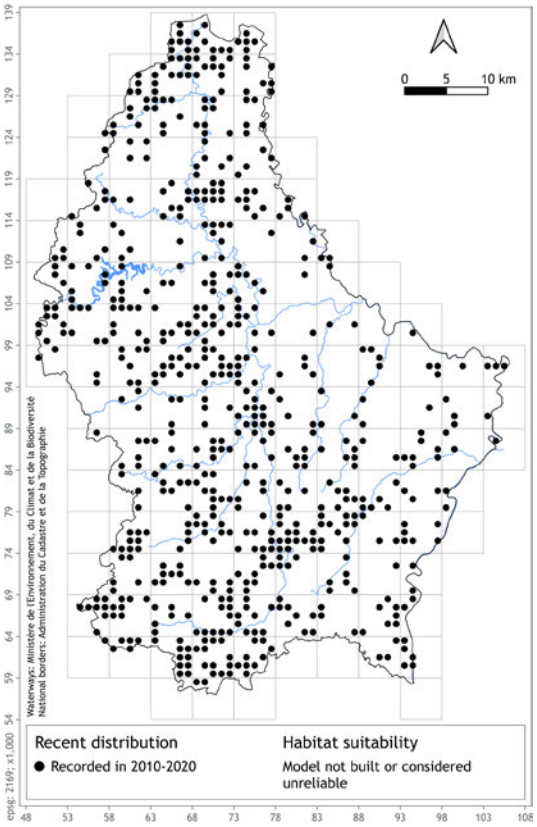


Fig. 4.403: Distribution map at 1-km spatial resolution for *Vanessa atalanta*.

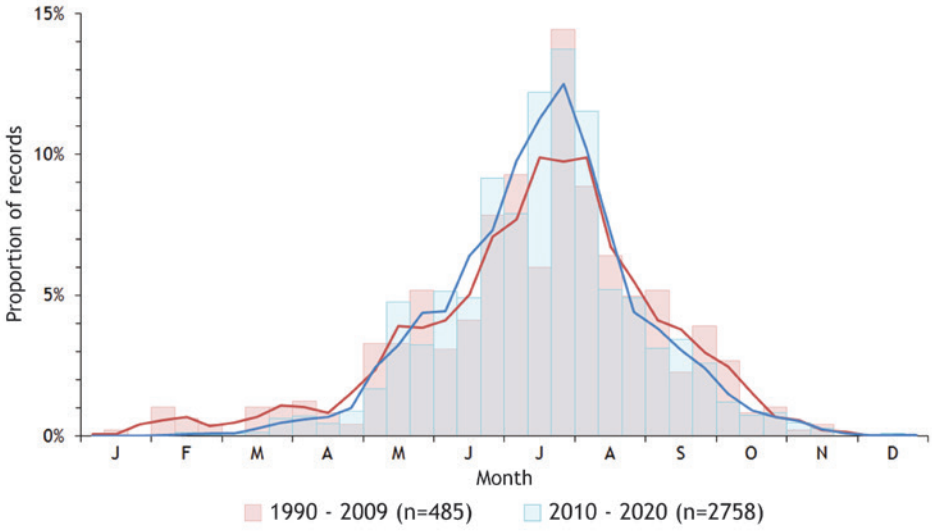


Fig. 4.404: Flight season of *Vanessa atalanta* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Vanessa cardui

(Linnaeus, 1758)

L: Dëschtelfalter

E: Painted lady

G: Distelfalter

F: Belle Dame

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

In summertime, *Vanessa cardui* breeds up to northern Fennoscandia while in winter, the migratory individuals reach tropical Africa. Favourable conditions in northern Africa and along their route can lead to massive arrivals in Europe.

Lifecycle

Univoltine, sometimes a second partial generation. First individuals arrive from the south in April with a flying peak in June. A second flying peak is induced by their offspring in late July. These individuals, born in Luxembourg, migrate to the south to breed in northern Africa. In spring, the next generation undertakes the migration in the opposite way.

Habitat

Very large variety of open biotopes.

Fig. 4.405: *Vanessa cardui* (Photo: Mireille Molitor).

Fig. 4.406: *Vanessa cardui* (Photo: Francis Birlenbach).

Larval host plants – Lays single eggs on the upper side of the terminal leaves of various species, primarily on thistles (*Cirsium* spp. and *Carduus* spp.) in Luxembourg. *Echium vulgare*, *Malva* spp. *Tussilago farfara*, *Arctium lappa*, and *Urtica dioica* are also mentioned in the literature.

Distribution

Luxembourg – Distributed across the whole country. Availability of suitable habitats is not shown for this migrant species.

Worldwide – Cosmopolitan species distributed almost worldwide, except in southern America and Antarctica.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -17%

Relative change in extent of occurrence (geographical range): +4%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Avoiding systematic thistle removal and limiting it only to species that can potentially become invasive in crops and grasslands (i.e., *Cirsium arvense*). Public awareness of the differences between the invasive and non-invasive thistles might improve the availability of these host plants, as well as nectar resources for many other butterfly species.

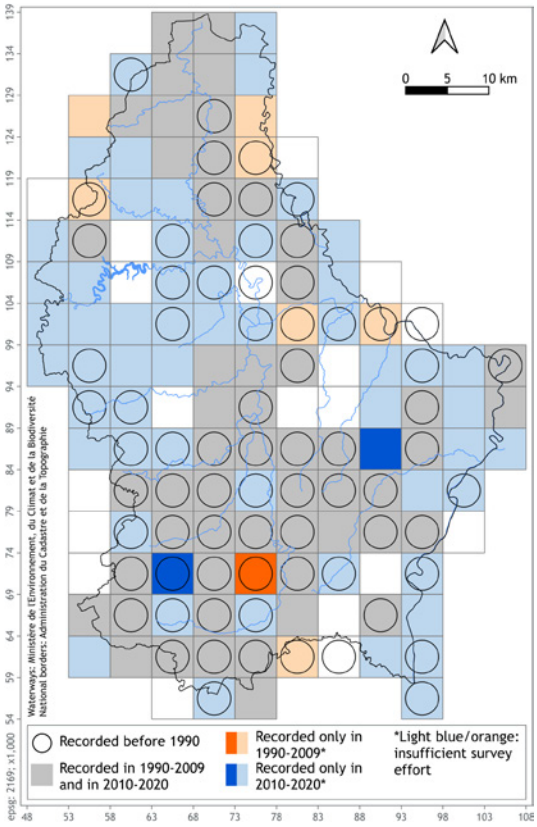


Fig. 4.407: Distribution change map at 5-km spatial resolution for *Vanessa cardui*.

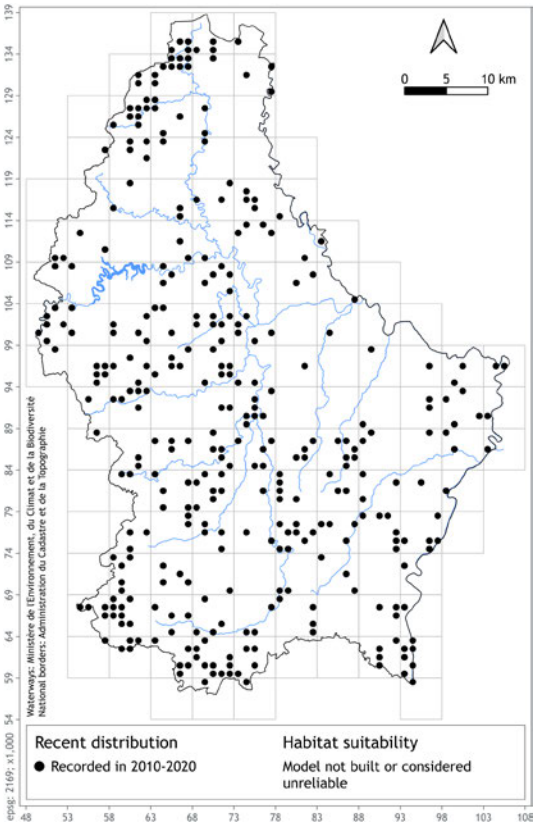


Fig. 4.408: Distribution map at 1-km spatial resolution for *Vanessa cardui*.

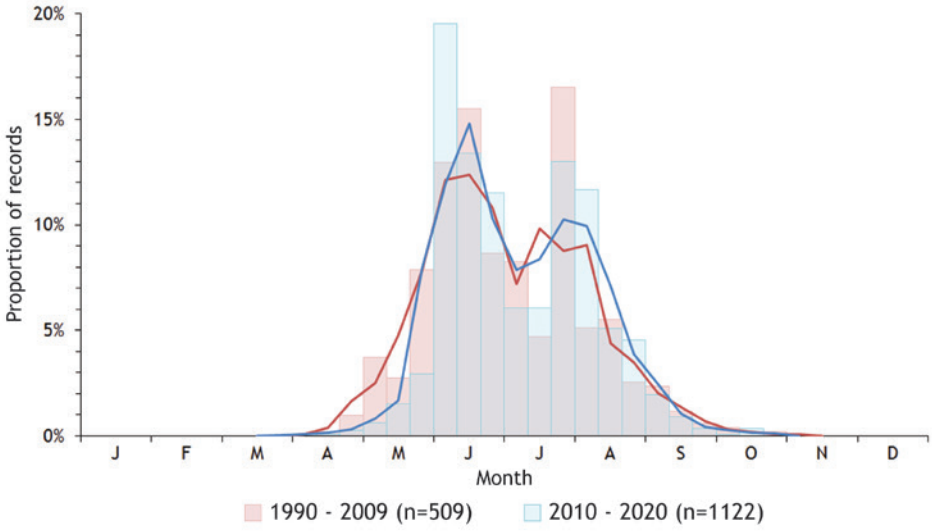


Fig. 4.409: Flight season of *Vanessa cardui* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Polygonia c-album
(Linnaeus, 1758)

L: C-Falter

E: Comma

G: C-Falter

F: Robert-le-Diable

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Polygonia c-album got its name from the little white c-shaped letter on the underside of the hindwings. It commonly sucks minerals or sugar from mud, ripe fruits, or faeces. Males are territorial. When disturbed, they make a short flight and often return to the same place.

Lifecycle

Mostly univoltine, but two generations in favourable years. Overwinters as adult, which may be seen at any time of the year in case of sufficiently warm weather conditions. Flies from March to October, with a first peak in spring (overwintering adults) and a second one in July (offspring).

Fig. 4.410: *Polygonia c-album* (Photo: Francis Birlenbach).

Fig. 4.411: *Polygonia c-album* (Photo: Marcel Hellers).

Habitat

Open deciduous woodlands, forest clearings and edges, but also hedgerows, gardens, parks, and orchards.

Larval host plants – Lays single eggs mostly on *Urtica dioica*, *Humulus lupulus*, and *Ulmus glabra*, but sometimes also on *Artemisia vulgaris*, *Corylus avellana*, *Crataegus laevigata*, *Lonicera periclymenum*, *Prunus spinosa*, *Rubus idaeus*, *Salix* spp., other *Ulmus* spp., and *Ribes* spp.

Distribution

Luxembourg – Distributed across the whole country.

Worldwide – Palearctic species, from northern Africa across most of Europe and temperate Asia to Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +11%

Relative change in extent of occurrence (geographical range): +8%

Although recorded in a slightly increasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting light penetration in forests and rotational management to create a mosaic of fallow patches along forest edges, in gardens, along hedgerows, field margins, and road verges.

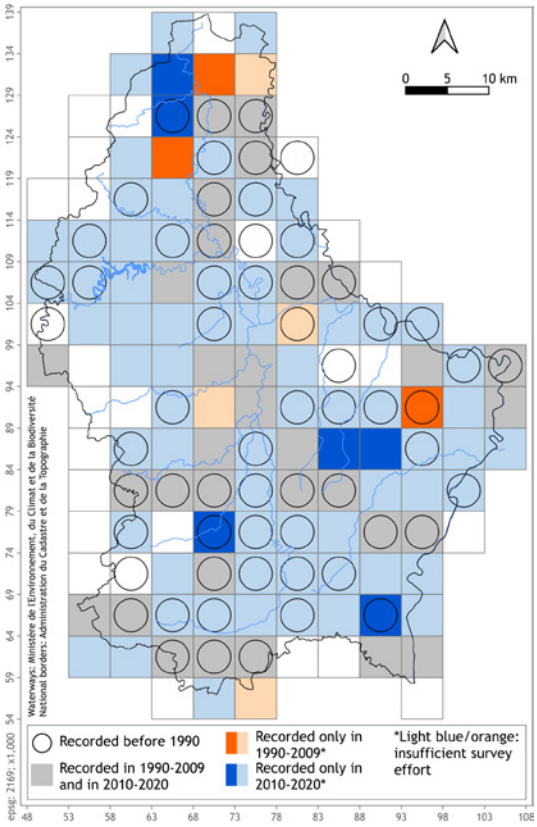


Fig. 4.412: Distribution change map at 5-km spatial resolution for *Polygonia c-album*.

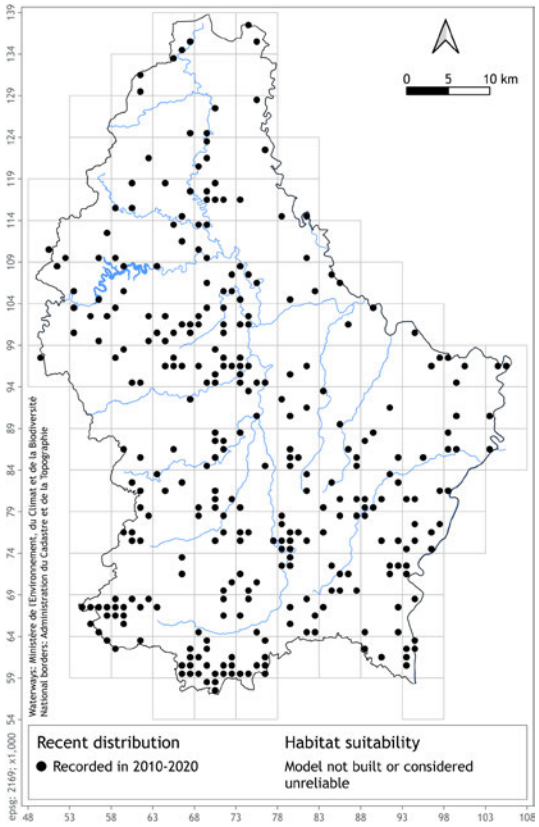


Fig. 4.413: Distribution map at 1-km spatial resolution for *Polygonia c-album*.

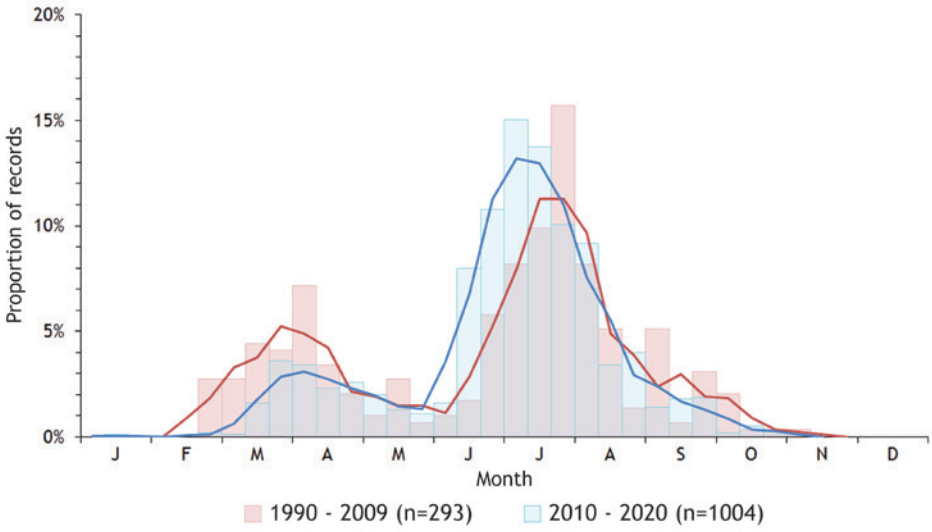


Fig. 4.414: Flight season of *Polygonia c-album* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Araschnia levana

(Linnaeus, 1758)

L: Landkäertchen

E: Map

G: Landkärtchenfalter

F: Carte géographique

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Originating from south-eastern Europe, *Araschnia levana* started to become relatively common in Luxembourg at the beginning of the 20th century. It exhibits pronounced seasonal dimorphism induced by the temperature during the chrysalis stage. Individuals are mainly orange in spring and black in summer.

Lifecycle

Bivoltine. Flies mostly from April to August, with a first peak in May (light form) and a second one, steeper, in late July (dark form). In favourable years, a third generation may happen (intermediate form). Overwinters as chrysalis.

Habitats

Wet and cool biotopes, such as forest edges, forest clearings and river sides, where nettles grow.

Fig. 4.415: *Araschnia levana* (Photo: Marcel Hellers).

Fig. 4.416: *Araschnia levana* (Photo: Michelle Clemens).

Nectar resources – Feeds mainly on *Anthriscus sylvestris*, *Cirsium* spp., *Eupatorium cannabinum*, and *Sambucus ebulus* flowers.

Larval host plants – Lays eggs on the underside of *Urtica dioica* leaves, with up to 20 on each other, creating little strings perpendicular to the surface of the leaf.

Distribution

Luxembourg – Distributed across the whole country with suitable habitats available in every region, especially in the Minette, in the lowland areas and in valley bottoms.

Worldwide – Across central Europe and temperate Asia to China, Korea, and Japan.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -12%

Relative change in extent of occurrence (geographical range): +4%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Preserving nettles and flowers along forest edges, forest paths and hedgerows, in gardens, forest clearings, and wetlands.

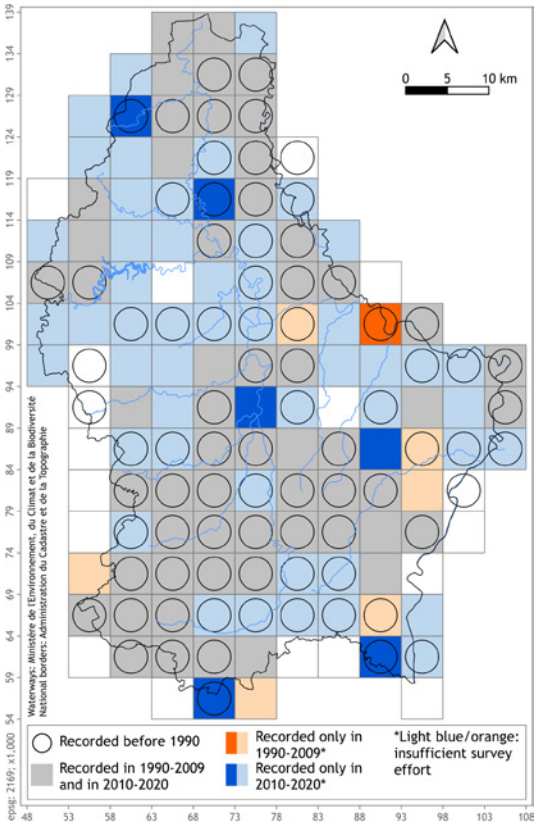


Fig. 4.417: Distribution change map at 5-km spatial resolution for *Araschnia levana*.

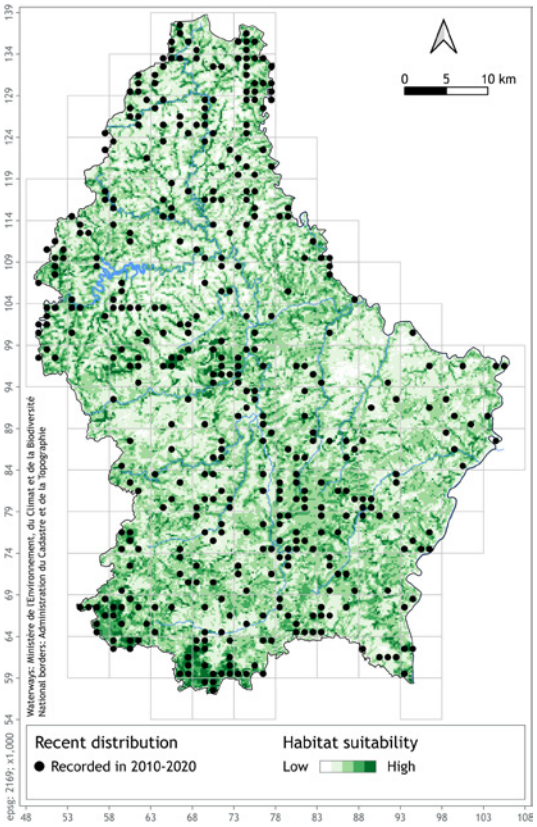


Fig. 4.418: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Araschnia levana*.

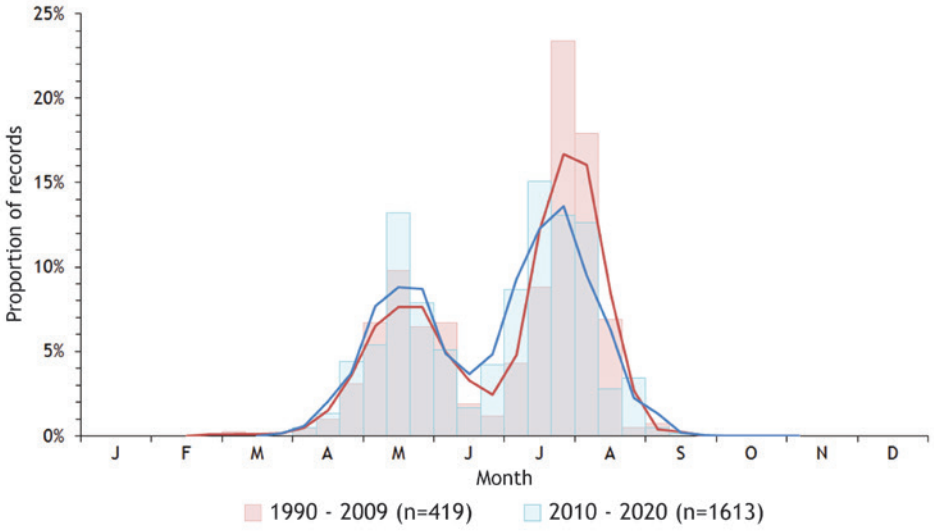


Fig. 4.419: Flight season of *Araschnia levana* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Pararge aegeria
(Linnaeus, 1758)

L: Bëschbrietspill
E: Speckled wood
G: Waldbrettspiel
F: Tircis

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Pararge aegeria is a common forest butterfly. Due to its appearance, dark brown with white or orange spots, it can be difficult to spot when settled on the ground. Males are territorial and some of them select a perch exposed to the sun to wait for a passing female.

Lifecycle

Mostly bivoltine, up to three generations in favourable years. Flies mostly from April to early October, with a first peak in May and a second one, slightly steeper, in mid-summer. Overwinters as caterpillar or chrysalis.

Habitat

Deciduous or coniferous forests with light spots and small clearings, as well as along forest edges, hedgerows, in gardens and urban parks.

Fig. 4.420: *Pararge aegeria* (Photo: Marcel Hellers).

Fig. 4.421: *Pararge aegeria* (Photo: Alain Dohet).

Larval host plants – Lays single eggs, often dropped among grasses while flying, mainly on or near *Agrostis capillaris*, *Brachypodium pinnatum*, *B. sylvaticum*, *Calamagrostis arundinacea*, *Deschampsia cespitosa*, *Dactylis glomerata*, *Elymus repens*, *Holcus lanatus*, *Lolium perenne*, *Molinia caerulea*, *Poa annua*, *P. pratensis*, and *P. trivialis*.

Distribution

Luxembourg – Distributed across the whole country with a widespread availability of suitable habitats.

Worldwide – Palearctic species, from north-western Africa, across most of Europe (up to southern Fennoscandia), to temperate Asia and Russia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -7%

Relative change in extent of occurrence (geographical range): +9%

Considered as stable.

Management

Promoting light penetration in forests (e.g., along forest paths) and open areas in forests.

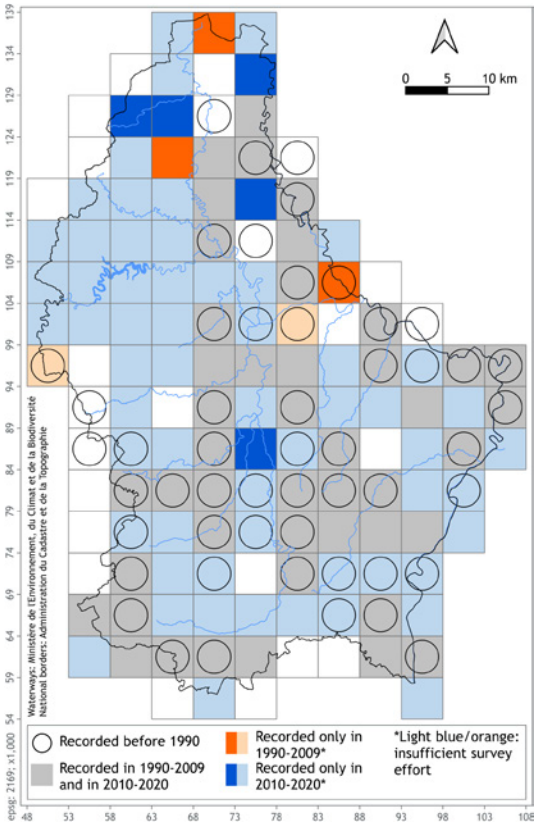


Fig. 4.422: Distribution change map at 5-km spatial resolution for *Pararge aegeria*.

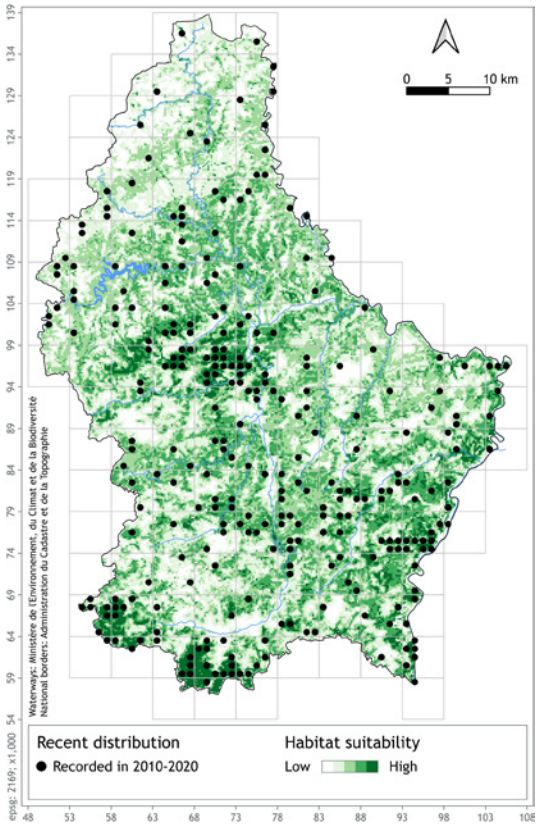


Fig. 4.423: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Pararge aegeria*.

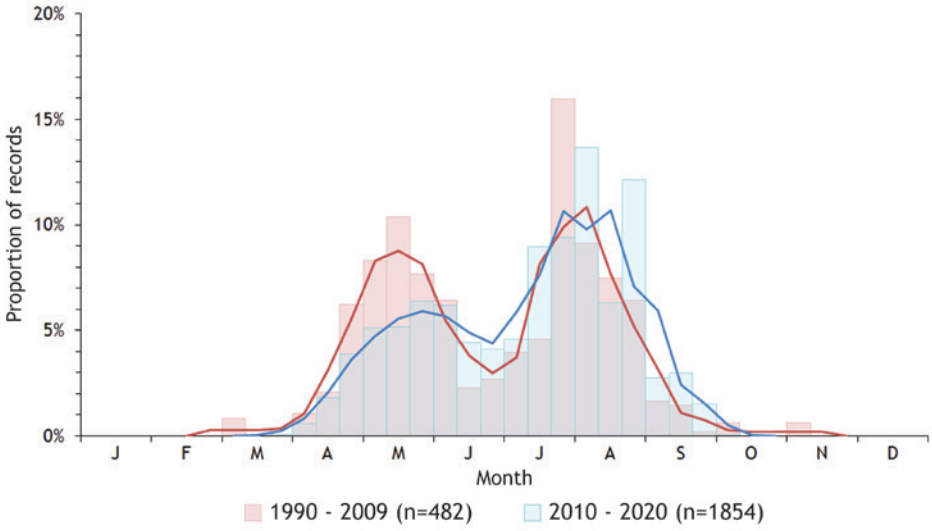


Fig. 4.424: Flight season of *Pararge aegeria* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Lasiommata megera

(Linnaeus, 1767)

L: Mauerfox

E: Wall brown

G: Mauerfuchs

F: Mégère

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Very active and takes off at the slightest movement, *Lasiommata megera* has a regular cycle of patrolling, resting and foraging. The energy spent makes its adult lifespan quite short. It benefits from cold and harsh winters followed by warm and dry summers.

Lifecycle

Mostly bivoltine, but three generations in favourable years. Flies mostly from May to September, with a first peak in late May and a second one, steeper, in early August. Overwinters as caterpillar.

Habitat

Open and sunny biotopes with the presence of bare ground, such as paths, forest edges, woodpiles, hedgerows, road verges, dry walls, terrace vineyards, old quarries, rocky dry areas and stony slopes.

Fig. 4.425: *Lasiommata megera* (Photo: Marcel Hellers).

Fig. 4.426: *Lasiommata megera* (Photo: Alain Dohet).

Larval host plants – Lays single eggs (occasionally in pairs or triplets), either near or on various species from the Poaceae family, such as *Agrostis capillaris*, *Brachypodium pinnatum*, *B. sylvaticum*, *Bromus erectus*, *B. sterilis*, *Dactylis glomerata*, *Deschampsia flexuosa*, *Festuca ovina*, *F. rubra*, *Holcus lanatus*, *H. mollis*, and *Poa annua*.

Distribution

Luxembourg – Distributed across the whole country with a widespread availability of suitable habitats.

Worldwide – Palearctic species, from northern Africa across Europe (up to southern Scandinavia) to temperate Asia, including the British Isles.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -19%

Relative change in extent of occurrence (geographical range): +7%

Even though recorded in a slightly decreasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting extensive management of well-exposed areas.

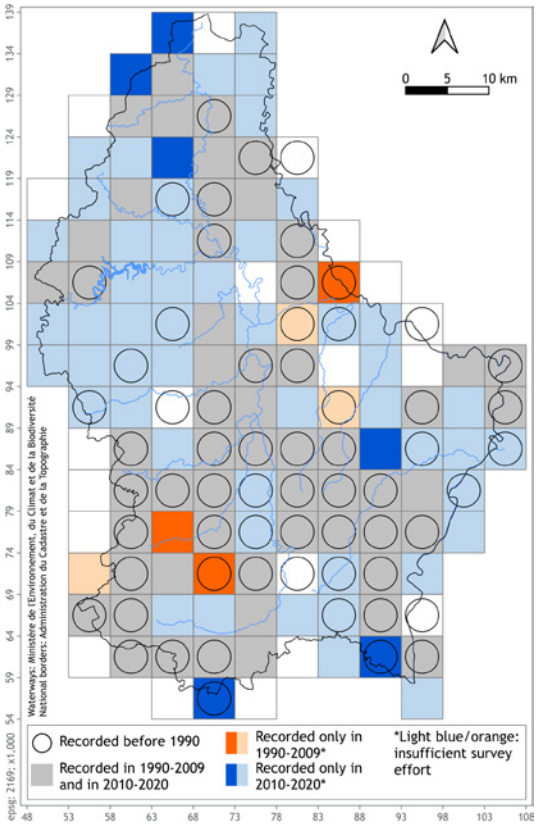


Fig. 4.427: Distribution change map at 5-km spatial resolution for *Lasiommata megera*.

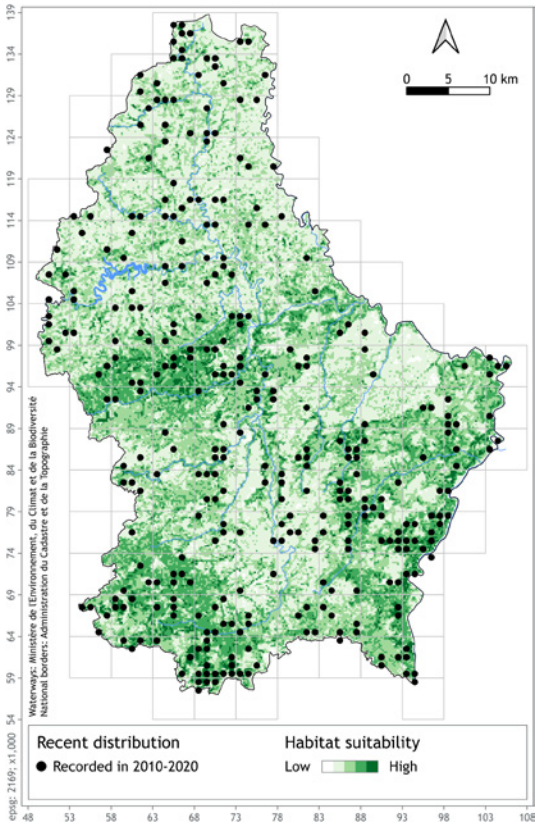


Fig. 4.428: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Lasiommata megera*.

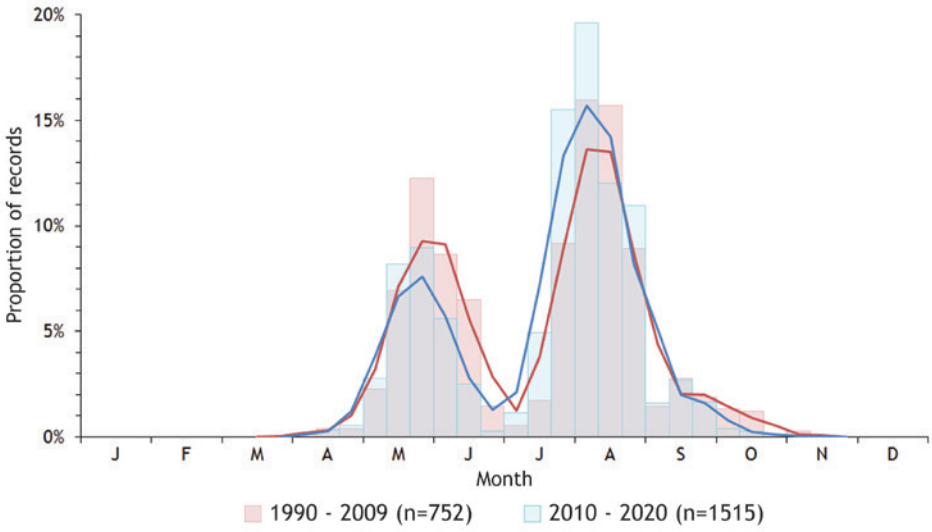


Fig. 4.429: Flight season of *Lasiommata megera* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Lasiommata maera

(Linnaeus, 1758)

L: Brongt A

E: Large wall brown

G: Braunauge

F: Némusien

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Endangered	Least Concern

Lasiommata maera is similar to *L. megera* but a little larger and less orange. They can both be found together in Luxembourg, but *L. maera* is rarer and relies on the presence of stony areas.

Lifecycle

Bivoltine. Flies from May to October, with a first peak in June and a second one, smaller, in August. Overwinters as caterpillar.

Habitat

Warm and well-exposed vertical cliffs at the bottom of which its host plants grow, such as grassy places in old quarries, rocky dry areas and stony slopes, dry stone walls, terrace vineyards, woodpiles, and stumps in forest clear-cuts.

Fig. 4.430: *Lasiommata maera* (Photo: Lionel L'Hoste).

Fig. 4.431: *Lasiommata maera* (Photo: Stéphane Vizthum).

Larval host plants – Lays single eggs on various species from the Poaceae family, such as *Brachypodium* spp., *Bromus erectus, Calamagrostis arundinacea, Deschampsia flexuosa, Festuca* spp., *Hordeum* spp., *Nardus stricta, Poa annua, P. bulbosa,* and *P. pratensis*.

Distribution

Luxembourg – Exclusively distributed in the Minette.

Worldwide – Palearctic species, from north-western Africa, across Europe from the Iberian Peninsula to Fennoscandia, to temperate Asia and western Siberia. Absent from the British Isles.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -57%

Relative change in extent of occurrence (geographical range): -98%

Strongly decreasing.

Management

Avoiding shrub encroachment and promoting extensive management of the grass cover in dry and stony biotopes.

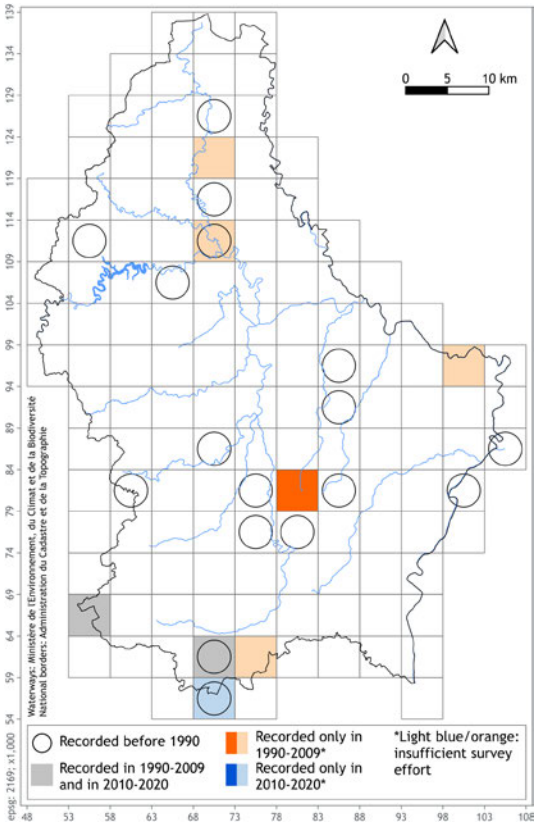


Fig. 4.432: Distribution change map at 5-km spatial resolution for *Lasiommata maera*.

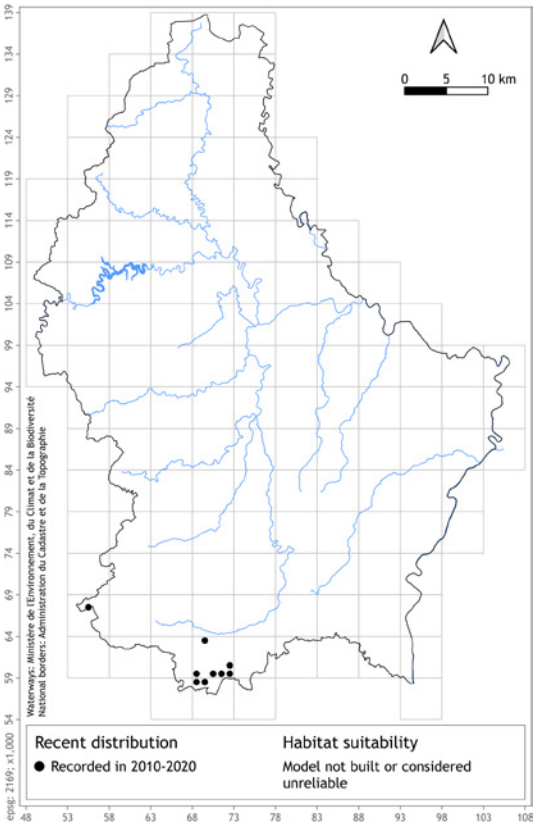


Fig. 4.433: Distribution map at 1-km spatial resolution for *Lasiommata maera*.

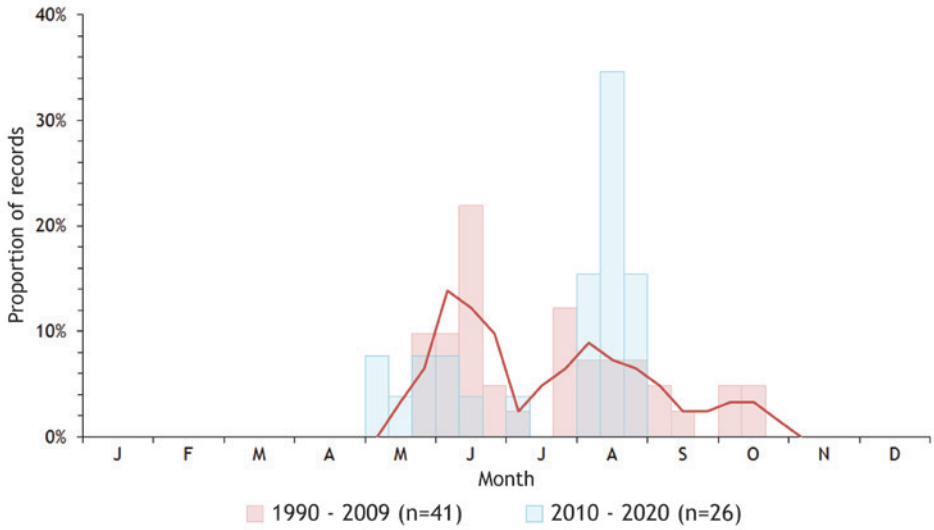


Fig. 4.434: Flight season of *Lasiommata maera* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Lopinga achine
(Scopoli, 1763)

L: Gielrengfalter
E: Woodland brown
G: Gelbringfalter
F: Bacchante

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC Annex IV
Red List category	Regionally Extinct since 1979	Vulnerable

Lopinga achine is a forest species with an irregular flight and is characterised by high inter-annual variations in abundance. Adults avoid full sunlight and always fly in partially shaded areas.

Lifecycle

Univoltine in neighbouring regions. Flies mostly from June to early July. Overwinters as half-grown caterpillar.

Habitat

Open deciduous forests with small clearings resulting from silvopastoral practices (i.e., forest used for cattle grazing and fattening). Grazing prevented the forest from encroachment and created many small open areas in forest particularly attractive for this species.

Fig. 4.435: *Lopinga achine* (Photo: Stéphane Vizthum).

Fig. 4.436: *Lopinga achine* (Photo: Stéphane Vizthum).

Larval host plants – Lays eggs in flight. Caterpillars feed on various species from the Poaceae family, such as *Brachipodium* spp. and *Carex* spp.

Distribution

Luxembourg – Previously recorded mostly in central Gutland. Last record in 1979 near Luxembourg-City.

Neighbouring countries – Since 2010, recorded in central French Lorraine. Extinct from Wallonia since 1926 (last record in southern Belgian Lorraine), from Saarland since the 1930s and from Rhineland-Palatinate since the 1990s.

Worldwide – Palearctic species, mainly distributed in central, eastern and northeastern Europe, from France through southern Poland, Romania and the Baltic States, up to southern Finland. Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. As it is sharply declining in Europe due to changes in forestry practices, a comeback is unlikely.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

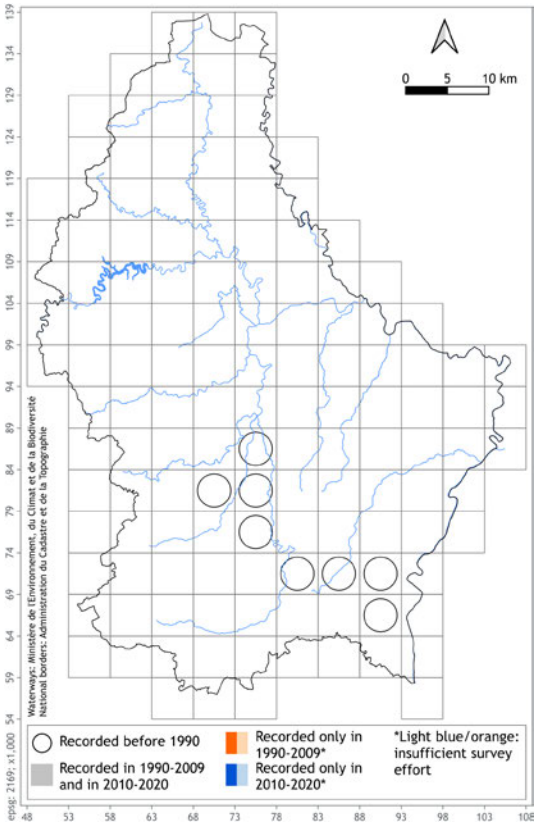


Fig. 4.437: Distribution change map at 5-km spatial resolution for *Lopinga achine*.

Fig. 4.438: *Lopinga achine* (Illustration: Anita Faber).

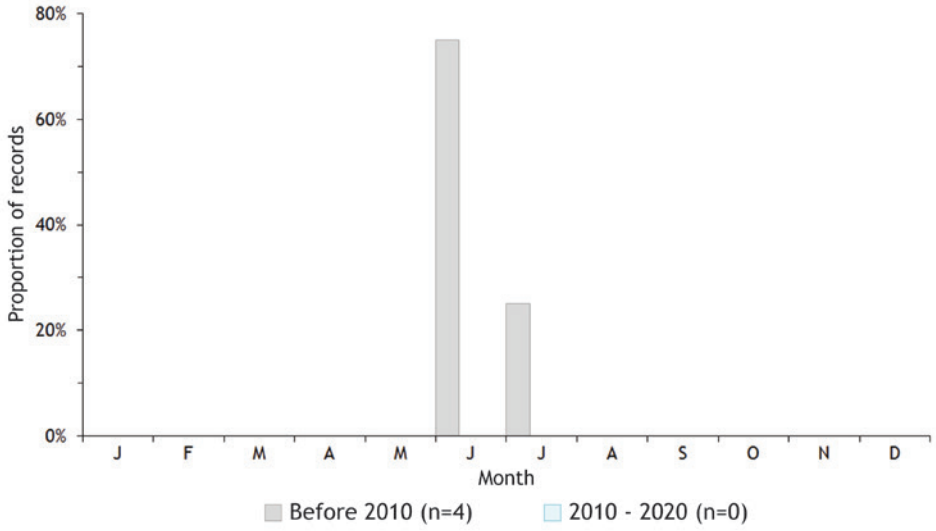


Fig. 4.439: Flight season of *Lopinga achine* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Coenonympha arcania
(Linnaeus, 1760)

L: Wäissgesträiften Heefalter

E: Pearly heath

G: Weißbündiges Wiesenvögelchen

F: Céphale

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Sometimes occurring with *Coenonympha pamphilus*, *C. arcania* is quite easy to identify thanks to its large white strip on the underside of its hindwings. Like *C. pamphilus*, it holds its wings together at rest.

Lifecycle

Univoltine. Flies from mid-May to early August, with a peak in mid-June. Overwinters as caterpillar.

Habitat

Various biotopes in mixed landscapes with extensive grassland, shrubs and woodland, such as forest edges, forest clearings, wet and dry grasslands with shrubs, and hay meadows.

Larval host plants – Lays single eggs (or in string) on leaves of *Brachypodium* spp., *Festuca* spp., *Melica* spp., and *Poa* spp.

Fig. 4.440: *Coenonympha arcania* (Photo: Michelle Clemens).

Fig. 4.441: *Coenonympha arcania* (Photo: Hubert Baltus).

Distribution

Luxembourg – Mainly distributed in the Oesling, the Minette, the central Gutland and the Moselle. Suitable habitats mostly available in the Minette and in the Oesling.

Worldwide – From western Europe (excluding the British Isles, the southern Iberian Peninsula, and northern Fennoscandia) to western Asia and western Russia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -22%

Relative change in extent of occurrence (geographical range): +3%

Even though recorded in a moderately decreasing number of 1-km grid cells, its range was considered as stable.

Management

Promoting extensive management (late mowing and reduced fertilisation) along road verges, forest paths and in nutrient-poor grasslands with small patches of shrubs.

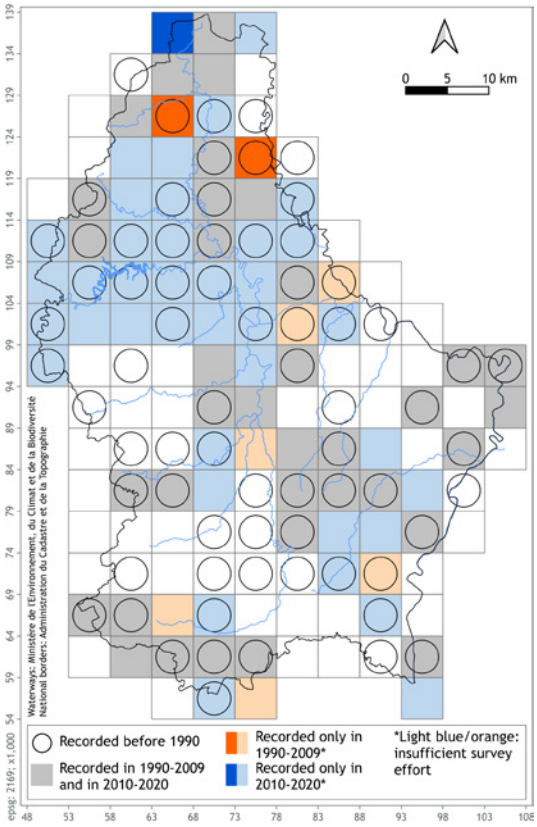


Fig. 4.442: Distribution change map at 5-km spatial resolution for *Coenonympha arcania*.

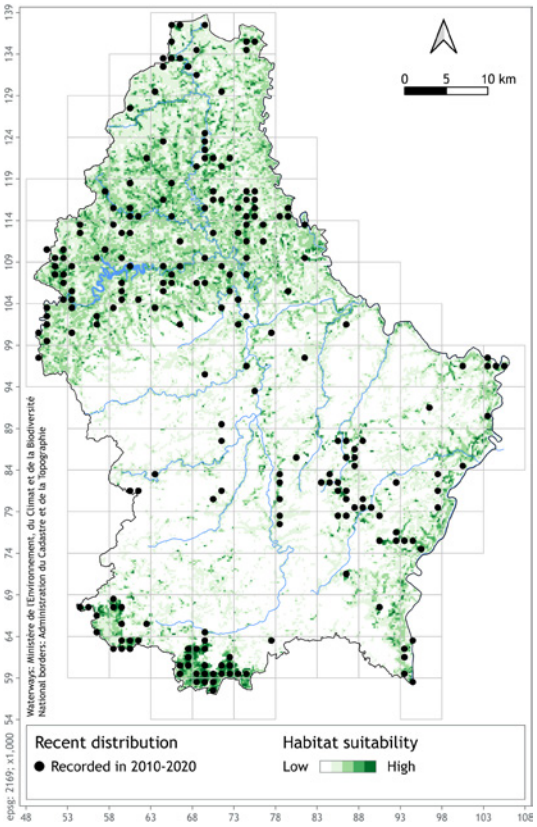


Fig. 4.443: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Coenonympha arcania*.

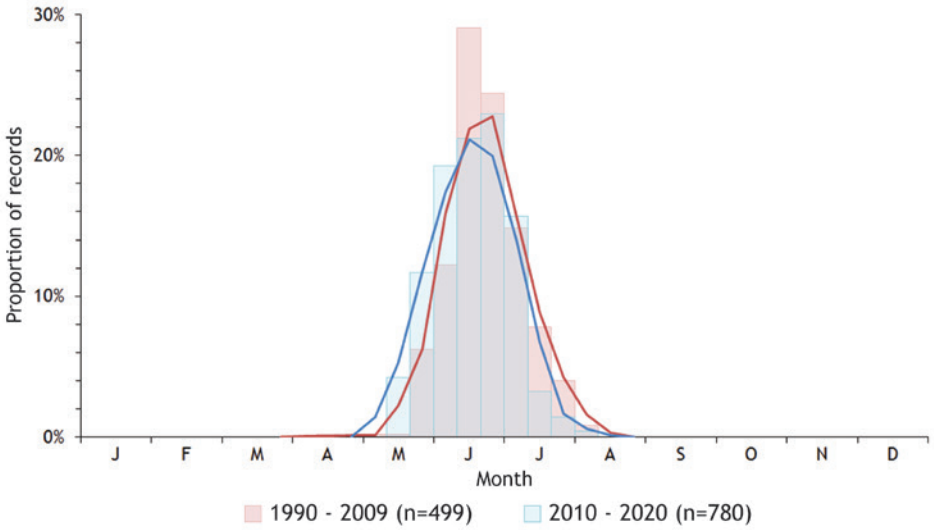


Fig. 4.444: Flight season of *Coenonympha arcania* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Coenonympha hero
(Linnaeus, 1760)

L: Bësch-Heefalter

E: Scarce heath

G: Wald-Wiesenvögelchen

F: Mélibée

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC Annex IV
Red List category	Regionally Extinct since 1977	Vulnerable

One of the most endangered European butterfly species due to the loss of its habitat. This rare species occurs only very sporadically in western Europe and is more widespread in eastern Europe.

Lifecycle

Univoltine in neighbouring regions. Flies mainly from mid-May to early July. Overwinters as young caterpillar.

Habitat

Moist to wet grass-rich meadows on nutrient-poor peat soils, clearings, and light forests, less frequently dry flower-rich hay meadows with sparse scrub and trees.

Fig. 4.445: *Coenonympha hero* (Photo: Wolfgang Wagner).

Fig. 4.446: *Coenonympha hero* (Photo: Wolfgang Wagner).

Larval host plants – Lays eggs on various species from the Poaceae family, such as *Leymus arenarius*, *Deschampsia cespitosa*, *Festuca* spp., and *Carex* spp.

Distribution

Luxembourg – Previously recorded mainly in the central Gutland, although the last records were near Kautenbach in the Oesling in 1977.

Neighbouring countries – Extinct in Saarland since 1920 and in Wallonia since 1992. Still recorded in a few sites in northern France.

Worldwide – Northwestern, central, and eastern Europe, from northern France to the Baltic States and Scandinavia. Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. Given its threatened status in Europe, its comeback is unlikely.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

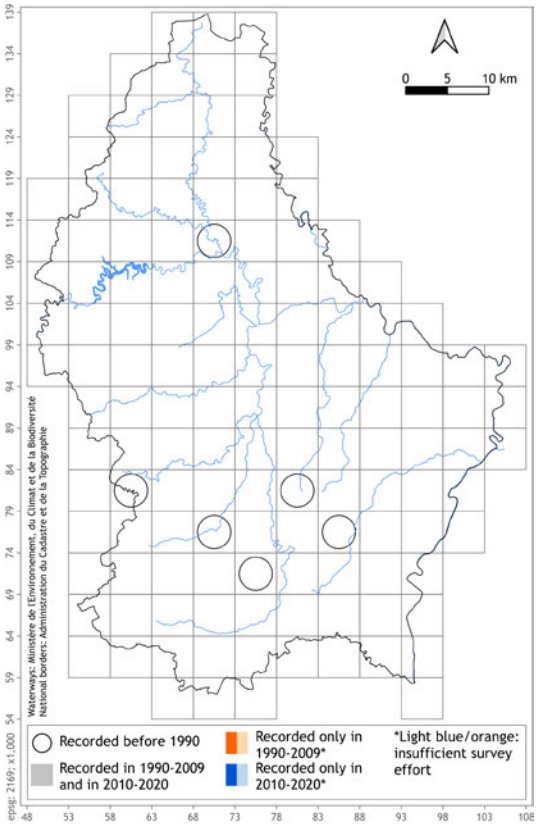


Fig. 4.447: Distribution change map at 5-km spatial resolution for *Coenonympha hero*.

Fig. 4.448: *Coenonympha hero* (Illustration: Anita Faber).

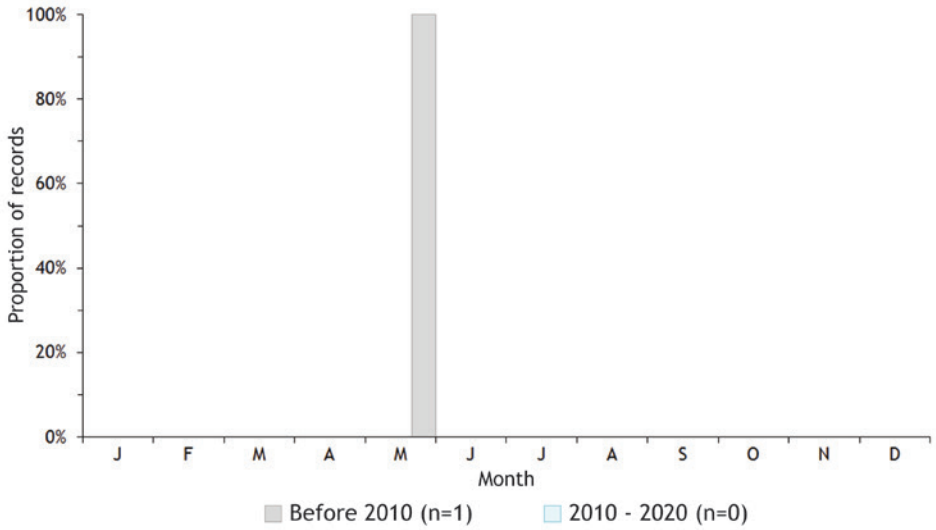


Fig. 4.449: Flight season of *Coenonympha hero* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Coenonympha pamphilus
(Linnaeus, 1758)

L: Klengen Heefalter

E: Small heath

G: Kleines Wiesenvögelchen

F: Fadet commun

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Not particularly mobile, *Coenonympha pamphilus* has a light flight similar to *C. arcania* but is easily distinguished by the absence of the wide white strip and the ocelli on the underside of its hindwings.

Lifecycle

Up to three generations. Flies mostly from late April to September, with peaks in late May and August. Overwinters as caterpillar.

Habitat

Wide variety of biotopes, such as flower-rich meadows, wet to dry grasslands, wastelands, forest clearings, road verges, gardens, parks, and field margins.

Fig. 4.450: *Coenonympha pamphilus* (Photo: Hubert Baltus).

Fig. 4.451: *Coenonympha pamphilus* (Photo: Michelle Clemens).

Larval host plants – Lays single eggs (or in strings) on various species from the Poaceae family, such as *Anthoxanthum odoratum*, *Brachypodium* spp., *Cynosurus cristatus*, *Festuca* spp., *Poa annua*, and *Nardus stricta.*

Distribution

Luxembourg – Distributed across the whole country with a widespread availability of suitable habitats.

Worldwide – Palearctic species widely distributed from northern Africa, through continental Europe, the Middle East, and temperate Asia to Mongolia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -1%

Relative change in extent of occurrence (geographical range): +3%

Considered as stable.

Management

Promoting extensive management (e.g., late mowing, extensive grazing, and reduced fertilisation) of grasslands, road verges, light forest paths, and field margins.

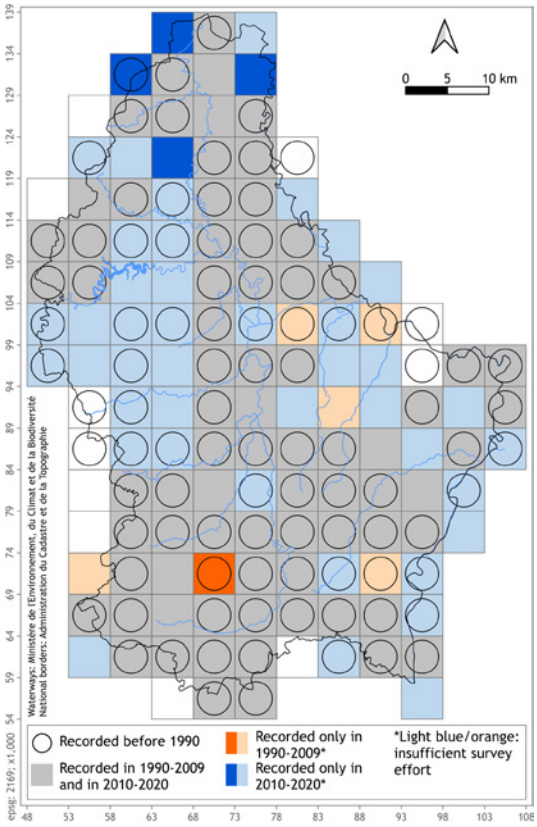


Fig. 4.452: Distribution change map at 5-km spatial resolution for *Coenonympha pamphilus*.

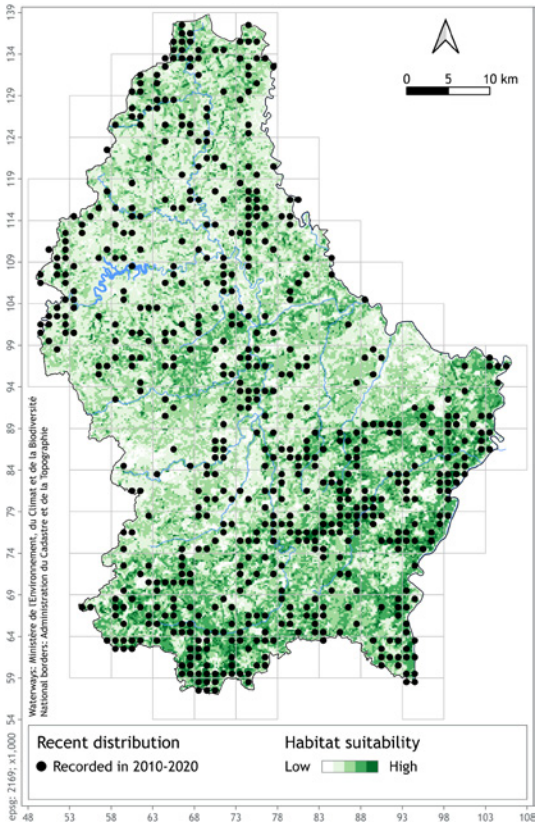


Fig. 4.453: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Coenonympha pamphilus*.

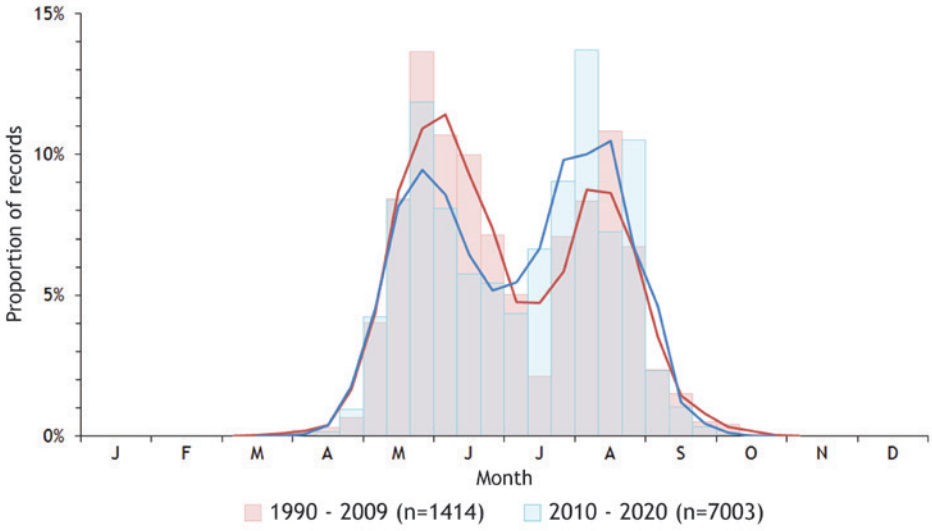


Fig. 4.454: Flight season of *Coenonympha pamphilus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Pyronia tithonus
(Linnaeus, 1771)

L: Klengt Ochsena

E: Gatekeeper

G: Rotbraunes Ochsenauge

F: Amaryllis

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Pyronia tithonus can be confused with *Maniola jurtina* when it has its wings closed, but *P. tithonus* likes to spend much of its time basking with open wings in the foliage of shrubs, brambles and other low vegetation.

Lifecycle

Univoltine. Flies mostly from early July to August, with a peak in late July. Overwinters as young caterpillar.

Habitat

Tall grasses close to shrubs, hedges or trees, typically along hedgerows, in shrubby grasslands, wastelands, open areas in forests, and forest edges.

Larval host plants – Lays single eggs on or near grasses growing in sheltered and sunny conditions. *Agrostis canina, A. capillaris, Brachypodium* spp., *Bromus erectus, Dactylis* spp., *Deschampsia cespitosa, Elymus repens, Festuca* spp., *Milium effusum, Phleum pretense,* and *Poa* spp. are mentioned in the literature.

Fig. 4.455: *Pyronia tithonus* (Photo: Michelle Clemens).

Fig. 4.456: *Pyronia tithonus* (Photo: Xavier Mestdagh).

Distribution

Luxembourg – Distributed across the whole country, but with low densities in the Oesling where suitable habitats are less available.

Worldwide – Lowland palearctic species distributed from Morocco across most of central and southern Europe to Asia Minor.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -1%

Relative change in extent of occurrence (geographical range): +3%

Considered as stable.

Management

Maintaining a mosaic of tall grasses along hedgerows, forest edges, shrubs and road verges through rotational management over multiple years.

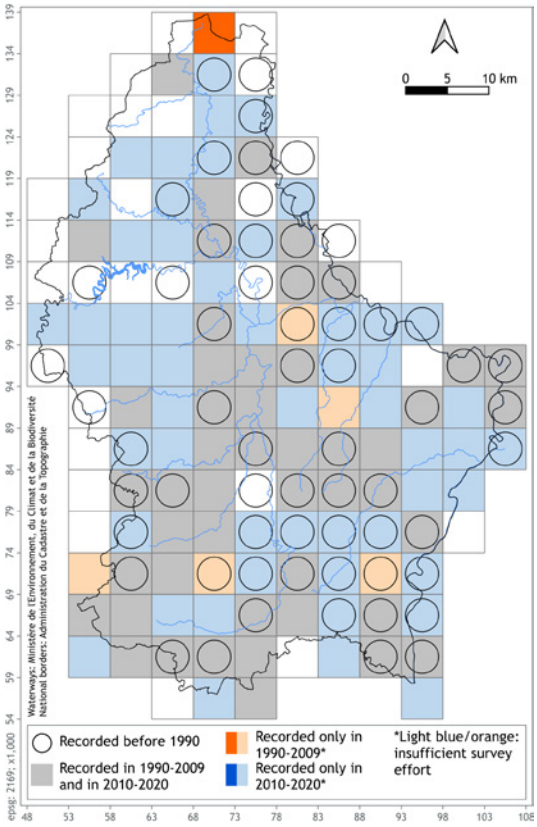


Fig. 4.457: Distribution change map at 5-km spatial resolution for *Pyronia tithonus*.

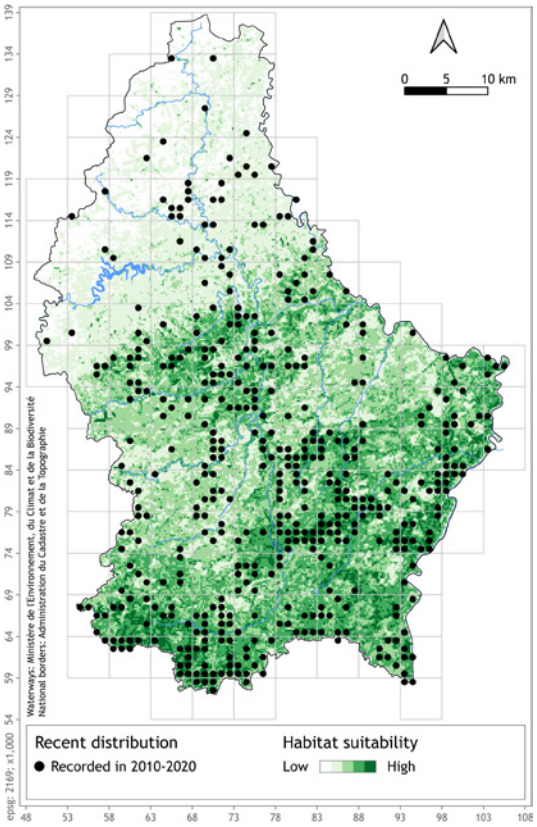


Fig. 4.458: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Pyronia tithonus*.

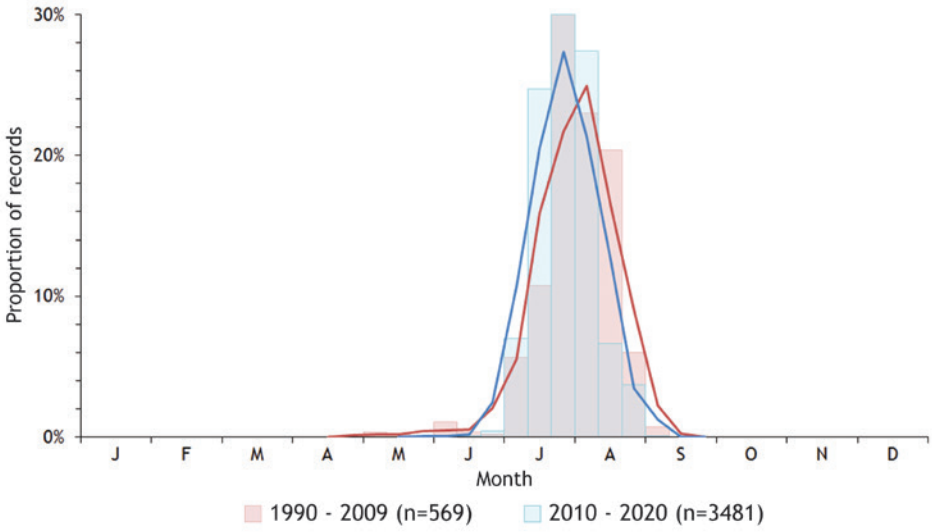


Fig. 4.459: Flight season of *Pyronia tithonus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Aphantopus hyperantus
(Linnaeus, 1758)

L: Schaarschtechbotzer

E: Ringlet

G: Schornsteinfeger

F: Tristan

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Aphantopus hyperantus can be found in large numbers, especially on flowers. Number, size and shape of the ocelli on the underside of the wings vary considerably among individuals.

Lifecycle

Univoltine. Flies mostly from June to mid-August with a peak in early July. Overwinters as caterpillar.

Habitat

Wide variety of shady biotopes where tall and uncultivated grasses grow, such as hay meadows, dry grasslands, forest edges, forest clearings, hedgerows, wastelands, river sides, and wetlands.

Larval host plants – Lays non-adhesive eggs scattered randomly over grasses. Caterpillars are nocturnal and feed on various species from the Poaceae family, such as *Agrostis* spp., *Brachypodium pinnatum*, *B. sylvaticum*, *Bromus* spp., *Dactylis* spp., *Deschampsia cespitosa*, *Elymus repens*, *Festuca* spp., *Holcus* spp., *Milium* spp., *Phleum pratense*, and *Poa* spp.

Fig. 4.460: *Aphantopus hyperantus* (Photo: Francis Birlenbach).

Fig. 4.461: *Aphantopus hyperantus* (Photo: Michelle Clemens).

Distribution

Luxembourg – Distributed across the whole country with a widespread availability of suitable habitats.

Worldwide – Widespread from northern Spain to the southern half of Fennoscandia, and across much of temperate Asia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +1%

Relative change in extent of occurrence (geographical range): +3%

Considered as stable.

Management

Promoting extensive management (e.g., late mowing and reduced fertilisation) of the herbaceous vegetation in the variety of biotopes used by the species.

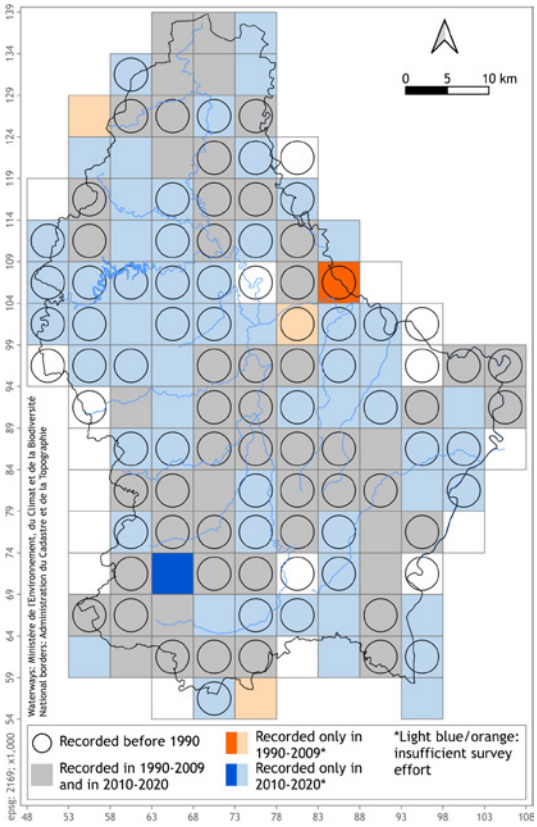


Fig. 4.462: Distribution change map at 5-km spatial resolution for *Aphantopus hyperantus*.

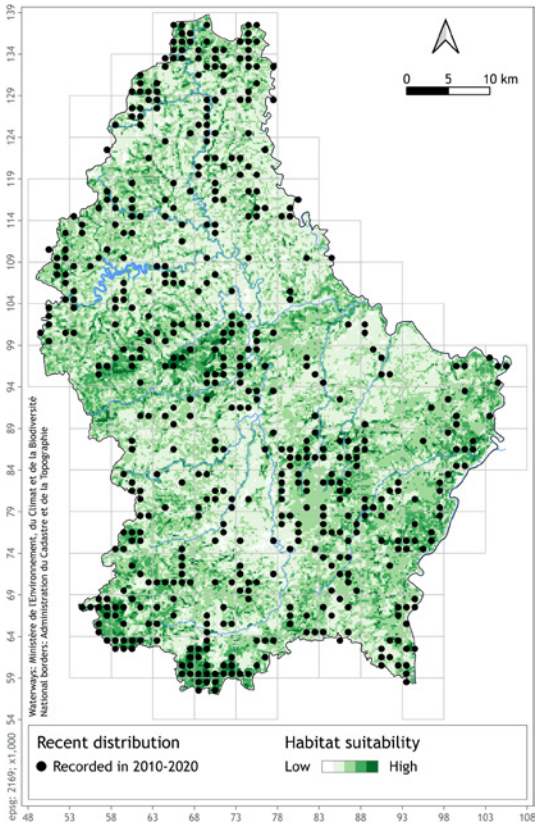


Fig. 4.463: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Aphantopus hyperantus*.

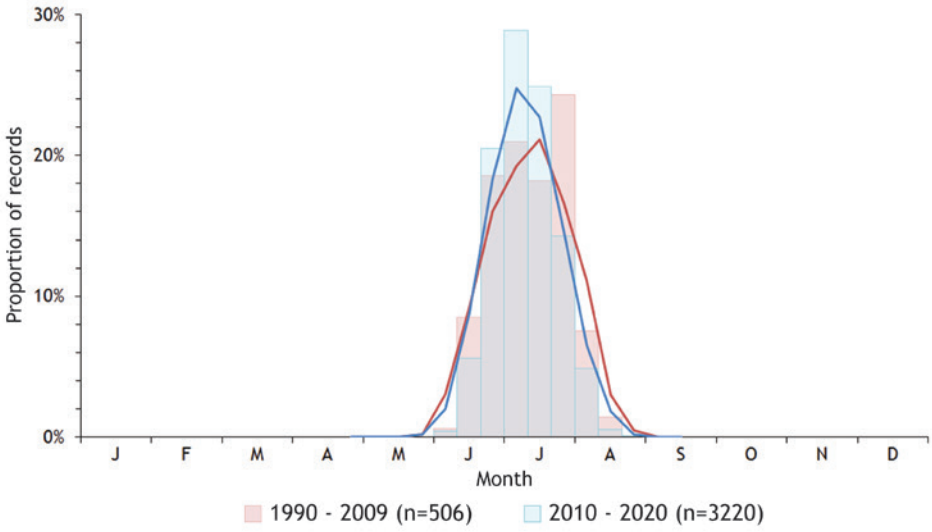


Fig. 4.464: Flight season of *Aphantopus hyperantus* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Maniola jurtina
(Linnaeus, 1758)

L: Ochsena

E: Meadow brown

G: Großes Ochsenauge

F: Myrtil

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Maniola jurtina is a generalist species with highly variable orange patches in size and brightness on the upper side of its wings. When foraging or resting, it usually keeps its wings closed.

Lifecycle

Univoltine. Flies mostly from June to August, with a peak in early July. Overwinters as caterpillar.

Habitat

Almost any open biotope, such as all types of grasslands, road verges, forest edges, hedgerows, gardens, and even in the margins of intensively grazed pastures.

Larval host plants – Lays single spherical eggs either near or on grasses, such as *Agrostis* spp., *Alopecurus* spp., *Anthoxanthum odoratum*, *Brachypodium* spp., *Bromus erectus*, *Dactylis glomerata*, *Deschampsia cespitosa*, *Elymus repens*, *Festuca* spp., *Phleum* spp., and *Poa* spp.

Fig. 4.465: *Maniola jurtina* (Photo: Michelle Clemens).

Fig. 4.466: *Maniola jurtina* (Photo: Roland Proess).

Distribution

Luxembourg – Homogeneously distributed across the whole country with suitable habitats available in every region.

Worldwide – One of the most common and widespread Palearctic species, from northwestern Africa across Europe, the Middle East, and Asia up to western Siberia.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +3%

Relative change in extent of occurrence (geographical range): +2%

Considered as stable.

Management

Promoting extensive management of grasslands such as reduced fertilisation, low livestock densities and late mowing.

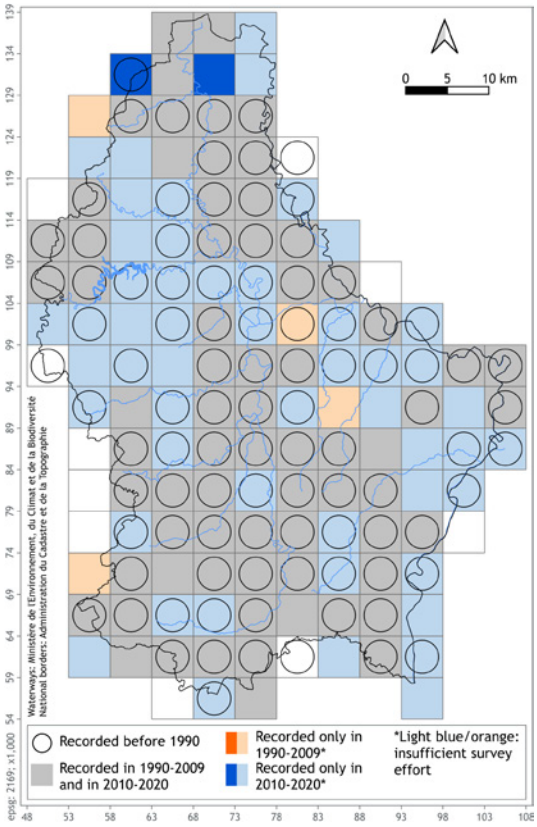


Fig. 4.467: Distribution change map at 5-km spatial resolution for *Maniola jurtina*.

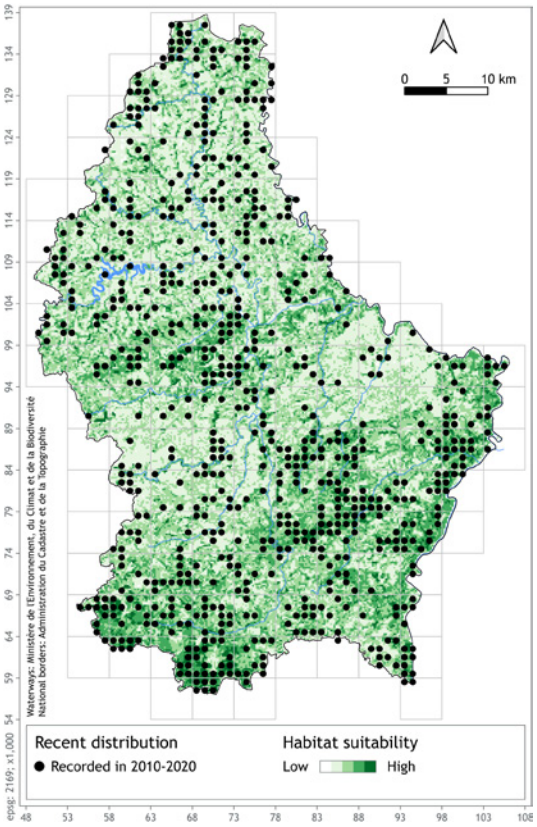


Fig. 4.468: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Maniola jurtina*.

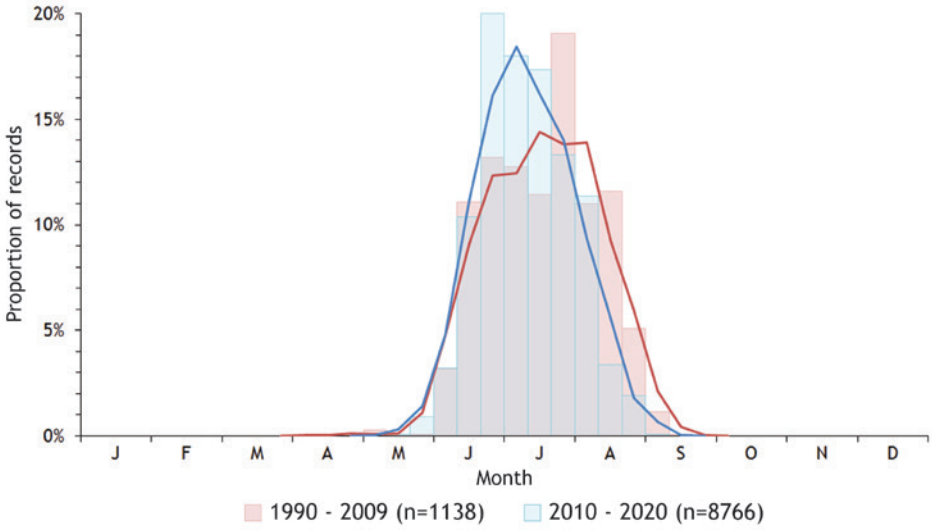


Fig. 4.469: Flight season of *Maniola jurtina* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Erebia aethiops

(Esper, 1777)

L: Grogesträifte Mouerefalter

E: Scotch argus

G: Graubindiger Mohrenfalter

F: Moiré sylvicole

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1966	Least Concern

Active in warm sunny conditions but once there is a slight drop in temperature, *Erebia aethiops* settles to bask on the vegetation.

Lifecycle

Univoltine in neighbouring regions. Flies mostly from July to early September. Overwinters as young caterpillar.

Habitat

Moist or dry, sunny or partly shady biotopes, such as moors, warm and slightly damp forest edges and clearings, on acidic or alkaline soils. In Wallonia, mainly calcareous meadows with juniper (*Juniperus communis*), pines (*Pinus* spp.), and various deciduous trees. Vegetation can be waist-high and should be rich in grasses and flowers.

Fig. 4.470: *Erebia aethiops* (Photo: Stéphane Vizthum).

Fig. 4.471: *Erebia aethiops* (Photo: Stéphane Vizthum).

Nectar resources – Typically feeds on tall herbaceous perennials.

Larval host plants – Lays eggs on various grasses from the Poaceae family, such as *Molinia* spp., *Bromus* spp., *Carex* spp., and *Brachipodium* spp.

Distribution

Luxembourg – Previously recorded in the Oesling and the Gutland. Last record in 1966 at Prënzebierg (Pétange).

Neighbouring countries – Since 2010, recorded in northwestern French Lorraine, in Belgian Calestienne, and northwestern Rhineland-Palatinate. Extinct from Saarland in the 1960s.

Worldwide – From central France, through southern Belgium, the northern Balkans up to Russia. Found in Scotland and England as well.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. A comeback is unlikely in the short term.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

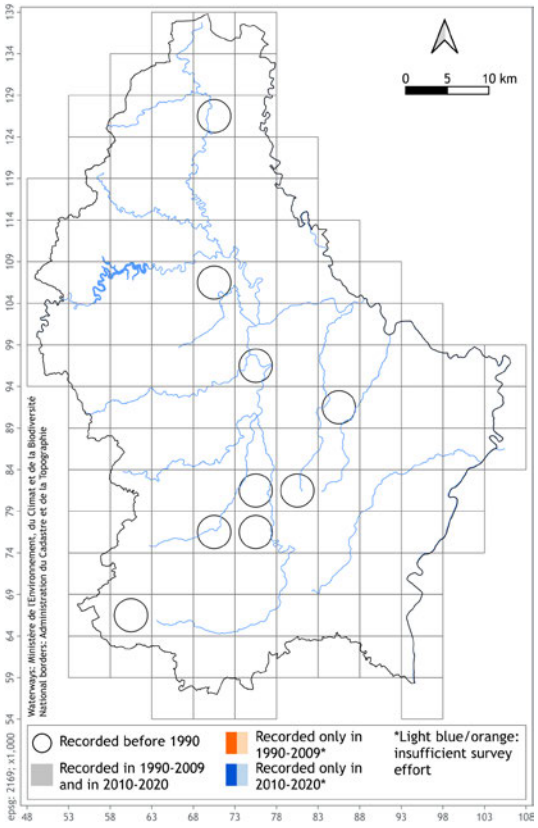


Fig. 4.472: Distribution change map at 5-km spatial resolution for *Erebia aethiops*.

Fig. 4.473: *Erebia aethiops* (Illustration: Anita Faber).

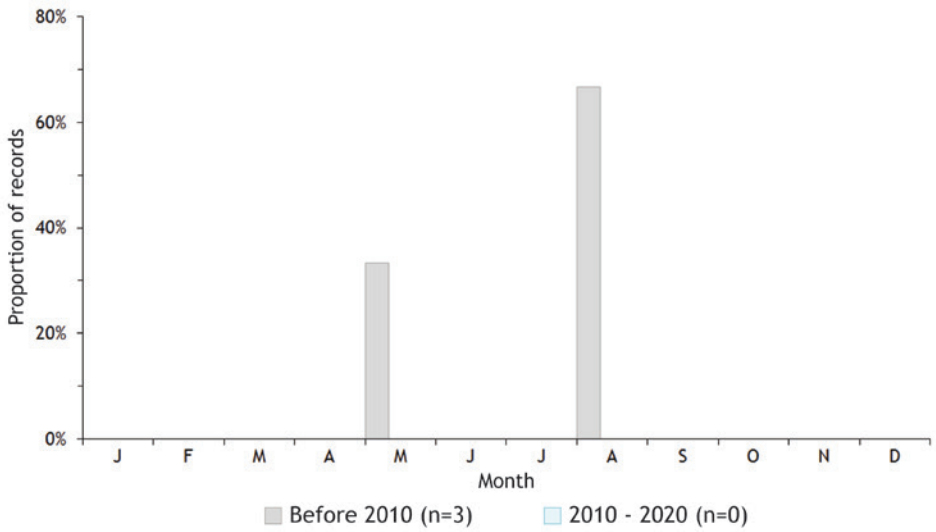


Fig. 4.474: Flight season of *Erebia aethiops* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Erebia medusa

([Denis & Schiffermüller], 1775)

L: Medusa-Mouerefalter

E: Woodland ringlet

G: Rundaugen-Mohrenfalter

F: Moiré franconien

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Near Threatened	Least Concern

The only species of the genus *Erebia* currently recorded in Luxembourg. *Erebia medusa* is easily recognisable with its dark look, its slow and weak flight just above the ground. Although using different types of biotopes and host plants, it is a relatively rare species.

Lifecycle

Univoltine. Flies from May to early June, with a peak in mid-May. Overwinters as caterpillar, sometimes during two consecutive years.

Habitat

Open biotopes with fairly high and dense herbaceous vegetation on nutrient-poor soils, including dry to wet grasslands, extensively managed meadows, wastelands and heathlands, on acidic or calcareous conditions.

Fig. 4.475: *Erebia medusa* (Photo: Stéphane Vizthum).

Fig. 4.476: *Erebia medusa* (Photo: Stéphane Vizthum).

Larval host plants – Lays single eggs on dry grasses near the ground, such as *Brachypodium pinnatum, Bromus erectus, Carex nigra, C. pilulifera, Digitaria sanguinalis, Festuca ovina, F. rubra, Milium effusum, Molinia caerulea, Panicum* spp. and *Poa* spp.

Distribution

Luxembourg – Almost exclusively distributed in the Minette and the Oesling with the most suitable habitats available in the Minette.

Worldwide – Most of Europe, from eastern France to western China.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -27%

Relative change in extent of occurrence (geographical range): -23%

Moderately decreasing. It has not been recently recorded in most of the Gutland.

Management

Avoiding shrub encroachment of nutrient-poor grasslands with extensive management (e.g., late mowing, reduced fertilisation and livestock densities).

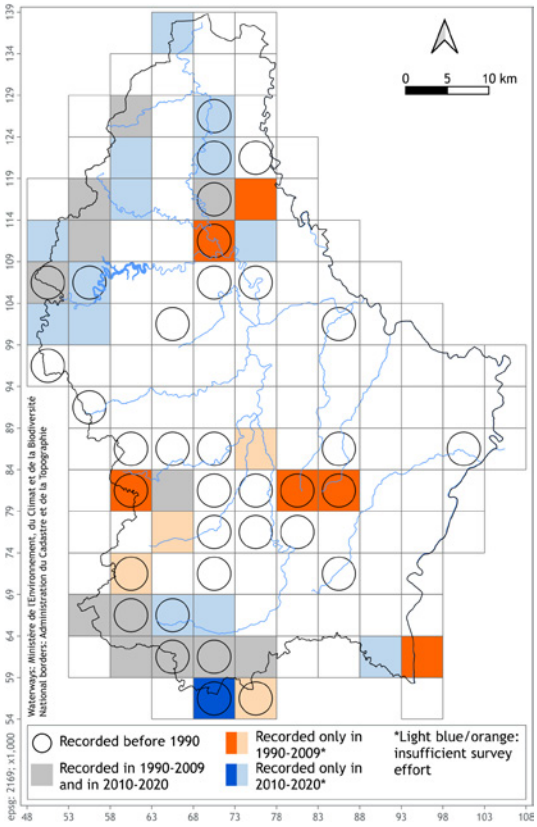


Fig. 4.477: Distribution change map at 5-km spatial resolution for *Erebia medusa*.

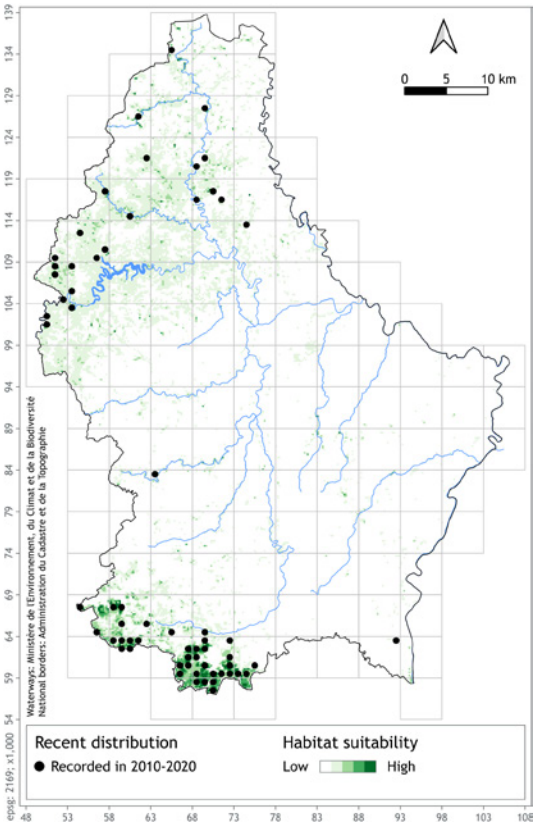


Fig. 4.478: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Erebia medusa*.

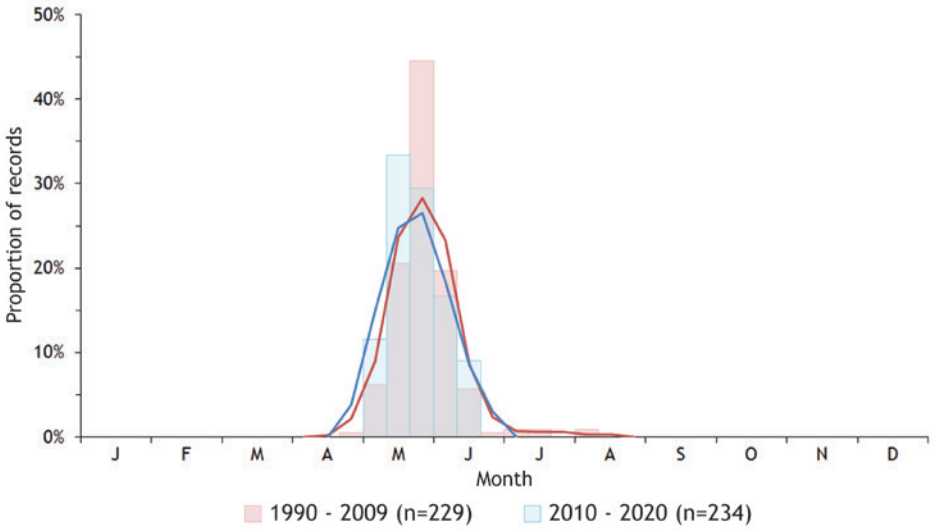


Fig. 4.479: Flight season of *Erebia medusa* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Melanargia galathea

(Linnaeus, 1758)

L: Schachbriet

E: Marbled white

G: Schachbrettfalter

F: Demi-deuil

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Least Concern	Least Concern

Although its white colour could suggest it belongs to the Pieridae family, *Melanargia galathea* is actually a species of the Nymphalidae family. It is unmistakable with other species found in Luxembourg.

Lifecycle

Univoltine. Flies from June to August, with a peak in early July. Overwinters as young caterpillar.

Habitat

Open (sometimes small-size) biotopes, such as hay meadows, dry to wet grasslands, road verges, field margins, and forest clearings.

Nectar resources – Preferentially feeds on Asteraceae flowers, especially *Centaurea* spp.

Fig. 4.480: *Melanargia galathea* (Photo: Martin Heyeres).

Fig. 4.481: *Melanargia galathea* (Photo: Francis Birlenbach).

Larval host plants – Lays white spherical eggs one by one on the ground while perching on a grass stem or even flying. Caterpillars feed on various species from the Poaceae family, such as *Brachypodium pinnatum*, *B. sylvaticum*, *Bromus* spp., *Dactylis glomerata*, *Festuca* spp., *Holcus* spp., *Molinia caerulea*, *Phleum* spp., and *Poa trivialis*.

Distribution

Luxembourg – Homogeneously distributed across the whole country with suitable habitats available in every region, especially in the southern half of the country.

Worldwide – Northern Africa, most of Europe from northern Spain to northern Germany (except Portugal and northern Europe), Asia Minor to southern Russia. Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): +1%

Relative change in extent of occurrence (geographical range): +4%

Considered as stable.

Management

Promoting extensive management (e.g., reduction of agricultural inputs or livestock densities, late mowing) in grasslands, field margins, road verges and forest clearing. Promoting ungrazed or unmown refuge areas.

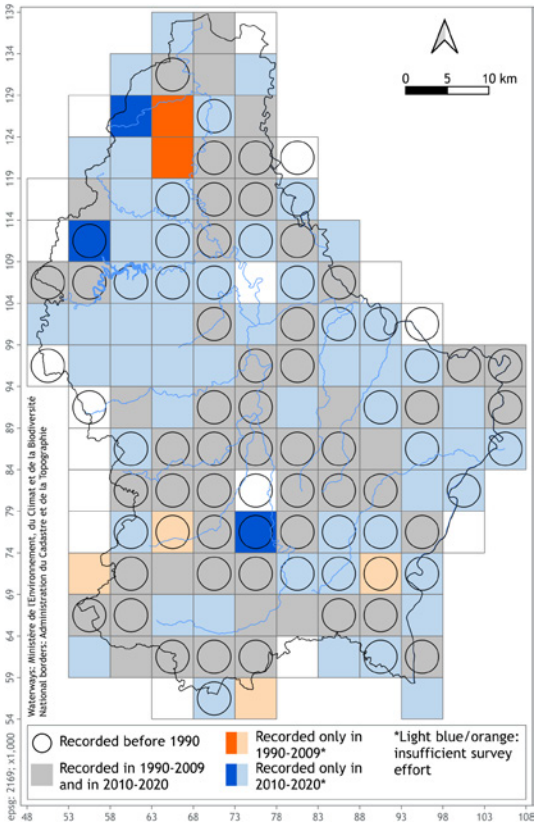


Fig. 4.482: Distribution change map at 5-km spatial resolution for *Melanargia galathea*.

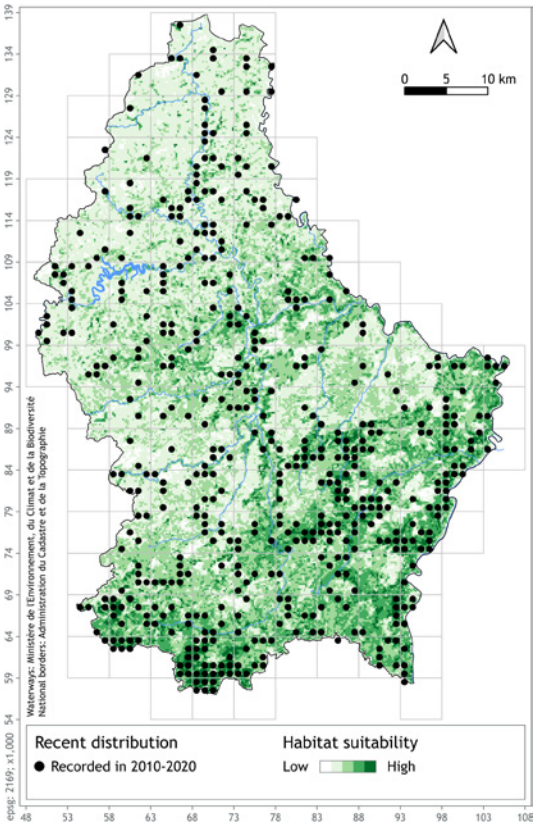


Fig. 4.483: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Melanargia galathea*.

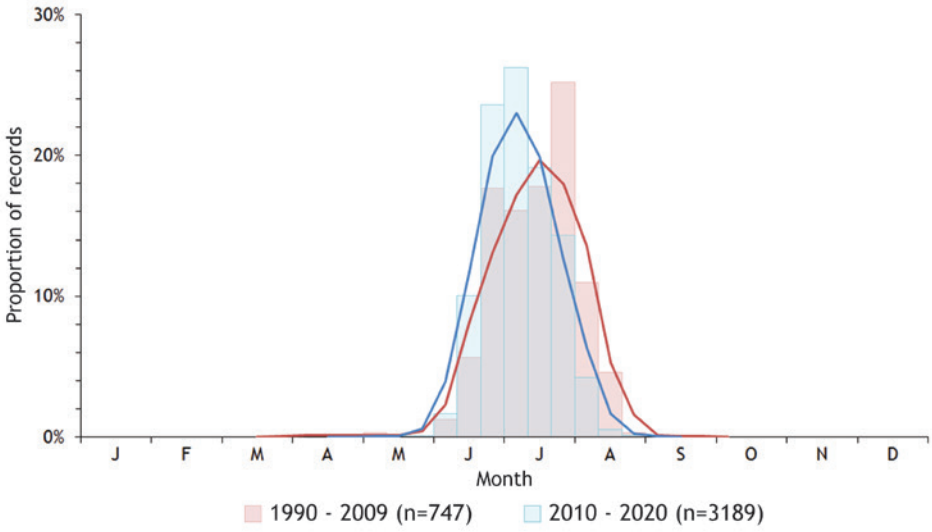


Fig. 4.484: Flight season of *Melanargia galathea* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Brintesia circe

(Fabricius, 1775)

L: Wäisse Bëschportier

E: Great banded grayling

G: Weißer Waldportier

F: Silène

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Regionally Extinct since 1984	Least Concern

Brintesia circe is a southern European species with a clumsy flight. Brown/black with a white stripe, adults are often seen basking with the wings closed on tree trunks, which provides a good camouflage.

Lifecycle

Univoltine in neighbouring regions. Flies mostly in August. Overwinters as young caterpillar.

Habitat

Warm, dry, and bushy biotopes covered with loose grass and sparse trees, such as dry calcareous grasslands.

Nectar resources – Adults are rarely observed on flowers but like to visit thistles (Carduoideae).

Fig. 4.485: *Brintesia circe* (Photo: Stéphane Vizthum).

Fig. 4.486: *Brintesia circe* (Photo: Stéphane Vizthum).

Larval host plants – Lays eggs in flight. Caterpillars feed on grasses from the Poaceae family, such as *Bromus erectus*, *Lolium* spp., and *Festuca* spp.

Distribution

Luxembourg – Previously recorded only twice (including one record with an inaccurate observation date), the last one from 1984 near Consdorf.

Neighbouring countries – Since 2010, recorded in northeastern French Lorraine as well as in the Birkenfeld district and the Palatinate Forest in Rhineland-Palatinate. Never recorded in Wallonia.

Worldwide – Central and southern Europe from the Iberian Peninsula, through Turkey, Caucasus, up to Iran. Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Considered as extinct. A possible comeback is not excluded in a context of global warming.

Management

Specific conservation measures are currently not needed as the species is not recorded in Luxembourg anymore.

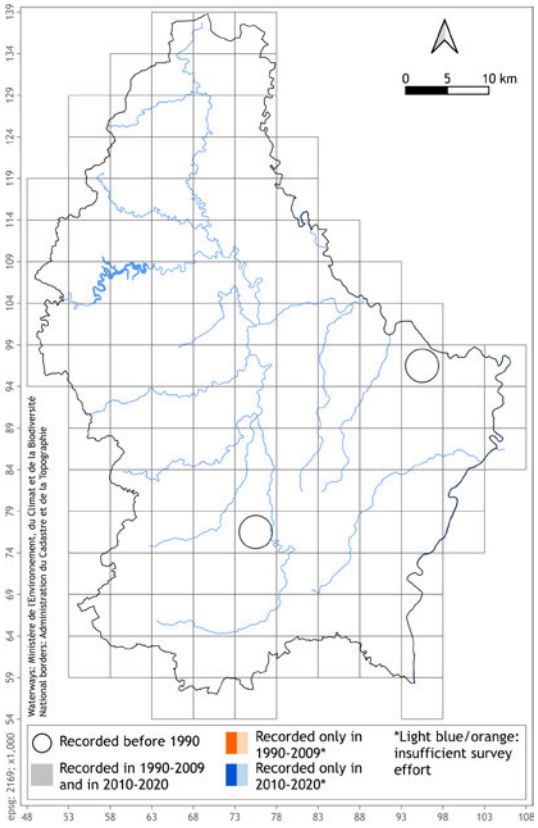


Fig. 4.487: Distribution change map at 5-km spatial resolution for *Brintesia circe*.

Fig. 4.488: *Brintesia circe* (Illustration: Anita Faber).

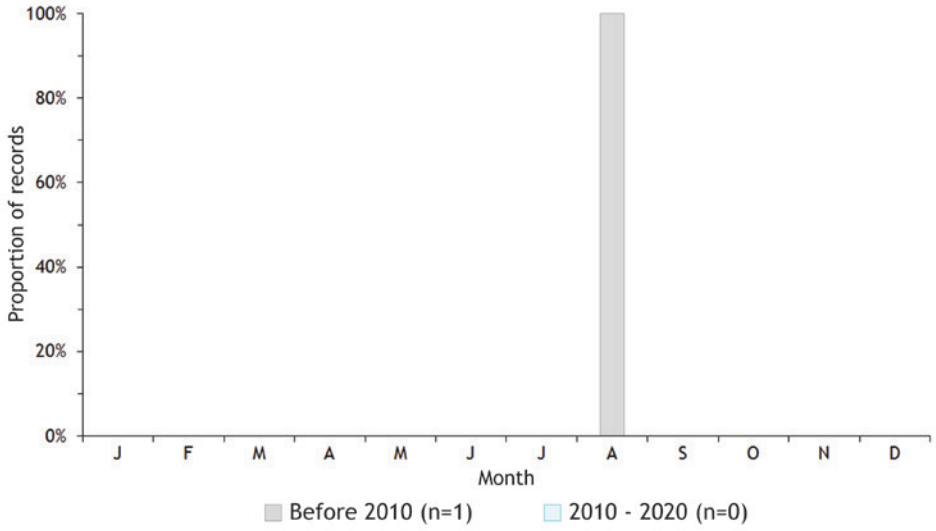


Fig. 4.489: Flight season of *Brintesia circe* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Chazara briseis
(Linnaeus, 1764)

L: Bierghex
E: Hermit
G: Berghexe
F: Hermite

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Applicable	Near Threatened

Chazara briseis is a southern European species in strong decline across its distribution range. Adults are often seen basking on stones and rocks, where they are well camouflaged thanks to their wing markings.

Lifecycle

Univoltine in neighbouring regions. Flies mostly in August. Overwinters as young caterpillar.

Habitat

Very warm and dry biotopes with short and sparse vegetation, sandy areas and stone rubble such as dry calcareous grasslands intensively grassed.

Larval host plants – Lays eggs on various species from the Poaceae family, such as *Bromus erectus* and *Festuca ovina*.

Fig. 4.490: *Chazara briseis* (Photo: Yvan Barbier).

Fig. 4.491: *Chazara briseis* (Photo: Yvan Barbier).

Distribution

Luxembourg – Previously recorded sporadically with a last record in 1976 near Untereisenbach.

Neighbouring countries – Since 2010, recorded very far from Luxembourg, in Bourgogne (France) and in Baden-Wuerttemberg and Thuringia (Germany). Extinct from Wallonia after 1946 and from Rhineland-Palatinate after 2000.

Worldwide – Northern Africa, southern Europe from the Iberian Peninsula to Turkey, Asia Minor, up to northwestern China. Luxembourg is at the northern margin of its global range.

Trends (<2010 *vs.* 2010-2020)

Trends were not estimated for this vagrant species. Its comeback is unlikely but not excluded in a context of global warming.

Management

Specific conservation measures are currently not needed.

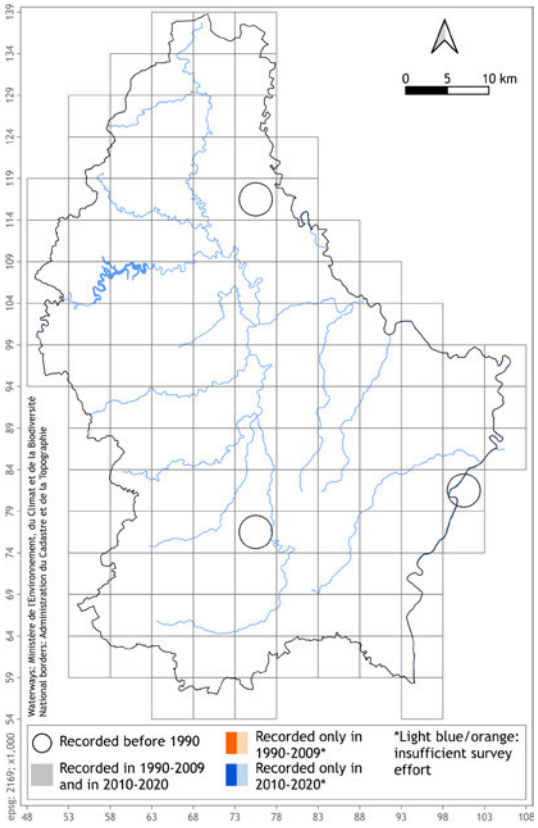


Fig. 4.492: Distribution change map at 5-km spatial resolution for *Chazara briseis*.

Fig. 4.493: *Chazara briseis* (Illustration: Anita Faber).

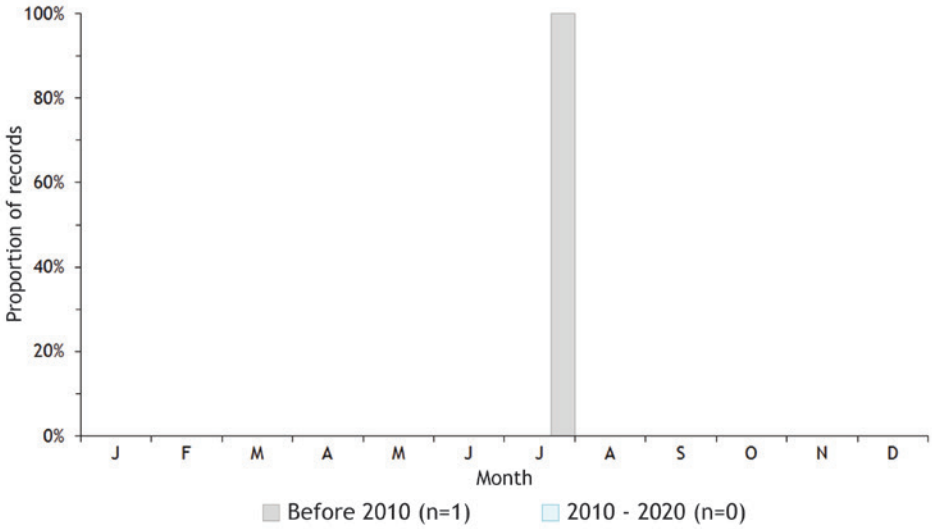


Fig. 4.494: Flight season of *Chazara briseis* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Hipparchia semele

(Linnaeus, 1758)

L: Ockergesträifte Samettfalter

E: Grayling

G: Ockerbindiger Samtfalter

F: Agreste

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Critically Endangered	Least Concern

Always resting with its wings closed, *Hipparchia semele* is a master in camouflage on bare ground where it likes to bask.

Lifecycle

Univoltine. Flies mostly from July to early September, with a peak in August. Overwinters as caterpillar.

Habitat

Sunny and dry biotopes where vegetation is sparse and with patches of bare ground, typically in dry and rocky calcareous grasslands, quarries, light forests, and moors with sparse vegetation.

Larval host plants – Lays single eggs close to the ground on the leaves of various species from the Poaceae family, such as *Agrostis capillaris*, *Brachypodium pinnatum*, *Carex ovalis*, *C. pilulifera*, *Deschampsia cespitosa*, *D. flexuosa*, *Elymus repens*, *Festuca ovina*, and *F. rubra*.

Fig. 4.495: *Hipparchia semele* (Photo: Xavier Mestdagh).

Fig. 4.496: *Hipparchia semele* (Photo: Alain Dohet).

Distribution

Luxembourg – Nowadays, exclusively distributed in the southeastern part of the Minette.

Worldwide – Throughout most of Europe, except northern Fennoscandia and the Mediterranean islands. Further East (up to western Russia), its situation is unclear because of difficulties to distinguish it from other species.

Trends (<2010 *vs.* 2010-2020)

Relative change in area of occupancy (estimated number of occupied 1-km grid cells): -36%

Relative change in extent of occurrence (geographical range): -99%

Although recorded in a moderately decreasing number of 1-km grid cells, its range strongly contracted in 2010-2020. It has only been recorded in the Minette for decades and has recently disappeared from western Minette, further reducing its range.

Management

Limiting shrub encroachment and promoting sparse vegetation and bare ground in dry biotopes through agro-pastoralism activities.

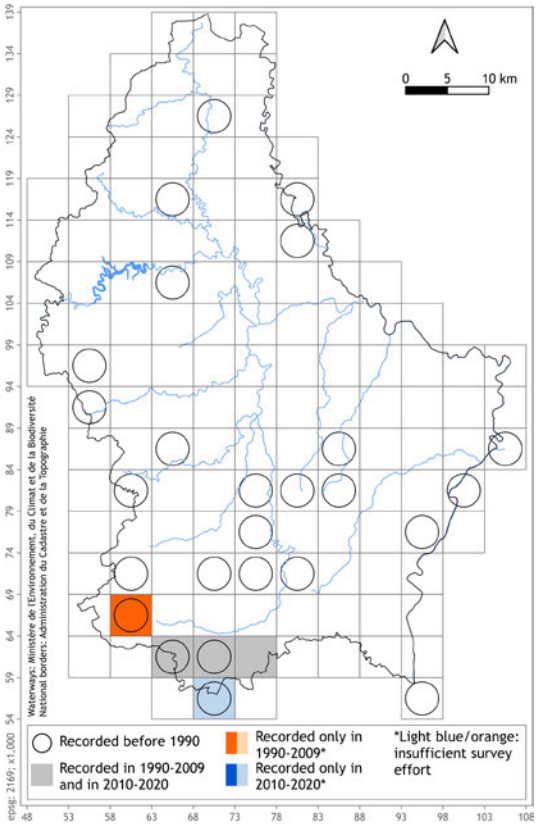


Fig. 4.497: Distribution change map at 5-km spatial resolution for *Hipparchia semele*.

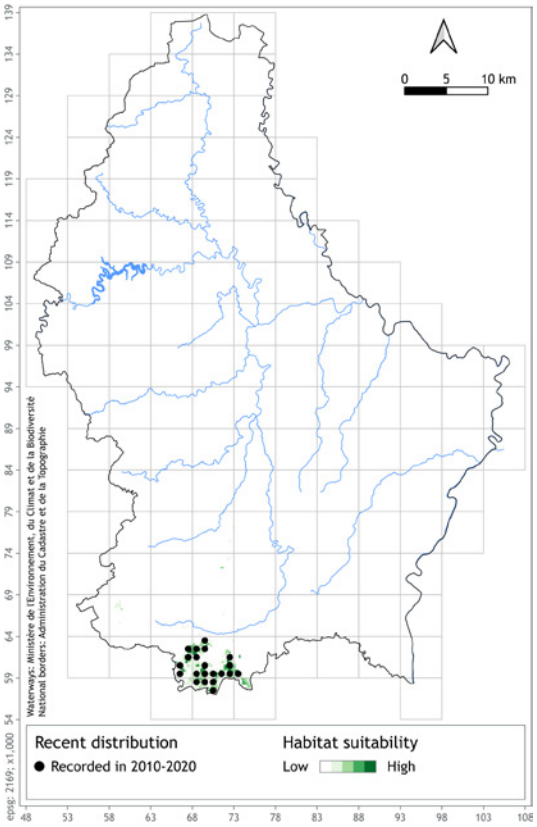


Fig. 4.498: Distribution map at 1-km spatial resolution and habitat suitability at 200-m spatial resolution for *Hipparchia semele*.

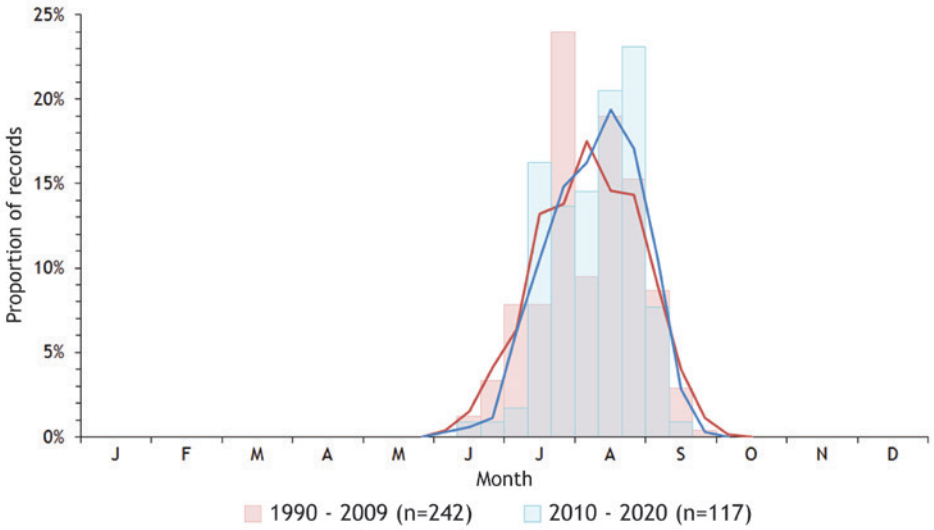


Fig. 4.499: Flight season of *Hipparchia semele* representing the frequency distribution of species records over time at a 10-day temporal resolution.

NYMPHALIDAE

Hipparchia hermione/fagi

(Linnaeus, 1764)/(Scopoli, 1763)

L: Klenge Bëschportier / Grousse Bëschportier

E: Rock grayling / Woodland grayling

G: Kleiner Waldportier / Großer Waldportier

F: Petit sylvandre / Grand sylvandre

	LU	EU
Protection status	Règlement Grand-Ducal 09/01/2009 Protected	Habitats Directive 92/43/EEC -
Red List category	Not Evaluated	Near Threatened/ Near Threatened

Hipparchia hermione and *H. fagi* are two very similar species requiring the use of a magnifying glass to differentiate males based on the examination of their genitalia. They often bask on the ground with the underside of their wings facing the sun. If it gets too hot, they rest on a tree trunk in the shade.

Lifecycle

Univoltine in neighbouring regions. Flies mainly in July and August. Overwinter as half-grown caterpillar. Phenological curves unavailable due to lack of precision on recording dates.

Habitat

H. hermione: pine forests on sandy soil, light woods, rocky moors and grasslands with scattered trees.

H. fagi: warm rocky forest edges and clearings.

Fig. 4.500: *Hipparchia hermione/fagi* (Photo: Vincent Gillet).

Fig. 4.501: *Hipparchia hermione/fagi* (Photo: Vincent Gillet).

Nectar resources – Preferentially feed on *Scabiosa columbaria* and *Centaurea* spp.

Larval host plants – Lay single eggs glued on various species from the Poaceae family, such as *Brachypodium* spp. and *Festuca* spp.

Distribution

Luxembourg – Previously recorded sporadically in almost every region. Last records in 1979 near Canach and Lenningen.

Neighbouring countries – Since 2010, recorded in southern French Lorraine and in Rhineland-Palatinate (*H. hermione*). Also recorded in one isolated location close to the Luxembourgish border in Saarland after 2001 (*H. fagi*). Absent from Wallonia (only one record for *H. fagi* in 1927).

Worldwide – Southern and southeastern Europe, from the Iberian Peninsula through Italy to the Baltic States.

Trends (<2010 *vs.* 2010-2020)

Trends were not estimated for this complex species. Although *H. fagi* was recorded near Perl (Saarland) after 2001, a comeback is unlikely for both species.

Management

Specific conservation measures are currently not needed as the complex H. hermione/fagi is not recorded in Luxembourg anymore.

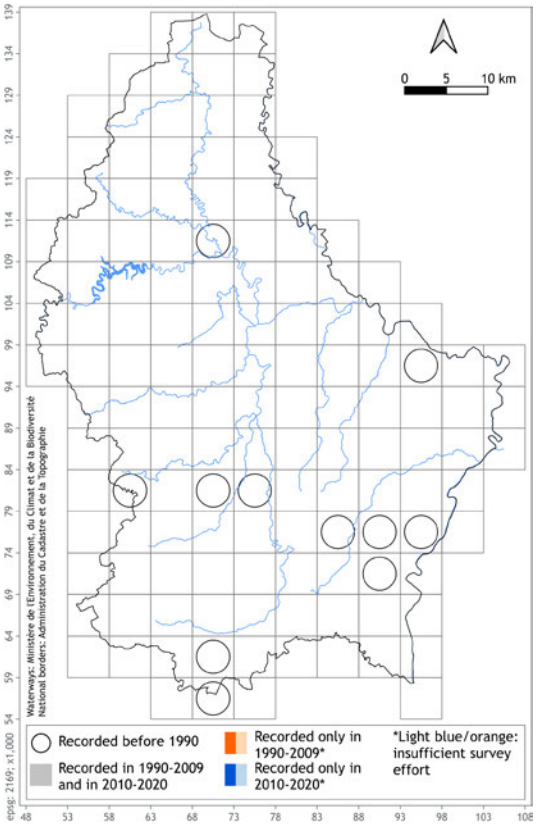


Fig. 4.502 for *Hipparchia hermione/fagi*.

Fig. 4.503: *Hipparchia hermione/fagi* (Illustration: Anita Faber).

4.4 Acknowledgements

We warmly thank Hubert Baltus, Yvan Barbier, Owen Beckett, Francis Birlenbach, Alain Dohet, Vincent Gillet, Jan Herr, Martin Heyeres, Xavier Janssens, Lysandre L'Hoste, Mireille Molitor, Philippe Mothiron, Roland Proess, Stéphane Vizthum, and Wolfgang Wagner who provided us with pictures of species (including eggs, caterpillars, and imagoes) and habitats. We are also very grateful to Anita Faber who made the drawings for all extinct species.

4.5 References

The following documents were consulted for the writing of the different species accounts:

Bene J., Konvièka M., Vrabec V. & Zámeèník J. 2003. - Do the sibling species of small whites, Leptidea sinapis and L. reali (Lepidoptera, Pieridae) differ in habitat preferences? Biologia 58: 943–951.

Bergerot B., Fontaine B., Renard M., Cadi A. & Julliard R. 2010. - Preferences for exotic flowers do not promote urban life in butterflies. Landscape and Urban Planning 96: 98–107.

Brattström O., Shapoval A., Wassenaar L. I., Hobson K. A. & Åkesson S. 2018. - Geographic origin and migration phenology of European red admirals (Vanessa atalanta) as revealed by stable isotopes. Movement Ecology 6: 25.

British Butterfly Aberrations 2018. - British Butterfly Aberrations. Available at: http://www.britishbutterflyaberrations.co.uk/.

Butterfly Conservation 2018. - Butterfly Conservation. Saving butterflies, moths and our environment. Available at: http://www.butterfly-conservation.org.

Caspari S. & Ulrich R. 2020. - Rote Liste und Gesamtartenliste der Tagfalter (Rhopalocera et Hesperiidae) und Widderchen (Zygaenidae) des Saarlandes. 5. Fassung. : 13, in Ministerium für Umwelt und Verbraucherschutz und Delattinia (Hrsg) (ed.), Rote Liste gefährdeter Planzen und Tiere des Saarlandes. Saarbrücken und Landsweiler-Reden.

CBNFC-ORI 2018. - Conservatoire botanique national de Franche-Comté - Observatoire régional des Invertébrés. Available at: https://cbnfc-ori.org/actualite/insectes-invertebres.

Conservatoire des Sites Lorrains & Société Lorraine d'Entomologie 2012. - Agir ensemble pour les Maculinea en Lorraine. Déclinaison régionale du Plan national d'actions en faveur des Maculinea. DREAL Lorraine, 55 p.

Conservatoire des Sites Lorrains & Société Lorraine d'Entomologie & DREAL 2012. - Agir ensemble pour les Maculinea en Lorraine. Déclinaison régionale 2012-2015 du Plan national d'actions en faveur des Maculinea. 62 p.

Cozzi G., Müller C. B. & Krauss J. 2008. - How do local habitat management and landscape structure at different spatial scales affect fritillary butterfly distribution on fragmented wetlands? Landscape Ecology 23: 269–283.

Cupedo F. & Hoen F. W. 2006. - Leptidea sinapis and Leptidea reali (Lepidoptera: Pieridae) in The Netherlands. Entomologische Berichten 66: 118–123.

Cuvelier S. & Casini P. M. 2015. - Melitea aurelia (Nickerl, 1850) en Italie septentrionale (Lepidoptera : Nymphalidae) : nouvelle population et confirmation de la détermination par dissection des genitalia. Lépidoptères - Revue des lépidoptéristes de France 24: 9–12.

De Prins W. 2016. - Catalogue of the Lepidoptera of Belgium. Entomobrochure 9: 1–282.

Dewulf L., Houard X. & Natureparif 2016. - Liste rouge régionale des Rhopalocères et des Zigènes d'Îles-de-France. Office pour les insectes et leur environnement - Association des Lépidoptéristes de France, Paris, 88 p.

DGARNE 2018. - La biodiversité en Wallonie: les papillons diurnes. Available at: http://biodiversite.wallonie.be/fr/papillons-diurnes.html?IDC=275.

Di Mauro D., Dietz T. & Rockwood L. 2007. - Determining the effect of urbanisation on generalist butterfly species diversity in butterfly gardens. Urban Ecosystems 10: 427–439.

Dinca V., Lukhtanov V. A., Talavera G. & Vila R. 2011. - Unexpected layers of cryptic diversity in wood white Leptidea butterflies. Nature communication 2: 1–8.

Eeles P. 2018. - UK Butterflies. Building a Community of Responsible Butterfly Enthusiasts in Britain & Ireland. Available at: http://www.ukbutterflies.co.uk/index.php.

Ellis S. & Wainwright D. (n.d.). - Butterfly Factsheets: Small Pearl-bordered Fritillary (Boloria selene). Butterfly Conservation, Wareham. Available at: https://butterfly-conservation.org/sites/default/files/sml-p-b-frit-psf.pdf.

Essayan R., Jugan D., Mora F. & Ruffoni A. 2013. - Atlas des papillons de jour de Bourgogne et Franche-Comté (Rhopalocera & Zygaenidae) (Vol. Hors-Série). Revue Scientifique Bourgogne-Nature, 494 p.

Fichefet V., Barbier Y., Baugnée J.-Y., Dufrêne M., Goffart P., Maes D. & Van Dyck H. 2008. - Papillons de jour de Wallonie (1985-2007). (Delbeuck C, Ed.). Groupe de travail Lépidoptères Lycaena & Service Public de Wallonie, Département de l'Etude du Milieu Naturel et Agricole (SPW/DGARNE), Gembloux, 320 p.

Filz K. J. 2013. - Global change impacts on biodiversity and their implications for species conservation. Department of Biogeography. Trier University, Trier, 210 p.

Fontaine B., Bergerot B., Le Viol I. & Julliard R. 2016. - Impact of urbanisation and gardening practices on common butterfly communities in France. Ecology and Evolution 6: 8174–8180.

Friberg M., Leimar O. & Wiklund C. 2013. - Heterospecific courtship, minority effects and niche separation between cryptic butterfly species. Journal of Evolutionary Biology 26: 971–979.

Fumi M. 2008. - Distinguishing between Leptidea sinapis and L. reali (Lepidoptera: Pieridae) using a morphometric approach: impact of measurement error on the discriminative characters. Zootaxa 1819: 40.

Gaedicke R., Nuss M., Steiner A. & Trusch R. 2017. - Verzeichnis der Schmetterlinge Deutschlands (Lepidoptera). 2. überarbeitete Auflage. (Berichte EN und, Ed.) (Vol. 21). Beiheft, Dresden, 362 p.

Gibbons R. 2018. - Butterflies of France. Available at: https://www.butterfliesoffrance.com/.

Goedert C. & Goebert C. 2014. - Ökologische Untersuchungen zu den Populationen von Pieris mannii Mayer 1851 nördlich der Alpen und speziell im Naturschutzgebiet Haardt bei Düdelingen (Lepidoptera, Pieridae). Lycée technique de Bonnevoie, in Zusammenarbeit mit dem MNHN de Luxembourg, 96 p.

Gourvil P.-Y., Soulet D., Couanon V., Sannier M., Drouet E., Simpson D. & Van Halder I. 2016. - Pré-Atlas des rhopalocères et zygènes d'Aquitaine. Synthèse des connaissances 1995 – 2015. (Conservatoire d'espaces naturels d'Aquitaine & Ligue pour la Protection des Oiseaux Aquitaine, Eds.). Conservatoire d'espaces naturels d'Aquitaine, 217 p.

Gourvil P.-Y., Soulet D., Couanon V., Sannier M., Drouet E., Simpson D. & Van Halder I. 2016. - Atlas des rhopalocères et zygènes d'Aquitaine. Fiche de recherche : La Lucine - Hamearis lucina. (Conservatoire d'espaces naturels d'Aquitaine & Ligue pour la Protection des Oiseaux Aquitaine, Eds.).

Gourvil P.-Y., Soulet D., Couanon V., Sannier M., Drouet E., Simpson D. & Van Halder I. 2016. - Atlas des rhopalocères et zygènes d'Aquitaine. Fiche de recherche : La Piéride de la Moutarde - Leptidea sinapis, La piéride de Réal - Leptidea reali. (Conservatoire d'espaces naturels d'Aquitaine & Ligue pour la Protection des Oiseaux Aquitaine, Eds.).

Habitats Directive 92/43/EEC. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31992L0043.

Henniaux C. 2015. - Evaluer et modéliser l'occupation des pelouses calcicoles de Lorraine par Maculinea arion. CEN Lorraine, 58 p.

Herr J. & Cungs J. 2021. - Plan national pour la protection de la nature 2. Plans d'actions espèces. Damier de la succise (Euphydryas aurinia) (…dans la région de la Minette). Projet de texte. Version janvier 2021. Administration de la nature et des forêts, Luxembourg, 15 p.

Herrmann R. 2010. - Die aktuelle Arealexpansion und Einbürgerung des Karstweißlings, Pieris mannii (Mayer, 1851), in Südwestdeutschland (Lepidoptera: Pieridae). Atalanta 41: 197–206.

Hoskins A. 2019. - Learn About Butterflies: the complete guide to the world of butterflies and moths. Available at: http://www.learnabout-butterflies.com.

Huntzinger M. 2003. - Effects of fire management practices on butterfly diversity in the forested western United States. Biological Conservation 113: 1–12.

Jacquot P. 2012. - Les papillons menacés en Franche-Comté: Damier du frêne (Euphydryas maturna). Union européenne, Direction régionale de l'Environnement, de l'Aménagement et du Logement de Franche-Comté, Conseil régional de Franche-Comté., 2 p.

Jacquot P. 2012. - Les papillons menacés en Franche-Comté: Azuré du serpolet (Maculinea arion). Direction régionale de l'Environnement, de l'Aménagement et du Logement de Franche-Comté, Conseil régional de Franche-Comté, 2 p.

Jacquot P. 2012. - Les papillons menacés en Franche-Comté: Bacchante (Lopinga achine). Union européenne, Direction régionale de l'Environnement, de l'Aménagement et du Logement de Franche-Comté, Conseil régional de Franche-Comté., 2 p.

Jacquot P. 2012. - Les papillons menacés en Franche-Comté: Cuivré de la bistorte (Lycaena helle). Union européenne, Direction régionale de l'Environnement, de l'Aménagement et du Logement de Franche-Comté, Conseil régional de Franche-Comté., 2 p.

Jacquot P. 2012. - Les papillons menacés en Franche-Comté: Cuivré des marais (Lycaena dispar). Union européenne, Direction régionale de l'Environnement, de l'Aménagement et du Logement de Franche-Comté, Conseil régional de Franche-Comté.

Jacquot P. 2012. - Les papillons menacés en Franche-Comté: Damier de la succise (Euphydryas aurinia). Union européenne, Direction régionale de l'Environnement, de l'Aménagement et du Logement de Franche-Comté, Conseil régional de Franche-Comté., 2 p.

Jacquot P. 2012. - Les papillons menacés en Franche-Comté: Hermite (Chazara briseis). Union européenne, Direction régionale de l'Environnement, de l'Aménagement et du Logement de Franche-Comté, Conseil régional de Franche-Comté., 2 p.

Jacquot P. 2012. - Les papillons menacés en Franche-Comté: Nacré de la canneberge (Boloria aquilonaris). Union européenne, Direction régionale de l'Environnement, de l'Aménagement et du Logement de Franche-Comté, Conseil régional de Franche-Comté., 2 p.

Jacquot P. 2014. - Fiche technique d'aide à la gestion et à l'entretien des biotopes à cuivré des marais Lycaena dispar (Haworth, 1802). CBNFC-ORI, 8 p.

Jacquot P. 2018. - Fiche technique d'aide à la gestion et à l'entretien des biotopes à cuivré de la bistorte Lycaena helle (Denis & Schiffermüller, 1775). CBNFC-ORI, 8 p.

Jugovic J., Koren T., Jurgovic J. & Koren T. 2014. - Wing pattern morphology of three closely related Melitaea (Lepidoptera, Nymphalidae) species reveals highly inaccurate external morphology-based species identification. Nota Lepidopterologica 37: 75–90.

Junck C., Proess R. & Rennwald E. 2009. - Plan national pour la protection de la nature (PNPN 2007-2011). Plan d'action Cuivré des marais Lycaena dispar. Ministère du Développement Durable et des Infrastructures, Luxemburg, 6 p.

Kan P. & Kan B. 2010. - Des centaines de chenilles de Nymphalis antiopa (L.) dans les saules (Lepidoptera: Nymphalidae). Lépidoptères - Revue des lépidoptéristes de France 19: 129–135.

Lafranchis T. 2000. - Les papillons de jour de France, Belgique et Luxembourg et leurs chenilles (Collection.). Biotope, Mèze (France), 448 p.

Lehtonen S., Lehtonen I., Teräs A., Varrela J., Virta P. & Vesterinen E. J. 2017. - DNA barcoding reveals widespread occurrence of Leptidea juvernica (Lepidoptera: Pieridae) in southern Finland. Entomologisk tidskrift 138: 151–159.

Lestang L. 2020. - Plan d'action espèce pour la protection de la nature au Grand-Duché de Luxembourg : l'azuré du serpolet, Phengaris arion (Linnaeus 1758). Version du 08/07/2020. Administration de la nature et des forêts, Luxembourg, 36 p.

Ligue Suisse pour la protection de la Nature 1987. - Les papillons de jour et leurs biotopes: espèces, dangers qui les menacent, protection. (Ligue Suisse pour la Protection de la Nature, Ed.) (Vol. 3). Pro Natura, Basel, 512 p.

Ligue Suisse pour la protection de la Nature & Groupe de travail des Lépidoptéristes 1999. - Les papillons et leurs biotopes: espèces, dangers qui les menacent, protection. (Ligue Suisse pour la protection de la Nature, Ed.) (Vol. 2). Pro Natura, Basel, 667 p.

Maes D., Vanreusel W. & Van Dyck H. 2013. - Dagvlinders in Vlaanderen: Nieuwe kennis voor betere actie. Lannoo Campus, Leuven, Belgium, 544 p.

Manil L. & Cuvelier S. 2014. - 2. Nymphalis xanthomelas (Esper, 1781) Migration massive sans suite ou expansion durable? Lépidoptères - Revue des lépidoptéristes de France 23: 69–75.

Mazel R. 2012. - Critères morphologiques de séparation des Leptidea sinapis L., L. reali Reissinger et L. juvernica Williams (Pieridae, Dismorphiinae). Revue de l'Association Roussillonnaise d'Entomologie 21: 1–9.

Mérit X. & Mérit V. 2000. - Colias hyale Linné ou Colias alfacariensis Ribbe? Clés pour la détermination de deux espèces difficiles (Lepidoptera: Pieridae). Bulletin des Lépidoptéristes Parisiens 9: 33–36.

Meyer M. & Pelles A. 1981. - Atlas provisoire des Insectes du Grand-Duché de Luxembourg. Lepidoptera, lère partie. Travaux scientifiques du Musée d'histoire naturelle de Luxembourg 1: 1–147.

Molitor M. & Schiltz C. 2013. - Plan national pour la protection de la nature. Plan d'actions espèces. Cuivré de la Bistorte, Lycaena helle (Denis et Schiffermüller, 1775). Version décembre 2013. Plan national pour la protection de la nature - Plans d'actions espèces. Ministère du Développment durable et des Infrastructures - Département de l'environnement. Natur&ëmwelt – Fondation Hëllef fir d'Natur, 23 p.

Molitor M. & Schiltz C. 2013. - Plan national pour la protection de la nature. Plans d'actions espèces. Cuivré de la Bistorte, Lycaena helle (Denis et Schiffermüller, 1775). Natur&ëmwelt - Fondation Hëllef fir d'Natur, 23 p.

Newland D., Still R., Swash A. & Tomlinson D. 2015. - Britain's butterflies: a field guide to the butterflies of britain and ireland. (Butterfly Conservation, Ed.). WILDGuides, Princeton University Press, Princeton, 240 p.

Nogret J. Y. & Vitzthum S. 2012. - Guide complet des papillons de jour de Lorraine & d'Alsace. Serpenoise, Metz, 296 p.

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

Pöyry J., Luoto M., Heikkinen R. K., Kuussaari M. & Saarinen K. 2009. - Species traits explain recent range shifts of Finnish butterflies. Global Change Biology 15: 732–743.

Reinhardt R., Harpke R., Caspari S., Dolek M., Kühn E., Musche M., Trusch R., Wiemers M. & Settele J. 2020. - Verbreitungsatlas der Tagfalter und Widderchen Deutschlands. Ulmer Eugen Verlag, Stuttgart, 432 p.

Rowlings M. 2018. - euroButterflies. Available at: http://www.eurobutterflies.com/index.php?region=EU.

Ryelandt J. 2015. - Fiche technique d'aide à la gestion et à l'entretien des biotopes du damier de la succise Euphydryas aurinia (Rottemburg, 1775). CBNFC-ORI, 8 p.

Ryelandt J. 2016. - Fiche technique d'aide à la gestion et à l'entretien des biotopes de la bacchante Lopinga achine (Scopoli, 1763). CBBFC-ORI, 8 p.

Ryelandt J. & Jugan D. 2016. - Les Lycaenidae de Bourgogne-Franche-Comté, clé d'identification. Conservatoire botanique national de Franche-Comté - Observatoire régional des Invertébrés, 63 p.

Saarinen K., Lahti T. & Marttila O. 2003. - Population trends of Finnish butterflies (Lepidoptera: Hesperioidea, Papilionoidea) in 1991–2000. Biodiversity & Conservation 12: 2147–2159.

Règlement grand-ducal du 9 janvier 2009 concernant la protection intégrale et partielle de certaines espèces animales de la faune sauvage. 2009. Available at: http://legilux.public.lu/eli/etat/leg/rgd/2009/01/09/n3/jo.

Shapiro A. 2018. - Art Shapiro's Butterfly Site. Monitoring butterfly populations across Central California for more than 45 years…. Available at: http://butterfly.ucdavis.edu/.

Société Lorraine d'Entomologie 2018. - Portail entomologique de Lorraine. Available at: https://lorraine-entomologie.org/webobs/index.php.

Stefanescu C. 2001. - The nature of migration in the red admiral butterfly Vanessa atalanta:

evidence from the population ecology in its southern range. Ecological Entomology 26: 525–536.

Talavera G. & Vila R. 2017. - Discovery of mass migration and breeding of the painted lady butterfly Vanessa cardui in the Sub-Sahara: the Europe–Africa migration revisited. Biological Journal of the Linnean Society 120: 274–285.

Tolman T., Lewington R. & Kosmos-Naturführer 1998. - Die Tagfalter Europas und Nordwestafrikas. Franckh-Kosmos, Stuttgart, 319 p.

van Swaay C. & Warren M. 2003. - Prime Butterfly Areas in Europe – Priority Sites for Conservation. National Reference Centre for Agriculture, Nature and Fisheries, Ministry of Agriculture, Nature Management and Fisheries, The Netherlands, 700 p.

van Swaay C., Warren M. & Loïs G. 2006. - Biotope use and trends of European butterflies. Journal of Insect Conservation 10: 189–209.

van Swaay C., Cuttelod A., Collins S., Maes D., López Munguira M., Šašić M., Settele J., Verovnik R., Verstrael T., Warren M., Wiemers M. & Wynhof I. 2010. - European Red List of Butterfies. Publications Office of the European Union. Available at: https://portals.iucn.org/library/node/9511

Vantieghem P. 2018. - First sightings of the southern small white Pieris Mannii (Lepidoptera: Pieridae) in the Low Countries. Phegea 46: 2–7.

Wagner W. 2018. - Schmetterlinge und ihre Ökologie. Available at: http://www.pyrgus.de/.

Wagner-Rollinger C. 1950. - Les lépidoptères du Grand-Duché de Luxembourg (et des régions limitrophes) I. Rhopalocera, Sphingoidea, Bombycoidea. Archives Tome XIX Nouvelle série de l'Insitut Grand-Ducal de Luxembourg, Section des Sciences naturelles, physiques et mathématiques. Musée d'Histoire Naturelle Luxembourg.

Wagner-Rollinger C. 1980. - Les biotopes de nos papillons diurnes (Lépidoptères Rhopalocères). P. Worré-Mertens, Luxembourg, 64 p.

Wagner-Rollinger C. 1983. - Les lépidoptères du Grand-Duché de Luxembourg et de ses régions limitrophes: notes supplémentaires. Lujana 1: 41–52.

Wagner-Rollinger C. & Luxembourg M. d'Histoire N. 1979. - Les lépidoptères du Garnd-Duché de Luxembourg (et des régions limitrophes) VII. Second supplément aux parties I, II, III, IV & V. Archives Tome XIX Nouvelle série de l'Insitut Grand-Ducal de Luxembourg, Section des Sciences naturelles, physiques et mathématiques. Musée d'Histoire Naturelle Luxembourg.

Wahlberg N. 1997. - The life history and ecology of Melitaea diamina (Nymphalidae) in Finland. Nota Lepidopterologica 20: 70–81.

Weber G., Conrad E. & Kayser M. 2012. - Les papillons de jour du Luxembourg. (natur&ëmwelt, Ed.). Imprimerie Heintz, 41 p.

Weidemann H.-J. 1986. - Tagfalter, Band 1. Entwicklung Lebensweise. Neumann-Neudamm Naturführer, Melsungen, 282 p.

Weidemann H.-J. 1988. - Tagfalter, Band 2. Biologie - Ökologie - Biotopschutz. Neumann-Neudamm Naturführer, Melsungen, 372 p.

Weiss J.-C. 2015. - Le déclin des papillons en Lorraine. Insectes 178: 1–6.

West Midlands Branch of Butterfly Conservation 2018. - West Midlands Branch of Butterfly Conservation website. Available at: http://www.westmidlands-butterflies.org.uk/species/butterflies.

Wynhoff I., van Swaay C., Veling K. & Vliegenthart A. 2010. - De nieuwe veldgids Dagvlinders. (De Vlinderstichting, Ed.). KNNV Uitgeverij i.s.m, Wageningen, 328 p.

5 A synthetic view of biotope management for butterflies in Luxembourg

Youri Martin[1,✉], Lionel L'Hoste[1], Sarah Vray[1], Lisette Cantú-Salazar[1], Michelle Clemens[2], Tiago De Sousa[3], Simone Schneider[4,5], Nicolas Titeux[1] and Xavier Mestdagh[1]

[1] Luxembourg Institute of Science and Technology (LIST)
5 Avenue des Hauts-Fourneaux
L-4362 Esch-sur-Alzette, Luxembourg

[2] Biological Station, Intercommunal Syndicate (SIAS)
L-2633 Senningerberg, Luxembourg

[3] Nature and Forest Agency (ANF)
L-9233 Diekirch, Luxembourg

[4] Intercommunal Syndicate for Nature Conservation (SICONA)
L-8393 Olm, Luxembourg

[5] Luxembourg National Museum of Natural History (MNHN)
L-2160 Luxembourg, Luxembourg

[✉] Corresponding author: youri.martin@list.lu

5.1 Introduction

One of the first causes of butterfly decline in Europe is the degradation and loss of their habitats (Warren et al. 2021), i.e., the sets of biophysical resources and conditions necessary to complete their lifecycle (Dennis, Shreeve & Van Dyck 2003; Hall, Krausman & Morrison 1997). These important resources and conditions for butterflies are found in different types of biotopes, i.e., areas distinguished by particular and uniform environmental conditions (Calow 2009; see Chapter 1 for the complete definitions of "habitat" and "biotope"), such as grasslands or forests, but are increasingly scattered across the landscape due to fragmentation. Urbanisation and agricultural intensification are the major driving forces of butterfly habitat degradation, loss and fragmentation. With the arrival of agricultural moto-mechanisation and chemical fertilisers, traditional extensive farming regimes were replaced by intensive large-scale practices, converting a countryside rich in small mixed crops and grassland plots shaped by hedges and trees into large monocultures, intensive pastures and hay meadows in early mowing (Mazoyer & Roudart 2006). Besides the intensification of grazing and mowing, many grasslands and other open semi-natural biotopes were fertilised and converted into arable croplands, or, for the less productive areas (e.g., wetlands and heathlands), converted into wood plantations (mainly exotic coniferous species). Hedges were destroyed and the massive use of nitrogen fertilisers led to the homogenisation of the flora in many biotopes. All these changes profoundly simplified the structure and composition of agricultural landscapes and led to a significant loss of host plants and nectar resources for many butterfly species (WallisDeVries, van Swaay & Plate 2012). Forests also underwent a strong intensification process, switching from favourable management practices for butterflies (mainly coppicing and forest grazing) to unfavourable practices, such as monocultures of timber and exotic coniferous tree plantations. This led to a decrease in heterogeneity of forest biotopes (including clearings) and their edges.

Favourable management measures are needed to preserve the remaining important biotopes for butterflies if we are to tackle their decline. Biotope management measures should target two main aims: 1) increasing the landscape heteroge-

neity by creating a mosaic of different biotopes, including small landscape features essential for the conditions and connectivity of the butterfly habitats (e.g., hedges, ponds, embankments, forest edges) and 2) accounting for the resources and conditions necessary for butterflies to complete their lifecycle in the management plans of each biotope. The nature of these actions varies across biotopes and may be oriented toward some target butterfly species (e.g., protected or threatened). A good knowledge of the ecological requirements of these species is therefore needed to ensure the availability and connectivity of suitable habitats for them across the landscape, such as host and nectar plants, micro-climatic conditions, refuges, basking and reproduction sites (see Chapter 1).

Areas that have drifted far from their semi-natural state and that are no longer providing suitable resources and conditions for butterflies may necessitate ecological restoration before the implementation of management measures, sometimes requiring drastic interventions (e.g., clear-cutting, sod-cutting, seedling). Restoration actions will not be discussed in this chapter. Other areas require less drastic changes in their management (e.g., changes in the intensity and the timing of mowing or grazing) to recover favourable semi-natural conditions. Marginal areas such as steep slopes, dry grasslands, marshes and fens are often abandoned as they have a low agricultural value, but they provide specific microclimates and other resources to the most threatened specialist butterfly species (Warren et al. 2021). The main nature conservation organisations in Luxembourg focus their actions on these specific biotopes with the help of governmental programmes, the Fonds pour la Protection de l'Environnement, the municipalities and the NGOs. In addition, several European LIFE projects (LIFE Arnikawiesen, LIFE Eislek, LIFE Orchis, LIFE Grassland) have been carrying out conservation and management actions to increase the availability of suitable habitats for butterflies.

This chapter highlights the link between the biophysical resources and conditions required for butterflies to complete their lifecycle and management practices for key biotopes in Luxembourg, namely grasslands, heathlands, forests, hedges, croplands, urban biotopes and wastelands.

5.2 Grasslands

5.2.1 Main grassland biotopes and key resources and conditions for butterflies

Grasslands are dominated by herbaceous plants and grasses. This biotope ranges from dry grassland (poor in soil nutrients, e.g., siliceous and calcareous grasslands) to mesophile grasslands (low to medium level in soil nutrients, e.g., false oat-grass meadows) and wet grasslands depending on various factors such as geology, topography, altitude, hydrology and management. Grasslands are traditionally managed by mowing, grazing, or sometimes the combination of both. They are among the most important biotopes for a large number of threatened organisms, such as butterflies for which they provide resources and conditions for most species in Europe (Wallis-DeVries & van Swaay 2009).

Mesophilic grasslands are best represented by species-rich false oat-grass meadows covering most of the preserved grassland habitat types present in Luxembourg (2,900 ha in total) (Fig. 5.1). Mesophilic grasslands are usually located on soils with low to medium nutrient levels. They are often managed as **hay meadows** or **pastures** (see section 2.2 below) and are usually very species-rich in plants, including some rare species. They provide host plants and nectar resources for many butterflies. The most common species found in this biotope are *Anthocharis cardamines*, *Aporia crataegi*, *Cyaniris semiargus*, *Lycaena tytirus*, *Melanargia galathea*, *Melitea cinxia*, *Polyommatus icarus*, *Coenonympha pamphilus* and *Maniola jurtina*.

Dry grasslands are very species-rich (fauna and flora) biotopes growing on nutrient-poor soil substrates (Fig. 5.2). In Luxembourg, dry grasslands are mainly associated with south facing slopes, limestone soils, well-drained soils, and/or shallow soils. Many Lycaenidae species (*Lysandra coridon, L. bellargus, Phengaris arion, Plebejus argus),* but also fritillaries (*Boloria dia, Melitaea aurelia, M. diamina)* and skippers (*Erynnis tages, Hesperia comma*, *Pyrgus armoricanus*) may be found in high densities in these dry and warm biotopes.

Wetlands are open biotopes not dominated by forests or standing water: riverbanks, floodplains, bogs, fens, and wet meadows and their fallow

stages (e.g., hydrophilous tall herb). Due to the specific micro-climatic, pedologic and hydrological conditions in wetlands, butterfly communities found in these biotopes are often well differentiated. Several species with a northern European distribution are found in wetlands at the southern limit of their range. Bistort meadows (*Bistorta officinalis*, Fig. 5.3) can be found in the Oesling and harbour glacial relict species, such as *Lycaena helle* and *Boloria eunomia*. Other species found in this biotope include *Boloria selene*, *Melitaea diamina* and *Lycaena hippothoe*. In the Gutland, wetlands host a different set of species with *Brenthis ino* associated to *Filipendula ulmaria* as well as *Lycaena dispar* associated with *Rumex obtusifolius* or *R. crispus* and flowering plants (e.g., *Lythrum salicaria*).

5.2.2 Grassland management for butterflies

The butterfly-friendly management of grasslands should maximise plant diversity, avoid shrub encroachment, limit the dominance of tall grasses to promote flowering plants, promote a low level of soil nutrients, and keep the necessary resources and conditions available for butterflies along the year. **Rotational management**, where a part of the parcel, either an entire portion or several fallow strips, is left unmanaged during a year or two, is an example of best management practice often applied. On the unmanaged part, plant species can grow and reproduce, while butterflies have the necessary resources and conditions to fulfil their lifecycle and colonise the whole grassland later. Rotational management means the whole parcel is completely mown or grazed after 2 or 3 years, which is generally enough to hold back shrubs. The modality of the rotational management (e.g., date of the first cut or grazing, size and location of the unmanaged part) can be fine-tuned according to the context of the parcel (e.g., Natura 2000 site, nature reserve, agricultural use, presence of threatened species) and based on detailed knowledge of the lifecycle of the targeted butterfly species in the area. In Luxembourg, the rotational management principle is compatible with some agri-environment schemes and biodiversity contracts supported by the legal authorities (Administration de la Nature et des Forêts 2017; Mémorial 2017).

Mowing is one method to maintain grasslands. Butterfly-friendly management requires that the vegetation should be cut only once or twice a year with the first cut as late as possible, with the renunciation of sowing, fertilisation and use of pesticides. Butterflies have more time and resources to fulfil their lifecycle with a reduced number of cuts. There is a specific biodiversity contract, which covers all the before mentioned criteria (Mémorial 2017). The subsidies for this contract rise with the delay of the first cut, the earliest date is June 15th and the latest August 1st, and when implemented, the second cut is recommended after August 15st. **Hay meadows** in **dry, mesophilic** or **wet grasslands** are mown for fodder production. In contrast to hay meadows, the silage meadows are mown earlier and more frequently and are more strongly fertilised. They harbour a high level of soil nutrients and a low diversity of plants with limited resources available for butterflies. **Wetlands** that are no longer in agricultural use need to be mown to prevent the natural succession to tall herb fringe communities dominated by *Filipendula ulmaria*, reed bed (e.g., *Phragmites australis*., *Phalaris arundinacea*) or willow trees (*Salix* sp.), that provide homogeneous and unfavourable closed habitat conditions compared to the open herbaceous biotopes (e.g., *Bistorta officinalis*) required for butterflies. They should be managed with the same general principle as for hay meadows of **mesophilic grasslands**: no fertilisers, first cut after June 15th with a rotational management, preferably in a mosaic landscape pattern and with the presence of fallow strips (Siebenaler et al. 2020). More humid wetlands can be mechanically mown with low ground pressure machines at the end of the summer when the water level is lower.

Grazing is the other most common management practice. Pastures are **dry**, **mesophilic** or **wet grasslands** that are grazed by animals early in spring and throughout the growing season. In contrast with mowing, **grazing** creates an interesting microhabitat heterogeneity and plant diversity that can be used as food and shelter resources for butterflies. Grazing management should therefore promote the heterogenisation of the parcel conditions and avoid homogenisation practices such as fertilisation, mowing of remains, overgrazing and control of weeds. Nectar resources are mainly composed of early bloomers, low-bearing, or less palatable plants. Livestock type and density, but also grazing duration and timing, will influence species richness and availability of nectar and host-plant resources for butterflies. Extensive grazing is advised and results in a mosaic of microhabitats with different heights of vegetation or bare soil providing

Fig. 5.1: Mesophilic grassland (false oatgrass meadows) managed as a hay meadow (Mertert, 25/05/2008, Simone Schneider).

Fig. 5.2: Flower-rich dry grassland attracting a high diversity of butterfly species in the Minette (Léiffrächen, Schifflange, 30/07/2021, Lionel L'Hoste).

Fig. 5.3: Typical Oesling valley with dominance of *Bistorta officinalis*, the larval host plant of *Lycaena helle* and *Boloria eunomia* (Walhausener Dickt, Hosingen, 08/06/2008, Simone Schneider).

Fig. 5.4: Grazed wetland in the Oesling showing the result of grazing management (Basbellain, Cornelysmillen, 17/11/2005, Mireille Molitor).

interesting resources and conditions for some butterfly species. Especially as several grassland plant species considered as weeds for farmers are essential host plants for butterflies. For example, *Rumex obtusifolius* and *R. crispus* are the host plants of *Lycaena dispar* and *L. phlaeas*, *Urtica dioica* is the host plant of several Nymphalidae species, and thistles provide high amounts of nectar to adult butterflies. Extensive grazing between April 1st and October 31th with rotation in the parcel and grazing break periods with limited livestock density (under 2 units/ha) is promoted through the biodiversity contracts in Luxembourg (Mémorial 2017).

Mesophilic grassland pastures are an important grassland type in Luxembourg. **Dry grasslands** are often best managed with pastoral sheep grazing. In Luxembourg, the different nature conservation organisations (SICONA, natur&ëmwelt and ANF) work in close collaboration with the shepherds to coordinate the grazing from one parcel to the next with an adequate timing for the conservation of protected species. The migration of sheep (and/or goats) between grassland areas provides the additional service of transporting seeds and small animals between parcels. A short grazing period with a high number of sheep reduces the disturbance period and can be adapted to the lifecycle phenology of target butterflies. To maintain an open biotope, shrub removal is often required in addition to grazing. A summer grazing of **wetlands** is recommended using itinerant sheep or cattle (e.g., Highland, Galloway) if mowing is not possible due to the humid conditions (Fig. 5.4). The management should always be tailored to the presence of rare and endangered species in these biotopes.

For all types of grasslands, a mosaic-like landscape management obtained from spreading the management actions in time and in space should be promoted because mowing or grazing all the parcels at the same time in the same area drastically reduces the resources available for butterflies. Fertilisation of grasslands should also be avoided to maintain plant diversity with rare species (Wolff et al. 2020).

5.3 Heathlands

5.3.1 Main heathland biotopes and key resources and conditions for butterflies

Heathlands are characterised by the dominance of small bushes from the Ericaceae family (e.g., *Calluna vulgaris*; Fig. 5.5 or *Erica tetralix*) and can be dry or wet. In Luxembourg, they are a secondary biotope resulting from deforestation followed by centuries of grazing. Heathlands are a legacy of an old land use practice implemented on acid soils with low nutrient level, and thus sensitive to fertilisation. The number of butterfly species observed in heathland varies with the pedology as well as the coverage and the diversity of the herbaceous vegetation. In Luxembourg, there are no butterfly species that rely solely on heathland, but some conservation-interest species typically occur in this biotope: *Aricia agestis*, *Plebejus argus*, *Callophrys rubi*, *Issoria lathonia* and *Favonius quercus*. Wolff, Gilhaus and Schneider (2017) suggest that *Lycaena phlaeas* and *L. tityrus* could be considered as typical species in the southwest heathlands of Luxembourg as they rely on *Rumex acetosella* that is widespread in this biotope.

5.3.2 Heathland management for butterflies

Heathlands should be managed to promote a mosaic of different open to semi open features representing the different development stages of the heather: bare soil patches with *Calluna vulgaris,* seedling patches with a taller cover of young calluna-plants, up to structures with dominant old calluna-bushes (Fartmann, Borchard & Buchholz 2015; Schirmel & Fartmann 2014; Siebenaler et al. 2021). To counteract encroachment by shrubs or ferns, periodical grazing by itinerant sheep is recommended; if necessary, shrubs need to be removed individually. In areas with overaged calluna-bushes, the restoration of open soil patches by light topsoil removal or choppering is required to promote the germination of new heather seeds and the regeneration of the heathlands (Wolff, Gilhaus & Schneider 2017).

Fig. 5.5. Calluna heathland (Heedchen, Dondelange, 20/08/2016, Simone Schneider).

5.4 Forests

5.4.1 Main forest biotopes and key resources and conditions for butterflies

This biotope includes a wide range of woody habitats, from the young plantation or natural regeneration to the mature timberland beech or mixed forest. Forests provide an important diversity of resources and conditions for butterflies (e.g., nectar and tree sap, host plants, shelters for thermoregulation, refuge areas, ecological corridors, mating areas) thanks to the heterogeneity of structures and successional stages. Butterflies seek sunlight and are therefore often observed close to (inner and outer) forest edges, forest canopy, roadsides, forest paths and clearings (Fig. 5.6). *Pararge aegeria* is a good example of a common forest species that exploits small light spots of few square meters, whereas old heterogeneous oak forests with larger spotlights are used by e.g., *Apatura iris*, *Favonius quercus* and *Satyrium ilicis*. Almost half of butterfly species recorded in Luxembourg can be observed in forests, including the most emblematic species from the genera *Apatura, Limenitis, Nymphalis, Satyrium, Thecla*, and *Favonius*. However, it is hardly possible to classify most butterflies as strictly forest-dwelling species (van Swaay, Warren & Loïs 2006) because a large number of species are observed at the interface between forests and open biotopes where many species find essential resources and conditions. Moreover, many species use forests during a part of their lifecycle only.

5.4.2 Forest management for butterflies

In general, forest management for butterflies should promote clearings, natural regeneration, and low tree densities. Natural clearings can be favoured by letting some old trees stand that may fall later to let through the sunlight required for host plants, nectar resources and the activities of butterflies. Hunters often manage open areas in their forest hunting lots, and these clearings could easily be managed as butterfly-friendly grasslands to provide the resources needed for butterflies

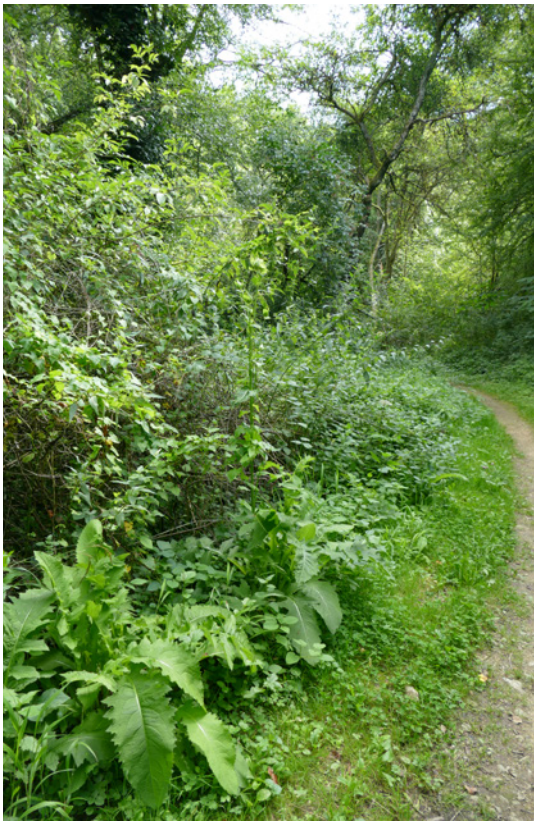


Fig. 5.6: Example of a forest path with a diversified vegetation from the ground to the tree layer (Haustadt, Beckingen (D), 14/08/2017, Simone Schneider).

(i.e., late mowing with rotation, see "Grasslands" section above). Forest edges and clearings need to be well structured with shrubs and brambles. Best management practices aim to avoid a marked boundary between forests and open areas by promoting three vegetation strata (herbaceous vegetation, shrubs and trees) (Fichefet et al. 2011). Therefore, a dynamic network of stratified forest edges with a width of at least 15 m left to natural succession is recommended. The management of the margins of forest paths and unpaved roads also form important sparse areas with linear structures used as dispersal corridors by butterflies.

Coppice management is a good example of a beneficial forest management for butterflies because it creates temporary, rotating biotopes providing resources for butterflies in different places at different times. Coppicing consists in cutting trees on short rotations (i.e., 15-30 years). Young tree stems then regrow from stumps or roots. With the small size of the parcels, this practice creates a diverse mosaic of different successional stages, from open clearings to closed canopy. Unfortunately, coppicing is declining in Luxembourg even if it is strongly recommended to keep this traditional forest management in some places for a variety of organisms. When coppicing is not possible, forest management should focus on creating clear deciduous forests with a diverse undergrowth to protect the typical species from these biotopes. Coniferous forests do not contain resources and conditions to support butterfly populations.

5.5 Hedges

5.5.1 Main hedge biotopes and key resources and conditions for butterflies

Hedges constitute linear structures that are essential to accommodate biodiversity in open agricultural landscapes (Fig. 5.7). They are composed of various woody plant species providing a multitude of structures and microclimatic conditions. The most common species are *Prunus spinosa, Crataegus monogyna, C. laevigata, Lonicera* sp., as well as their accompanying species at the edge of hedges (e.g., *Rubus fruticosus* agg., *R. idaeus*, *Humulus lupulus*). They provide shelters, host plants and nectar resources to many butterfly species such as *Satyrium* spp. Hedges also serve as ecological corridors for flying butterflies that tend to follow their structure and connect butterfly (meta)populations in fragmented agricultural landscapes (e.g., Dover & Fry 2001).

5.5.2 Hedge management for butterflies

A rotational management regime of hedges is required to ensure the highest diversity of indigenous woody plant species with different requirements to co-occur. Hedges should be subdivided into sections that are left unmanaged for a certain number of years. Management activities (e.g., edge cutting, trimming) should be implemented in late winter. It is estimated that approximately 28% of hedges were destroyed in Luxembourg between 1962 and 1999 (Hansa 2006). The remaining

Fig. 5.7: Hedges (Reckange, Mersch, 17/04/2016, Claudine Junck & Fernand Schoos).

hedges should therefore be highly protected for butterflies and new ones need to be planted.

5.6 Croplands

5.6.1 Main cropland biotopes and key resources and conditions for butterflies

Crops and their margins range from favourable to very unfavourable biotopes for butterflies, depending on their nature and on management practice and intensity. Flower-rich leguminous crops (alfalfa, clover) are probably the most interesting ones for butterflies. Depending on the timing of the harvest, these crops provide host plants for *Colias hyale*, *C. crocea*, *Cupido argiades*, *Glaucopsyche alexis*, *Polyommatus icarus*, *Pieris napi* and *P. rapae*, as well as nectar resources for many other species. *Issoria lathonia* is a noteworthy butterfly species able to breed in open agricultural landscapes where enough violets occur (*Viola arvensis* or *V. tricolor*). Field margins are often colonised by many threatened arable weeds or other flowering plants that provide key resources for butterflies (Fig. 5.8). In combination with hedges and fallow lands, field margins accommodate most of the butterfly species living in agricultural landscapes and they deserve more attention for management and restoration.

5.6.2 Cropland management for butterflies

Agricultural landscapes could accommodate a higher diversity of butterflies if the ensemble of parcels would be managed in a more integrated way over time and in space and if the nature and heterogeneity of the crops would create an attractive mosaic of suitable biotopes. Yet, this often questions the entire conventional and intensive farming system. A good example of butterfly-friendly agriculture could come from organic farming systems and agro-ecological practices that are not based on the supply of chemical inputs, as for the conventional agriculture, but rather on the sustainable exploitation of natural resources and ecosystem services. The reestablishment of leguminous crops at the head of the rotation instead of the use of chemical

Fig. 5.8: Cornfield with a field margin and a flowering strip along the road. Field margins can provide important resources for several species when extensively managed with late mowing. (Wincrange, 27/06/2010, Mireille Molitor).

fertilisers, as well as the reinstatement of fallows, are examples of management practices beneficial to butterflies and other pollinators. Furthermore, the late mowing of field margins to promote wild plants is also very important to provide shelters and ecological corridors for butterflies (Fig. 5.8). Maintaining rare and old varieties of arable plants can also help to promote butterfly diversity and other pollinators in agricultural landscapes because they can provide important nectar resources in and around crops where wildflowers are often missing (Lenerz et al. 2017).

To counteract the negative impacts of intensive cropland management, the Luxembourgish Government introduced a set of agri-environmental schemes (Ministère de l'Agriculture de la Viticulture et du Développement rural 2017) and biodiversity contracts open to farmers on a voluntary basis (Mémorial 2017). The biodiversity contracts cover different forms of extensive agriculture practices and provide a certain flexibility allowing trade-offs between the needs of the farmer and the consequences on biodiversity. These biodiversity contracts are more restrictive than the agri-environmental schemes and forbid the use of pesticides and fertilisers in all their programs.

5.7 Urban biotopes and wastelands

5.7.1 Main urban and wasteland biotopes and key resources and conditions for butterflies

Urban areas mainly covered by mineral materials (stone or concrete) or turf provide few resources for butterflies. However, urban green spaces (Fig. 5.9) and private gardens as well as green roofs or facades can be suitable for butterflies if they offer enough nectar resources, host plants, and shelters (e.g., Garbuzov & Ratnieks 2014). Wastelands are also very attractive and contribute the most to butterfly conservation in urban environments (Bonthoux et al. 2014). Wastelands are abandoned areas usually maintained open by human activities (e.g., agriculture, industry, mining, quarry, lines of communication or energy). The stage and structure of the vegetation depend on wasteland age, soil and microclimate, ranging from pioneer to pre-forest stages harbouring contrasting butterfly communities. Urban biotopes can constitute refuges for several butterfly species: *Thymelicus lineola, T. sylvestris, Polyommatus icarus, Papilio machaon, Vanessa atalanta, V. cardui, Aglais urticae, A. io, Araschnia levana*, and many Pieridae species.

5.7.2 Urban biotopes and wasteland management for butterflies

Wastelands are typically not regularly managed, but specific actions should ideally focus on preventing the encroachment of the vegetation and the establishment of invasive alien plant species decreasing the suitability of the biotopes for butterflies (list of Invasive Alien Species (IAS) in Luxembourg: www.neobiota.lu). A good

Fig. 5.9: Urban area with an example of green space suitable for butterflies (Bettembourg, 25/05/2018, SICONA).

example of these harmful IAS is the butterfly-bush (*Buddleja davidii*), which is highly attractive to some butterfly species and rapidly invading wastelands and urban biotopes throughout the world (Tallent-Halsell & Watt 2009), crowding out the native plant populations that would provide essential host plants and nectar resources for butterflies. Such IAS should be prohibited from selling in gardening centres and should be removed from urban biotopes, wastelands and gardens. If possible, more sophisticated management could be applied to target some biotopes or species of interest by limiting the ecological succession at a certain stage of interest (e.g., grazing or mowing to maintain the herbaceous vegetation).

Private gardens or public areas can also be managed to accommodate butterflies, and everyone can help save and protect butterflies and other pollinators by taking simple measures. It has been shown that the negative impacts of urbanisation can be partly counter-balanced by butterfly-friendly gardening (Fontaine et al. 2016). This does not require much additional costs or gardening efforts. Adequate management for butterflies means providing host plants and nectar resources with native flower plants, reducing mowing intensity, leaving refuges of areas mown only once a year, no use of pesticides and chemical fertilisers, managing shrubs or hedges, and avoiding an excessive use of ornamental stone or mulch areas. Pieces of information are available to the public about pollinator-friendly practices in gardens (see www.ounipestiziden.lu; https://naturelo.meco.lu, /https://sicona.lu/projekte/paeiperlek/; Becker & Zenthöfer 2015; Mouvement Ecologique 2017).

Efforts have recently been made in Luxembourg to favour nature-friendly creation and management of public areas. Thanks to the advice from the biological stations, the Administration de la Nature et des Forêts and several NGOs, the managers of many public green spaces have been switching to an ecological planning of new infrastructures based on a nature-friendly management perspective (Pailhès & Sound Ecology S.À.R.L 2019). The ecological design of public spaces in urban areas has had another boost after the introduction of a law forbidding the use of pesticides in public areas (Loi du 19 décembre 2014 relative aux produits phytopharmaceutiques, Art.11). Grass surfaces are mown less frequently and later in the year when it is compatible with road visibility and safety. Road margins are cut once to twice a year and herbicides are forbidden to allow flowers to blossom. Moreover, flowerbeds should now be

sown or planted with (perennial) native species instead of using mulching and exotic shrub plantations. Recommendations for the creation of natural green spaces with native species can be found in a practical guide targeting municipalities (Even & Schneider 2019).

5.8 Take-home messages

- The intensification of land use by human activities profoundly simplified the structure and the composition of the landscapes and led to a significant loss of biotopes suitable for butterflies in Luxembourg;
- There is a need to strengthen biodiversity-friendly practices inside and outside nature reserves if we are to preserve butterfly species diversity and ecosystem services;
- Biotope management is one of the best available biodiversity conservation tools because it is based on human interventions (e.g., grazing, mowing, coppicing, …);
- Management allows to maintain the vegetation of open areas at different stages and prevents the natural succession to forests;
- Biotope management should be planned at the landscape level and adapted to the local/regional conditions with the aim to increase the size and the quality of the targeted sites as well as their connectivity (e.g., by creating ecological corridors or stepping stones);
- Management actions should aim to create heterogeneity of biotopes at micro, local and landscape scales to increase diversity of conditions and resources available for butterflies;
- Spreading the human interventions in time and in space with the rotational management principle is crucial because butterflies need to find conditions and resources throughout the year to accomplish their lifecycle;
- Contractual nature conservation schemes in Luxembourg provide a tool to increase biodiversity through extensification of management practices on agricultural land;
- Urban and wasteland areas can also be managed and designed to accommodate butterflies.

5.9 References

Administration de la Nature et des Fôrets 2017. - Naturschutz durch Nutzung. Naturschutz durch landwirtschaftliche Nutzung Sicherung der Artenvielfalt im Großherzogtum Luxemburg im Zuge des Neuen Biodiversitätsprogamms. 19 p.

Becker L. & Zenthöfer J. 2015. - Fir e liewege Gaart. (Administration de la nature et des forêts, Ed.). Administration de la nature et des forêts, Luxembourg, 32 p.

Bonthoux S., Brun M., Di Pietro F., Greulich S. & Bouché-Pillon S. 2014. - How can wastelands promote biodiversity in cities? A review. Landscape and Urban Planning 132: 79–88.

Calow P. 2009. - Encyclopedia of Ecology and Environmental Management. Encyclopedia of Ecology and Environmental Management. Blackwell Publishing Ltd., Oxford, UK, 1–805 p.

Dennis R. L. H., Shreeve T. G. & Van Dyck H. 2003. - Towards a functional resource-based concept for habitat: a butterfly biology viewpoint. Oikos 102: 417–426.

Dover J. W. & Fry G. L. A. 2001. - Experimental simulation of some visual and physical components of a hedge and the effects on butterfly behaviour in an agricultural landscape. Entomologia Experimentalis et Applicata 100: 221–233.

Even J. & Schneider S. 2019. - Anlage von naturnahen Grünflächen im Siedlungsbereich - Ein Praxisratgeber für Gemeinden. SICONA Naturschutzsyndikat, 52 p.

Fartmann T., Borchard F. & Buchholz S. 2015. - Montane heathland rejuvenation by choppering - Effects on vascular plant and arthropod assemblages. Journal for Nature Conservation 28: 35–44.

Fichefet V., Branquart E., Claessens H., Delescaille L.-M., Dufrêne M., Graitson E., Paquet J.-Y. & Wibail L. 2011. - Milieux ouverts forestiers, lisières forestières et biodiversité: de la théorie à la pratique. Service public de Wallonie, Gembloux, 182 p.

Fontaine B., Bergerot B., Le Viol I. & Julliard R. 2016. - Impact of urbanisation and gardening practices on common butterfly communities in France. Ecology and Evolution 6: 8174–8180.

Garbuzov M. & Ratnieks F. L. W. 2014. - Quantifying variation among garden plants in attractiveness to bees and other flower-visiting insects. Functional Ecology 28: 364–374.

Hall L. S., Krausman P. R. & Morrison M. L. 1997. - The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25: 173–182.

Hansa L. 2006. - Landschaftsmonitoring Luxembourg 2005.

Lenerz M., Ries C., van Elsen T. & Schneider S. 2017. - Preservation of arable plant species in Luxemburg with protected fields, arable plant reserves and organic farming. Scientific Research Center of the National Museum of Natural History. Available at: https://www.mnhn.lu/science/2017/03/05/preservation-of-arable-plant-species-in-luxemburg-with-protected-fields-arable-plant-reserves-and-organic-farming/?lang=en.

Mazoyer M. & Roudart L. 2006. - A history of world agriculture, from the neolithic age to the current crisis. Monthly Review Press, New York, 525 p.

Mémorial 2017. - Règlement grand-ducal du 11 septembre 2017 instituant un ensemble de régimes d'aides pour la sauvegarde de la diversité biologique en milieu rural. : 1–70, in Mémorial A Recueil de législation du Journal officiel du grand-duché de Luxembourg N° 863 du 11 septembre 2017.

Ministère de l'Agriculture de la Viticulture et du Développement rural 2017. - Règlement grand-ducal du 24 mai 2017 instituant des régimes d'aide en faveur de méthodes de production agricole respectueuses de l'environnement. Mémorial A - Journal officiel du Grand-Duché de Luxembourg 545: 30.

Mouvement Ecologique 2017. - A voller Bléi! (In full bloom!) Turn your garden and balcony into a bee's paradise. (Mouvement Ecologique, Ed.). Mouvement Ecologique, Luxemburg, 9 p.

Pailhès M. & Sound Ecology S.À.R.L 2019. - Life is thriving in Kirchberg! Ecological management of urban areas. (Administration de la Nature et des Forêts & Fonds d'Urbanisation et d'Aménagement du Plateau de Kirchberg, Eds.). Imprimerie Centrale, Luxembourg, 27 p.

Schirmel J. & Fartmann T. 2014. - Coastal heathland succession influences butterfly community composition and threatens endangered butterfly species. Journal of Insect Conservation 18: 111–120.

Siebenaler L., Wolff C., Steinbach-Zoldan A., Zoldan J.-, Werner, Hochkirch A., Steinmetz M. & Schneider S. 2020. - Insektenfauna der Feuchtwiesenkomplexe um die 'Bartringer Houbaach' -Entwicklung innerhalb 25 Jahren. Bulletin de la Société des Naturalistes Luxembourgeois 122: 163–196.

Siebenaler L., Wolff C., Weigand A., Herrera Mesías F., Schneider N., Braunert C., Gerend R., Hellers M. & Schneider S. 2021. - Untersuchung ausgewählter Arthropodengruppen auf der renaturierten Heidefläche 'Heedchen' in der Gemeinde Kehlen, Luxemburg. Bulletin de la Société des Naturalistes Luxembourgeois 123: 137–180.

Tallent-Halsell N. G. & Watt M. S. 2009. - The Invasive Buddleja davidii (Butterfly Bush). The Botanical Review 75: 292–325.

van Swaay C., Warren M. & Loïs G. 2006. - Biotope use and trends of European butterflies. Journal of Insect Conservation 10: 189–209.

WallisDeVries M. F. & van Swaay C. 2009. - Grasslands as habitats for butterflies in Europe. : 26–34, in Veen P., Jefferson R., de Smidt J. & van der Straaten J. (eds.), Grasslands in Europe. KNNV Publishing.

WallisDeVries M. F., Van Swaay C. & Plate C. L. 2012. - Changes in nectar supply: A possible cause of widespread butterfly decline. Current Zoology 58: 384–391.

Warren M. S., Maes D., van Swaay C., Goffart P., Van Dyck H., Bourn N. A. D., Wynhoff I., Hoare D. & Ellis S. 2021. - The decline of butterflies in Europe: Problems, significance, and possible solutions. Proceedings of the National Academy of Sciences 118: e2002551117.

Warren M. S., Maes D., van Swaay C., Goffart P., Van Dyck H., Bourn N. A. D., Wynhoff I., Hoare D. & Ellis S. 2021. - The decline of butterflies in Europe: Problems, significance, and possible solutions. Proceedings of the National Academy of Sciences 118: e2002551117.

Wolff C., Colling G., Naumann S., Glesener L. & Schneider S. 2020. - Erfolgreicher Erhalt von artenreichem Extensivgrünland im Zentrum und Südwesten Luxemburgs-eine erste Bilanz Successful conservation of species-rich grasslands in central and south-west Luxembourg-first results. Tuexenia 40: 247–268.

Wolff C., Gilhaus K. & Schneider S. 2017. - Butterflies and grasshoppers in historical and recently restored heathlands and sand grasslands in the southwest of Luxembourg. Bulletin de la Société des Naturalistes Luxembourgeois 119: 113–128.

6 Species index

6.1 Scientific names

6.2 Luxembourgish common names

6.3 English common names

6.4 German common names

6.5 French common names

Les volumes de la série FERRANTIA paraissent à intervalles non réguliers. Ils peuvent être consultés en ligne à l'adresse suivante:

http://www.mnhn.lu/ferrantia/

Adresse de courriel pour les commandes:

diffusion@mnhn.lu

LISTE DES NUMÉROS PARUS À CETTE DATE

Travaux scientifiques du Musée national d'histoire naturelle (1981-1999)

I Atlas provisoire des Insectes du Grand-Duché de Luxembourg. Lepidoptera. 1ère partie (Rhopalocera, Hesperiidae). Marc Meyer et Alphonse Pelles, 1981.

II Nouvelles études paléontologiques et biostratigraphiques sur les Ammonites du Grand-Duché de Luxembourg, de la Province du Luxembourg et de la région Lorraine attenante. Pierre L. Maubeuge, 1984.

III Revision of the recent Western Europe species of genus *Potamocypris* (Crustacea, Ostracoda). Part 1: Species with short swimming setae on the second antennae. Claude Meisch, 1984.

IV-1 Hétéroptères du Grand-Duché de Luxembourg: *Psallus (Hylopsallus) pseudoplatani* n. sp. (Miridae, Phylinae) et espèces apparentées. Léopold Reichling, 1984.

IV-2 Hétéroptères du Grand-Duché de Luxembourg: Quelques espèces peu connues, rares ou inattendues. Léopold Reichling, 1985.

V La bryoflore du Grand-Duché de Luxembourg: taxons nouveaux, rares ou méconnus. Ph. De Zuttere, J. Werner et R. Schumacker, 1985.

VI Revision of the recent Western Europe species of genus *Potamocypris* (Crustacea, Ostracoda). Part 2: Species with long swimming setae on the second antennae. Claude Meisch, 1985.

VII Les Bryozoaires du Grand-Duché de Luxembourg et des régions limitrophes. Gaby Geimer et Jos. Massard, 1986.

VIII Répartition et écologie des macrolichens épiphytiques dans le Grand-Duché de Luxembourg. Elisabeth Wagner-Schaber, 1987.

IX La limite nord-orientale de l'aire de *Conopodium majus* (Gouan) Loret en Europe occidentale. Régine Fabri, 1987.

X Epifaune et endofaune de *Liogryphaea arcuata* (Lamarck). Contribution à l'écologie des populations de *Liogryphaea arcuata* (Lamarck) dans le Sinémurien au NE du Bassin de Paris. Armand Hary, 1987.

XI Liste rouge des Bryophytes du Grand-Duché de Luxembourg. Jean Werner, 1987.

XII Relic stratified scress occurences in the Oesling (Grand-Duchy of Luxembourg), approximate age and some fabric properties. Peter A. Riezebos, 1987.

XIII Die Gastropodenfauna der "angulata-Zone" des Steinbruchs "Reckingerwald" bei Brouch. Hellmut Meier et Kurt Meiers, 1988.

XIV Les lichens épiphytiques et leurs champignons lichénicoles (macrolichens exceptés) du Luxembourg. Paul Diederich, 1989.

XV Liste annotée des Ostracodes actuels non-marins trouvés en France (Crustacea, Ostracoda). Claude Meisch, Karel Wouters et Koen Martens, 1989.

XVI Atlas des lichens épiphytiques et de leurs champignons lichénicoles (macrolichens exceptés) du Luxembourg. Paul Diederich, 1990.

XVII Beitrag zur Faunistik und Ökologie der Schmetterlinge im ehemaligen Erzabbaugebiet "Haardt" bei Düdelingen. Jos. Cungs, 1991.

XVIII Moosflora und -Vegetation der Mesobrometen über Steinmergelkeuper im Luxemburger und im Bitburger Gutland. Jean Werner, 1992.

19 Ostracoda. Nico W. Broodbakker, Koen Martens, Claude Meisch, Trajan K. Petkovski and Karel Wouters, 1993.

20 Les haies au Grand-Duché de Luxembourg. Konjev Desender, Didier Drugmand, Marc Moes, Claudio Walzberg, 1993.

21 Ecology and Vegetation of Mt Trikora, New Guinea (Irian Jaya / Indonesia). Jean-Marie Mangen, 1993.

22 A checklist of the recent non-marine ostracods (Crustacea, Ostracoda) from the inland waters of South America and adjacent islands. Koen Martens & Francis Behen, 1993.

23 Ostracoda. Claude Meisch, Roland Fuhrmann, Karel Wouters, Gabriele Beyer and Trajan Petrovski, 1996.

24 Die Moosflora des Luxemburger Oeslings. Jean Werner, 1996.

25 Atlas des ptéridophytes des régions lorraines et vosgiennes, avec les territoires adjacents, Georges Henri Parent, 1997.

26 Evaluation de la qualité des cours d'eau au Luxembourg en tant qu'habitat pour la loutre. Groupe Loutre Luxembourg, 1997.

27 Notes Paléontologiques et Biostratigraphiques sur le Grand Duché de Luxembourg et les régions voisines. Pierre Louis Maubeuge & Dominique Delsate, 1997.

28 Die Moosflora der Kleinen Luxemburger Schweiz (Müllertal). Florian Hans, 1998.

29 Etude sur les genres *Globorilusopsis* Maubeuge, 1994 et *Simoniceras* n. gen. du Lias Supérieur du Grand-Duché de Luxembourg (Calyptoptomatida). Pierre Louis Maubeuge, 1998.

30 L'Ichthyofaune du Toarcien luxembourgeois. Cadre général et catalogue statistique. Dominique Delsate, 1999.

31 Proceedings of the 3rd European Batdetector Workshop. 16-20 August 1996 Larochette (Lux.). Christine Harbusch & Jacques Pir (eds.), 1999.

32 Les collections paléontologiques du Musée national d'histoire naturelle de Luxembourg. Fossiles du Trias et du Jurassique. Dominique Delsate, Chris Duffin & Robi Weis, 1999.

FERRANTIA (2002-)

33 Die Fledermäuse Luxemburgs (Mammalia: Chiroptera). Christine Harbusch, Edmée Engel, Jacques Pir, 2002.

34 The Protura of Luxembourg. Andrzej Szeptycki, Norbert Stomp, Wanda M. Weiner, 2003.

35 Liste rouge des bryophytes du Luxembourg. Jean Werner, 2003.

36 Paléontologie au Luxembourg. Simone Guérin-Franiatte (éd.), 2003.

37 Verbreitungsatlas der Amphibien des Großherzogtums Luxemburg. Roland Proess (éd.), 2003.

38 Trois études sur la Zone Rouge de Verdun. I. Herpétofaune. II. La diversité floristique. III. Les sites d'intérêt botanique et zoologique. Georges H. Parent, 2004.

39 Verbreitungsatlas der Heuschrecken des Großherzogtums Luxemburg. Roland Proess, 2004.

40 Les macrolichens de Belgique, du Luxembourg et du nord de la France - Clés de détermination. E. Sérusiaux, P. Diederich & J. Lambinon, 2004.

41 Die Fauna der Quellen und des hyporheischen Interstitials in Luxemburg unter besonderer Berücksichtigung der Milben (Acari), Muschelkrebse (Ostracoda) und Ruderfusskrebse (Copepoda). Reinhard Gerecke, Fabio Stoch, Claude Meisch, Isabel Schrankel, 2005.

42 Red List of the Vascular Plants of Luxembourg. Guy Colling, 2005.

43 Contribution à la climatologie du Luxembourg. Analyses historiques, scénarios futurs. Christian Ries (éd.), 2005.

44 Sandstone Landscapes in Europe - Past, Present and Future. Proceedings of the 2nd International Conference on Sandstone Landscapes. Vianden (Luxembourg) 25-28.05.2005. Christian Ries & Yves Krippel (eds.), 2005.

45 Additions et corrections au catalogue des plantes vasculaires de l'arrondissement de Montmédy. Etude sur l'évolution séculaire de la flore. Georges H. Parent, 2006.

46 Beiträge zur Paläontologie des Unterdevons Luxemburgs (1). Christian Franke (Hrsg.), 2006.

47 Verbreitungsatlas der Libellen des Großherzogtums Luxemburg. Roland Proess, 2006.

48 Les Hêtres tortillards, *Fagus sylvatica* L. var. *tortuosa* Pépin, de Lorraine, dans leur contexte européen. Georges H. Parent, 2006.

49 Inventaire minéralogique du Luxembourg - Stolzembourg, Schimpach, Goesdorf. Simon Philippo (éd.), 2007.

50 Inventaire de la biodiversité dans la forêt "Schnellert" (Commune de Berdorf) - Erfassung der Biodiversität im Waldgebiet "Schnellert" (Gemeinde Berdorf). Marc Meyer & Evelyne Carrières (éds.), 2007.

51 Proceedings of the first international Recorder conference. Luxembourg 2-3 December 2005. Tania Walisch (ed.), 2007.

52 Verbreitungsatlas der Reptilien des Großherzogtums Luxemburg. Roland Proess (éd.), 2007.

53 Les arbres introduits au Luxembourg. Inventaire des essences arborescentes non indigènes de pleineterre présentes sur le territoire du Grand-Duché de Luxembourg. Antoinette Welter, Jean Turk, Joé Trossen, 2008.

54 Fossils as Drugs: pharmaceutical palaeontology. Christopher J. Duffin, 2008.

55 Proceedings of the first conference on faunistics and zoogeography of European Trichoptera. Luxembourg 2nd - 4th September 2005. Marc Meyer & Peter Neu (eds.), 2008.

56 Colonial nesting in the Great Crested Grebe *Podiceps cristatus* (Linné 1758). Research results from a colony on the Dutch IJsselmeer in comparison to other studies on colonial nesting in the species. André Konter, 2008.

57 Die Waldgesellschaften Luxemburgs. Vegetation, Standort, Vorkommen und Gefähr-dung. Thomas Niemeyer, Christian Ries & Werner Härdtle, 2010.

58 Beiträge zur Paläontologie des Unterdevons Luxemburgs (2). Christian Franke (Hrsg.), 2010.

59 Proceedings of the 3rd international symposium Coleoid Cephalopods Through Time. Luxembourg 8th - 11th October 2008. Dirk Fuchs (editor), 2010.

60 Verbreitungsatlas der Zikaden Luxemburgs - Textband. Rolf Niedringhaus, Robert Biedermann, Herbert Nickel, 2010.

61 Verbreitungsatlas der Zikaden Luxemburgs - Atlasband. Rolf Niedringhaus, Robert Biedermann, Herbert Nickel, 2010.

62 Le Jurassique inférieur et moyen au Luxembourg - Nouvelles données paléontologiques et biostratigraphiques. Robert Weis & Simone Guérin-Franiatte (éds.), 2010

63 La Flore calcicole et basophile du Massif vosgien. Georges H. Parent, 2011.

64 Rearing of unionoid mussels (with special emphasis on the Freshwater Pearl Mussel Margaritifera margaritifera). Frank Thielen (editor), 2011.

65 Les bryophytes du Luxembourg - Liste annotée et atlas. The bryophytes of Luxembourg - Annotated list and atlas. Jean Werner, 2011.

66 Die Graslandgesellschaften Luxemburgs. Simone Schneider, 2011.

67 Comparative studies of behaviour in allo-patric subspecies of Grebes, Podicipedidae. Black-necked Grebe *Podiceps nigricollis* (Brehm 1831) and White-tufted Grebe *Rollandia rolland* (Quoy & Gaimard 1824). André Konter, 2012.

68 Beiträge zur Paläontologie des Unterdevons Luxemburgs (3). Christian Franke (Hrsg.), 2012.

69 Die Höhlenfauna Luxemburgs. Dieter Weber (Hrsg.), 2013.

70 Verbreitungsatlas der Weberknechte des Großherzogtums Luxemburg. Christoph Muster & Marc Meyer, 2014.

71 Le Jurassique au Luxembourg (1) - Vertébrés, échinodermes et céphalopodes du Bajocien. Roby Weis & Ben Thuy (éds.), 2015.

72 Aberrant plumages in grebes Podicipedidae - An analysis of albinism, leucism, brown and other aberrations in all grebe species worldwide. André Konter, 2015.

73 Beiträge zur Paläontologie des Unterdevons Luxemburgs (4). Christian Franke (Hrsg.), 2016.

74 Les sources de la région gréseuse du Luxembourg. Sociologie de la bryoflore et conservation. Jean Werner & Alexandra Arendt, 2016.

75 Verbreitungsatlas der Amphibien des Großherzogtums Luxembourg. Roland Proess (Hrsg.), 2016.

76 Die Rüsselkäferfauna (Coleoptera, Curculionoidea) der Silikatmagerrasen im nördlichen Luxemburg. Carlo Braunert, 2017.

77 Inventaire minéralogique du Luxembourg et de la region: Goesdorf et Beauraing. Simon Philippo (éditeur), 2018.

78 Verbreitungsatlas der Reptilien des Großherzogtums Luxemburgs. Roland Proess (Hrsg.), 2018.

79 Atlas of the Insects of the Grand-Duchy of Luxembourg: Coleoptera, Cerambycidae. Francesco Vitali, 2018.

80 Quelques associations de bryophytes sur rochers de grès acides et bois pourrissant au Luxembourg. Jean Werner, 2018.

81 Minéralogie de la commune de Visé (Argenteau, Richelle et Visé), Province de Liège, Belgique. Simon Philippo (éditeur), 2019.

82 Die Geschichte der Lappentaucher Podicipedidae in der Ornithologie: Namen, Abbildungen, systematische Stellung und wissenschaftliche Fortschritte. Einblicke in die Fortschritte in der Ornithologie am Beispiel der "Steißfüße" und der Entwicklung ihrer phylogenetischen Beziehungen. André Konter, 2020.

83 Paléontologie au Luxembourg (2) - Les ammonites de la Minette. Andrea Di Cencio, Driss Sadki, Robert Weis (eds.), 2020.

84 Atlas des fourmis luxembourgeoises (Hymenoptera, Formicidae). Philippe Wegnez, David Ignace, Cécile Morro, 2021.

85 Verbreitungsatlas der Wassermilben des Goßherzogtums Luxemburg. Reinhard Gerecke, Peter Martin, Claudio Walzberg, Tania Walisch, 2022.

86 Beobachtungen zur Entwicklung der Wasservogelwelt nach der Renaturierung der Sauer unterhalb von Steinheim. André Konter, 2022.

87 Atlas and catalogue of the mosquitoes (Diptera, Culicidae) of Luxembourg. Francis Schaffner, Alexander Weigand, Christian Ries, 2023.

88 La collection des Primates naturalisés du Musée national d'histoire naturelle de Luxembourg. Bernard L. Gatinot, 2023.

89 Les collections ornithologiques du Musée national d'histoire naturelle de Luxembourg. Claude Heidt, 2023.

90 Butterflies in Luxembourg: distribution, trends and conservation. X. Mestdagh, L. L'Hoste, N. Titeux (eds.), 2024.

INSTRUCTIONS TO AUTHORS

Please check our internet site http://www.mnhn.lu for the latest version of these instructions!

Scope

FERRANTIA is a series of monographic works (20-250 pages in final layout) dealing with life and earth sciences, preferably related in some way or other to the Grand-Duchy of Luxembourg.

It publishes original results of botanical, zoological, ecological, geological, mineralogical, paleontological, geophysical and astrophysical research and related fields.

A complete issue of FERRANTIA may be devoted to several papers on a single topic as the responsibility of an invited editor.

Copyright

By submitting their manuscript, authors accept that it will be published under the Creative Commons licence CC BY-NC-ND 3.0 LU (https://creativecommons.org/licenses/by-nc-nd/3.0/lu/). After being published, all volumes are freely available as pdf at the site https://www.mnhn.lu/ferrantia/.

The submission of a manuscript to FERRANTIA implies that the paper must not have been accepted for publication or be under consideration elsewhere.

Reviewing

Articles submitted for publication are reviewed by the editorial board and by one or two referees. The final decision on acceptance or rejection of the manuscript is taken by the editorial board. Manuscripts not prepared according to the following instructions to authors will be returned for correction prior to review.

Nomenclature

Papers with a systematic content should strictly follow the International Codes of Nomenclature.

Specimens

We recommend that the authors should deposit at least a part of the type material in the MNHN collections.

Publication dates

FERRANTIA pays special attention to publication dates, which are always specified to the day of publication.

Manuscripts

Manuscripts, without limitation of the number of pages, must conform strictly to the instructions to authors, and should be sent to the Editor:

Redaction FERRANTIA
25, rue Munster
L-2160 Luxembourg

Format

The main text is submitted as unformatted text document in A4 format with a font size of 10-12 pts, preferably double-spaced, with margins of at least 3 cm and all pages numbered. Tables and figures (300 dpi in the page size of the journal) are submitted as separate files (see Tables and figures). The captions and legends can be included at the end of the main text.

Structure

Manuscripts are to be written in simple, correct and concise English, French or German. Manuscripts in the Luxembourg language may be considered for review after consultation with the editors. The manuscripts should be organized as follows:

- a brief title (should not include the name of new taxa);
- a suggested running head (no more than 50 characters);
- name(s) and first name(s) of author(s), followed by their full address(es) and, if possible, e-mail or fax number;
- abstracts in English, French and German, each 200-800 words long; new taxa names should be included in the abstract; the abstract should be precise and descriptive, in order to be reproduced as such in data bases; avoid vague sentences such as "three new species are described" or "species are compared to species already known"; include precise differential characters;
- text of the article, in the following order: Introduction, Abbreviations used, Material and methods, Results and/or Observations, Discussion, Acknowledgements, References. The arrangement of the parts "Results/Observations" and "Discussion" may be modulated according to the length and subject of the article; very long papers may include a table of contents;
- for systematic descriptions, each description should follow the order: name of taxon with author and date, synonymy, type material, etymology, material examined, distribution, diagnosis and/or description, remarks.
- description of geological features should include type level, type horizon, type locality. This order may be adapted according to the concerned groups: consult a recent issue of FERRANTIA;
- taxon names must be stated with author (and publication date, separated by a comma, where appropriate) at

least once at the first mention. At subsequent mentions of the same taxon, or other taxa of the same genus, the genus name may be abbreviated (*Rosa canina* L. to *R. canina*).

- use n. sp., n. gen., n. fam., etc. for new taxa;
- use italicized words only for taxa of generic and sub-generic ranks;
- use lowercase characters for authority names
- references to illustrations and tables should be indicated as follows: (Fig. 1), (Fig. a, d), (Fig. 2a-d), (Figs 3; 6), (Figs 3-5; Tab. 2); (Tab. 1); for German texts use Abb. instead of Fig.
- footnotes should not be used.

Tables and figures

Copies of all figures and tables should be included with the manuscript. They can be either included in the text at the correct locations with their legends or referenced in the text and included as annexes.

For printing all figures must be provided as separate image files in a convenient format and resolution (TIF or JPEG for photographs, GIF, PNG or TIF for graphs and figures).

The editorial board will pay special attention to the quality and relevance of illustrations. Colored illustrations are accepted where appropriate and necessary.

Line drawings must be in Indian ink or high quality laser printouts; high contrast Fotographs are required,

Illustrations can be grouped into composite plates the elements of which are identified by letters (a, b, c...). Plates are not placed at the end of the article: they will be considered as figures and numbered as such. Arrange figures to fit in one (70 x 200 mm) or two columns (144 x 200 mm) or one half page (144 x 100 mm). Letters, numbers, etc., for each figure, are to be indicated on an accompanying overlay, not on the original figure. They will be inserted by the printer. A scale bar is required for each figure, when appropriate. No diagram or table is to exceed one page; longer tables should be divided.

References

In main text, references to authors, in lower case, should be presented without comma before year, as follows: Smith (2001), Smith (2001, 2002), (Smith 2001), Smith et al. (2003), (Smith 2001; Jones 2002), (Smith & Jones 2003, 2005), (Smith, Jones & Johnson 2003), (Smith et al. 2003), Smith (2001: 1; 2003: 5), Smith (2001: fig. 2).

References should be presented as follows, in alphabetical order. Do not abbreviate journal names:

Høeg J. T. & Lützen J. 1985. - Comparative morphology and phylogeny of the family Thompsoniidae (Cirripedia: Rhizocephala: Akentrogonida) with description of three new genera and seven new species. Zoologica Scripta 22: 363-386.

Marshall C. R. 1987. - Lungfish: phylogeny and parsimony, in Bernis W. E., Burggren W. W. & Kemp N. E. (eds), The Biology and Evolution of Lungfishes, Journal of Morphology 1: 151-152.

Röckel D., Korn W. & Kohn A. J. 1995. - Manual of the Living Conidae. Volume 1: Indo-Pacific Region. Christa Hemmen, Wiesbaden, 517 p.

Schwaner T. D. 1985. - Population structure of black tiger snakes, *Notechis ater niger*, on off-shore islands of South Australia: 35-46, in Grigg G., Shine R. & Ehmann H. (eds), Biology of Australasian Frogs and Reptiles. Surrey Beatty and Sons, Sydney.

Gerecke R., Stoch F., Meisch C. & Schrankel I. 2005. - Die Fauna der Quellen und des hyporheischen Interstitials in Luxemburg unter besonderer Berücksichtigung der Milben (Acari), Muschelkrebse (Ostracoda) und Ruderfusskrebse (Copepoda). Ferrantia 41, Musée national d'histoire naturelle, Luxembourg, 140 p.

Proofs and reprints

Proofs will be sent to the author (or the first author) for correction and must be returned within two weeks by priority air mail. Authors will receive twenty-five reprints free of charge; further reprints can be ordered at a charge indicated on a form supplied with the proofs.

Page layout of final publication

paper size	170 x 240 mm
page size	144 x 200 mm
nomber of columns	2
column width	70 mm
space between columns	4 mm
top margin	22 mm
bottom margin	18 mm
inside margin	15 mm
outside margin	11 mm

Fonts

Body text: Palatino linotype (serif), 9pt

Titles, legends, headers, footers: Trebuchet (sans-serif)

Ferrantia

Travaux scientifiques
du Musée national
d'histoire naturelle
Luxembourg

www.mnhn.lu

90 2024