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The Coleoptera diversity in the Giroc forest, part of the site Natura 2000 Lunca Timisului, Romania

Paul DRĂGOI[1], Ciprian George FORA[1*]

[1] University of Life Sciences "King Mihai I" from Timisoara, Faculty of Engineering and Applied Technologies, Department of Forestry, e-mail: pauldragoi1911@yahoo.com, ciprian.fora@usvt.ro

Corresponding author: ciprian.fora@usvt.ro

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Abstract
The site Natura 2000 Lunca Timisului conserves habitats and species of Community interest, on more than 10 thousand hectares, in West of Romania, a considerable surface of the protected area (60%), being covered by forests. Giroc forest is a part of the site Natura 2000 Lunca Timisului, which covers 256 ha, at altitude of 90 m, composed by following species: oak, ash, hornbeam, field maple, with mean age of 114 years for oak, 73 years for ash, 65 years for hornbeam and 79 years for field maple. Due to their major beneficial role in the ecosystem as a whole and, implicitly, in the forest ecosystem, knowledge of insect species diversity and the size of their populations is an essential element in describing the quality of the habitat, the living environment. Knowing that the anthropic influence in the Giroc forest is substantial and appreciating that climatic changes can influence insect species diversity, we set out to observe their existence during to the second part of the growing season, from July to September. In the present paper we aimed to inventory the insect species in old and scrubby trees, dry stand trees, moss-covered dead trunks and old stumps. Insect collection was carried out either by using transparent winged scoops or by direct observation and capture from the targeted material of interest. In the three experimental areas, the 13-coleopteran species, belonging to 9 families. The most numerous species were from the Family Elateridae (12%), followed by others families (Cerambycidae, Elateridae, Carabidae, Chysomelidae, Staphylinidae, Silvanidae, Hydrophilidae, Mordellidae, Mycetophagidae), each one with one species. In addition, species belonging to the Order Hemiptera, Dermaptera and Blattodea has been found. Based on the results obtained, we can state that species diversity was relatively low in the second part of the growing season, which indicates the necessity to assess the populations diversity even in the first part of the year and the need to comply with responsible measures for the conservation of biodiversity in forests subject to anthropogenic influence and rapid climate change.

Keywords: inventory, insects, population, protected area

Introduction

The order of Coleoptera includes insects with a special evolutionary path, which adapt over time to different living environments such as aquatic, terrestrial, in stored agricultural products, etc. As for the richness of this order, it is known that the number of species of coleoptera studied and described so far is about 400,000, but the inventory of species is incomplete, still presenting many gaps. Under the Coleoptera order, among the 211 known families [3], the richest in species are: Curculionidae, Cerambycidae, Carabidae, Chrysomelidae, Tenebrionidae and Staphylinidae.

In terms of the spread of coleoptera, they are widespread all over the globe, except in the Arctic, Antarctica and high mountain peaks. The highest abundance of species is intuitively found in tropical regions.

Coleopters vary in size, body shape, limbs, antennas, wings, and colour of individuals. Sexual dimorphism can also be observed, with males of some species visibly different from females of the same species, usually males having a different lifespan. Thus, females, although larger in size, are longer than males, characteristic of the egg laying period [1].

Coleopters are an important link in the ecosystems they are part of. Therefore, each species performs a certain function in nature. Thus, species that consume roots, wood, fruit, leaves, sap of plants, dead or decomposing plant or animal organic matter, while other species have pathogenic action, transmitting various infections [1].

The climate and anthropogenic transformations of the environment, experienced at global level, have led to the reduction of biodiversity, thus causing complex ecological consequences such as the disappearance of native species, the introduction of other allochthon species, the disruption of essential processes within the ecosystem with the impairment of interspecific relations [6].

Since the order of Coleoptera is the most numerous and also the most widespread insect group on the globe, with about 400,000 species worldwide and over 7500 species in the fauna of Romania, the analysis of coleoptera fauna is vital in ecological research, as studies have proven [8].

Thus, the study of coleopters is currently widely used in order to estimate the level of ecosystem alteration and to measure the impact of climate change [20].

Next, we will list some of the advantages that make the order of Coleoptera suitable for such studies: The order of Coleoptera is represented by species present in all types of habitats, be they aquatic or terrestrial (except oceans, seas, areas with extremely low temperatures); it is the most widespread and numerous groups in the animal kingdom. it is a group of species covering most heterotrophic categories in an ecosystem [21].

The dead wood in forest ecosystems is a key component of them, as it fulfils several extremely important roles in terms of biodiversity, the nutrient cycle in the ecosystem and energy flows, thus the decomposition of wood being a key ecosystem-wide process [24].

Dead wood and decomposing wood are also natural indicators of ‘ecosystem health’, as they are sensitive to both changes in a habitat and management practices applied in that ecosystem [16]. The microhabitats they host are sensitive and directly exposed to disturbances such as human interventions [11]. Saproxylic coleoptera species that depend on dead wood, build complex interaction networks and make a major contribution to biodiversity and forest processes [22].

The capture of flying insects with window-flight traps is currently the most commonly used technique for catching active saproxylic flying beetles. Window-flight traps consist of a vertical barrier for flying insects, considered invisible to them. Upon striking the barrier, most cockroaches fall down and end up in a collection container with preservative liquids. Window-flight suspended traps are useful for site comparisons because they have less variability between traps. Although interception traps do not provide precise information about the micro-habitat, they are often more effective than extraction methods. About 60% of flying beetle fauna can be caught in window traps, thus providing a representative picture of saproxylic beetle fauna. The window trap is widely available and highly efficient, with many advantages: It is easy to standardize and replicate, simple to build, does not require much work and allows the capture of a large number of small and cryptic flying taxa. [4].

Material and Method

Research site. The research site is situated in “Timis plains” on the left shore of the Timis river, in the south-east area of Timis county, in Giroc forest. The forest is administrated by the Forests National Directorate - Romsilva, Forest Directorate Timis, Forest District Lunca Timisului. The main access route is represented by the communal road Giroc - Canton A.B.A. Banat, which goes through the north-east of the forest.

The forest is composed mainly by oak with a proportion of 58% and age of 114 years, followed by ash with 22% around 73 years old, and hornbeam with 8% aging around 63 years, the remaining percentage of trees being comprised of common maple, poplar, black locust and a very small percentage of other species like wild cherry. The specific flora is represented by Arum-Pulmonaria. Due to the geographical position and composition of the species, this area can be easily classified as a plain mixed forest and meadow. The unit under study falls under the climate province C.f.a.x. after Köppen, the type of Mediterranean transition climate – temperate continental, which is characterized by milder winters, warm summers and annual variations of low temperatures.

On the whole surface of 256 ha of the Giroc forest, there are two overlapped natural areas protected by the European ecological network “Natura 2000” namely ROSCI0109 - Lunca Timisului and ROSPA0128 - Lunca Timisului (figure 1).

The best suited characteristics of the area relevant for our study was found in the east part of the forest, where there is a high density of decaying wood in the form of old and scrubby trees, dry standing trees, moss-covered dead trunks, old stumps, fallen branches and leftovers from wood harvesting. Offering access with a low grade of difficulty, being secluded from the typical paths that are used by people for recreation purposes.

We selected three test surfaces of 100 square meters each, in the areas that were abundant of decaying wood and were expected to provide the highest density and variation of insects.

The first surface has the most elements of decaying wood int a high variety of forms (12 logs, 4 fallen branches, 3 stumps and 3 broken and standing trees), low consistency of trees (0.6) and presence of a clearing.

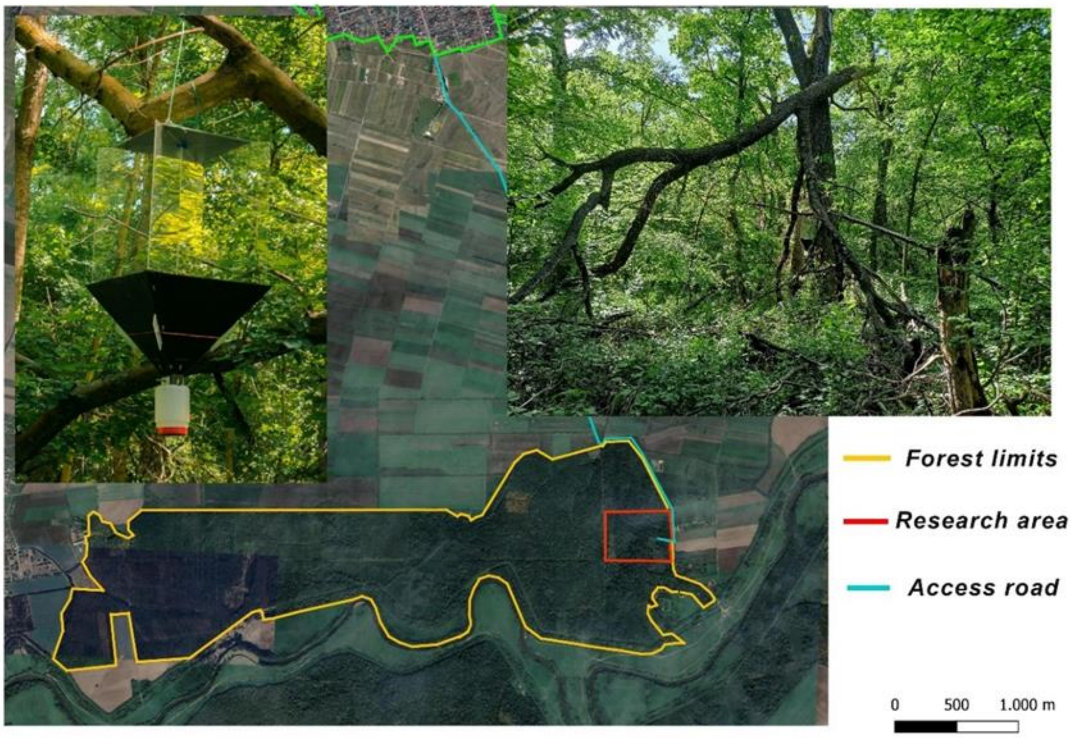

Figure 1. Research site, trap and habitat

The second surface has a smaller quantity of decaying wood (3 logs, 2 stumps, 2 standing dead trees, and some piles of leftovers from wood harvesting), but also has a clearing from an old harvest.

The third surface has a medium amount of decaying wood (5 logs, 6 standing broken or dead trees, 4 fallen branches and 1 stump) the main characteristics of this surface is a high consistency (0.8) and a high number of standing affected trees.

Collection method. *Establishment of sample areas*. Data collection on the presence of coleoptera species was done using transparent wing traps and direct field observations. The effectiveness of this method depends very much on the choice of location of the traps. The most important aspect with regard to the choice of sample areas was the presence of large amounts of dead wood and weakened trees. Three sample areas of 100 m^2 were chosen, where satisfactory quantities of dead wood were found in various forms (logs, breaks, stumps, windthrow) and in various stages of decay.

Traps design. The traps used are a modification of the "Barrier" type traps, retaining only the funnel and the collection container, the panels being replaced by transparent ones. Also, the space inside the panels where the pheromone was placed is completely missing, and no attractant is needed to obtain the experimental results. The component parts are: two panels of transparent and colourless acrylic plates of size (50 cm wide, 65cm length with a tapered point in the funnel, and 2mm thickness) arranged perpendicular to each other; a lid made of an aluminium plate on the top, to provide the best possible fixation of the panels and to reduce the amount of plant material and precipitation that could end up in the funnel; a pyramid-shaped funnel to direct the insects to the collecting jar; the plastic collecting jar, attached to the funnel by a steel screw with a 6 mm diameter nut; the lid with a thread and a metal sieve to drain off water from the rainfall and retain insects; the fixing lugs, made of Ø 2 mm copper wire, attached to acrylic panels and cover. In total the dimensions of a trap are 35 cm width and 82 cm height (35x35x82).

Traps placement. On each research area, 2 traps were placed at a distance of approximately 30 m from each other, hanging from trees, each trail being mounted in close proximity to pieces of dead wood or weakened trees. For easy access to the collection container, the runs were mounted so that the lowest part, i.e. the lid of the collection jar, was at a height of 1.75 m.

Insects collection. Sample collection was carried out weekly at 7-day intervals in plastic test-tube containers with lids, on which the date and place of collection were noted. Storage of biological materials until species identification was carried out in the freezer at -18°C. Species identification was carried out according to morphological criteria in the laboratory.

Statistical analysis. The low number of insects caught during the observation period for each species did not allow statistical interpretation of the results and calculation of diversity indices. However, using Excel software, the results obtained could be presented in table form, useful for the purpose of the scientific work.

Results and Discussion

In the following tables (1, 2 and 3), is presented the inventory of each test surface regarding the type of decaying wood of research areas. In order to express the decaying stage of the trees we chose to assign the description as "Dry", meaning the wood is still structurally strong having some of the bark still attached or fallen underneath the log, and "Advanced" meaning the structure of the wood is crumbly and soft often times, without any bark left therefore, being unable to be identify as what species it was and noted in the table with "Not available".

Table 1. Inventory of decaying wood in 1st research surface

Crt. no.	1st research surface				
	Type of wood	Species	Diameter (cm)	Length (m)	Decaying stage
1.	Log	Ash	62	3,7	Advanced
2.	Log	Ash	34	4,7	Dry
3.	Broken branch	Maple	16	2	Dry
4.	Stump	Not available	62	Not available	Advanced
5.	Log	Hornbeam	32	8,2	Dry
6.	Broken branch	Ash	10	3	Dry
7.	Log	Maple	32	9	Dry
8.	Standing trunk	Hornbeam	16	8	Dry
9.	Broken branch	Ash	20	10	Dry
10.	Log	Hornbeam	24	4,6	Dry
11.	Log	Wild cherry	42	8,4	Advanced
12.	Stump	Not available	40	Not available	Advanced
13.	Log	Ash	30	7	Dry
14.	Stump	Not available	66	Not available	Advanced
15.	Log	Oak	52	6	Dry
16.	Log	Not available	22	5,3	Dry
17.	Log	Not available	58	5	Advanced
18.	Log	Not available	58	2	Advanced
19.	Broken and hung	Hornbeam	24	10	Dry
20.	Log	Hornbeam	28	8	Dry
21.	Standing trunk	Not available	18	4	Dry

Table 2. Inventory of decaying wood in 2nd research surface

Crt. no.	2nd research surface				
	Type of wood	Species	Diameter (cm)	Length (m)	Decaying stage
1.	Log	Oak	48	11	Dry
2.	Fragmented log	Maple	42	7,5	Dry
3.	Stump	Not available	42	Not available	Advanced
4.	Fallen branches	Ash	32	6	Dry
5.	Standing trunk	Ash	40	1	Dry (with sprouts)
6.	Stump	Not available	46	Not available	Advanced

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7.	Standing trunk	Ash	82	8	Dry
8.	Log	Ash	46	10	Dry
9.	Piles of exploitation debris	Not available	>5	5	Dry
10.	Piles of exploitation debris	Not available	>5	3	Dry

Table 3. Inventory of decaying wood in 3rd research surface

Crt. no.	3rd research surface				
	Type of wood	Species	Diameter (cm)	Length (m)	Decaying stage
1.	Standing trunk	Oak	68	8	Dry
2.	Log	Oak	58	9	Dry
3.	Fallen branches	Oak	26	11	Dry
4.	Hanging branches	Oak	24	Not available	Dry
5.	Stump	Not available	56	Not available	Advanced
6.	Standing trunk	Maple	36	5	Dry
7.	Standing trunk	Not available	56	5	Advanced
8.	Broken branches	Not available	18-20	Not available	Dry
9.	Log	Oak	46	12	Dry
10.	Log	Oak	52	16	Dry
11.	Standing trunk	Ash	44	6	Dry
12.	Broken fallen tree	Not available	58	Not available	Dry
13.	Standing trunk	Oak	72	8	Dry
14.	Log	Oak	62	10	Dry
15.	Broken branches	Not available	18-30	Not available	Dry
16.	Standing trunk	Ash	42	11	Dry
17.	Log	Oak	80	13	Dry

Following the research, we can confirm that full inventory or enumeration of all insect taxa in a site or landscape is not possible due to high diversity, taxonomic challenges and time constraints. As stated in the study of Spector (2006).

Destruction of land habitats, rising temperatures, introduction of allochthon species, ecological characteristics, evolution, there are several other key factors that are often associated with the decline in the world's insect population. According to a study by Sánchez-Bayo and his collaborators (2019), the order of Coleoptera is among the most affected by these changes occurring in natural habitats. This is also seen in the results obtained in our study, which indicate a fairly small number of coleoptera during this period.

Also, by linking the amounts of dead decaying wood and the number of individuals observed in each surface, we can confirm that in order to ensure the protection of rare species of saproxylic coleoptera in forest ecosystems, it is essential to maintain sufficient quantities of dead wood, (up to 50 m³ per hectare) according to studies by Grove (2002). The origin of dead wood from the studied surfaces is consistent with that mentioned by Grove (2002). This is the result of natural calamities, such as broken and wind-turned trees, and includes tall trunks left after exploitation cuts, as well as the preservation of old and scurvy trees [11].

The results have shown that the richness and diversity of intercepted beetles were quite low in Giroc Forest. It is known that window traps are activity traps, therefore, species with low activity were rarely caught in interception traps or not detected; for instance, tree hollow specialists with low dispersal abilities are omitted

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from this type of sampling technique [15]. Species with short adult stage phenophase may also remain undetected. Consequently, the composition of window traps is a raw estimate of the actual composition of saproxylic beetle community. The habitat-guilds of dead decomposing wood, freshly cut wood, fungi-dwelling beetles are almost equally represented suggesting that the complex food webs responsible for wood decomposition and nutrient cycling in the forest are functioning in the studied area, an important observation in the context of the growing concern about the decline of saproxylic organisms in managed forests [29].

A vast perspective about the presence of species caught int this period of time is showed in the following illustration (Figure 2).

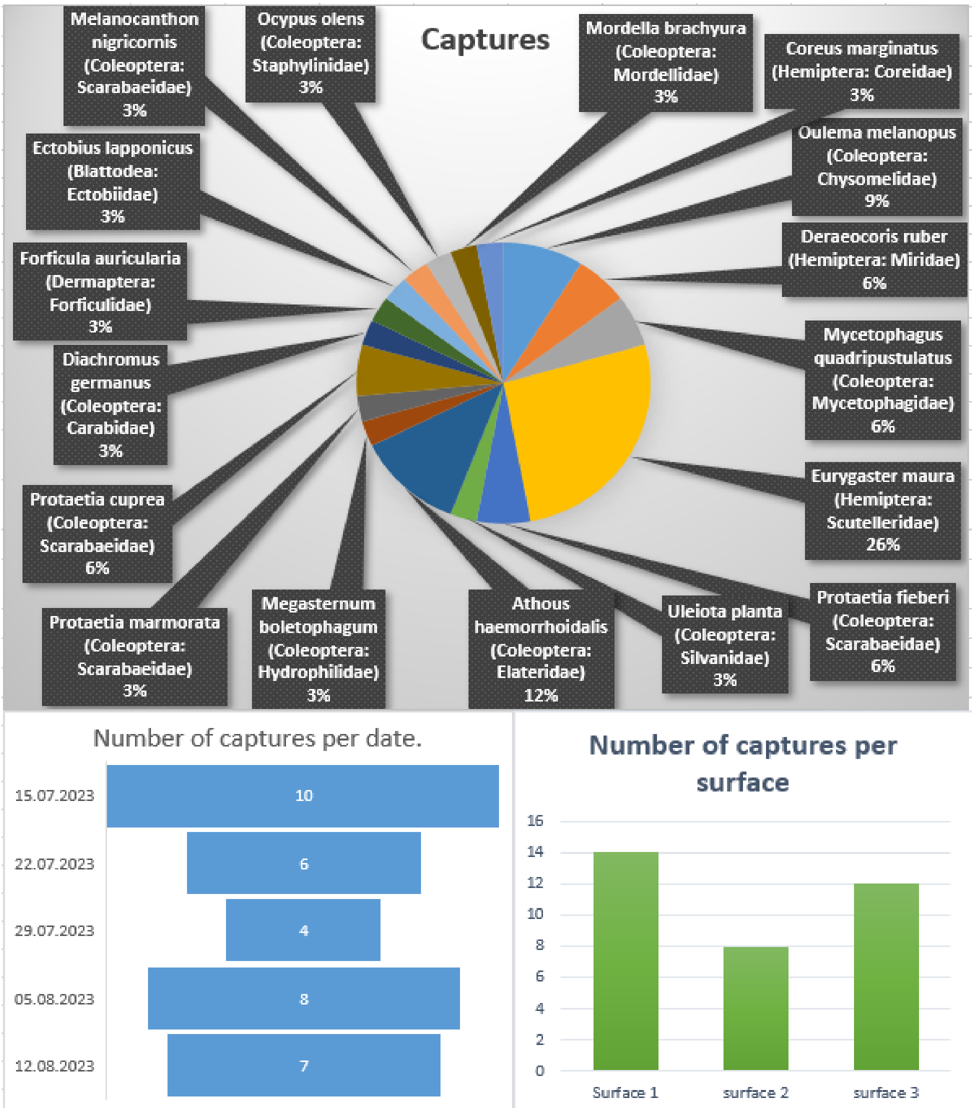

Figure 2. Proportion of the species and individuals caught

One of the most interesting discoveries took place in July 11 in the third test surface in the space between trap 6 and trap 5, where there was spotted a specimen of Alpine longhorn beetle *Rosalia alpina* (figure 3). This is very unusual if we look at the normal areal of this species. Species typically inhabits deciduous forests, particularly those with old and decaying beech trees, which are crucial for its lifecycle. It prefers habitats at higher elevations but can also be found at lower altitudes in suitable environments, in our case Giroc forest. The Alpine longhorn beetle is listed in the European Habitats Directive and is protected under various national regulations across its range to help conserve its populations and habitats.

The results of the experiment did not reach the expectations due to the low number of individuals caught and a relatively low diversity of species. It was observed that after august 19th, there were no more captures in the traps, until the end of the autumn.

Saproxylic coleopters play an essential role in the circuit of substances in nature and in the decomposition of organic matter [30]. However, the climate change we are experiencing and the reduction of forested areas have caused their diversity to diminish from year to year.

Figure 3. *Rosalia alpina*

As the saproxylic species of the order Coleoptera show increased sensitivity to disturbances, they have become the indicator of prosperity and well-being for many forests in Europe [28].

Saproxylic coleopters have a direct, limited action on the decomposition process. First, broken and dead trees are populated by xylophage coleopters and mycetophagids, which serve to make holes in the bark, holes through which about 30 other xylophage organisms will then enter [23].

This process accelerates the process of fragmentation and then the process of the bark detachment. Their effect on decomposition itself is insignificant, and the fractionation of dead wood by xylophage coleopters and their larvae also has a minor quantitative weight [14].

The decomposition of dead wood also depends on precipitation, the position of the wood (horizontal, ground or vertical), the thickness of the wood, the species of tree, the age and the class of wood (it is known that hardwood, wet, decomposes faster than coniferous wood of soft essences subject to the same conditions) [13].

Xylophage coleopters are usually present on dead wood in the first three stages of the decomposition process, specifically during the period when the wood is present. Coleopters can be found on dead trees from the second year after drying up to the seventh year. Some species of saproxylic coleoptera transfer the spores to xylophages after visits to healthy trees before they are dried.

Coleopters are also important because they participate in pest control in forest ecosystems. This effect is achieved by the action of saproxylic zoophages on the xylophage species of the *Scolytinae subfamily,* thus achieving a biological control of the wood caries [31].

Adult coleopters play an important role in ecosystems, as they contribute to the pollination of flowering plants, while also contributing to the growth of trophic sources for semi-flowering and herbivorous vertebrates, and last but not least, to the fruition of trees. At the same time, they interact with other categories of organisms, being an important source of food for insect and bird mammals [7].

It is known that insects, including representatives of the order Coleoptera, provide considerable services and functions to the ecosystem. Of these important functions, we recall: Waste removal, pollination, and biological control. For example, as a result of the exclusion of detritus and decomposing insects from a forest ecosystem, unused, undecomposed organic matter will accumulate in the soil and habitat [2].

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The decline in insect biodiversity around the globe is generally due to a growing body of human activities around the globe, such as habitat destruction through deforestation, hunting, the expansion of agriculture, pesticide use, industrialization and urbanization, but also other threats such as invasive species and climate change [12].

Destruction of terrestrial and aquatic habitats, increase in temperatures, introduction of allochthone species, ecological characteristics, evolution, wildfires are a few other key factors that are often associated with the decline in the world's insect population. According to a study by Sánchez-Bayo and his collaborators (2019), the order of Coleoptera is among the most affected by these changes occurring in natural habitats.

Inventory as a method of biodiversity monitoring involves recording (including surveillance, sampling, sorting, identification, cataloguing, the creation of databases and documentation of species or other components of biodiversity on various spatial scales: local (site, landscape), regional (bioregion, biome, continent) or global [26].

Therefore, the purpose of the inventory is to document both the composition and spatial distribution of biodiversity, to identify the significant components of this diversity (values or assets) and to prioritize areas for conservation protection and management [5].

A complete inventory or enumeration of all insect taxa in a site or landscape is not possible due to high diversity, taxonomic challenges and constraints of time, finances and personnel (Spector, 2006). Therefore, in inventory studies, usually a single taxon or relatively small group of taxa is selected and used as surrogates (umbrella taxa or biodiversity indicators) to estimate broad spatial patterns of biodiversity [26].

Another approach is to use species occupancy models to identify species presumed to be indicators of biodiversity, which are then used to predict the richness of species of taxonomic groups [10].

The method of monitoring involves measuring temporal changes in species abundance, species wealth, or species associations, or other components of biodiversity, such as the size/boundaries of the geographical area [9].

It is used to assess how a site or location can change over time from a predetermined standard (baseline), usually in relation to environmental characteristics (threats, habitat restoration) [26].

It is essential that monitoring is adapted to improve land management. For example, it can assess the effects of management actions aimed at mitigating specific threat processes or measuring ecosystem recovery through ecological restoration [18].

A key aspect of monitoring is detectable, which is the probability that a species present in a site will actually be detected. Detectability is a crucial factor to consider in the design of monitoring protocols, as it allows correction of the observed value against the actual value, estimated on the basis of the sampling unit adopted [25].

In order to ensure the protection of rare species of saproxylic coleoptera in forest ecosystems, it is essential to maintain sufficient quantities of dead wood up to 50 m^3 per hectare. This wood should come from natural calamities such as broken and windswept trees, and include tall trunks left after sanitizing cuts, as well as keeping old and scurvy trees [11].

Land protection was considered to be a more resource efficient use than the laws on species protection [17]. Protected areas are designated for biodiversity conservation, education or tourism, with little or no scope for economic activities such as agriculture and forestry. As a result, protected areas benefit society by reducing poverty, providing employment opportunities and providing many health benefits. They have been considered one of the most effective uses of insect conservation funds globally [19].

Conclusions

Between 15 July 2023 – 16 September 2023, 13-coleopteran species, relating to 9 families were identified. The most numerous species of coleoptera were from the Family Elateridae (12%), followed by others families (Cerambycidae, Scarabearidae, Carabidae, Chysomelidae, Staphylinidae, Silvanidae, Hydrophilidae, Mordellidae, Mycetophagidae), each one with one species. In addition, species relating to the Order Hemiptera, Dermaptera and Blattodea has been found.

Looking at the sufficient presence of decomposed wood compared to the small number of beetles captured during this period, it can be seen that the beetle population is affected by climatic and anthropogenic influences.

According to the Red List of European species of beetles, in the Giroc Forest we had a single individual of *Rosalia alpina*, this indicates, first of all, that there are conditions that are favourable for this species, but the fact that no other individuals have been identified results in the conclusion that the population is very low.

The relatively short period of the study makes it difficult to establish affirmations related to the dynamics of the coleoptera populations over time, which implies the continuation of studies in the following periods.

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