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FONDATION POUR LA RECHERCHE SUR LA BIODIVERSITÉ

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CENTRE FOR THE SYNTHESIS AND ANALYSIS OF BIODIVERSITY

Project summary

LOLA BMS

How local-scale processes build up the large-scale response of butterflies to global changes: Integrative analysis across monitoring schemes

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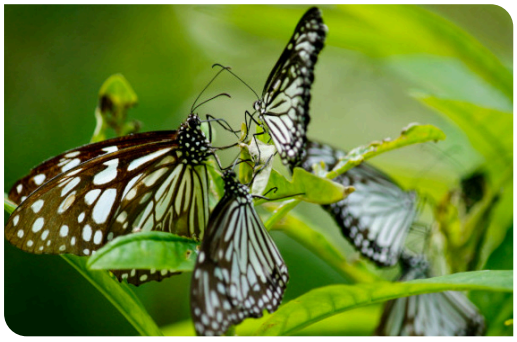

Long-term, standardized monitoring programs are key to assessing the state of biodiversity. They enable the impacts of environmental change on population abundance to be quantified and provide evidence of the status of species and ecosystems against policy targets.

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Context and objectives

Monitoring butterflies is one of the earliest examples of citizen science and most programs are based on the protocol developed for the original Butterfly Monitoring Schemes (BMS) in the UK. Today, standardized monitoring programs are taking place in more than 22 countries across Europe and many more around the world. Until recently, most of these data were essentially used to provide calculation for national trends and some parallel studies conducted at larger scales, but till now, little has been known about how these local changes affect regional patterns, and how they are organized across scales and along broad gradients.

In the LOLA-BMS project, by promoting productive collaborations and triggering the development of innovative approaches, a team of 15 experts including ecologists, statisticians and modellers, leveraged information contained in these unique data sets. Our aim was twofold, first to assess butterfly responses to global climate change and examine how local processes translate into large patterns, and second to build an infrastructure to facilitate collaboration and exchange between monitoring schemes. The latter will enable new questions to be addressed beyond the limits of established borders and improve capacity that will benefit both established and developing schemes.

Methods and approaches used for the project

We first adapted a recently developed two-stage modelling approach to account for seasonal patterns in butterfly count data by using data across a range of BMS. By this means we have been able to compute standardized abundance indices and perform rigorous trend analysis at multiple scales. These locally calculated trends were then analysed to examine patterns in species response to change in climate, land use, agricultural intensity and to assess some early outcomes of conservation efforts. The impact of these drivers on species trends was analysed along a broad latitudinal gradient from Spain to Finland.

Principal conclusions

The improved and standardized method for calculating annual abundance index is capable of producing significantly less biased and more accurate estimates of butterfly abundance than that achieved by other methods. The method is particularly powerful when used with combined data sets, and most beneficial for sites where information is relatively limited.

Our analyses show that a substantial number of butterfly species have expanded their distribution range northward. When assessing the effect of climate change on local populations, we found significant difference among species' response, including some evidence of local adaptation in species response to aridity. Overall, species thriving in regions with low aridity are more sensitive to annual drought events than species found in regions with a greater level of aridity, which, in Europe, are the warmer regions.

When considered together, however, the effect of land use change on butterfly population exceeded the effect of climate change. The impact of habitat loss was most detrimental to species associated with non-forested habitats. While the overall impact of the Natura 2000 designation, one of the most important efforts to protect biodiversity across Europe, is positive for a large proportion of butterfly species, a significant proportion of species thriving in open habitats (semi-natural grasslands perhaps with up to 30% tree cover) had lower abundance in well-protected regions under the Natura 2000 designation. This pattern contrasts

with that observed for woodland species which are considerably more likely to be positively affected by Natura 2000 designation.

Anticipated (or actual) impact of these results for science, society, and public and private decision making

Global climate change is affecting the distribution and abundance of butterflies across Europe, with many species showing a northward shift in their distribution. Overlaying this result is the significant local and regional decline in many species as a result of land use and habitat change due to human activity. Species associated with non-forested areas (*e.g.* grasslands) show the most significant decline. Although the effect of climate is less strong than the effect of habitat loss, evidence of the effect of climate change is still clear as populations found at the warmer edge of their climatic niche have greater decline then those found in relatively cooler regions.

The effect of climate change on species distribution and phenology (timing of life events) has considerable significance for local species assemblages with potentially striking effect on crucial processes (*e.g.* species interactions). This affects the contribution of the species to ecosystem function and services.

Biodiversity protection across Europe relies on the extensive network of sites under the Natura 2000 designation, and while our results show evidence that there is an overall positive effect on butterfly and bird species of these protected areas, the positive impact of the Natura 2000 designation on butterflies' abundance is biased toward species associated with forested habitats. This highlights the importance of establishing management plans that will meet the full range of habitat requirements of butterfly species. This project clearly shows the importance of monitoring biodiversity to measure and assess its change in space and over time. Such understanding is particularly important, considering the continuing changes we will be facing over the next decades.

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