PhD THESIS

Studies on the entomofauna in the meadows located in the Bilbor depression, Harghita county, and the elaboration of biodiversity conservation plans

(SUMMARY OF Ph.D. THESIS)

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INTRODUCTION

In the last period, on the European level, a continuous decrease in the diversity of habitats in mountain areas and of the species in these ecosystems has been observed (WEZEL et al., 2021). The greatest loss of biodiversity is reported on the abandoned meadows, which are in continuous degradation, where there is a decrease in plants with high fodder value and an expansion of those without fodder value (PRUCHNIEWICZ, 2017). Biodiversity is an agroecological indicator (CLERGUÉ et al., 2005). The traditional agricultural practices applied to the hayfields and mountain meadows allow the maintenance of the existing flora and fauna, contributing to the preservation of biodiversity (LESSARD-THERRIEN et al., 2017).

In these ecosystems, the invertebrate fauna is essential. Many carabid species are important ecological indicators because they react quickly to the impact of pesticides. Carabids are indicators of the types of soil, the type of vegetation and including the chemistry of the environment, they indicate pollution with substances.

Butterflies represent one of the most important groups of pollinators in nature (OLLERTON et al., 2011). Butterflies are bioindicators of some ecosystems, being very sensitive to the changes that occur in the habitat (CHOUDHARY and CHISHTY, 2020). Butterflies are the trophic base for predatory species, and the reduction of their populations affects the trophic chains in the ecosystem (LEMELIN et al., 2019).

Recently, globally, there has been a decline in the populations of these species (ROY et al., 2015). The causes of the disappearance of butterflies are multiple. Changing the natural environment has dramatic consequences for the flora and fauna of affected areas, and butterflies are no exception. Butterflies are among the most sensitive indicators of environmental degradation. This situation is mostly determined by the destruction and fragmentation of the natural habitat (KAJZER-BONK and NOWICKI, 2023). Climate change is also a threat to butterflies. Global warming strongly affects lepidoptera, which are a bioindicator of climate change (HILL et al., 2021; RÖDDER et al., 2021). The anthropogenic factor often causes the degradation of the natural habitat in mountain areas, which then leads to a decrease in the biodiversity of fauna and flora (LESSARD-THERRIEN et al., 2017).

Protecting entomofauna is an alternative in promoting entomological tourism which has become a new niche in the tourism industry (KUCHER et al., 2023). Tourism is an income-generating activity, infrastructure development and job growth (YAKYMCHUK et al., 2021).

1. Structure of the doctoral thesis

The PhD Thesis includes a total of 129 pages and has been structured in two parts:

- Current State of Knowledge – 1st part (30 pages)
- Personal Contribution - 2nd part (99 pages)

The second part of the thesis summarizes a number of 99 pages, structured in 6 chapters, presenting the objectives pursued, meterial and methor, the particularities of the natural environment, the results obtained and discussions, conclusions and recommendations based on the obtained results, as well as its originality and innovative contributions. The thesis comprises a total of 28 tables, 64 figures and 182 bibliographic titles.

2. Research objectives

- Monitoring of coleoptera on the meadows in the Bilbor area;
- Monitoring of lepidoptera in the Bilbor area;
- Analysis of the entomofauna structure of coleoptera and lepidoptera;
- Calculation of ecological indicators for the collected species;
- The study of the biodiversity of the flora on the meadows;
- Evaluation of the tourist potential of Bilbor commune.

3. Material and methods

The research objectives contained in the doctoral thesis project were pursued in Bilbor commune, which has an area of 38 km^2, located in the north of Harghita county, with the following coordinates: 47°04' north latitude and 25°29' east longitude. The altitude is between 900-1050 m.

5.1. Coleoptera monitoring

Barber type traps were used to monitor the coleopteran fauna. We annually installed a number of 5 Barber traps in the investigated perimeter to increase the insect collection surface. The traps were checked between the end of May and the end of August. 6 checks were carried out annually, respecting approximately the same date for each experimental year.

5.2. Lepidoptera monitoring

In the period 2019-2021, entomological nets of diurnal lepidopteran species were collected in the last decade of May-August from meadows and hayfields. The biological material collected was analyzed in the laboratory of the Entomology discipline at USAMV Cluj-Napoca. Based on the external morphological characteristics and the coloristic-ornamental peculiarities of the wings, each collected species was identified. For each species, based on a laborious study of the specialized literature, information was sought regarding its bioecology and especially its trophic basis. Knowing the trophic base, conservation measures of the host plants can be established. Based on this information, combined with the study of local phytocenoses, the management plan for the protection of lepidopteran entomofauna will be developed.

3.3. Calculation of ecological indicators for the collected coleoptera and lepidoptera species

The collected biological material was mathematically processed to obtain a series of ecological indicators, such as: abundance, dominance, constancy and the index of ecological significance.

3.4. The study of flora biodiversity

On the hayfields in Bilbor, the evaluation of the plant structure was carried out on six hayfield plots where different management methods are applied. Plots 1 and 2 are abandoned hayfields. On the other 4 hay plots that are declared at APIA for obtaining subsidies granted from the budget, different traditional methods of use are applied that contribute to the conservation of the habitat.

On plots 3 and 4, the "Agri-environment and climate" measure, implemented since 2017, is applied. On plot 5, the "Ecological agriculture" measure is applied from 2020, and on plot 6, from 2021, the "Agro- environment + ecological agriculture".

On each mapped plot, in June 2022, 4 samples were taken on an area of 4x4 m and the structure of the plants was analyzed. The identified plants were classified into three groups: Poaceae family, Fabaceae family and other families. For species from the Poaceae and Fabaceae families, which are plants with high fodder value, the coverage percentage of each species was established. The species from the other families, which were in number 129, when establishing the degree of coverage, it was calculated at the family level. Many species of these plants enter the trophic base of diurnal lepidoptera, the adults feeding on their pollen, and the larvae on the vegetative organs.

4. Results and discussions

4.1. Results regarding the structure, dynamics and ecological parameters of coleopteran species collected with Barber traps

In 2017, 268 specimens, which systematically belong to 55 species, from 13 families, were collected during the 6 periods of coleopteran monitoring with the help of Barber traps. The most catches were made during the July 1 collection (67 specimens), and the fewest during the last collection (15 specimens). Most catches belong to the Carabidae family, with 75 specimens represented by 14 species, which means approximately 30% of the total catches. Most specimens captured belong to the species *Carabus ulrichii* Germar, *Harpalus calceatus* Duft. and *Harpalus distinguendus* Duft. From the Ipidae family, 54 specimens were collected, belonging to 6 species, and representing 20.2% of the total catches. The most ipids catches were of the species: *Ips typographus* L., *Ips amitinus* Eichh., *Pityogenes chalcographus* L. and *Pityokteines curvidens* Germ. Of the total catches, 58.2% are phytophagous beetles (represented by 27 species), and 41.8% of them are predatory beetles (represented by 28 species).

In 2018, 305 specimens, which systematically belong to 56 species, from 13 families, were collected during the 6 coleopteran monitoring periods with the help of Barber traps. The most catches were made during the collection on June 28 (84 specimens), and the fewest during the last collection (20 specimens). And this year most catches belong to the Carabidae family, with 79 specimens represented by 13 species, which means 25.9% of the total catches. Most specimens captured belong to the species *Harpalus tardus* Panz., *Carabus ulrichii* Germar and *Harpalus distinguendus*

Duft. From the Ipidae family, 66 specimens were collected, belonging to 6 species, and representing 21.6% of the total catches. The most catches of ipids were of the species: *Ips typographus* L., *Ips amitinus* Eichh. and *Pityokteines curvidens* Germ. The next family is the Staphylinidae family, also with 31 catches (10.2% of catches) represented by 9 species and Curculionidae, with 28 catches (9.2% of catches) represented by 5 species. It is closely followed by the Elateridae family, with 23 captured specimens (7.5% of the catches) belonging to 5 species. Of the total catches, 58.4% are phytophagous beetles (represented by 28 species), and 41.6% of them are predatory beetles (represented by 28 species).

In the two years, 573 specimens of coleopterans belonging to 65 species were captured, which are systematically classified into 13 families.

When analyzing the ecological indicators, the situation is as follows:

The species *Ips typographus* L. had the highest abundance in 2017 with 18 specimens, and in 2018 also *Ips typographus* L. with 30 specimens.

From the point of view of dominance, in 2017, 15 species are subrecedent, 23 species are recessive, 15 species are subdominant and 2 species are dominant. The dominant species is *Carabus ulrichii* Germar. and *Ips typographus* L., and in 2018, 25 species are subrecedent, 17 species are recessive, 12 species are subdominant and 2 species are dominant. The dominant species are *Ips typographus* L. and *Olibrus affinis* Sturm.

From the point of view of constancy, in 2017 there are 50 accidental species and 5 species are accessories. The accessory species are: *Carabus ulrichii* Germar, *Harpalus calceatus* Duft., *Harpalus distinguendus* Duft., *Ips typographus* L.. and *Silpha obscura* L., and in 2018, 48 accidental species and 8 species are accessories. The accessory species are: *Carabus ulrichii* Germar, *Harpalus distinguendus* Duft., *Harpalus tardus* Panz., *Coccinella septempunctata* L., *Ips amitinus* Eichh., *Ips typographus* L., *Olibrus affinis* Sturm. and *Silpha carinata* Herbst.

According to the indices of ecological significance in 2017, there were 17 accidental species, 35 species are accessories with the value of the index between 0.1 - 1.0%, and 3 species are accessories with the value of the index between 1.1 - 5.0% (*Carabus ulrichii* Germar, *Harpalus distinguendus* Duft., *Silpha obscura* L.), and in 2018 there were 19 accidental species, 33 species are accessories with the value of the index between 0.1 - 1.0%, and 4 species are accessories with the value index between 1.1 - 5.0% (*Harpalus tardus* Panz., *Ips amitinus* Eichh., *Ips typographus* L. and *Olibrus affinis* Sturm.).

4.2. Results regarding the monitoring of lepidopteran species

The Bilbor Depression is characterized by a relatively good state of conservation of biodiversity. 29 species of diurnal butterflies from the families were reported in the area: 7 from the fam. Lycaenidae (*Aricia agestis* Denis&Schiffermüller, *Lycaena dispar rutila* Wern., *Lycaena thersamon* Esper, *Plebeius argus* L., *Plebeius idas* L., *Polyommatus icarus* Rott., *Pseudophilotes schiffermuelleri* Hem.), 17 from the fam. Nymphalidae

(*Aglais urticae* L., *Araschnia levana* L., *Argynnis adippe* Denis&Schiffermüller, *Argynnis aglaja* L., *Argynnis niobe* L., *Argynnis paphia* L., *Boloria selene* Denis&Schiffermüller, *Coenonympha pamphilus* L., *Erebia ligea nikostrate* Fruhstorfer, *Inachis io* L., *Issoria lathonia* L., *Lasiommata megera* L., *Maniola jurtina* L., *Melanargia galathea* L., *Minois dryas* L., *Polygonia c-album* L., *Vanessa atalanta* L.) and 5 from the fam. Pieridae (*Artogeia napi* L., *Colias australis* Verity, *Colias myrmidone* Esper, *Leptidea sinapis* L., *Pieris mannii* Mayer.).

According to the national conservation status, the vulnerable species are: *Lycaena dispar rutile* Werneburg, *Lycaena thersamon* Esper. (Lycaenidae), *Boloria selene* Denis&Schiffermüller (Nymphalidae) and *Colias australis* Verity, *Colias myrmidone* Esper, *Pieris mannii* Mayer. (Pieridae), and potentially threatened species are: *Plebeius idas* L., *Pseudophilotes schiffermuelleri* Hemming. (Lycaenidae) and *Aglais urticae* L., *Araschnia levana* L., *Argynnis adippe* Denis & Schiffermüller, *Argynnis paphia* L., *Coenonympha pamphilus* L., *Minois dryas* L., *Polygonia c-album* L. (Nymphalidae).

The species with the greatest abundance are: *Maniola jurtina* L., *Boloria selene* Denis&Schif., *Argynnis paphia* L., *Coenonympha pamphilus* L. (Nymphalidae), *Pseudophilotes schiffermuelleri* Hem. (Lycaenidae) and *Pieris mannii* Mayer (Pieridae).

The relatively good conservation status of biodiversity is confirmed by the fact that the population of *Pseudophilotes schiffermuelleri* Hemming, *Argynnis paphia* L. and *Coenonympha pamphilus* L., which are potentially threatened taxa in Romania, is well represented in this area.

From the Nymphalidae family, *Boloria selene* Denis&Schiffermüller, is one of the vulnerable taxa in the country, but in the Bilbor area it is a well-represented species.

Colias myrmidone Esper which is declining in Europe, being even on the verge of extinction, still has a very small population only in the Bilbor and Gheorgheni area at an altitude of about 1000 m.

The species *Lycaena dispar rutile* Werneburg, *Lycaena thersamon* Esper (Lycaenidae) and *Colias australis* Verity (Pieridae), considered vulnerable taxa in the country, still have a very small population in the Bilbor area.

In order to continue to maintain biodiversity, it is necessary to comply with some measures that are included in a strategic plan for the conservation of biodiversity.

When analyzing the ecological indicators, the situation is as follows:

The species *Maniola jurtina* L. has the greatest abundance with 187 specimens.

From the point of view of dominance, 9 species are subrecedent, 7 species are recessive, 7 species are subdominant, 5 species are dominant and one species is eudominant (*Maniola jurtina* L.).

From the point of view of constancy, 7 species are accidental, 18 species are accessory and 4 species are constant (*Boloria selene* Denis & Schif., *Coenonympha pamphilus* L. and *Pieris mannii* Mayer).

According to the indices of ecological significance, 17 species are accessories (W_2), 8 species are accessories (W_3), 3 species are characteristic of W4, with the value of the index between 5.1 - 10.0%: (*Boloria selene* Denis&Schif, *Coenonympha pamphilus* L. and *Pieris mannii* Mayer) and a characteristic species W_5 (*Maniola jurtina* L.).

4.3. Results regarding the analysis of the flora on meadows and hayfields

The lowest biodiversity was reported on abandoned meadows. The number of plant species identified was between 21 species and 27 species. The lowest participation of species from the Poaceae and Fabaceae families was reported on abandoned meadows. Among the Poaceae, the dominant species is *Nardus stricta*, with up to 27% of the composition of the Poaceae flora, followed by *Deschampsia flexuasa*, species with a low fodder value. Among the species of other families, the dominant species is the blueberry, *Vaccinium myrtillus* and *Vaccinium vitis-idaea*, which are invasive species on abandoned meadows.

The greatest floristic diversity was reported in the plots with the application of APIA measures: 62-71 plant species where the "Agri-environment and climate" measure is applied, 49 species where the "Ecological agriculture" measure is applied and 56 species where the " Agro-environment + ecological agriculture", which also favors the maintenance of lepidopteran entomofauna.

On the meadows where biodiversity conservation measures are applied among Poaceae, the dominant species is *Agrostis capillaris* with up to 13.5% of the composition of the Poaceae flora, and *Festuca rubra*, with a percentage of participation of up to 18% species with high fodder value

The Fabaceae family contributes up to 9% in the floristic composition in the plots with the application of biodiversity conservation methods, and the dominant species is *Trifolium pratense*.

In the plots investigated, 129 plant species were identified, which are systematically classified into 28 families. Among the most important families for the trophic base of lepidoptera are: Asteraceae with 33 species, Lamiaceae with 12 species, Rosaceae with 10 species, Caryophyllaceae with 7 species, Plantaginaceae with 6 species, Ranunculaceae with 6 species, Polygonaceae with 5 species, Violaceae with 5 species, Apiaceae with 4 species, Juncaceae with 3 species, Cyperaceae with 2 species.

4.4. Results regarding the tourist potential of Bilbor commune.

Different types of tourism can be developed in the Bilbor area: mountain, spa, gastronomic, scientific. The fauna of lepidoptera and odonates in the area could contribute to the development of scientific tourism.

Tourism brings benefits not only for tourists, but also for the local community, further stimulating the appreciation and protection of local traditions, but also the increase in the number of jobs and the valorization of local food products.

5. Conclusions and recommendations

On the investigated meadows, zoophagous species from the order Coleoptera have a contribution of approximately 42% in the structure of the collected coleoptera, these being from the families Carabidae and Staphylinidae.

In the Bilbor area, some of the lepidoptera species with a national status of vulnerability or potentially threatened still have a suitable population.

For these species, it is necessary to take all the protection measures, by drawing up a management plan for the conservation of biodiversity.

Through the development of a conservative management through the application of "Agri-environment and climate" and "Ecological agriculture" measures, an increase in plants with high fodder value and a conservation of plant species that are part of the trophic base of lepidoptera have been observed.

Recommendations

In the Bilbor area, mowing is recommended to be done after July 1st, after the flowering period of the plants, because the diurnal butterflies identified feed on the nectar of the plants.

In order to maintain the biodiversity of the flora, in the case of grazing, it is very important to maintain a traditional grazing, and the herd to be correlated with the certification of each pasture,

Maintaining natural habitats by reducing the application of pesticides and amendments that can change the composition of the flora.

Promotion of APIA measures for exploitation of meadows and natural pastures.

By promoting and implementing local tourism in Bilbor, it can become a pillar of sustainable development, bringing benefits not only for tourists, but also for the local community, further stimulating the appreciation and protection of local traditions.

Elaboration and continuous updating of the local development management plan.

6. Originality and innovative contributions of the thesis

- Studies were done for the first time to monitor the entomofauna of coleoptera and lepidoptera in the meadows and pastures of the Bilbor area.
- The ecological index values of the collected coleoptera and lepidoptera species were calculated.
- The flora of meadows and pastures correlated with their exploitation methods was analyzed.
- The tourist potential of the Bilbor area was analyzed.
- The main measures to be integrated into the management plan for the development of the area, for the conservation of endangered lepidopteran species, were established.

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