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UPDATES ON *Lycaena helle* IN ALPINE HABITATS: NEW DATA FROM ROMANIA AND A REVIEW OF MANAGEMENT PRACTICES

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Abstract

Until recently, viable populations of Lycaena helle (violet copper butterfly) from Romania were known from low-altitude areas (below 600 m asl). However, this glacial relict faces heavy threats across its Eurosiberian range, with declines in abundance, distribution and habitat quality frequently reported. Many populations have disappeared, especially from the lowland regions, with the currently known populations being found mainly at higher altitudes. Recent national peatland restoration projects in Romania have led to faunal discoveries, including new populations of L. helle in the alpine bioregion. This current study provides new and original information on population size estimates from Dornelor Depression, describes other areas inhabited by this protected species in Suceava County, and reexamines older museum specimens. Given the limited knowledge about the ecological requirements of high-altitude L. helle populations, we review global conservation practices. Evidence indicates that maintaining meadows at mid-successional stage is essential for supporting this butterfly. Therefore, management should focus on balancing rotational mowing or moderate intensity grazing to maintain heterogeneous vegetation while preventing woody encroachment due to abandonment. These practices ensure appropriate coverage for the larval host plant, Bistorta officinalis.

Key words*: conservation management, extinction threats, protected species, rotational grazing, translocation.*

INTRODUCTION

Invertebrates are a significant part of our world and are essential for maintaining ecosystem functioning. Numerous studies have raised concerns regarding the decline and extinction of terrestrial invertebrates, particularly butterflies, on both local and global scales (Eisenhauer et al., 2019; Warren et al., 2021). As one of the main pollinator groups with a substantial economic role, butterfly populations are decreasing sharply, in some documented cases by as much as 90%. These declines are driven by habitat destruction, climate change, and anthropogenic activities (Harris et al., 2024). Agricultural development leads to the loss of mosaic habitat elements, such as hedges and ditches, along with increased pesticide use, contributing to the decline of many sensitive invertebrate species (Mancini et al., 2023).

For example, the butterfly *Lycaena helle* (Denis & Schiffermüller, 1775), a glacial relict, is significantly impacted by these alterations. On the other hand, abandoning sites once used for farming or animal grazing can also negatively impact this species, especially when vegetation succession progresses beyond mid-successional stages (Habel et al., 2014). At the European level, *L. helle* is legally protected under the Council Directive 92/43/EEC (1992), being included in Annexes II and IV of the Habitats Directive, and is classified as Endangered (EN) according to the Red Data Book of European Butterflies (Van Swaay et al., 2010).

The distribution of the Violet Copper (*L. helle*) extends from Western Europe, including Central and Northern Scandinavia, across Siberia and Mongolia, to North-Eastern China and Northern Korea (Tolman & Lewington, 2008; Habel et al., 2014). Although new populations continue to be identified, particularly in the southern parts of its range, such as the Balkan Peninsula (Popović et al., 2014; Kolev & Shtinkov, 2015) and Turkey (Çalışkan & Hasbenli, 2022), these populations are often isolated, fragmented or facing significant threats. Furthermore, natural populations have been declared extinct in several European countries, including the Czech Republic, Hungary, Italy, Latvia, and Slovakia (Van Swaay et al., 2010).

L. helle can be found up to 2000 m a.s.l. in Europe (Tolman & Lewington, 2008). It inhabits peatlands, including *Sphagnum* bogs, wet meadows, and swampy fallow lands. Its populations are found in forest edges, riverbanks, and clearings and are associated with habitats rich in *Bistorta officinalis* Delarbre, the larval host plant (Székely, 2008; Rákosy, 2013).

Restoring degraded peatlands has become a priority, as these ecosystems act as vital carbon sinks (Nordbeck & Hogl, 2024) and balance the local climate. Extensive drainage for agricultural purposes has led to a significant loss of peatland ecosystem services and biodiversity (Fraixedas et al., 2017; Koivunen et al., 2023). In response, several restoration projects have been initiated in Romania since 2015. These projects, including fauna monitoring studies, revealed in 2022 the first known population of *L. helle* in Romania's Alpine bioregion (Ion et al., 2023).

Here, we aimed to conduct a preliminary assessment of the population size at this newly identified site. We also successfully extended our searches for the species in other high-altitude peatlands and continued checking the specimens in museum collections. Additionally, we discuss potential management methods to ensure the long-term conservation of these sensitive butterfly populations.

MATERIALS AND METHODS

Between 2022 and 2024, the Institute of Biology Bucharest, part of the Romanian Academy, led two initiatives focused on restoring and conserving peatland ecosystems in Romania through the PeatRO initiative, funded by EEA Grants. These included the "Degraded Mires and Peatlands Restoration of North-East 1 Region of Romania" (PeatRO2) and "Degraded Mires and Peatlands Restoration of North-East 2 Region of Romania" (PeatRO3). A preliminary evaluation of the peatlands' conservation status before restoration was conducted for each site, assessing, among other factors, vegetation and indicator or specialized species from various taxonomic groups. The restoration efforts targeted several peatlands in Suceava and Maramureș counties, with two sites standing out due to their significant lepidopteran fauna.

Coșna study area, Suceava county

The peat bog near the secondary school in Coșna (Suceava) is where the new alpine population of violet coppers (*L. helle*) was first discovered (Ion et al., 2023) in May 2022 (47°22'22.2" N 25°10'27.4" E, 959 m. a.s.l.). The wet, peaty soil extends over 21 ha and is located in the Dorna Depression. Ion et al. (2023) provided a detailed description of the vegetation and habitat, highlighting the wet meadows dominated by *B. officinalis*, marshy areas with scattered trees, drainage channels with hygrophilous species, and bog woodlands with *Pinus sylvestris* L. and *Sphagnum* moss. These areas are, however, surrounded by elements of the rural settlement.

On May 18th 2023, a populational study of *L. helle* was performed using direct observation through the transect count method. The transects typically ranged from 50 to 200 m in length and 5 m in width, with altitudes varying between 860 and 880 m (Van Swaay et al., 2012). In all, 13 transects were analysed by five invertebrate experts across an area of three hectares (Figure 1). The transects were grouped as follows: five located behind the Coșna school, five on a wet meadow near the wooden footpath, and three along the forest edges. The range between transects was 5 m. All experts began the observations simultaneously to avoid overlapping results. Butterflies were recorded, photographed, and GPS coordinates of transect start points were noted. The observations took place from 15.00 and 17.00 p.m., alongside recordings of air temperature, wind speed

(Beaufort scale), and cloud cover (Rákosy, 2013).

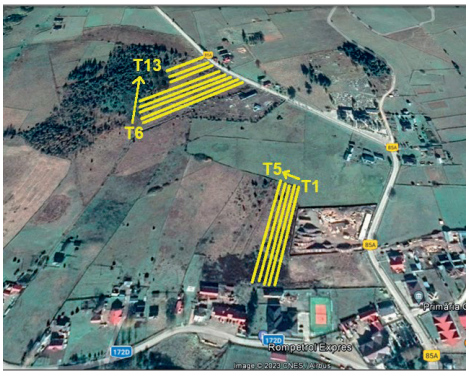

Figure 1. Investigated transects (yellow lines) for species *Lycaena helle* from Coşna, Suceava County, May 2023 (source: original map generated in ArcGIS 10.7.1. (ESRI, Redlands) with freely available basemap layers)

Găina - Lucina study area

Four degraded bog woodlands from Moldova-Sulita, Suceava County (47°39'21.7" N 25°10'37.0" E, 1050-1380 m a.s.l.), were restored under the PeatRO2 project. During each visit aimed at restoration activities, the team also conducted invertebrate fauna surveys using direct visual observation along transects, without capture, focusing on various invertebrate groups. Starting with 2023, following the discovery of the alpine population of *L. helle* in the Dornelor Depression, special attention was given to butterfly fauna, particularly Lycaenidae species.

The bogs are part of the Natura 2000 site Găina–Lucina (ROSCI0086), with one of them, "Tinovul Găina-Lucina", designated as a nature reserve for the protection of flora and vegetation. Other researchers, in addition to the project team, have visited the area for entomological observations between 1993 and 2024. However, before 2023, surveys were conducted only in the second half of the summer. Noteworthy lepidopterological observations were made by the team led by Constantin Corduneanu and through individual visits by Mihai Stanescu and Cosmin Manci.

Between June 2023 and July 2024, C. Corduneanu and his team conducted a butterfly count in the protected site ROSCI0086 Găina - Lucina, Suceava County, using the "15-minute butterfly" count method. The participants spent 15 minutes in nature using a phone application (Sevilleja et al., 2019) (https://butterfly-monitoring.net/ebms-app). This method requires favourable weather conditions and is designed for mass-participation in citizen science projects, requiring no prior training. Such simplified sampling protocols are particularly suitable for public engagement of non-experts and educational initiatives (Butler et al., 2024). Moreover, scientific literature suggests that species population trends estimated using butterfly count data are comparable to those obtained through standardized monitoring protocols (Dennis et al., 2017).

In 2023, 10 area counts took place on different days between June and August, while in 2024, 13 area counts were carried out in May, June, and July. Each survey covered a 500 m² observation area.

At Găina - Lucina an aerial survey, using a DJI Mini 2 drone was employed to assess the habitat distribution and to identify areas with high coverage of the *B. officinalis,* the host plant of the violet cooper, in order to guide searches. Botanical surveys were carried out in parallel with these methods, with experts identifying plant species *in situ*, assessing their proportions within the floristic structure and composition, and evaluating the site's conservation value. Vegetation surveys were conducted using relevés following the Braun-Blanquet (1964) approach, allowing for a detailed assessment of species cover and abundance, as well as the identification of the plant association and habitat type, which guided the conservation assessment. Itinerary investigations were carried out several times over the vegetation season to reflect changes in composition. Plant taxonomy follows the nomenclature established by Flora Europaea, which is available at Euro+Med PlantBase (Euro+Med, 2006).

The phytosociological nomenclature follows the synthesis works on the vegetation of Romania (Coldea, 1997; Sanda et al., 2008; Doniță et al., 2005). We identified *Sphagnum* specimens in the laboratory using light microscopy. The identification keys used for *Sphagnum* were by Plămadă (1998) and Laine et al. (2018). For bryophytes nomenclature we used Hodgetts et al. (2020).

The map illustrating the approximate distribution of *L. helle* populations within the restored peatlands was generated using the collected data in ArcGIS 10.7.1. To ensure species protection, precise coordinates are not provided for sensitive areas like the counts area at Găina - Lucina.

Museum data

The butterfly collection of the Natural Sciences Department within the Museum of Dacian and Roman Civilization Deva was revised, and the specimens of interest (catalogue number 8870) were photographed by one of the authors.

RESULTS AND DISCUSSIONS

New information on the distribution and preliminary estimates of the population status of the endangered butterfly *L. helle* in Romania were reported, along with the characteristics of its highland habitats, where its populations have been discovered

Field data

Coșna population

Considering the meteorological aspects, the air temperature fluctuated between 20 and 22ºC on the day of our observations. The cloud coverage was 10%, and the wind speed was 3 degrees on Beaufort scale (12-19 km/h). In all the investigated transects, the adults of *L. helle* were on wing, predominantly feeding on *Cardamine pratensis* L. but also *Viola* sp., *Ranunculus acris* L., *Ranunculus repens* L.. We frequently observed them close to one another, indicating a high activity level in the area (Figure 2). After counting all observations from 13 transects, 71 specimens of *L. helle* were recorded (26 females, 14 males, and 31 unknown) in an area of 3 ha (Table 1), roughly corresponding to 23 individuals/ha. A small comparison between the three types of microhabitats (the meadow near the school, the one near the wooden footpath, and at the forest edge), points to the highest number of individuals in the area located in the proximity of the wooden path, possibly do the high density of *B. officinalis* and to the lower impact of human presence. However, it is worth investigating whether this artificial element provides any direct advantage, such as resting sites or wind shelters similar to shrubs (Habel et al., 2014), as we found no reference to this in the literature.

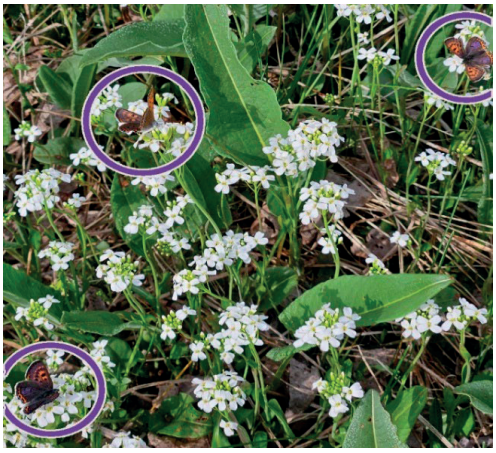

Figure 2. Several adults of *Lycaena helle* feeding on *Cardamine pratensis* before the flowering time of the host plant, *Bistorta officinalis* (source: original; photo by Helepciuc F.E., 18.05.2023)

Table 1. Population data of species *Lycaena helle* from Coșna locality, Suceava County, May 2023 (♀= female, ♂= male; N/A- unidentified)

Transect number	Geographical coordinates	No. of individuals	Sex ratio
1	N:47022'12.52" E:25010'41.10"	3	2♀:1♂
2	N:47022'12.53 E:25010'39.99"	3	1♀:2♂
3	N:47022'12.73" E:25010'38.79"	6	5♀:1♂
4	N:47022'13.00" E:25010'38.04"	5	1♀:4 ♂
5	N:47022'13.30" E:25010'37.20"	7	4♀:2♂
6	N:47022'23.70" E:25010'34.02"	9	5♀:4♂
7	N:47022'23.76" E:25010'33.55"	4	3♀:1♂
8	N:47022'23.80" E:25010'33.12"	14	N/A
9	N:47022'23.87" E:25010'32.88"	4	N/A
10	N:47022'23.87" E:25010'32.61"	2	2♀
11	N:47022'25.08" E:25010'32.50"	5	N/A
12	N:47022'25.37" E:25010'32.26"	2	N/A
13	N:47022'26.61" E:25010'31.74"	7	3♀:4♂
TOTAL numerical abundance on 3 hectares = 71 individuals 26♀:14♂ (40N/A)			

The most comprehensive population study of *L. helle* in Romania was conducted by Craioveanu et al. (2014) during 2011-2012 in the Lăpușel locality, Maramureș County. According to their findings, approximately 14,000 individuals from both generations were identified within an area of 64 ha. The authors concluded this population is viable, albeit due to forest management practices. Calculating the density translates to 219 individuals per ha in Lăpușel. In comparison, data from Coșna show 23 individuals per hectare, suggesting that *the L. helle* population in this area may be less viable. However, our survey of this population was conducted only in May, and unlike Craioveanu et al. (2014), which employed mark-recapture methods, we used a different approach, as such studies require a derogation from the protection rules of the Habitats Directive, Council Directive 92/43/EEC (1992). Nonetheless, the observed sex ratio in the field, with a dominance of females, indicates population resilience, as even small numbers of females have been shown to establish and sustain extensive colonies (Descimon & Bachelard, 2014).

Găina - Lucina population

The area encompasses various habitats, resembling those at Coșna, but covers a significantly larger area and includes multiple bog woodlands. Within this landscape, we documented a new alpine population of *L. helle* (Figure 3), inhabiting meadows with extensive patches dominated by *B. officinalis*, extending into the swamp forest's peripheral zones. This marks the second confirmed population of violet copper found through the PeatRO peatland restoration projects, located at an even higher altitude. In the same year, the team led by C. Corduneanu also documented the species. Unlike Coșna (Suceava), this area is predominantly surrounded by forests (Figure 4), with only a guesthouse, a horse farm, and a few buildings nearby.

The monitoring efforts in ROSCI0086 Găina - Lucina included a total of 23 area counts, with 10 conducted in 2023 and 13 in 2024. The recorded observations varied from no individuals of *L. helle* to a maximum of 10 per count. Since each count occurred on different days and covered various areas of 500m² within the site, we estimated the population density per ha by extrapolating the data (Table 2).

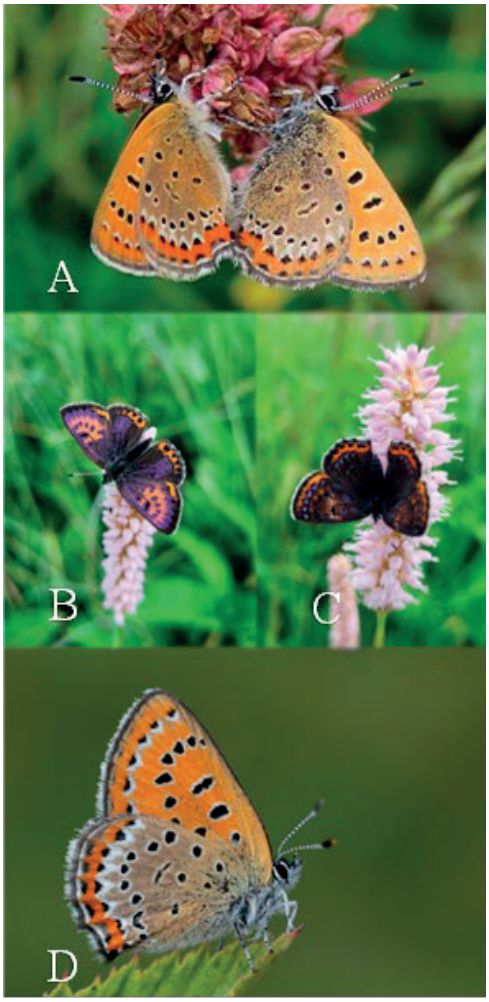

Figure 3. *Lycaena helle* at Găina - Lucina (source: original): A - Mating pair (photo by Corduneanu C., 24.06.2024); B - Male and C - Female, on host plant *Bistorta officinalis*, upper side views (photos by Bîrsan C.C., 22.06.2023); D - Male under side view of the wings (photo by Manci C., 09.06.2024)

In 2023, the population density of *L. helle* ranged between 40 and 200 individuals per ha, indicating the presence of well-established local populations in suitable habitat patches. In 2024, the estimated densities declined slightly, ranging from 20 to 120 individuals per ha. This decrease may indicate either natural population fluctuations or environmental factors affecting the observation of species abundance.

Table 2. Number of individuals for *Lycaena helle*, counted with the "15 minutes butterfly count" method, at Găina - Lucina, Suceava County, 2023-2024

Area count no.	Data	Altitude (m)	No. of individuals
1	10.06.2023	1160	10
2	22.06.2023	1160	4
3	30.06.2023	1160	5
4	01.07.2023	1170	2
5	01.07.2023	1160	4
6	08.07.2023	1160	2
7	16.07.2023	1160	2
8	17.07.2023	1200	
9	17.07.2023	1170	
10	03.08.2023	1160	
11	19.05.2024	1160	6
12	21.06.2024	1160	
13	22.06.2024	1160	5
14	22.06.2024	1580	
15	23.06.2024	1160	3
16	23.06.2024	1300-1350	
17	23.06.2024	1170	2
18	23.06.2024	1170	
19	23.06.2024	1155	
20	24.06.2024	1160	2
21	12.07.2024	1160	1
22	13.07.2024	1200	
23	13.07.2024	1160	

Assessment of the habitat area supporting the violet copper (Figure 4) exceeds 300 ha, with meadows actually occupied by individuals - estimated to cover approximately 10% of this area. Using an average density of 110 individuals per hectare, we calculated a total of roughly 3,700 individuals. It is worth noting that during a visit in June 2024, Manci C. discovered a *B. officinalis* patch with a high density of butterflies (approximately 250 individuals/ha). The weather conditions were, however, unusual, characterized by a warm, overcast atmosphere and considerable wind. The butterflies appeared restless. This population seems to be of similar size and structure to the one at lower altitudes in Lăpușel (Craioveanu et al., 2014). However, like the Coșna population (Ion et al., 2023), there are notable differences compared to lowland populations. The individuals are often seen flying over open semi-natural habitats, meadows, and towards the bog woodland, but seldom within the forest.

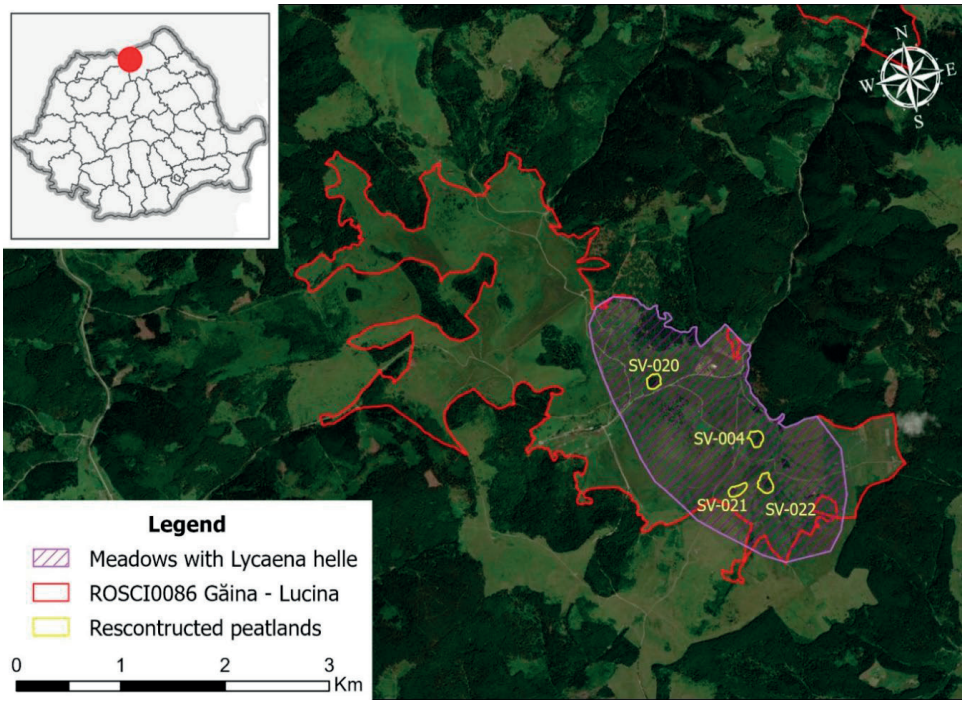

Figure 4. Boundaries of the habitat hosting *Lycaena helle* (purple) in the protected site ROSCI0086 Găina - Lucina area (red). The restored peatlands are marked in yellow: SV-004 – Tinovul Găina - Lucina, SV-020 – Tinovul de lângă drum – Lucina, SV-021 – Tinovul Vestic Lucina, and SV-022 – Tinovul Estic Lucina. (source: original map generated in ArcGIS 10.7.1. (ESRI, Redlands) with freely available basemap layers).

Based on the presence/absence of the species during all site visits, the adults appears to be active from mid-May to end of July. After August 1st, only a few individuals with worn wings were recorded by C. Manci and C. Corduneanu, while M. Stănescu and the PeatRO team found none. This suggests that the species likely follows a single, prolonged generation in this area, though further studies are needed to confirm this finding. If confirmed, the phenology of this alpine population differs from the bivoltine lowland populations in Romania (Craioveanu et al., 2014) and is more similar to other univoltine populations in Central Europe (Tolman & Lewington, 2008).

Alongside *L. helle*, other rare butterfly species were recorded within the same area or further north and west, including several species protected at European or national level (Directive 92/43/EEC/ Law 49/2011): *Lycaena. dispar* Haworth, 1803 (Annex 3 and 4A), *Parnassius mnemosyne* (Linnaeus, 1758) (Annex 4A), and *Phengaris arion* (Linnaeus, 1758) (Annex 4A). Other notable species are *Eumedonia eumedon* (Esper, 1780), *Lycaena hippothoe* (Linnaeus, 1761), *Coenonympha tullia* (Müller, 1764) and *Plusia putnami* Grote, 1873. Furthermore, we identified the presence of *Boloria eunomia* (Esper, 1799) (Figure 5), previously not recorded from Romania (Corduneanu et al., 2025; Rákosy, 2024). The observed density of this species in the Lucina study area reached up to 100 individuals/ha. *B. eunomia* is also a bog specialist and a relict species, with larvae feeding on *B. officinalis*, as well as some *Viola* and *Vaccinium* species (Tolman & Lewington, 2008; Klimczuk & Sielezniew, 2020). Both *B. eunomia* and *L. helle* are considered 'ecological siblings' and are often found together (Descimon & Bachelard, 2014; Kolev & Shtinkov, 2015). However, they differ in their nectar sources - although *B. officinalis* is primary - and their overwintering strategies (Goffart et al., 2010).

The mosaic of habitats within the studied area is characterized by mesophilic meadows, wet meadows, and marshes with eutrophic ecology that alternate with the bog woodland on peaty soil (Figure 6).

Most mesophilic grasslands are fenced, ungrazed, and used for mowing. They grow on slightly sloping land with a moderate humidity regime belonging to *Festuco rubrae-Agrostietum capillaris* Horvat 1951 phytocenoses (Figure 7).

With a coverage between 80-95%, the herbaceous layer, although edified by *Festuca rubra* L. and *Agrostis capillaris* L., is dominated by *B. officinalis*, especially during the flowering time. In the floristic composition can be found: *Arnica montana* L., *Campanula patula* L., *Phyteuma tetramerum* Schur, *P. vagneri* A.Kern., *Hypochaeris uniflora* Vill., *Trifolium montanum* L, *T. pratense* L., *Rumex acetosa* L., *Ranunculus acris, Succisa pratensis* Moench, *Pilosella aurantiaca* (L.) F. W. Schultz & Sch. Bip., *Viola tricolor* L., *Scorzonera rosea* Waldst. & Kit., *Rhinanthus angustifolius* C. C. Gmel, etc.

Figure 5. *Boloria eunomia* at Găina - Lucina on larval host plant *Bistorta officinalis* (source: original; photo by Manci C., 08.06.2024)

Figure 6. Aerial view of diverse habitats at ROSCI0086 Găina - Lucina site (source: original; photo by Bîrsan C-C., 25.06.2023)

Although the host plant *B. officinalis* is distributed in uneven size patches, it can be observed, during the flowering period, how it

connects those mosaic habitats very well by its ability to overcome the ecological barriers and penetrate the marginal area of the oligotrophic swamp forest (Figure 7). Such conditions are highly beneficial for *L. helle*, ensuring suitable sites for egg-laying and feeding, providing shelter during windy and rainy weather, and serving as vantage points for males.

Figure 7 Mesophilic meadows dominated by *Bistorta officinalis*, extending into the lagg zone of the bog woodland, providing favorable conditions for *L. helle* (source: original; photo by Bîrsan C-C., 22.06.2023)

Everywhere where the land becomes flat, with a high humidity regime, are present species that belong to hygrophilous phytocoenoses of *Scheuchzerio - Caricetea fuscae* R. Tx. 1937 and *Molinio - Arrhenatheretea* R. Tx. 1937: *Caltha palustris* L., *Dactylorhiza maculata* (L.) Soó, *Potentilla erecta* (L.) Raeusch., *Viola palustris* L., *Ranunculus repens*, *Parnassia palustris* L., *Myosotis scorpioides* L., *Lysimachia nummularia* L. etc. in the lower herbaceous layer and *Deschampsia cespitosa* (L.) P. Beauv., *Equisetum sylvaticum* L., *Festuca pratensis* Huds., *Filipendula ulmaria* (L.) Maxim., *Geum rivale* L., *Juncus effusus* L., *Ligularia sibirica* (L.) Cass., *Lysimachia vulgaris* L., *Trollius europaeus* L., *Valeriana dioica* subsp. s*implicifolia* (Rchb.) Nyman, etc. in the upper herbaceous layer. The habitat transitions gradually into the wet eutrophic meadows dominated by *Carex* species from the lagg area of bog woodland. Scattered bushes of *Alnus incana* (L.) Moench, *Salix aurita* L., *S. cinerea* L., *S. pentandra* L., *S. caprea* L. are growing in this marshy land.

The bog woodland vegetation, assigned to *Sphagno-Picetum* (Tüxen 1937) Hartman 1953 association, has a relatively poor floristic composition due to the restrictive conditions offered by the oligotrophic swamp (Figure 8).

Figure 8. The bog woodland vegetation providing shelter during windy and rainy weather for several butterfly species (source: original; photo by Buta L., 25.07.2022)

In the structure of the plant community, four distinct layers can be identified, respectively: the arborescent layer, which is dominanted by the species *Pinus sylvestris* L. and *Picea abies* (L.) H. Karst. with rare individuals of *Betula pendula* Roth; together achieve a coverage of 50-90%; the shrub layer includes the juveniles of *Pinus sylvestris*, *Picea abies* with *Betula pendula* and small bushes of *Betula nana* L., the latter being found exclusively in the Tinovul Găina Lucina area (Figure 9); *Eriophorum vaginatum* L. dominates the layer of grasses and small shrubs alongside *Vaccinium myrtillus* L., *V. vitis-idaea* L., *V. oxycoccos* L., *V. microcarpum* (Rupr.) Schmalh. and achieve large coverages, up to 75%, where the tree layer is less developed. The moss, which is an essential component of the peat bog ecosystem, is well-developed and dominated by *Sphagnum* species (with the genus *Sphagnum* being protected under the European Habitats Directive, Council Directive 92/43/EEC (1992)) in various peat bogs from the studied area (Figure 9).

Figure 9. *Sphagnum* moss hummocks with *Betula nana* bushes (Tinovul Găina - Lucina) (source: original; photo by Bîrsan C-C., 22.06.2023)

In "Tinovul de lângă drum", the species identified include *Sphagnum angustifolium* (Russow) C.E.O. Jensen, *Sphagnum divinum* Flatberg & K. Hassel, *S. girgensohnii* Russow, *S. medium* Limpr., and *S. russowii* Warnst. In "Tinovul Găina Lucina", *S. angustifolium*, *S. capillifolium* (Ehrh.) Hedw., *S. divinum*, *S. quinquefarium* (Braithw.) Warnst., and *S. rubellum* Wilson dominate. Meanwhile, in "Tinovul Vestic Lucina", *S. fuscum* (Schimp.) H. Klinggr. and *S. warnstorfii* Russow are present. These bryological findings contribute particularly to clarifying the distribution of *S. divinum* and *S. medium*, which have been historically confused with *Sphagnum magellanicum Brid.* due to taxonomic complexities (Tomović et al., 2024a, 2024b).

Museum data

The revision of the specimens from Deva Museum proved the correct identification of *L. helle* from Vadu Dobri, Hunedoara County (Figure 10). This finding suggests another population still could exist in the western part of Hunedoara County. However, the exact location of these populations from Hunedoara County, in Lunca Cernii de Jos, and Bătrăna-Bunila (Dobrei valley) (Burnaz, 2002a, b), are poorly defined and hard to find, partially due to the difficult accessibility of the area.

Management of alpine populations

The species is closely associated with forested habitats in the well-documented lowland population of *L. helle* in Romania (Craioveanu et al., 2014). It is restricted to mesohygrophilous meadows, where woody vegetation is essential,

Figure 10. *Lycaena helle*, male, Museum of Dacian and Roman Civilization Deva, Natural Sciences Department collection (source: original; photo by Stănescu M., 10.05.2023)

meadows, where woody vegetation is essential, particularly in clearings of oak or alder forests. Open habitats surrounding the forest are unsuitable for the species (Craioveanu et al., 2014), almost fully isolating the populations. Therefore, the violet copper is heavily influenced by forest management practices. Natural succession is crucial for preserving these populations. Abandonment leads to canopy closure, while clear-cutting reduces suitable habitats. Craioveanu (2014) documented that selective cutting within the forest and periodic planting of saplings ensures a variety of tree ages, preserving forest glades with diverse structural layers that are beneficial to the species. The lack of these actions leads to the disappearance of the larval food plant, a decline, or even extinction of *L. helle* populations, such as those in the Sites of Community Importance ROSCI0214 Râul Tur (Nagy & László, 2020).

The recently discovered highland populations face different problems.

The population at Coșna is surrounded by expanding human settlements, and our findings indicate a low population size. This is particularly worrisome because, although it still inhabits the *B. officinalis* meadows, these areas

could dry out and be replaced by heavily mowed terrains or even entirely by houses. In such a case, the individuals, if they survive, might be forced to retreat into the bog forest and face the same challenges as lowland populations. Findings suggest that endangered butterflies and their habitats are more vulnerable outside protected areas (Kajzer-Bonk & Nowicki, 2022). Moreover, settlement growth in smaller localities tends to create more pronounced landscape fragmentation than in larger ones (Li et al., 2021), further restricting the chances of the population naturally moving to nearby meadows if appropriate conditions exist. As part of the peatland restoration project, we have proposed and submitted documentation for a new Natura 2000 site, "Mestecănașul de la Coșna," based on the information available in Ion et al. (2023), aiming to protect the violet copper population. We aim to continue advising local authorities and the community about their unique natural heritage. We also want to highlight the potential for sustainable tourism through its protection. This approach appears to be a sustainable option, similar to some projects developed in Cluj County with the guidance of Professor László Rákosy, under the brand name Ținutul Fluturelui Albaștru (Ciornei, 2020).

The second alpine population at Lucina is situated inside a Natura 2000 protected area in ROSCI0086 Găina – Lucina, further away from localities, and it seems to be mostly undisturbed by the growth of human settlement. The grasslands and meadows at Găina - Lucina appear to remain under balanced management, as also noted by Ursu et al. (2017). Some of the threats to the bog woodlands in this area, such as drainage, have been addressed through the PeatRO projects by constructing dams to block the drainage channels. The threat posed by organic residues (Ursu et al., 2017) has been further mitigated through the removal of manure from the area of "Tinovul de lângă drum" while the horse farm above "Tinovul Găina-Lucina" has placed the manure on a concrete platform, minimizing its impact on the bog.

Meadow abandonment and afforestation are factors driving the decline of many endangered butterfly species, but the former is sometimes reversible with proper management (Kajzer-Bonk & Nowicki, 2023). However, neither seems to be a future threat in this area. Instead, increased farm activities could lead to a shift in the current grazing and mowing practices.

Evidence shows that this butterfly species requires meadows to be kept at a mid-successional stage, which can be accomplished through grazing and mowing. Nonetheless, research from the Belgian Ardennes indicates that both *L. helle* and *B. eunomia* may suffer due to both management strategies (Goffart et al., 2010). According to the authors, managers should prioritize a balanced strategy that preserves enough refuge areas annually and involves mowing in long-term rotations. Every other year in late summer, grazing should occur with few animals per unit area.

The habitats and *L helle* population at Lucina (Suceava County) are likely among the best-preserved in Romania. The site could serve as a potential refuge for this sensitive butterfly species and may be considered a source for re-introduction efforts, subject to further investigation. Three populations have been established through translocation in Europe for the violet copper. The first two, in France (1975 and 1992), expanded quickly, although one is now in decline (Descimon & Bachelard, 2014). In the Czech Republic, in the Šumava Mountains, however, its expansion has been slower since its introduction in 2002, possibly due to topographical factors (Peškařová et al., 2024).

CONCLUSIONS

Carefully implemented restoration activities can uncover yet unknown populations of rare species. These projects strengthen both research and conservation efforts for targeted species, enhancing our understanding of variations in species and regional habitat preferences.

Pressures and threats vary between populations, and adequate management should be employed in close collaboration with local communities.

Population translocation can be seen as a solution in case of imminent threat, but population genetics studies should be carried out to document differences among lowland and highland populations.

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