ECOLOGICAL RESEARCH ON THE DYNAMICS OF ARTHROPODS FROM GRASSLANDS ON THE OUTSKIRTS OF "DUMBRAVA SIBIULUI" FOREST (SIBIU, ROMANIA) IN THE PERIOD 2012 - 2014

Cristina STANCĂ-MOISE[*], Maria TĂNASE

[*]*"Lucian Blaga" University of Sibiu, Faculty of Faculty of Agricultural Sciences, Food Industry and Environmental Protection, Sibiu, Romania*
Corresponding author: Cristina Moise, "Lucian Blaga" University of Sibiu, Faculty of Agricultural Sciences, Food Industry and Environmental Protection, 5-7 Ion Ratiu, 550371 Sibiu, Romania, phone: 0040269234111, fax: 0040269234111, e-mail: cristinamoise1@yahoo.com

Abstract. At international and European level, great emphasis is laid upon preserving various ecosystems biodiversity; the current researches make Romania meet these goals. Knowing the composition of the fauna and of the interrelations between the structural parts of the examined biocenotic, a grassland on the outskirts of Sibiu city located in central Romania, is of particular importance for making ecological studies. For assessment of its current condition, we have been conducting a comprehensive research over three years: 2012, 2013, 2014, during the months of July, August, September, examining the dynamics of arthropods, intended to ensure their inventorying and monitoring, with a total of 49.422 specimens collected during the said three years. The biocenotic structure of arthropods from grassland is superficially displayed in the lists of the collected species. The quantitative relationships between the number of specimens and the reported number of species can be achieved by using ecological indicators used in analyzing the data obtained. This paper is a starting point to further research in this direction.

Keywords: arthropods, diversity, grassland, zoogeography, dynamics.

INTRODUCTION

The biocenotic structure of the ecosystem has always been a topic of discussion of applied ecology studies, various papers requiring certain principles of biocenotic sorting. Over the years, such research were conducted in Romania by [11-13, 18, 19, 33]. Over the years, research and inventories of the following insect groups have been carried out within perimeter of "Dumbrava Sibiului" Forest and the surrounding areas: diurnal *Macrolepidoptera* [14, 15, 26, 29], epigynous entomofauna inside the forest [16, 27, 28, 30, 31], xylophagous *Coleoptera* [2-6].

This paperwork complements the research in the area of Sibiu and implicitly of Romania, in a grassland near Sibiu City, right next to the highway that links the city to the locality of Cisnădioara (Figure 1). The GPS coordinates of the location are 45°.44' 13.74' north latitude and 24°.06' 22.26' east longitude. This land is located in the foothills of Sibiu Depression, and extends on an area of 20,000 m^2.

MATERIALS AND METHODS

2.1.Study area

The pedoclimatic conditions of the area are characterized by the middle and upper terraces with poor soils and hydrophobic soils whose genesis is related to the presence of shallow aquifers with brown alluvial soils. The mineral substrate is predominated by gravels and sandy-skeletal deposits, which provide the natural drainage [7].

In terms of climate, the study area is located in Romania, in Sibiu County in a region with sub-humid climate. The average annual precipitation is of 662 mm. The average annual temperature is about 9.4° C. The annual aridity index has a value of 35 and two of the monthly aridity indexes have the value of about 28 and only one drops below this value (in September) but without reaching the aridity limit [32]. The analysis of the above parameters shows that the terrace where the grassland is placed is at the edge of the forest area towards silvosteppe (Figure 1).

We extract the following systematic list from the floristic analysis of the grassland [8] containing some of the plant species of wild flora. The bank-terraced vegetation consists of a dense grassy carpet, which in June, before mowing, entirely covers the soil. The grassy layer is a good relatively high humidity hayfield of mesohygrophilous type. This microclimatic element is enhanced by the presence of a stream in the western side of the grassland. One of the most common species of grass associations is *Festuca pratensis*. The analysis of wild flora highlights nine economically distinct groups, namely the group of meso-hydrophytes which include *Agrostis tenuis* and a group of *Festuca pratensis,* which grow in well aerated places. In sandy areas grow mesophyll species such as: *Poa pratensis, Plantago lanceolatum, Achillea millefolium, Campanula patula*, but also less mesohygrophilous herbaceous plant species such as *Agrostis alba, Deschampia cespitosa and Ranunculus repens*. The most important association in this grassy layer is *Holcus lanatus*, together with other species of: *Agrostis stolonifera, Carex vulpina and Alopecurus pratensis*. Due to the high number of mesohygrophilous and hygrophyte species, the studied grassland falls into the association of *Agrostideto-Festucetum pratensis* [8]. In terms of forest located in the eastern part of the grassland, the main forest dominant species is the oak *Quercus robur.*

2.2.Methods

The biological material sampling and the observations were carried out in July, August, September (see A-VII, VIII-B, C-IX) over the years 2012, 2013, 2014. In order to include the entire studied habitat, five fragments of land of 4 m^2 each, located at different distances from each other, were chosen as sampling areas (Figure 1).

Figure 1. The satellite map of Romania, Dumbrava Sibiului Forest, covering the collection grassland (adapted after Google Earth)

These were marked as I, II, III, IV, V. From the grassy layer of (the thickness of the stratum) arthropod samples have been collected at approximately equal intervals from July to September during the three years (Figure 2). The samples have been collected by mowing, using the sweep collection net (400 sweep-nettings have been performed on the surface of a lot).

On the course of the 3 years we have strived to ensure collection time intervals as short as possible, specifying the average, the maximum and the minimum temperature of each date; the said dates are the following: A- namely July: July 12, 2012 (25.8° C average air temperature, 34.2°C maximum temperature and 18.6 ° C minimum temperature), July 10, 2013 (20.68°C average air temperature, 27.7°C maximum temperature, 15.2 °C minimum temperature), July 11, 2014 (16.1 °C average air temperature, 21.9°C maximum temperature; 11.2°C minimum temperature) resulting a total number of 26,797 specimens;

B-August: August 3, 2012 (17.9^{o}C average air temperature, 22.7 ^{o}C maximum temperature, 14.7 ^{o}C minimum temperature), August 1, 2013 (22.5^{o}C average air temperature; 28.0 ^{o}C maximum temperature; 15.2 ^{o}C minimum temperature), August 1, 2014 (20.9 ^{o}C average air temperature; 29.8 ^{o}C maximum temperature; 14.5 ^{o}C minimum temperature) resulting a total number of 12.209 specimens; C-September: September 4, 2012 (19.5 ^{o}C average air temperature; 27.3 ^{o}C maximum temperature; 13.6 ^{o}C minimum temperature), September 2, 2013 (16.7 ^{o}C average air temperature; 20.7 ^{o}C maximum temperature; 11.1 ^{o}C minimum temperature), September 3, 2014(16.1 ^{o}C average air temperature; 21.9 ^{o}C maximum temperature; 11.2 ^{o}C minimum temperature) resulting a total number of 10.416 specimens.

The dynamics of the *Heteroptera* complex can be reflected also by the development of the similarity degree between its compositions in two successive moments. In other words, we wonder whether there is a substantial change in terms of diversity of species between complex A and the immediately subsequent B class. Stugren's similarity coefficient has been applied to determine this aspect (1982).

$$qs = \frac{c}{\frac{a+b}{2}} = \frac{2c}{a+b}$$

where:

a = the number of individuals, contained in a population A

b = the number of individuals contained in a population B

c = the number of individuals common to both populations

If qs> 0 and qs≤+1, the theories are discriminant, significantly different through the range of species.

If qs<0 and qs ≥-1territories are interrelated, they have a degree of affinity.

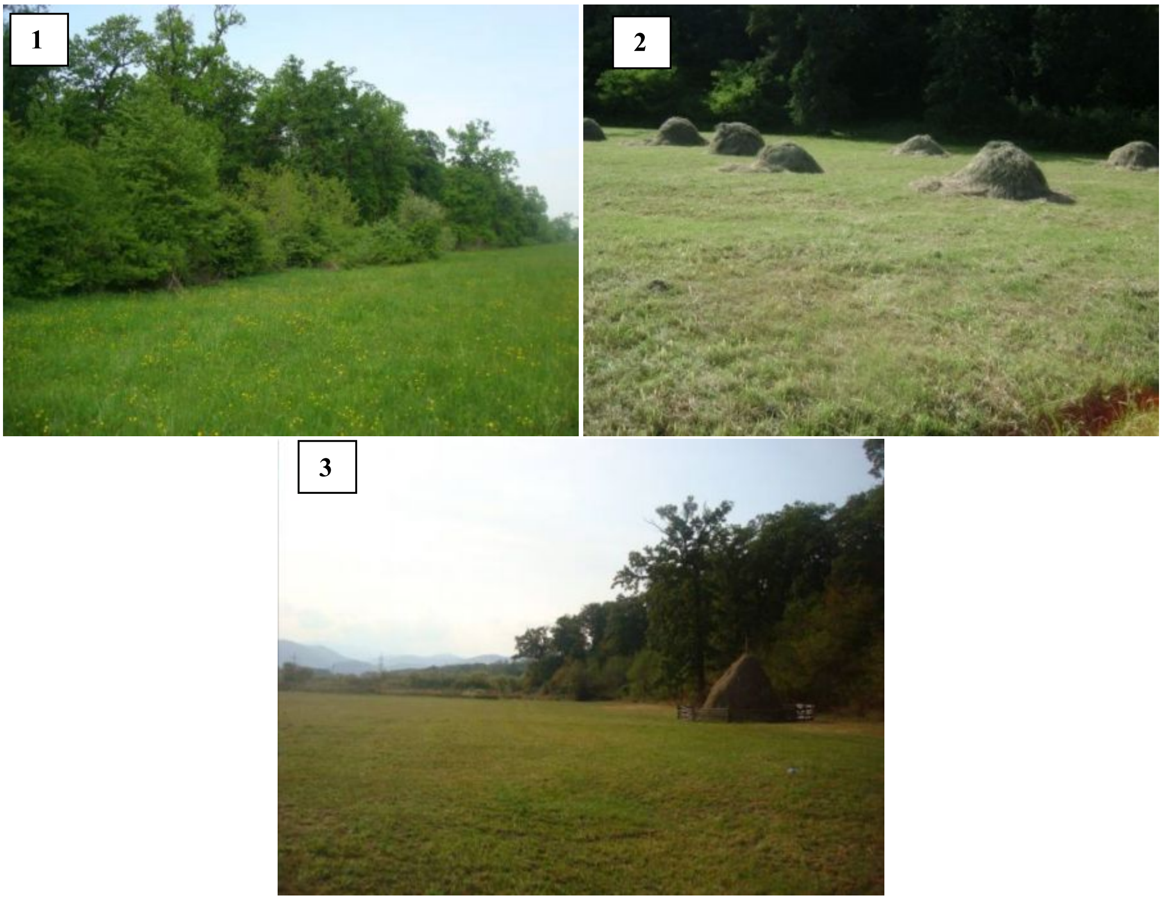

Figure 2. The studied grassland, images from each month of collection 1-July (VII), 2-August (VIII), 3-September(IX), year (foto. orig.)

We calculated the similarity coefficient for all batches of samples collected during the three years of research, and found that there is correlation between the diversity of species of the *Heteroptera* complex in two successive moments. The values we have obtained range from -0.5 and -0.8, which proves that the territories are somehow connected in terms of species abundance.

RESULTS

3.1.Faunal composition

Following examination of site samples, the faunal composition of the studied grassland appeared to be as follows: as shown in (Figure 3) during the 3 years of the study the population of arthropods has reached the maximum value in July of each year (2012 to 8459 specimens, 2013-9573 specimens, 2014-8765 specimens), a total of 26.797 collected specimens. This is due to the fact that in this particular month there was a thick and tall grassy layer, before the first mowing. The decrease of the number of specimens in the following months: 26.797 specimens in July, 12.209 specimens in August and 10.416 specimens in September was the result of the grassy layer regressing after mowing. In such conditions, the arthropod population migrates, it may also occupy other biocenosis, in this case the neighboring hayfield from the western part that has not been mowed yet, the agricultural crops in the northern side or the eastern forest of the studied grassland.

In terms of entomofauna composition the main orders of insects studied (Figure 4,5,6,), the prevalence in descending order throughout the three-year study period was *Heteroptera*: 21.1% (2012); 23.1% (2013); 21.9% (2014); *Collembola*: 17.7% (2012); 17.9% (2013); 18.8% (2014); *Homoptera* 18.3% (2012); 18.7% (2013); 18.8% (2014) 16.9%; *Diptera* 14.06% (2012), 13.06% (2013), 13.5% (2014). The *Coleoptera* occupies a high share in July 5.4% (2012); 5.1% (2013); 5.2% (2014) and then decreases in August: 4.3% (2012); 4.6% (2013), 4.9% (2014) and in September it can be observed a further increase in their numbers 5.6% (2012); 5.1% (2013); 5.3% (2014).

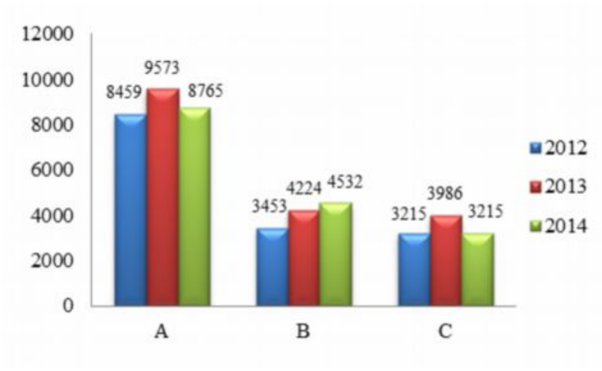

Figure 3. The global dynamics of arthropods during the three years (2012, 2013, 2014) and during the three months of collection (A-July, B-August, C-September)

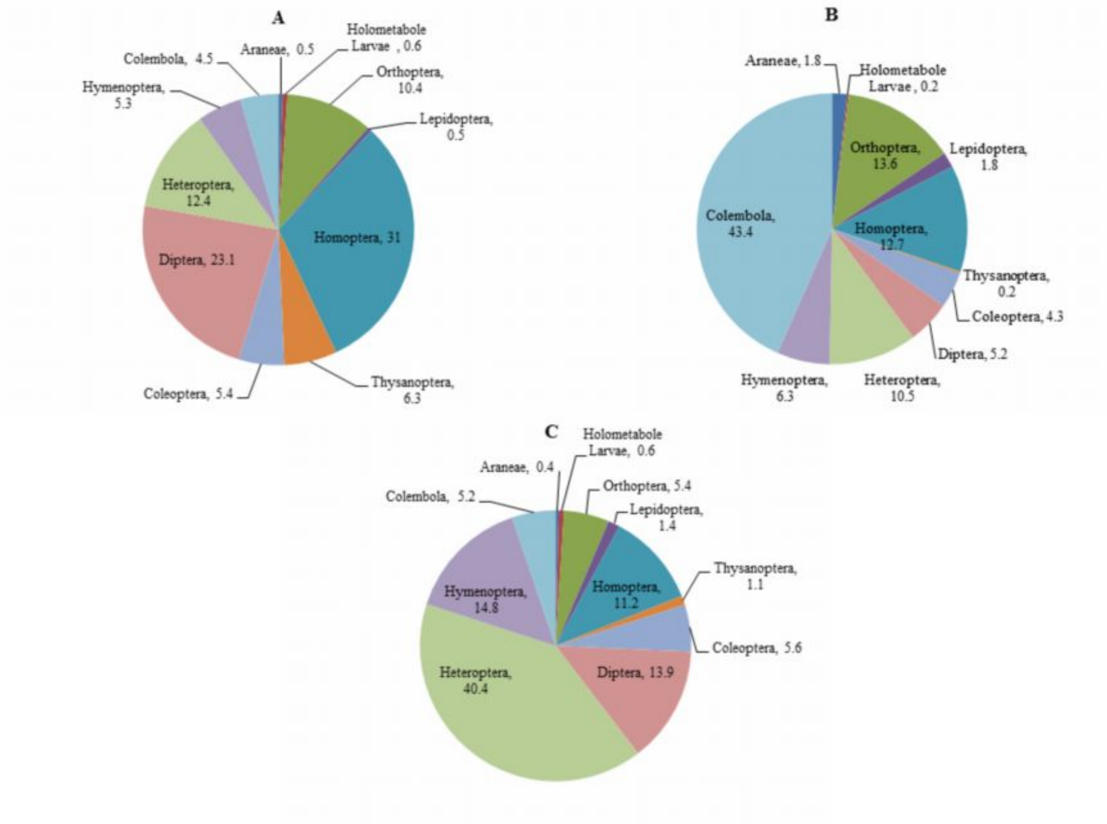

Figure 4. Faunal composition of insects and Araneae (%) in 2012: A-July; B-August; C-September

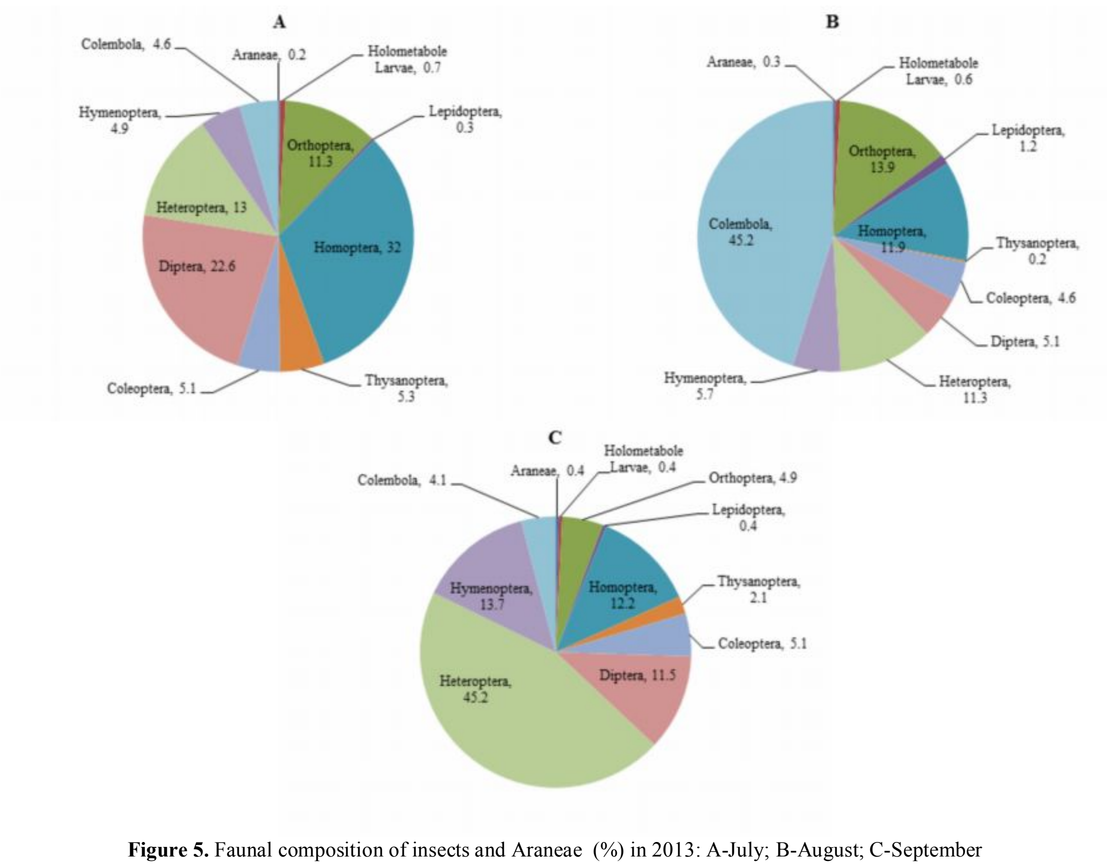

Figure 5. Faunal composition of insects and Araneae (%) in 2013: A-July; B-August; C-September

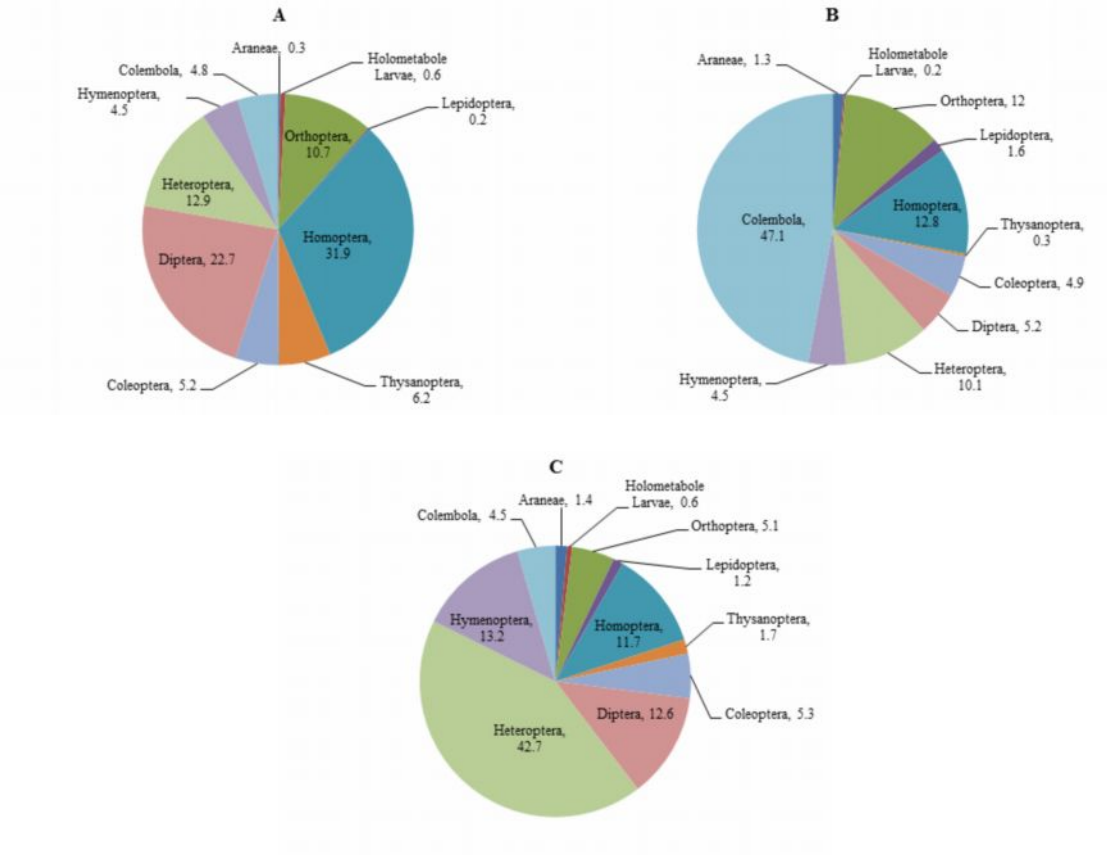

Figure 6. Faunal composition of insects and Araneae (%) in 2014: A-July; B-August; C-September

The *Orthoptera* does not occupy a significant share in the faunal spectrum of the examined grassland. This is explained by the fact that the mesohygrophil structure of the studied hayfield is not favorable to these insect species and Araneae. In the course of the relevant months the share of *Orthoptera* population is: 9.8% (2012); 10.03% (2013), 9.3% (2014). The data obtained during the three years of study reveal that the faunal spectrum of the insects is closely linked to the mesohygrophil nature of the studied grassland [1].

Insect-araneae ratio (Figures 7, 8, 9,). This ratio remains relatively constant throughout the three months of collection and the 3 years of study. This shows the relative stability of the structure of the studied ecosystem.

3.2.Trophic structure

Figure 10 reveals that the dominant species are the in some cases *Diptera*, *Collembola* exceed *Homoptera* and the *Heteroptera*, these insect groups representing the primary food utilization, the main transformer of the organic matter and energy. Therefore the phytophagous insects living on the grassy layer is the main trophic basis of the whole epigynous biocenosis [34]. Zoophagous insects with 24.656 specimens (2012-2014 years) and saprophagous insects with 560 specimens (2012-2014 years) can be found at the surface of the soil transforms the dead plant organic matter, occupying the lowest share. We can reach the conclusion that the energy flow of the food chain is sustained by the presence of phytophagous insects which totaled 16.937 collected specimens (2012-2014 years).

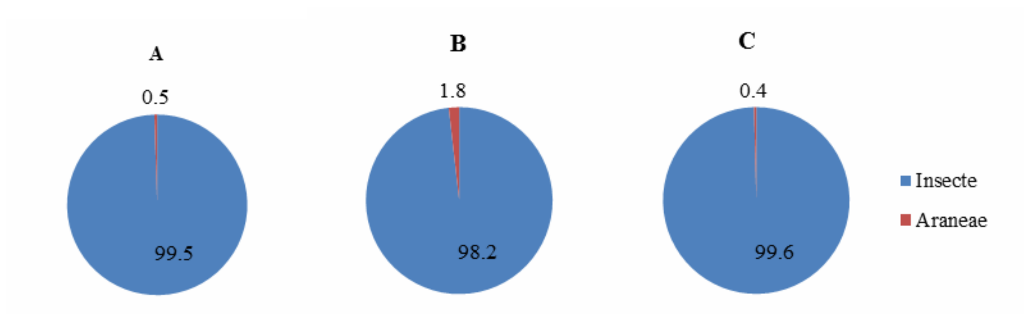

Figure 7. The share of insects and araneae (the percentage represents the number of specimens in the months of collection, year 2012 (A -July, B-August, C-September)

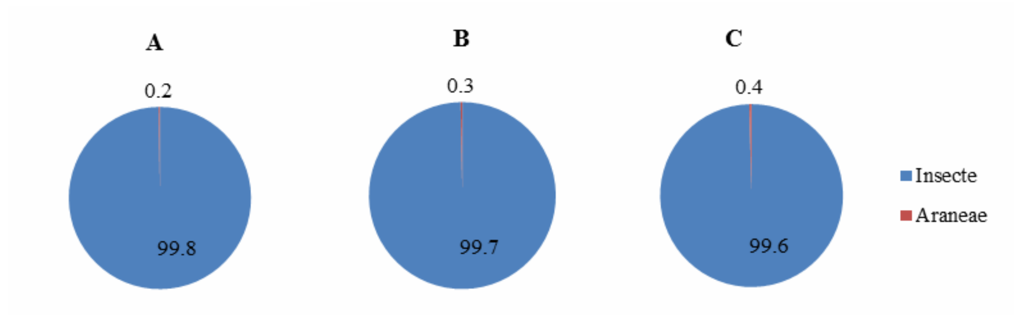

Figure 8. The share of insects and araneae (the percentage represents the number of specimens in the months of collection, year 2013 (A- July; B- August; C- September).

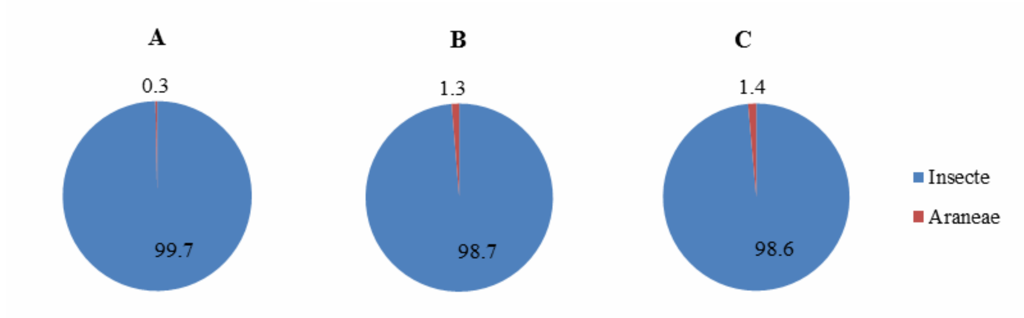

Figure 9. The share of insects and araneae (the percentage represents the number of specimens in the months of collection, 2014 (A- July; B- August; C- September)

3.3.The numerical dynamics of the arthropods

As revealed by the results of three years of investigation, their number decreases after mowing, and the increase of phytophagous insects and decrease of the saprophagous and zoophagous insects can be noted after the grass begins to grow. This decrease of the number of species of zoophagous and saprophagous insects is explained by the fact that after mowing, in the absence of the food sources, until restoration of the wild flora, they are forced to move in the adjacent biocenoses.

3.4.Diversity of Coleopteran

The insects from the *Coleoptera* order caught during the years of research have been studied to family level, this ecosystem component was examined in terms of its temporary diversity.

As shown by Figures 12, 13, 14 the number of the coleopteran has a maximum value in July, being represented of several families, namely: *Coccinellidae*: 4.4% (2012); 4.2% (2013); 4.2%, (2014). *Crysomelidae*: 24.6%, (2012); 24.8% (2013), 25%, (2014); *Curculionidae*: 59.8% (2012); 58.3% (2013); 58.7% (2014); *Staphylinidae*: 3.5%, (2012); 3.9% (2013); 3.5% (2014); *Nitidulidae*: 2.3%, (2012); 3%, (2013); 2.3% (2014); *Lathrididae*: 4.6%, during 2012; 4.5 % (2013) and 4.6% (2014). *Scarabeidae*: 3.7%, (2012); 4.6% (2013), 4.1%, (2014).

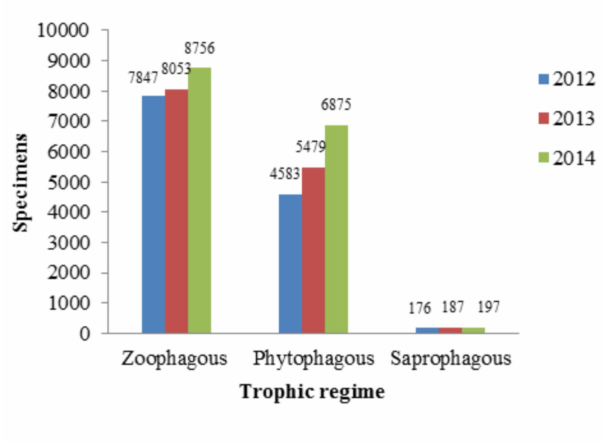

Figure 10. Quantitative ratio between zoophagous, phytophagous and saprophagous insects

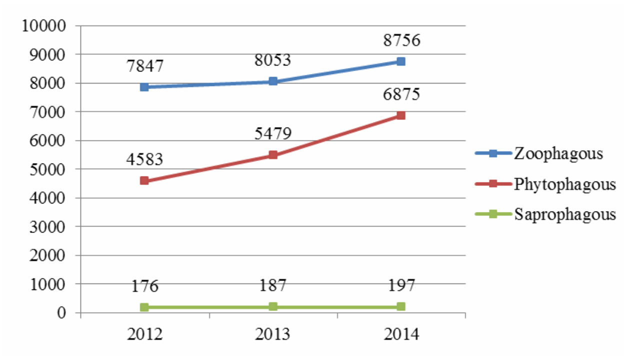

Figure 11. Numerical dynamics of the phytophagous and zoophagous insects

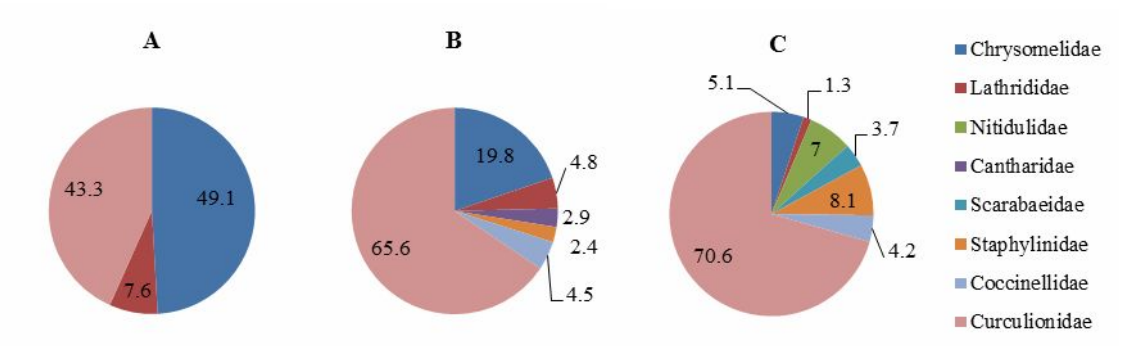

Figure 12. The faunal spectrum (%). The share of families in the insect order *Coleoptera* during the three months of collection (A-July), (B-August), (C-September) of the year 2012

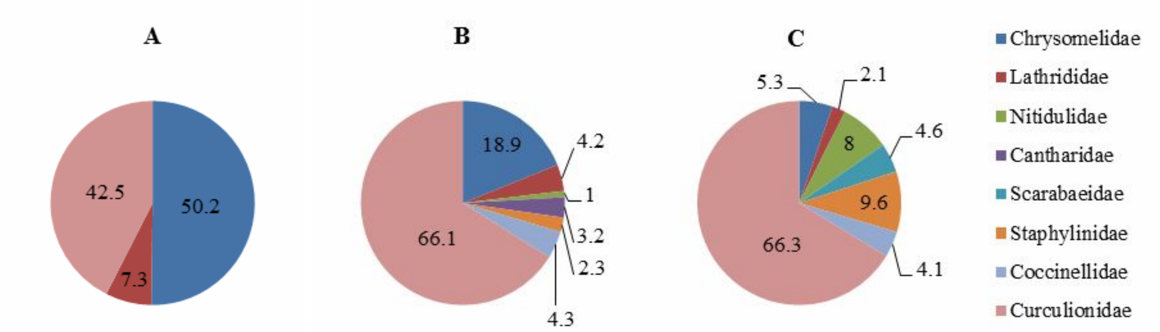

Figure 13. The faunal spectrum (%). The share of families in the insect order *Coleoptera* during the three months of collection, (A-July), (B-August), (C-September) of the year 2013

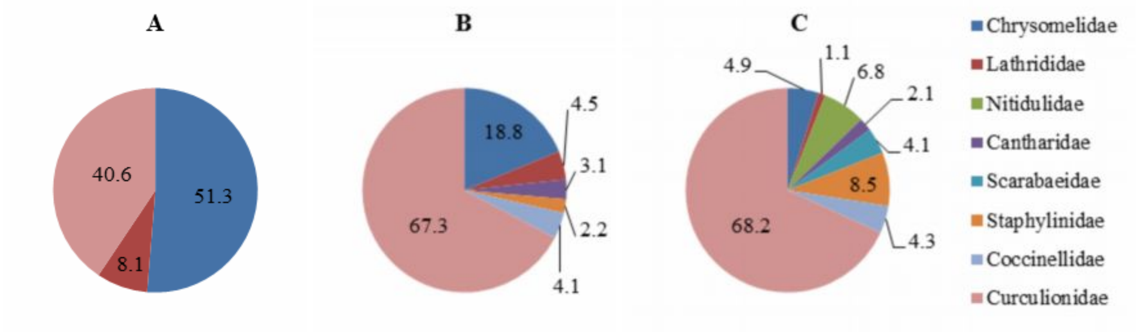

Figure 14. The faunal spectrum (%). The share of families in the insect order *Coleoptera* during the three months of collection (A-July), (B-August), (C-September) of the year 2014

In August and September there is a sudden change of dominance due to mowing which determines the microclimate change, causing decrease in humidity and in the amount of light reaching the soil. In the first months, the species of the *Curculionidae* family are predominant and then, in September, the share *Chrysomelidelor* increases. All the other *Coleoptera* families are represented by a small number of species.

3.5.Diversity of heteropteran

The insects from the insect order *Heteroptera* have been studied in terms of species and diversity. It is known that the *Heteropteran* insects are a systematic group of insects that play an important role in the system of interrelations within the natural and agricultural biocenosis. Most of them are phytophagous insects, which may weaken the biological resistance and the production of plants. Other species have proved to be biotic agents of viral disease transmission to the crop plants. In exchange, some species of *Miridae* and all species of *Anthocoridae*, *Reduviidae* and *Nabidae*, play the role of secondary consumers in the agrobiocenosis food chains, that by destroying a large number of small insects like aphids, coleopteran and their larvae, reduce the primary consumers, contributing to keeping a stationary and dynamically balanced ecosystem [20].

Following inventorying the *Heteroptera*, 22 species have been identified. Many of them are represented by a single specimen, which shows the high diversity of the complex. Table 1 shows that the number of species reaches a maximum count in July and then suddenly decreases due to mowing. The violent breakage of biocenotic connections after mowing caused disturbance in the development of the dominant species complex [21].

At the beginning of September, with the growth of the grassland vegetation, the complex restores to the initial condition. In terms of numerical dynamics of the *Heteroptera* groups, as Table 1 shows it, the dominant

Table 1. Variation in the number of species of *Heteroptera*

Hetereroptera spp.	**2012**			**2013**			**2014**		
	A (July)	**B** (August)	**C** (September)	**A** (July)	**B** (August)	**C** (September)	**A** (July)	**B** (August)	**C** (September)
Adelphocoris lineolatus	45	2	4	36	-	5	43	-	5
Adelphocoris seticornis	8	-	5	3	1	7	9	2	4
Aelia acuminata	3	-	-	1	-	-	2	1	-
Alydus calcaratus	1	-	2	1	2	5	-	-	1
Corpocoris purpureipennis	3	1	2	4	1	-	6	2	3
Dolycoris baccarum	2	1	-	1	-	-	2	-	3
Eurygaster testudinaria	2	1	-	4	3	7	3	1	-
Eusarcornis aeneus	6	2	5	4	1	2	7	3	1
Exolygus pratensis	5	2	4	3	-	1	4	1	-
Exolygus rugulipennis	3	-	12	3	2	15	2	1	4
Halticus apterus	645	213	759	735	231	846	719	175	761
Dictyonota tricornis	5	1	17	-	2	19	1	3	21
Leptoptera dolobrata	34	7	15	45	14	23	20	4	11
Plagiognathus chrysanthemi	75	2	1	54	1	-	65	2	-
Nabis rugosus	54	23	36	21	15	62	34	12	45
Notostira erratica	-	-	31	-	5	1	-	-	13
Orius niger	3	-	1	4	1	3	7	2	9
Orthocephalus vittipennis	7	2	5	2	3	11	2	-	1
Orthops campestris	1	-	3	2	-	5	1	-	1
Orthops kalmi	1	5	4	3	2	7	1	-	3
Strictopleurus parumpunctatus	2	1	-	6	1	4	9	1	5
Trigonothylus ruflicornis	27	7	9	31	3	11	15	2	7

species is represented by the oligophagous insects (Figure 11). A variation in the number of specimens namely in July, when it is quite high, and then it considerably decreases after mowing could be noted within this group.

DISCUSSION

The results of our research show that the studied mesohygrophil grassland is an ecosystem composed of a large number of elements, both in terms of systematic group number (*Heteroptera, Collembola, Homoptera, Diptera*, *Coleoptera, Orthoptera*) and the number of species (year 2012-15.127 specimens, year 2013-17.783, year 2014-16.512 specimens) collected totalizing 49.422 specimens. During the 3 years, 22 species of the *Heteroptera* Order have been reported. The identification of the other groups of arthropods up to the level of species prevents us from determining the total number of species. Compared to the large number of insect species, the plant species from the wild flora appear to be less diversified, and that the specific weather conditions of each year [20] influenced the numerical ratio of arthropods in the studied grassland.

In terms of fauna, the studied grassland is a Central North European type of hayfield similar to the ones from the Bavarian region in Germany [35] or Switzerland [1] where has been studied the ecological effect of arthropods on an intensively exploited grassland, where the *Diptera* and *Homoptera* and *Collembola* prevail as well, while the *Orthoptera* and the Lepidoptera do not contribute substantially to building the biocenosis.

The ratio between the other insect orders vary according to the literature data [9, 17, 22- 25, 34]. Our study found an approximately equal share of insects from the order *Diptera* and the order *Homoptera*, while the species from the order *Orthoptera* and the order Lepidoptera has been poorly represented in the studied biocenosis, over the years and periods of collection, the months: July (VII), August (VIII), September (IX). Biologically, the arthropod species abundance within the area of the grassland promotes the ecosystem functions, and the insect species of the order Lepidoptera and the order *Hymepoptera* are pollinators; the zoophagous insect species with the largest share play a role in the biological control pests of crop plants grown in agricultural parcels around the grassland.

According to our data, the different taxonomy and ecological groups significantly vary in terms of species and spatial expansion, being exposed to disruption by a violent external factor such as mowing of July. Nonetheless, we would like to underline that the mowing caused no change in the overall quantitative composition of the grassland. As previously shown, the insect-araneae ratio has remained relatively constant throughout the three years of study and all the periods of collection, the order based distribution of insects hasn't been significantly changed, the values obtained being very similar. The diversity of the *Heteroptera* species and of the other groups has been deeply affected by mowing as [10] observed in his study.

The hayfield is repopulated after mowing partly by the return of emigrant species or wind-blown species in the surrounding areas of the grassland, but also by the growth of juvenile specimens that have survived in the adjacent soil areas.

The research has been conducted over 3 years on the meadow at the borders of "Dumbrava Sibiului" Forest (Sibiu, Romania), providing us a huge amount of information in terms of time and space values of the monitored parameters, and dynamics of arthropods as well. The study of ecological diversity index, on the one hand enables a more complete characterization of the structure and of the role of arthropods in biocenosis activity and, on the other hand, a quantitative comparison of its components.

REFERENCES

[1] Albrecht, M., Schmid, B., Obrist, M. K., Schüpbach, B., Kleijn, D., Duelli, P., (2010): Effects of ecological compensation meadows on arthropod diversity in adjacent intensively managed grassland. Biological Conservation, 143: 642–649.

[2] Bucşa, C., Curtean, A., (1995): Studiul cenologic al scolitidelor (Coleoptera: Scolytidae) din Pădurea Dumbrava Sibiului. Acta Oecologica, 2: 25-50 (in Romanian).

[3] Bucşa, C., Curtean, A., (1996): Cerambicide xilofage (Cerambycidae; Coleoptera) din Parcul natural Pădurea Dumbrava Sibiului. Acta Oecologic, 2: 21-35 (in Romanian).

[4] Bucşa, C., (1997): Anobiide (Coleoptera: Anobiidae) xilofage din Pădurea Dumbrava Sibiului şi Muzeul "Astra" Sibiu. Acta Oecologica, 4: 5-26 (in Romanian).

[5] Bucşa, C., (2002): Perioadele de zbor la coleopterele xilofage (Insecta: Coleoptera) din Parcul Natural Pădurea Dumbrava Sibiului. Acta Oecologica, 2:111-124 (in Romanian).

[6] Bucşa, C., (2004): Coleoptere entomofage, saprofage şi parazite asociate coleopterelor xilofage din Parcul natural Dumbrava Sibiului. Studii şi Comunicări Muzeul Brukenthal-Ştiinţele Naturii, 29:128-138 (in Romanian).

[7] Bucşa, C., Tăuşan, I., (2011): Istoricul cercetarilor entomologice din împrejurimile Sibiului. Lucrari al Simpozionului Biodiversitatea şi Managementul insectelor din România, 179-200 (in Romanian).

[8] Drăgulescu, C., (2003): Sibiu County Cormoflora. Brasov, Romania: Pelecanus Publisher, 533 p.

[9] Kleijn, D., Sutherland, W.J. (2003): How effective are European agri-environment schemes in conserving and promoting biodiversity? Journal of Applied Ecology, 40: 947–969.

[10] Manhart, C., Marschalek, H., Karg, J., (2004): Renaturierung feucht-nassen Grünlands im Voralpenraum. Untersuchungen zur Vegetationsentwicklung sowie zur Biomasse und Diversität bei Insekten. Natur und Landschaft, 79(6): 257-263 (in German).

[11] Manole, T., Mărgărit, Gr., Dănulescu, M., (1993): Unele aspecte ecologice cu privire la fauna dăunătoare şi utilă din ecosistemele de pajişti din zona Braşov. Analele Institutului de Cercetări pentru Protecţia Plantelor Bucureşti, 25:79-88 (in Romanian).

[12] Manole, T., Mărgărit, Gr., Dănulescu, M., (1996): Cercetări privind entomofauna dăunătoare şi utilă din culturile de graminee perene de pajişti din zona pedoclimaticăp Braşov (II), Analele Institutului de Cercetări pentru Protecţia Plantelor Bucureşti, 27:147-164 (in Romanian).

[13] Manole, T., Iamandei, M., Dănulescu, M., (2002): The possibility to characterize the grassland ecosystems from Braşov district with the biodiversity indexes (V), Research of grassland production and utilization Braşov, 128-131.

[14] Moise, C., Sand, C., (2012): Research on Macrolepidoptera species (Insecta: Lepidoptera) collected In Dumbrava Sibului Forest (Romania) in conditions of the year 2011 and their status line in IUCN 2001 system. The Annals of Oradea University. Biology fascicle, 1: 55-66.

[15] Moise, C., (2014): The butterflies red list (Insecta: Lepidoptera) collected from Dumbrava Sibiului forest (Romania) during 2001-2012. The Annals of Oradea University. Biology Fascicle, 1: 39-44.

[16] Moise., C, Tanase, M., (2013): Researches on the epigeous entomofauna in the Dumbrava Sibiului oak forest (Sibiu, County, Romania). The Annals of Oradea University. Biology Fascicle, 1: 89-96.

[17] Morris, M.G., (2000): The effects of structure and its dynamics on the ecology and conservation of arthropods in British grasslands. Biological Conservation, 95: 129–142.

[18] Perju, T., Dănulescu, M., (1997): Stadiul actual al cercetărilor ştiinţifice privind fauna de insecte a pajiştilor de graminee din România. Buletinul Informativ Societatea Lepidopterologică Română. Cluj-Napoca, 8: 155-162 (in Romanian).

[19] Perju, T., Dănulescu, M., Malschi, D., Oltean, L., (2002): Ecological evaluation of entomofauna from pasture and grasses forage cultures. Research of grassland production and utilization. Braşov, 141-121.

[20] Perner, J., Wytrykush, C., Kahmen, A., Buchmann, N., Egerer, I., Creutzburg, S., Odat, N., Audorff, V., Weisser, W., (2005): Effects of plant diversity, plant productivity and habitat parameters on arthropod abundance in montane European grasslands. Ecography, 28: 1-14.

[21] Plantureux, S., Peeters, A., McCracken, D., (2005): Biodiversity in intensive grasslands: Effect of management, improvement and challenges. Agronomy Research, 3: 153-164.

[22] Pywell, R.F., Warman, E.A., Hulmes, L., Hulmes, S., Nuttall, P., Sparks, T.H., Critchley, C.N.R. and Sherwood, A., (2006): Effectiveness of new agri-environment schemes in providing foraging resources for bumblebees in intensively farmed landscapes. Biological Conservation, 129:192–206.

[23] Schweiger, O., Maelfait, J.P., Wingerden, W., Hendrickx, F., Billeter, R., Speelmans, M., Augenstein, I., Aukema, B., Aviron, S., Bailey, D., (2005): Quantifying the impact of environmental factors on arthropod communities in agricultural landscapes across organizational levels and spatial scales. Journal of Applied Ecology, 42: 1129–1139.

[24] Siemann, E., (1998): Experimental tests of effects of plant productivity and diversity on grassland arthropod diversity. Ecology, 79: 2057–2070.

[25] Sjödin, N.E., Bengtsson, J., Ekbom, B., (2008): The influence of grazing intensity and landscape composition on the diversity and abundance of flower-visiting insects. Journal of Applied Ecology, 45(3): 763-772.
[26] Stancă-Moise, C., (2012): Macrolepidopterele din Pădurea Dumbrava Sibiului, Sibiu, Romania: ”Lucian Blaga” University of Sibiu Publisher, 271p.
[27] Stancă-Moise, C., Tănase, M., (2013): Researches on the epigeous entomofauna in the Dumbrava Sibiului oak forest (Sibiu, County, Romania), The Annals of Oradea University. Biology fascicle, 20(2): 89-96.
[28] Stancă-Moise, C., (2014): Diversity and the main ecological requirements of the epigeic species of forest ecosystems in the Sibiu county, in the years 2013-2014. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 14(3): 323-326.
[29] Stancă-Moise, C., (2015): Contributions to (Coleoptera: Staphylinidae) in Dumbrava Sibiului forest, Romania in terms of the years 2013-2014. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 15(1):301-305.
[30] Stancă-Moise, C., (2015): Information on the Macrolepidoptera fauna of “Dumbrava Sibiului” oak forest (Sibiu, Romania), The Annals of Oradea University. Biology fascicle, 22(1): 33-46.
[31] Stancă-Moise, C., (2015): Observations on Coleoptera fauna from the Dumbrava Sibiului forest (Sibiu, Romania) in the 2015 yea, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 15(3):289-292.
[32] Stancă-Moise, C., (2015): The presence of species *Morimus funereus* Mulsat, 1862 (long horned beetle) Coleoptera:Cerambycidae in a forest of oak conditions, 2015. Scientific Papers Series Management Economic Engineering in Agriculture and Rural Development, 15(4):315 -318.
[33] Spânu, S., (2012): The pluviometric regime in Cibin hydrographic basin. Acta Oecologica Carpatica Sibiu, 13-18.
[34] Stugren, B., (1982): Bazele ecologiei generale. Editura Ştiinţifică şi Enciclopedică Bucureşti. 147-178 (in Romanian).
[35] Zahn, A., Rodrigues, L., Rainho, A., Palmeirim, J., (2007): Critical times of the year for Myotis myotis, a temperate zone bat: roles of climate and food resources. Acta Chiropterologica, 9(1): 115-125.
[36] Zahn, A., Englmaier, I., Drobny, M., (2010): Food availability for insectivores in grasslands – arthropod abundance in pastures, meadows and fallow land. Applied Ecology and Environmental Research. Budapest, Hungary, 8(2): 87-100.

Received: 13 January 2016
Accepted: 2 April 2016
Published Online: 4 April 2016
Analele Universităţii din Oradea, Fascicula Biologie
http://www.bioresearch.ro/revistaen.html
Print-ISSN: 1224-5119
e-ISSN: 1844-7589
CD-ISSN: 1842-6433
University of Oradea Publishing House