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Terrestrial invertebrate communities from Resighea region (Satu-Mare County, Romania)

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Abstract: The purpose of this study is to make an inventory of the terrestrial invertebrate taxa in a plain region with three types of habitat: grassland, canopy and leaf litter, the samples being collected with different methods. The study took place between May and September 2008, thus revealing the dynamics of the invertebrate community also. We have calculated the diversity indexes for all habitats, established the trophic specialization and constancy of the groups. We found out that the most diverse habitat and the richest in species and individuals was the leaf litter habitat.

Keywords: grassland invertebrates, canopy, leaf litter, dynamics, diversity, Romania.

Introduction

The researches on terrestrial arthropods from the western part of Romania are scarce and almost inexistent for Resighea region except some studies on the Heteroptera fauna (Bud 2006) and terrestrial Isopoda fauna (Moisa 2006, Tomescu et al. 2008).

Recent studies on terrestrial invertebrates from Satu-Mare County were made in the lower course of Tur River during the inventory of flora and fauna of the Tur River Natural Reserve. These studies focused on the following invertebrate groups: Odonata (Szállassy 2008), Homoptera (Orosz 2008), Lepidoptera (Szabó 2008), Formicidae (Kiss & Fetykó 2008), Araneae (Fetykó 2008).

The aim of this study was to establish the composition of different terrestrial invertebrate communities from the main habitats of Resighea region. The objectives were to inventory the invertebrate groups from the canopy, grass and leaf litter, to elucidate the structure of communities according to the vegetation and to determine their diversity in the three different habitats.

Materials and methods

Study area

Satu-Mare County is located in the north-western part of Romania. Resighea village (47°36' N, 22°19' E) belongs administratively to Pişcolt village and it is situated in the south-western part of the county (Fig.1). The studied region is located in a subunit of the Western Plain (Câmpia de Vest) named Careiului Plain (Câmpia Careiului), at an altitude of 143 m. This plain is a great sand accumulation with relief of dunes planted with vineyards.

The Careiului Plain where the studied area is located was declared Natura 2000 site as a Special Area of Conservation code ROSCI0020. The surface of this site is about 24,224 ha.

The sampling sites were located between Resighea and Scărişoara Nouă villages. The area is made from sand dunes in alternation with swamps and small ponds (Fig.2). Samples were collected from a swamp, sand dunes and the neighbouring forest.

The swamp has dense vegetation consisting mainly of *Calamagrostis canescens*, *Carex* sp., *Phragmites communis* and other smaller plant species. The sand dunes are covered by a typically steppe vegetation represented by *Festuca*, *Corynephorus* and other Poaceae. The herbaceous vegetation contains patches of shrubs. The forests from this area are remains of the oak forests (or ash and elm forests) which covered in the past almost the whole county, or consist of *Robinia pseudacacia* (black locust) plantations.

Sampling and Data analysis

The invertebrates were sampled from May to September in 2008. We have collected a number of 28 samples from which 12 were sweep net samples, 10 leaf litter concentrator samples and 6 umbrella net samples.

The samples were selected in a laboratory under a 40X stereo microscope, submerged in 70% ethylic alcohol, followed by the identification and taxonomic classification of invertebrates (Crişan & Cupşa 1999, Crişan & Mureşan 1999, Cupşa

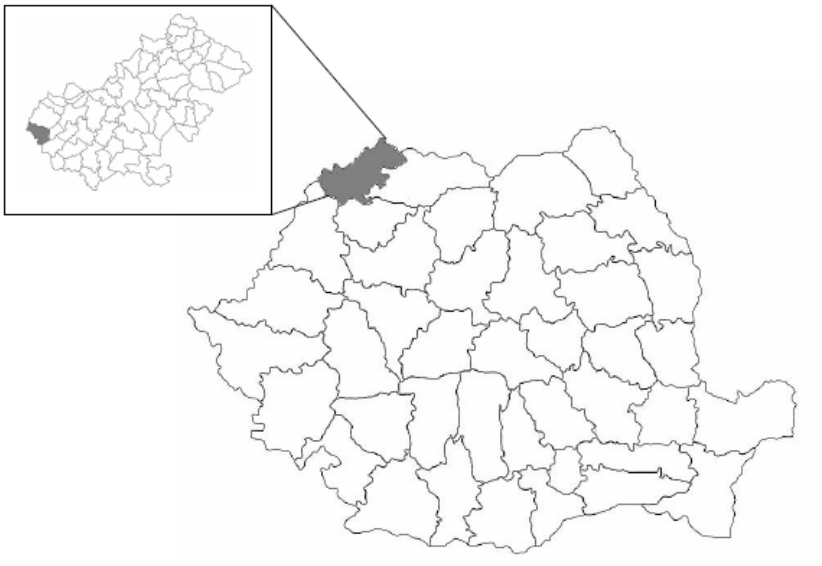

Figure 1. Location of the studied area in Romania

Figure 2. General view of the research area.

2004) and by the statistical interpretation of the results, after computing: the frequency, the constancy, the abundance, the Margalef index (D_1), the Simpson index (I), the Shannon-Wiener index (H), the evenness index (E) (Burcă 2004, Sîrbu & Benedek 2004). In order to draw the conclusions corresponding graphic representations were made.

Results

In the 28 samples collected with the three different sampling methods, we identified a number of 18,895 specimens belonging to 27 taxonomic groups (or insect larvae). The highest number of specimens 3,187, was found in sample 17 collected in July by leaf litter

concentrator. The lowest number (10) belongs to sample 10, collected in August, by the same method (Table 2). The highest number of taxa collected by this method was 17 and the lowest was 4. By this sampling method we have collected both the highest and lowest number of specimens and taxa during the study period.

In the samples collected by sweep net method the number of taxa ranged between 9 (samples 1 and 4, May) and 14 (sample 20, August), the number of specimens varied between 63 (sample 1, May) and 1684 (sample 26, September). In the samples collected by umbrella net the number of taxa ranged from 7 (sample 3, May) to 12 (sample 28, September) and the number of specimens varied from 108 (sample 14, July) to 224 (sample 28, September) (Table 1).

In the samples collected by sweep net the highest abundance is held by Brachycera in 4 samples (1, 7, 11, 16), followed by Cicadellidae (samples 19, 20, 24, 26) Afidina (sample 10), other Homoptera (sample 2), Heteroptera (sample 13) and adult Coleoptera (sample 4). The lowest value of abundance was obtained for Acarina (sample 26), followed by Gastropoda (sample 16), Collembola (sample 7), Orthoptera (sample 1), Thysanoptera (sample 20), Heteroptera (samples 2 and 10), Coleoptera larvae (sample 13), Lepidoptera adults (samples 11, 16 and 24), Lepidoptera larvae (sample 24), Hymenoptera (sample 4) and Mecoptera (sample 19) (Table 1).

The highest frequencies in the samples collected by sweep net were determined for Araneae, Heteroptera, adult Coleoptera, Formicidae and Brachycera, all these having a frequency of 100%. The lowest frequency 8.33%, was obtained for Thysanoptera, Coleoptera larvae, Tipulidae and Mecoptera (Table 1). The constancy reflects that 28% of the taxa are euconstant, 29% constant, 14% accessorial and 29% accidental (Fig. 3).

Table 1. Abundance (%), frequency of the invertebrate taxa (%) and diversity indexes of the samples collected from the studied area by sweep net, during May – September 2008.

	1 9.V	2 9.V	4 9.V	7 6.VI	10 6.VI	11 6.VI	13 4.VII	16 4.VII	19 9.VIII	20 9.VIII	24 5.IX	26 5.IX	F%
Gastropoda	0	0	0	0	0	0	0.32	0.1	0.28	0.48	0.19	0.48	50
Araneae	17.46	3.85	8.82	5.97	17.05	2.13	11.66	7.45	21.7	9.65	11.58	5.88	100
Acarina	1.59	2.2	0	0	0	0.16	2.86	3.36	0.83	2.74	18.33	0.06	75
Collembola	0	4.4	0	0.32	0	2.29	10.29	2.62	4.31	4.29	5.98	0	66.66
Orthoptera	1.59	20.33	22.06	1.81	2.33	6.16	2.01	3.67	0	0	0	0.3	75
Thysanoptera	0	0	0	0	0	0	0	0	0	0.24	0	0	8.33
Homoptera – Aphidinae	1.59	0	0	9.91	25.58	16.11	3.92	4.41	1.25	2.03	0.83	0	75
Homoptera – Cicadellidae	0	0	0	13.11	5.43	13.11	11.56	16.58	31.57	44.58	25.08	61.94	75
Homoptera larvae	9.52	34.07	2.94	0	0	0	0	0	0	0	0	0	25
Heteroptera	4.76	0.55	2.94	1.17	0.78	1.18	31.6	5.25	3.89	2.74	1.78	2.08	100
Coleoptera (adults)	19.05	5.49	26.47	9.49	8.53	3.16	6.79	3.25	8.62	5.36	3.12	2.85	100
Coleoptera (larvae)	0	0	0	0	0	0	0.21	0	0	0	0	0	8.33
Lepidoptera (adults)	0	0	2.94	0.85	5.43	0.08	0	0.1	0.42	0.6	0.13	0.18	75
Lepidoptera (larvae)	0	0	0	0.64	3.1	0	0	0.31	0	0.36	0.13	0.36	50
Hymenoptera - Formicidae	11.11	6.59	7.35	6.72	3.1	2.61	0.85	0.84	1.39	0.83	0.95	0.18	100
Other Hymenoptera	0	3.3	1.47	7.57	6.98	2.13	0.85	7.45	1.81	2.98	6.87	4.1	91.66
Diptera – Tipulidae	0	0	0	0	0	0	0	0	0	0	0.25	0	8.33
Diptera – Brachycera	33.33	19.23	25	40.83	20.16	50.71	17.07	44.39	21.97	22.05	24.76	21.62	100
Mecoptera	0	0	0	0	0	0	0	0	0.14	0	0	0	8.33
Unidentified insects	0	0	0	0	1.55	0	0	0	0	0	0	0	8.33
Unidentified larvae	0	0	0	1.6	0	0.16	0	0.21	1.81	0	0	0	33.33
No. taxa	9	10	9	11	10	12	12	13	13	14	13	11	
No. individuals	63	182	68	938	129	1266	943	953	719	839	1571	1684	
Shannon index	1.8	1.83	1.81	1.91	2.09	1.61	2	1.86	1.85	1.77	1.91	1.2	
Simpson index	0.81	0.8	0.81	0.78	0.85	0.69	0.83	0.76	0.79	0.74	0.82	0.56	
Margalef index	1.93	1.73	1.9	1.75	2.26	1.68	1.75	2.04	1.98	2.08	1.77	1.48	
Evenness	0.82	0.79	0.82	0.74	0.84	0.63	0.78	0.69	0.7	0.65	0.72	0.48	

Table 2. Abundance (%), frequency (%) of the invertebrate taxa and diversity indexes of the samples collected from the studied area by umbrella net and leaf litter concentrator, during May – September 2008.

	umbrella net							leaf litter concentrator									
	3 - 9.V	8 - 6.VI	14 - 4.VII	23 - 9.VIII	25 - 5.IX	28 - 5.IX	F%	5 - 9.V	6 - 9.V	9 - 6.VI	12 - 6.VI	15 - 4.VII	17 - 4.VII	18 - 9.VIII	21 - 9.VIII	22 - 9.VIII	27 - 5.IX	F%
Oligochaeta	0	0	0	0	0	0	0	21.36	17.69	2.32	2.33	1.68	0.09	0	4.08	0.46	0	80
Gastropoda	0	0.9	0.93	2.31	1.59	0	66.66	15.53	27.69	8.57	19.77	19.86	1.98	70	23.31	3.24	14.51	100
Pseudoscorpionida	0	0	0	0	0	0	0	2.91	1.54	0.53	1.16	0.45	0.72	10	0.23	2.31	1.06	100
Araneae	2.78	7.24	21.3	64.62	34.92	12.5	100	0	0	0.92	3.49	3.1	0.63	10	3.15	0.46	11.08	80
Opiliones	0	0	0	0	0	0	0	0	0	0	0	0.19	0	0	0	0	0.26	20
Acarina	0	0	0.93	0	0	4.02	33.33	8.74	23.08	54.02	20.93	30.27	51.27	0	36.01	28.24	6.86	90
Isopoda	0	0	0	0	0	0	0	0	1.54	0.97	0	3.69	0	0	3.26	0	0.53	50
Diplopoda	0	0	0	0	0	0	0	1.94	1.54	2.95	2.33	3.49	0.91	10	2.1	1.89	2.64	100
Chilopoda	0	0	0	0	0	0	0	0	0.77	0.44	0	1.03	0.44	0	0.7	0	0.26	60
Collembola	0	0	9.26	0.77	0	0	33.33	1.94	7.69	19.99	31.4	14.55	16.88	0	11.31	5.56	25.86	90
Orthoptera	0	0	0	0	0	0.45	16.66	0	0	0	0	0	0	0	0	0	0.26	10
Psocoptera	0	0	0	0	0	19.2	16.66	0	0	0	0	0	0	0	1.63	0	16.09	20
Thysanoptera	0	0	0	0	0	0	0	0	0	0.05	0	0.13	0	0	0	0.93	0	30
Homoptera Aphidina	48.33	9.5	0	0	0	0.45	50	0	2.31	0.29	0	6.86	12.11	0	0	0.46	0	50
Homoptera Cicadellidae	0.56	13.12	0	6.15	0	2.68	66.66	0	0	0.15	0	0.19	0	0	0.12	0.46	0	40
Homoptera larvae	0	1.81	8.33	0	1.59	0	50	0	0	0	0	0	0	0	0	0	0	0
Heteroptera	0	12.67	0.93	2.31	1.59	9.38	83.33	0	0	0	0	0	1.6	0	0.58	44.91	0	30
Coleoptera (adults)	10.56	0	25	4.62	37.3	26.79	83.33	3.88	2.31	2.47	1.16	4.98	1.29	0	6.06	1.39	3.69	90
Neuroptera	0	0	0	0.77	0	10.27	33.33	0	0	0	0	0	0	0	0	0	0	0
Lepidoptera (adults)	0.56	0	1.85	0	0.79	0	50	0	0	0	0	0	0	0	0	0	0	0
Lepidoptera (larvae)	0	0	4.63	0	3.17	3.57	50	0	0	0	0	0	0	0	0	0	0	0
Hymenoptera Formicidae	10	23.08	12.96	3.85	0.79	0	83.33	0.97	6.92	2.37	1.16	0.58	1.69	0	2.8	1.39	6.33	90
Other Hymenoptera	0	14.03	3.7	1.54	16.67	8.04	83.33	0	0	0.44	0	0.32	0.31	0	0.7	0.46	0.53	60
Diptera – Brachycera	27.22	15.84	8.33	10	1.59	2.86	100	0.97	0	0.58	0	1.03	0.41	0	0.47	0	1.58	60
Other Diptera (larvae)	0	0	0	0	0	0	0	41.75	6.92	0	16.28	0	0	0	0	0	0	30
Mecoptera	0	0	0	0.77	0	0	16.66	0	0	0	0	0	0	0	0	0	0	0
Unidentified larvae	0	1.81	1.85	2.31	0	0	50	0	0	2.95	0	7.57	9.66	0	3.5	8.33	8.44	60
No. taxa	7	9	11	11	9	12		9	12	16	10	17	14	4	16	14	15	
No. ind.	180	221	108	130	126	224		103	130	2066	86	1546	3187	10	858	216	379	
Shannon index	1.33	2.04	2.12	1.39	1.48	2.08		1.67	1.97	1.08	1.75	2.11	1.57	0.94	1.99	1.63	2.17	
Simpson index	0.67	0.86	0.86	0.57	0.71	0.85		0.75	0.83	0.66	0.8	0.83	0.68	0.53	0.79	0.71	0.86	
Margalef index	1.16	1.67	2.56	2.26	1.86	2.03		1.94	2.26	2.1	2.02	2.31	1.74	1.3	2.37	2.6	2.53	
Evenness	0.68	0.89	0.83	0.56	0.64	0.84		0.73	0.79	0.38	0.76	0.73	0.58	0.68	0.7	0.6	0.78	

All indexes have the highest value in the case of sample 10 and the lowest for sample 26 (Table 1).

In the samples collected by umbrella net the highest abundance was determined for Araneae (sample 23), followed by Homoptera (sample 3), Coleoptera adults (samples 25 and 28) and Formicidae (sample 8). The lowest value of abundance was obtained for sample 28 in the case of Orthoptera and Afidinae, followed by Lepidoptera adults and Cicadellidae (sample 3), Collembola and Neuroptera (sample 23), Formicidae (sample 25), Gastropoda (samples 8 and 14), Acarina and Heteroptera (sample 14) (Table 2).

The highest values of frequency in the samples collected by umbrella net were determined for Araneae, Brachycera (100%), followed by Heteroptera, Coleoptera adults, Formicidae, other Hymenoptera (83.33%). The lowest values of frequency are held by Orthoptera, Psocoptera and Mecoptera (16.66%) (Table 2). The constan-

cy revealed that 32% of the species are euconstant, 11% constant, 41% accessorial and 16% accidental in the habitat (Fig. 4).

The diversity indexes have the highest values for sample 14 and the lowest for sample 3 excepting Simpson index which is the lowest in the case of sample 23. The evenness has the highest value for sample 8 and the lowest for sample 23 (Table 2).

In the samples collected by leaf litter concentrator the value of abundance is the highest in the case of Gastropoda in sample 18, followed by Acarina in sample 9 (but also with high abundance in samples 12, 15, 17, 21), Heteroptera (sample 22), Diptera larvae (sample 5) and Collembola (sample 27). The lowest abundance was obtained for Thysanoptera (sample 9), followed by Oligochaeta (sample 17), Afidina (samples 22), Cicadellidae (sample 21 and 22), Chilopoda, Opiliones (sample 27), Araneae (sample 22), Pseudoscorpionida (sample 12) (Table 2).

The highest values of frequency in the samples collected by leaf litter concentrator were determined for Gastropoda, Pseudoscorpionida, Diplopoda (100%) followed by Acarina, Collembola, Coleoptera adults and Formicidae (90%). The lowest values of frequency were obtained for Orthoptera (10%), Psocoptera, Opiliones (20%), Thysanoptera, Heteroptera and Diptera larvae (30%) (Table 2). The constancy displayed that 40% of the taxa are euconstant, 17% constant, 26% accessorial and 17% accidental (Fig. 5).

The calculated indexes have the highest value for sample 27 and the lowest for sample 18. The evenness has the highest value in sample 6 and the lowest in sample 9 (Table 2).

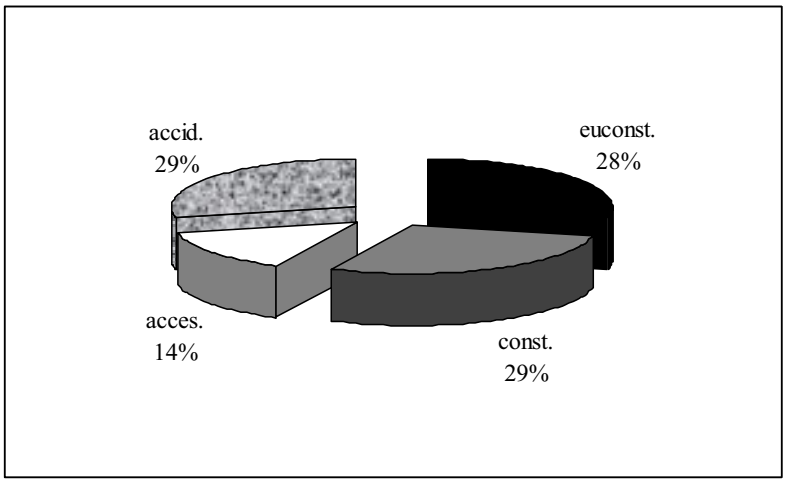

Figure 3. Constancy of the invertebrate taxa collected from the studied area by sweep net, during May – September 2008.

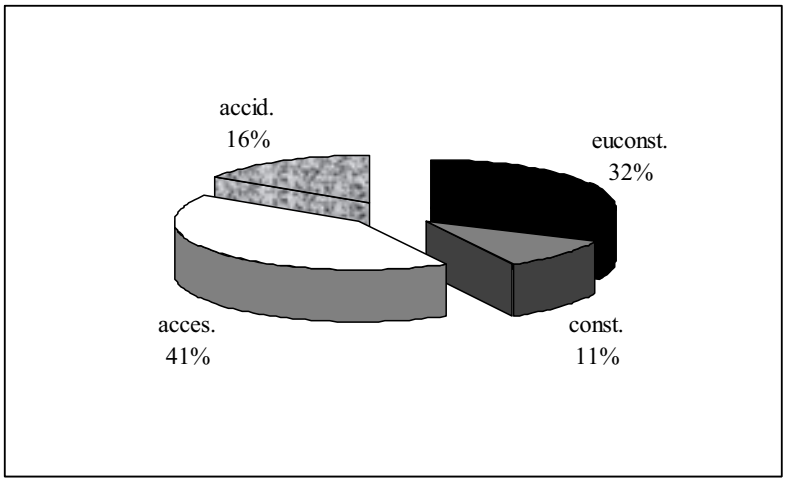

Figure 4. Constancy of the invertebrate taxa collected from the studied area by umbrella net, during May – September 2008.

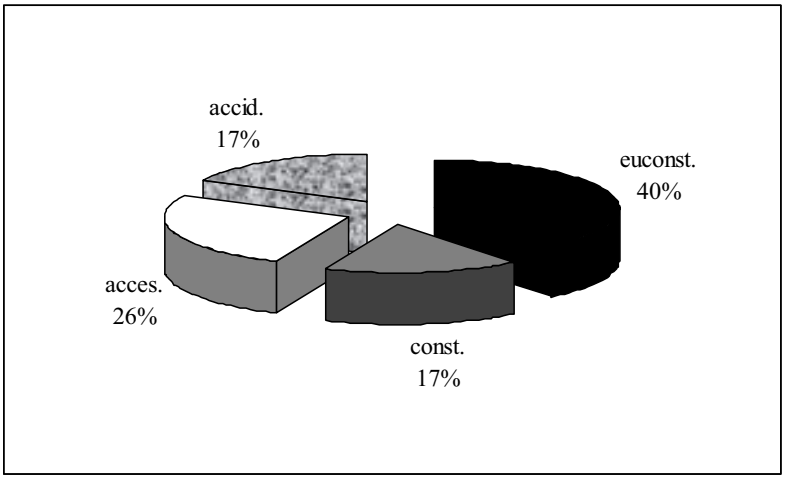

Figure 5. Constancy of the invertebrate taxa collected from the studied area by leaf litter concentrator, during May – September 2008

Discussion

By the sweep net method we can collect arthropods that occur on the vegetation and insects which do not fly very much or very well. Samples by this method were taken during the morning when insects are slower due to low body temperature.

During the five month of the study a number of 8,089 specimens were collected with this method, 313 in May, 1067 in June, 1896 in July, 1558 in August and 3255 in September. The number of individuals and species increases from spring to summer, together with the rising of temperature. This factor determines the hatching of the imagos of insect species. Insects are also dependent on the phenology of vegetation in grasslands, on the development of vegetative organs of plants in the warm season, because these offer a good trophic base for phytophagous species and also shelter.

The almost double number of specimens in September compared to the previous months is due to the great increase of Cicadellidae and Diptera. In the studied area in September the air temperature was high enough to allow insects to be active, vegetation was still present and provided the necessary trophic base. At the same time, by the end of summer a new generation of insects hatched from the eggs laid down in the previous months.

Concerning the trophic specialisation of the collected invertebrates, most of them were phytophagous species (around 55.55%), followed by omnivorous (33.33%) and predatory species (11.11%) (Fig.6). The predators are represented by few species from Araneidae, Mecoptera and Coleoptera groups. This fact is due to the sampling method's characteristics which allow the capture of species living on the vegetation for most of the time. But one of the most important predatory groups, the Carabidae, cannot be sampled by this method, because they rarely climb the vegetation, generally they are found on the ground and they are the most important and numerous predators in grassland ecosystems (Varvara & Zugravu 2006, Varvara & Apostol 2008).

Gastropods, the unique group which does not belong to arthropods were observed during July and September when most of them climbed the vegetation for aestivation, as a response to high temperatures and low precipitations in this period of the year (Prior 1985, Attia 2004).

Thysanoptera were observed only once in August, when we found one individual. This fact shows that this group has a very scarce distribution in the investigated area. Thrips are sensitive to the abiotic factors of the environment especially to high temperature and aridity (Vasiliu-Oromulu 2004a,b). Therefore, it is not surprising that we found this low number of thrips in the investigated area which is very arid and has hot summer.

Coleoptera larvae were found only once in July. The vegetation in the studied area is dominated by xerophytic Gramineae which is not a very good nutritive substratum for Coleoptera species with larval stages on plant leaves.

Mecoptera and Tipulidae were observed only once in August. They are usually forest or humid area inhabitants and appear rarely in the grasslands near the forests, but they do not settle here because the temperature and aridity are too high (Crişan & Cupşa 1999, Cupşa 2004, Pritchard 1983).

6 of the observed taxa are euconstant and were found during the entire study period. From the euconstant taxa the Aranea have the highest abundance and

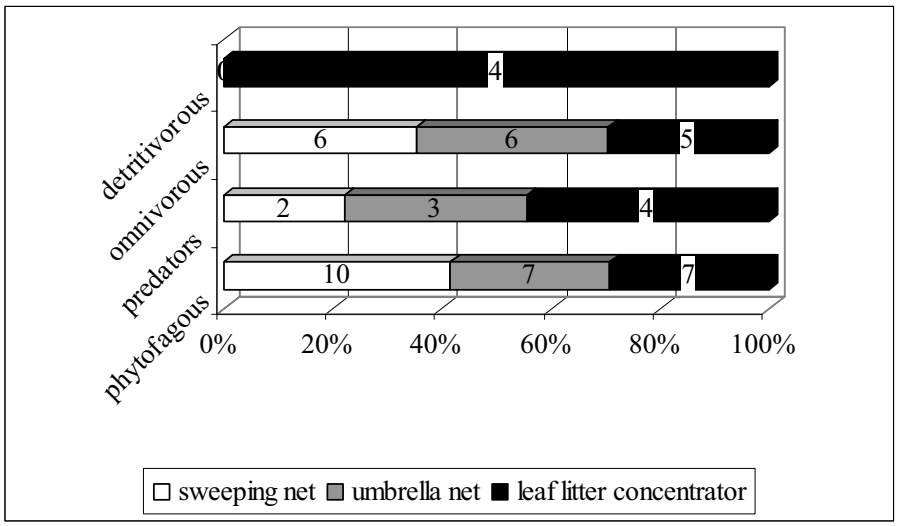

Figure 6. Trophic structure of the invertebrate fauna collected with the three sampling methods.

represent an important control element of the community as predators. They face with success the anthropic impact and the variable abiotic factors (Jeanneret et al. 2005).

Heteroptera are also euconstant, but their abundance is low except sample 13 from July when we found a great number of specimens in larval stage. Their abundance's values from the rest of the sampling events are very similar. The higher number of specimens in the summer period is due to the larvae hatching after reproduction.

Formicidae species are present in a relatively constant number during the entire study period; their abundance is significant in the samples in which the total number of individuals is low. In those samples the Formicidae seems to be more abundant, but the total number of individuals does not vary much comparing with other months. The general abundance of Formicidae is low because they are highly mobile species and explore all kind of habitats searching for food (Heron 2005). Formicidae are more abundant on soil than on grassy vegetation because on soil we can found their colonies and nests and also because they are less tolerant to high temperatures (Heron 2005).

The other Hymenoptera groups are also euconstant and have a higher abundance than Formicidae with the exception of May. Unlike other observations (Cameron & Bryant 1999) which indicate that Hymenoptera are a very abundant group in the grassland, we found a low abundance due to the vegetation type of the studied area, which mostly consist of Gramineae and other anemophilous grasses that do not attract Hymenoptera pollinators which are almost absent in the samples (Kwaiser & Hendrix 2008).

Brachycera are almost the most abundant group in all months. The number of species and individuals depends greatly on the presence of host plant species on which Brachycera species are feeding or larvae are developing (Boucher 1998).

From the constant groups the Acarina have small abundances except sample 24 from September in which their abundance was very high. This is probably due to the hatching of a new generation as a consequence of the reproduction during the summer period. Collembola had low abundances throughout the entire study period, because they are not usually found on vegetation, more commonly we can found them on the soil and in more humid habitats (Cupşa 2004).

Orthoptera were observed in every period of the study, excepting August. In September their number was very low. The greatest number of individuals was found in May, because in this period of the year the specimens are in nymph stage and they are small and can be easily caught with the sweeping net. In the following period of the year the imagos, which are more mobile, hatch and thus the capturing success of Orthoptera decreases.

Aphidina were observed during the entire study period, but their abundance is low in May and September. In June they reach the highest abundance as a result of the parthenogenetic reproduction. In August and September their abundance drops again, because some adults die and their density decrease (Teodorescu et al. 2003).

The collected Cicadellidae belong almost exclusively to *Cicadella viridis* species. We have observed in May only individuals in juvenile stage. Starting with June the adults hatched and their abundance increased in every month till September. This observation is according to the studies of other authors (Pavan & Gambon 2004).

Lepidoptera were encountered during the entire study period with low abundances, because they are a very mobile group, difficult to collect with the sweeping net method. We captured especially Microlepidoptera and nocturnal species which were resting during the day on the vegetation. Larval stages were found from June with a low abundance because the vegetation consists of xerophytic species which are not a very good trophic base for a diverse Lepidoptera community.

The number of species collected with this method is relatively constant during the study period, except May when we observed fewer species because in this period of the year appear especially those species which are less thermophilous as the hatching of larva from eggs depends on the temperature of the environment. For the phytophagous species the development of the aerial parts of grasses is essential because these constitute the trophic base for this group. The number of individuals follows almost the same tendency except September when the number of the specimens is more than double compared to August. This great increasing is due to the high number of Cicadellidae and Diptera collected in this month.

The lowest value of diversity was observed in sample 26 in which Cicadellidae have a high abundance (61.94%), followed by Diptera Brachycera (21.62%), the other groups having very small abundances. For the same reasons, the evenness is the lowest in this sample (Table 1).

The arthropod community is based mostly on phytophagous species which are closely related to the vegetation structure and diversity and their density is controlled by the predatory Araneidae group and also by Carabidae found on the ground.

By the umbrella net method we have collected invertebrates from the canopy which feed on the tree leaves or prey on the phytophagous groups.

The total number of specimens collected with this method was 889 varying between 108 in sample 14 from July and 224 in sample 28 from September. The relatively high number of individuals in May proves that the leaves from the canopy were already well developed and allowed the feeding of phytophagous invertebrates which thus had an adequate trophic base. Concerning the trophic specialization 7 taxa representing 43.75% are phytophagous, 3 representing 18.75% are predatory and 37.5% are omnivorous or parasitic (Fig. 6). The great percent of phytophagous species is due to the availability of their trophic base represented by tree leaves and flowers.

Diptera had a greater abundance in May and June than in the other months, probably due to the better developed trophic base in these months in the canopy (leaves and inhabiting arthropods) than in the grassland, where the plants need more time to develop their aerial organs.

Heteroptera are probably missing only in May because they spend their winter in the forest floor in the leaf litter and become active when temperature is high enough to determine their mobility needed in order to climb to the canopy. In May the samples were collected in the date of 9th and the temperature in this period was not high enough to activate some invertebrates. Hymenoptera are missing for the same reason and also because some of the species spend the winter in egg stage and need time to hatch. The abundance of these two groups is not very high in the canopy samples because they are not characteristic canopy groups.

The absence of Coleoptera in June is probably haphazardly as they reach high abundances almost throughout the entire study period except August. The increased abundance in September is due to the hatching of the new generation from eggs laid down in early summer. Formicidae are lacking in September when probably they descent from the canopy and remain close to their nests because of lower air temperatures during autumn (Yanoviak et al. 2008). Their abundance was the highest in June in correlation with the high abundance of Afidina, which are one of their most important food resource in the canopy (Rico-Gray & Oliveira 2007).

Gastropods are constant in the canopy lacking only in May and September. This fact is due to the temperatures of these two months, in May gastropods are not yet active and in September they are looking for wintering habitats. In the rest of the periods they are present with a small abundance. The canopy offers them good trophic base and protection against drying out. Aphidina were constant during the study period lacking in July and in sample 25 from September. This is due to the fact that in their life cycle they move from trees to herbaceous plants and also in definite period of the year alate specimens are lacking and the sampling by umbrella net will not contain apteran Afidina which are better attached to canopy leaves. The abundance of the group remains low during the entire study period.

Acarina were found only in July and September probably due to the sampling method, which cannot reveal some of the Acarina species because they are living attached with their mouthparts to the leaves. We presume this because the number of canopy Acarina spe-

cies is usually relatively high (Walter & Behan-Pelletier 1999).

Collembola usually occur in tree canopies but are more abundant where there are epiphytic plants or canopy soils (Yanoviak et al. 2003).

We encountered Orthoptera once, in sample 28 and their presence in the canopy is accidental, they usually live in the grass, but those species that can fly may be found on smaller trees.

Psocoptera were identified in only one sample (28). Like Collembola they also occur in tree canopies with many epiphytic plants (Southwood et al. 2005).

Homopteran larvae were present in June, July and in sample 25 from September. Their abundance is the highest in July, probably due to the hatching from eggs laid down during spring.

The abundance of Neuroptera is greater during early autumn (September) and especially at the edge of forests and in bushes (Duelli et al. 2002).

The low abundance of the Lepidoptera adults is due to the fact that this sampling method allows adults to fly away, so only few of them can be collected. The low abundance of larvae shows that the number of species and their density is not very high in the canopy.

Mecoptera were observed only in August with low abundance. Mecoptera prefer the forest habitat where they are living in the herbaceous fringe (Duelli et al. 2002).

The evenness is the greatest in June. The lowest value of the diversity was observed in May for Shannon-Wiener and Margalef indexes, when Aphidina were very abundant (48.33%), followed by Diptera Brachycera (27.22%), and the other groups had very small abundances. For Simpson index the lowest value was obtained in August, when the Araneae were very abundant compared with other groups (64.62%) The evenness is the lowest in this sample for the same reasons (Table 2).

The arthropod community is based mostly on phytophagous species which are closely related to the vegetation structure and diversity and their density is controlled by the predatory Araneidae. The canopy samples were mainly collected from isolated trees or tree groups from the grassland, so they do not contain many typical forest species, but mostly grassland species which can climb trees and feed on them.

The samples collected by leaf litter concentrator method produced the highest number of specimens 8,581. The samples from June and July contained the greatest number of individuals (e.g. sample 17 from July had 3,187 specimens). The lowest number of specimens (10) was identified in sample 18 from September. This sample was collected from a sandy area, where the vegetation was scarce and the insolation very high. The temperature at the ground level was too high for the most of the species.

The trophic spectrum of the collected invertebrates is diversified; we found a great number of detritivorous taxa characteristic for the leaf litter. Some of the groups (Oligochaeta, Diplopoda, Isopoda) were missing in the samples collected with the other two methods. Also, there are present specific predators such as Pseudoscorpionida, Opiliones and Chilopoda. The proportion of phytophagous species is 35% due to the herbaceous stratum of the forest which offers a trophic base for these species and also constitutes a refuge for the grassland phytophagous species during the hot summer season. The proportion of omnivorous species is 25% and that of predators 20%; these two groups are more diverse than in the previously studied habitats (Fig. 6).

Oligochaeta are euconstant and are absent only from sample 18, in August, when the lack of precipitations forced them to burrow deeper into the soil. They are more abundant in periods when the soil is moistly and then they can be found also in the leaf litter. Gastropoda were found in all samples with relative high abundance even in sample 18 from August when they pass through an aestivation period (Prior 1985, Attia 2004).

We identified Pseudoscorpionida in all samples, but with a low abundance because the samples were collected from a dry land which is not the most preferred habitat of them (Aguiar et al. 2006). At the same time, their presence is directly correlated with the organic carbon content of the soil (da Silva Moço et al. 2009).

Acarina are lacking only in sample 18, in the rest of the samples their abundance is very high and in many samples they are the most abundant group. Their abundance varies between the studied months, the highest values being reached in the summer periods due to the elevated temperatures (Murray et al. 2009).

Diplopoda were observed in all samples with low abundance. They are big sized detritivorous arthropods and have usually low densities in the leaf litter and great species homogeneity (Kappes et al. 2009).

Collembola were identified in all samples excepting that from May when, because of the lower temperature, the decomposing activity in the leaf litter is low and they are not attracted to this type of habitat (Detsis 2000).

Coleoptera were present in all samples except number 18. Their densities were low due to the great mobility of this group, to the scarce food resources (Varvara & Zugravu 2006) and to their relatively great size which not allowed a very high density.

Formicidae were absent in sample 18 and in the other samples had low densities because the leaf litter not provided a good food resource for them. They are

searching for food on vegetation and use the ground mainly as a pass to their nest and food sources (Yanoviak et al. 2008).

Chilopoda were observed in 60% of the samples with low abundances due to the fact that they are predators and very mobile species and occur with relatively small densities in the leaf litter, their density and species' number being dependent on the environmental factor as well (Jabin et al. 2007).

Hymenoptera and Brachycera were identified in 60% of the samples with very low abundances since the leaf litter not represent an adequate habitat for their feeding, because the lack of the herbaceous vegetation which can represent their trophic base.

Isopods were observed in 50% of the samples, their densities were low although they are a typical group of the leaf litter fauna. The investigated forest is a planted one, in a swampy habitat, and perhaps the species which inhabited formerly the swamp did not bear this habitat change and from the neighbouring forests the typical forest isopods penetrated only in small extent.

Thysanoptera were observed in 30% of the samples and they have low abundances. Considering that they are parasites on herbaceous plant species this fact was expectable (Vasiliu-Oromulu 2004a,b).

Heteroptera were observed in 30% of the samples they being present from July with low abundances. Most species from the grassland seek winter shelter in the forest (Teodorescu et al. 2003). Also, some of them can feed on herbaceous species from the forest floor.

Opiliones were identified in 20% of the samples with small abundances. They are mobile species and abound in habitats with high productivity and also compete for their preys with Araneae (Shochat et al. 2004).

Orthoptera occur accidentally. They come from the nearby grassland and are not typical for the leaf litter.

Psocoptera were encountered only in August and September. They are thermophilous and moist habitat species which occur with low abundance even in the tropical climate (Anu et al. 2009).

All three diversity indexes have the highest values in September when the number of species and individuals are not very great (15 groups, 379 specimens) and none of the groups has very high abundance. The lowest value of diversity was recorded for sample 18 which had only 4 groups and 10 individuals. The evenness is highest in May, for sample 6 when the different groups have close values of abundance and the lowest value was obtained for sample 9 in which Acarina have a very high abundance (over 50%) (Table 2).

The high percent of constant and euconstant groups reveals that the invertebrate community from the leaf litter is a stable one, more stable compared to that of the other two investigated habitats.

We observed that in the grassland the relative uniformity of the flora conduced to a not very diverse invertebrate community, but the low human impact (lack of grazing and cutting of plants) allowed invertebrates to develop dense populations. In the canopy the low diversity of tree species determined a relative uniformity of the community. Also the small extent of the forest led to a community composed especially of accessorial and accidental species. The leaf litter was more diverse; however because of the small surface of the forest and the aridity of the habitat some of the species had low abundance. The forest is a planted one and occupies a former swamp, thus some of the forest species had to immigrate from the remnants of the neighbouring natural forests.

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