Exploring the impact of temperature on butterfly abundance and diversity (Lepidoptera: Rhopalocera) across selected localities in Serbia

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Introduction

Climate change, particularly global warming, has been identified as a significant driver of the observed declines in insect pollinator populations. Gaining insight into how animals, especially ectotherms, respond to thermal variation is critical for projecting the ecological consequences of climate change on biodiversity. Butterflies, like many other insects, depend on behavioral thermoregulation to maintain optimal body temperatures and interspecific variability in thermal sensitivity renders some species more susceptible to climate-induced stress. Pollinators deliver essential ecosystem services, particularly in the maintenance of both agricultural productivity and ecological function. In response to declining pollinator populations, numerous policy frameworks and research initiatives have been implemented to evaluate the underlying causes and ecological repercussions of this trend on a global scale. This decline is particularly concerning given that approximately 75% of global food crop species and the reproductive success of most wild plant communities are dependent on pollination services (Ollerton et al., 2011; Meinzen et al., 2024).

Material & Methods

The study was conducted at 33 localities in the Republic of Serbia (Figure 1). In total, 105 butterfly species (Lepidoptera: Rhopalocera) were registered during three seasons (spring, summer and autumn) in the year 2022. In order to examine the relationship between the independent environmental and landscape variables (cloudiness; sunshine; temperature; wind; management type –grazing, mowing and beehives; green cover; total flower cover; grass buffer; agricultural buffer) and the dependent variables (abundance and species composition of diurnal butterflies), multivariate analysis of the data set was applied using the Canoco 5 software package (Lepš & Šmilauer, 2003). To evaluate the effect, we used generalized linear models and canonical correspondence analyses (CCA). To identify the most significant independent variables influencing species composition and the abundance of butterflies, the “forward selection” model selection method was conducted. Furthermore, Van Dobben circles (t- value biplots) were used to assess the significance of specific species preference for temperature.

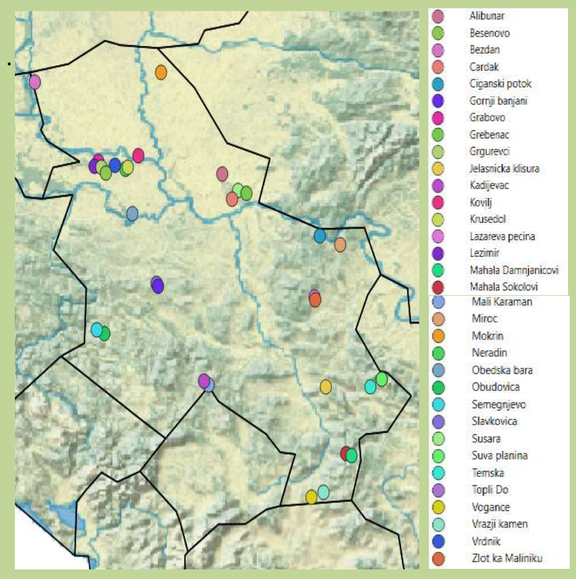

Fig 1. Map of selected localities in Serbia

Results & Discussion

The results of CCA analysis showed the effect of selected environmental and landscape variables on the abundance and species composition of selected butterfly species (Figure 2). Forward selection showed a high dependence of the examined species on green cover and temperature (Table 1). Butterfly species which demonstrated preferences for lower values of temperature compared to other species were as follows: *Erebia medusa* (IUCN- LC), *Melitaea arduinna, Melitaea trivia, Brenthis ino, Callophrys rubi* and *Pseudophilotes vicrama* (Figure 3).
Brenthis ino and Pseudophilotes vicrama (IUCN- NT) are listed as strictly protected in the Republic of Serbia (Službeni glasnik RS, br. 47/2011). Given the results, species with preferences for lower temperatures may experience population decline in the future.

Table 1. Contribution of most important variables to explain species data.

Variable	%	F- statistic	P- value
Green cover (GC)	13.8	2.2	0.002
Temperature (Temp)	13.8	2.3	0.002
Grazing	10.0	1.7	0.002
Grassland buffer (GrasBuff)	9.0	1.5	0.012
Agricultural Buffer (AgrBuffr)	8.9	1.5	0.01

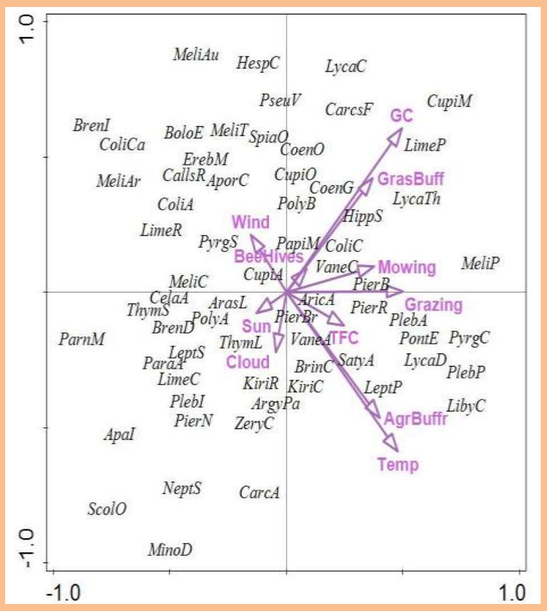

Figure 2. CCA biplot diagram for species and environmental/landscape variables. The full number of species is not displayed on the graph to maintain visibility.

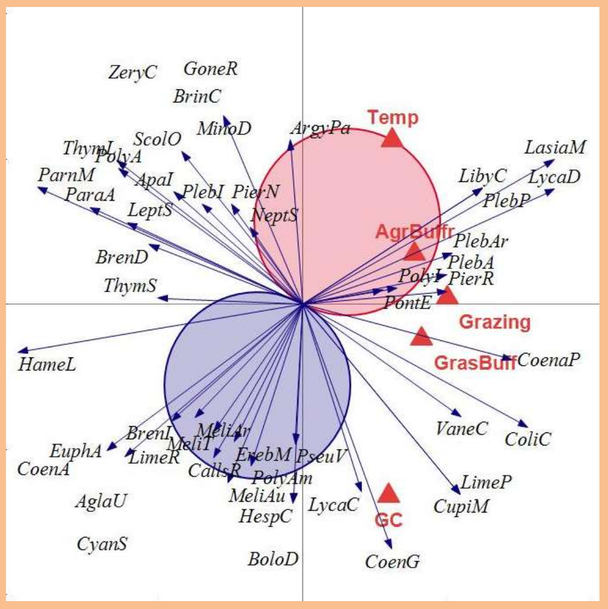

Figure 3. t-value biplot of temperature

WHAT NEXT?

Ongoing climate change and anthropogenic pressures are driving declines in butterfly abundance and diversity. To inform conservation strategies, the establishment of **long-term**, **standardized monitoring programs** is essential for detecting population trends and assessing species-specific vulnerabilities. Additionally, **enhancing public awareness** of the ecological importance of butterflies and their threatened status is critical for fostering support for conservation initiatives.

References

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