PREDATOR SOIL FAUNA WITH IMPACT ON DEFOLIATOR POPULATIONS FROM OAK FORESTS OF MOLDAVIA

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Abstract

The study of soil fauna was carried out in the spring of 2002, in 11 oak forests, placed in the basin of Siret river infested, by defoliators (Tortrix viridana, Geometridae, Apethymus filiformis, Noctuidae). The biological material (78310 specimens) collected from 31 Barber trap batteries (12 traps/battery with concentrated salt solution) was classified from systematical and food regimen point of view.

Structure and abundance of soil fauna depends on site and stand characteristics, level of infestation with defoliators and influence of anthropic factor (pollution, chemical treatments).

A special role in maintaining the biocenotical balance is played by predator soil fauna. The most important groups of predators from the studied forests are coleopters from the families Carabidae and Staphylinidae and spiders and mites from orders Aranea and Acarina (genus Eutrombidium).

Carabidae species with a special impact on oak defoliators are Abax ater, A. ovalis, Carabus coriaceus, C. excelens, C. violaceus, Harpalus pubescens, H. griseus, H. calceatus, Calosoma inquisitor, Molops piceus, Pterostichus sp., Notiophilus sp..

The predator soil fauna reacts obviously at direct and indirect action of stress factors like chemical treatments, which diminish the available food.

Keywords: biological control, oak defoliators, predator soil fauna

INTRODUCTION

The complexity of trophic relations established in forests ecosystems requires very good knowledge regarding faunistical communities, including defoliator insects.

Oak forests, frequently affected by defoliators (Lymantria dispar, Tortrix viridana, Geometridae, lately Apethymus filiformis), are interesting from the identification of self protection resources point of view and the study of natural factors which maintain the defoliator population at low level of density is very important. On of these factors, less studied in our country, is predator soil fauna.

The object of our study was to identify the main predators in order to quantify their impact on defoliators populations in some oak forests.

MATERIAL AND METHODS

Fieldwork was carried out in oak forests infested by the main defoliators (Tortrix viridana, Geometridae, Apethymus filiformis), inventorying pest populations and collecting soil fauna.

In the spring of 2002 we established the caterpillars (larvae) densities and real defoliation. In order to capture soil fauna were installed under the crown of sample trees, around the trunk, Barber traps, in batteries of 12 pieces in cross, at a distance of 1m of each other. A very concentrated salt solution was used as conservant. The samples were collected at 30-40 days in the period 15th of April-15th of July. The components of soil fauna were identified in the lab, being analysed and classified on systematical categories and food regimens.

RESULTS

The level of infestation with oak defoliators

Experimental plots were placed in 11 oak forests (mainly Quercus petraea stands), from the basin of Siret river, infested by defoliators, at altitudes of 150-450m (table 1).

The infestation with caterpillars (larvae) of Tortrix viridana, Geometridae, Apethymus filiformis, Noctuidae varied in these forests from very low (Paltinata-Caiuti) to very high (Cornatel-Caiuti, Popesti-Podul Iloaiei, Bunesti-Raducaneni, Valea Teiului-Husi).

In fact the values of defoliation were smaller than we expected, under 50%. This was the result of the action of natural limitative factors, among which are included predators from soil fauna.

The structure and abundance of soil fauna in oak forests infested by defoliators.

The structure of biological material collected from the 31 Barber traps depends on site and stand conditions, level of infestation with defoliators and influence of anthropic factors (pollution, chemical control, and so on).

Out of table 2 can be observed a much lower participation of some important groups

Table 1. Site and stand elements in oak forests infested by defoliators in experimental plots with Barber traps

Forest direction	Forest district	Forest	Production unit	Management unit	Tipe of forest	Type of station	Type of soil	Altitude	Exposition	Slope	Composition	Age -years-	Consistency	Defoliators density (%) number of larvae/oponed buds T.v.	G.	Af	N	Σ	Prognosed defolation -%-	Real defotion 2002 -%-
			V	45	5111	5153	3101	400	S	25^0	10Go	70	0,8	6,2	2,6	0,0	0,0	8,8	4,8	4,2
		Paltinata	V	62	5113	5152	3101	450	SE	17^0	9Go1DT	85	0,8	6,7	1,7	0,0	0,0	8,4	7,6	7,2
			V	73	5113	5152	3101	310	NV	25^0	9Go1DT	40	0,8	10,1	1,7	0,0	0,0	11,8	10,3	11,0
			VI	18	5121	5142	2407	410	SE	20^0	10Go	130	0,6	7,6	1,2	4,4	1,9	15,1	10,1	25,5
			VI	51	5113	5152	3101	260	S	30^0	10Go	150	0,5	3,4	1,7	6,3	0,0	11,4	9,5	7,8
Bacău	Căiuți	Heltiu	VI	58	5121	5153	3101	380	SV	15^0	10Go	85	0,3	0,0	0,0	0,0	5,7	5,7	6,0	5,7
			VI	68	5111	5153	3101	310	SV	20^0	10Go	100	0,7	2,0	1,5	5,3	0,0	8,8	8,6	4,4
			VI	87	5113	5152	3101	240	E	15^0	10Go	90	0,7	7,1	0,6	4,5	0,0	12,2	11,9	10,6
			VII	9	5111	5153	2401	320	NV	20^0	9Go1Fa	80	0,8	44,1	82,3	0,0	2,0	128,4	109,3	48,7
		Cornățel	VII	40	5111	5153	2401	310	SE	15^0	10Go	60	0,8	35,9	11,9	0,0	0,0	47,8	39,0	23,4
			VII	45	5111	5153	2401	220	E	10^0	9Go1Dt	45	0,8	125,3	19,2	0,0	2,4	146,9	80,5	31,5
			II	20A	5113	7420	2407	220	SV	9^0	9Go1Dt	60	0,8	18,0	39,9	0,0	0,0	57,9	38,0	19,1
Botoșani	Truşești	Dracșani	II	21B	5113	7420	2407	175	NE	10^0	10Go	60	0,8	15,7	47,3	0,0	0,0	63,0	31,9	26,6
			II	22A	5113	7420	2407	160	SV	8^0	10Go	55	0,8	21,6	21,0	0,0	0,0	42,6	29,9	29,1
		Guranda	IV	18A	5323	7420	2407	200	Plan	0^0	3Go4Ca2Ci1Ju	70	0,7	14,0	4,0	0,0	0,0	18,0	10,9	10,0
	Podu Iloaiei	Popești	III	82A	5121	5142	2407	150	NE	10^0	7Go2St1DT	80	0,7	52,1	26,4	0,0	1,8	80,3	51,0	34,7
Iași		Gheorghițoaia	V	30B	6215	7430	2201	200	E	8^0	7St2Ca1Fa	130	0,8	13,6	4,5	0,0	0,4	18,5	15,1	9,0
	Răducăneni	Bacalu	II	16	5312	6153	1601	300	NV	10^0	5St3Pa2Go	25	0,8	7,0	5,0	0,0	1,0	13,0	10,5	9,5
		Bunești	IV	74	5323	6152	2401	300	E	10^0	7Go1Te2Dt	125	0,7	21,0	74,9	0,0	2,0	97,9	51,7	28,8
		Dobrina	III	12	5321	5153	3101	270	V	12^0	6Go2Te1Ju1DT	100	0,9	30,7	25,4	0,0	0,0	56,1	37,4	18,1
			IV	9	5111	5153	1601	250	Plan	0^0	9Go1Ju	100	0,7	68,0	6,0	0,0	3,0	77,0	51,3	7,2
Vaslui	Huşi	Valea Teiului	IV	22	5111	5153	1601	260	NE	10^0	4Go3Ca2Ju1Dt	40	0,8	55,0	24,0	0,0	16,0	105,0	70,0	1,3
			IV	35	5113	5152	1601	280	Plan	0^0	10Go	130	0,7	44,0	46,0	0,0	1,0	91,0	47,9	29,6

x - plane treatment with Sumi-Alpha ULV

Tv - Tortrix viridana
G - Geometridae
Af - Apethymus filiformis
N - Noctuidae
Ca - Carpinus betulus
Go - Quercus petrae
Dt - Different hard wood species
Fa - Fagus silvatica
Te - Tilia cordata
Ci - Cerasus avium
Ju - Acer campestre
St - Quercus robur

of predators (spiders from orders Opiliones and Aranea, red mites from the family Stigmotrombidiidae, millepedes from the family Lithobiidae, insects from the order Coleoptera-families Carabidae and Staphylinidae) in oak forests from the Trotus Valley (Quercus petraea and mixed stands with Q.petraea) affected by pollution (Petrochemical Combinat Borzesti) and treated frequently against defoliators in the last 20 years. Here the proportion of predator fauna varies between 6,9% in the forest Cornatel and 18,8% in the forest Paltinata (forest district Caiuti-Bacau).

In the other forests from Moldavia, less affected by pollution and chemical treatments, the accumulation of predator populations is higher (18,5% in the forest

Table 2. Structure of soil fauna in some oak forest from Moldavia in the spring of 2002

Food	Sistematical category			x	xx	x	xxx	xxx	x	xxx	xxx	xxx	xxx	xxx
	Class	Order	Family	Păltinata	Heltiu	Cornățel	Drăcșani	Guranda	Popești	Gheorghitoaia	Bacalu	Bunești	Dobrina	Valea Teiului
Predators	Arachnida	Opiliones	-	1,6	1,7	0,6	1,6	25,0	10,4	0,8	12,1	4,4	4,1	7,6
		Aranea	-	6,4	4,9	1,5	11,5	2,2	20,9	3,3	8,2	4,1	2,8	9,0
		Acarina	Stigmotrombidiidae (Eutrombidium)	5,1	2,4	1,1	0,8	2,2	1,1	0,3	1,1	1,2	1,2	2,0
		Pseudoscorpiones	-	0,2	0,03	-	-	-	0,1	-	-	-	-	0,1
	Miriapoda	Chilipoda	Lithobiidae	2,4	0,7	0,2	0,1	0,1	0,2	3,1	0,3	0,4	0,1	0,1
	Insecta	Coleoptera	Carabidae	2,1	1,9	2,4	23,4	19,8	3,5	8,2	7,2	13,5	13,7	20,5
			Coccinelidae	0,02	-	-	-	-	-	-	-	-	-	-
			Dermestidae	0,04	0,01	0,03	-	-	0,2	-	-	0,03	-	-
			Lampyridae	-	0,2	0,05	0,4	0,4	-	0,3	-	0,01	-	0,1
			Staphylinidae	0,6	0,1	0,6	0,9	0,1	0,5	2,9	1,0	0,6	1,3	0,1
		Dermaptera	Forficulidae	0,2	0,1	0,4	0,03	0,5	0,7	0,01	0,1	0,05	0,6	0,6
		Hymenoptera	Braconidae	0,1	0,1	0,02	-	-	0,4	0,3	0,1	0,05	-	-
			Ichneumonidae	0,1	-	0,04	0,03	-	-	0,2	0,1	0,04	-	1,0
		TOTAL INSECTA		3,1	2,4	3,5	24,8	20,8	5,3	11,0	8,5	14,3	15,6	22,3
	Reptilia			-	-	-	-	-	-	-	0,04	-	-	-
	TOTAL PREDATORS			18,8	12,1	6,9	38,8	50,3	38,0	18,5	30,2	24,4	23,8	41,1
Phytophagous	Molusca	Gasteropoda		0,2	0,5	0,08	0,1	-	0,1	0,2	0,01	0,06	0,1	0,2
	Insecta	Coleoptera	Carabidae, Cerambicidae Crryssomelidae, Curculionidae, Elateridae, Halticinae, Lagriidae Scarabeidae	1,2	0,4	0,4	0,5	0,7	0,1	0,6	2,4	1,3	0,5	3,7
		Heteroptera		0,1	0,02	0,02	-	-	0,4	-	0,01	0,2	0,1	0,2
		Homoptera		-	-	-	0,08	-	0,1	0,01	0,09	0,04	1,1	0,1
		Hymenoptera	Aphidae, Cynipidae, Vespidae	0,1	0,04	-	1,2	0,1	0,2	0,2	0,6	-	0,4	0,4
			Tenthredinidae (Apethymus)	0,5	0,8	0,02	-	-	0,1	-	-	-	-	0,1
		Lepidoptera	Omizi	1,8	0,7	1,3	2,0	3,7	5,9	0,2	0,6	3,4	1,2	7,6
	Mamalia	Rodentia		0,01	-	-	0,02	-	0,1	0,1	0,09	-	-	-
	TOTAL PHYTOPHAGOUS			3,9	2,5	1,8	3,9	4,5	7,0	1,3	3,8	5,0	3,4	12,3
Omnivorous	Arahnida, Insecta	Acarina, Coleoptera		34,1	22,5	14,6	18,3	12,0	16,3	40,1	8,6	12,9	37,6	17,2
		Hymenoptera	Formicidae	3,4	49,8	63,8	9,9	7,0	9,3	5,6	31,3	32,6	0,7	3,6
	TOTAL OMNIVOROUS			37,5	72,3	78,4	28,1	19,0	25,6	45,7	39,9	45,5	38,3	20,8
Necrophagous	Insecta	Coleptera	Silphidae, Scarabeidae	1,9	0,3	3,1	10,5	4,8	4,7	10,2	7,5	0,8	5,2	3,5
Detritivorous	Nematoda, Crustacea, Oligochaeta, Miriapoda, Insecta			37,9	12,8	9,8	18,7	21,4	24,7	24,3	18,6	24,3	29,3	22,3
TOTAL SPECIES / BATERY (RELATIV ABUNDACE)				1900	2896	45,84	1497	1154	1272	2328	4601	3646	1099	3361

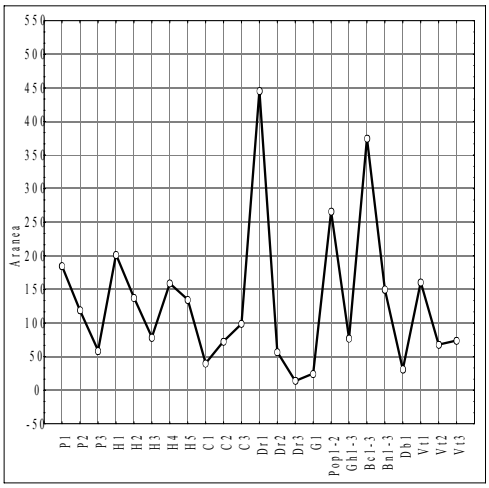

Figura 1 - Relativ abundance of Aranea species in oak forest infested defoliators in the spring of 2002

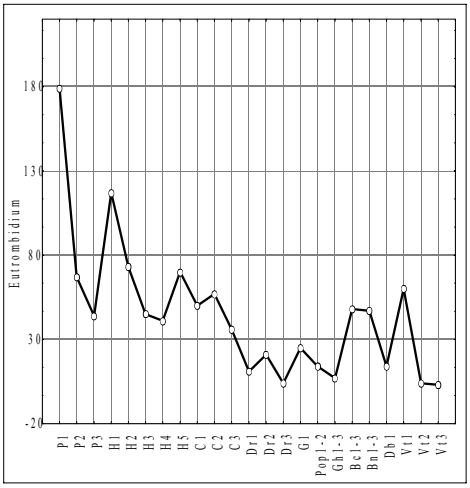

Figura 2 - Relativ abundance of red mites fromgenus Eutrombidium in oak forests infested by defoliators in the spring of 2002

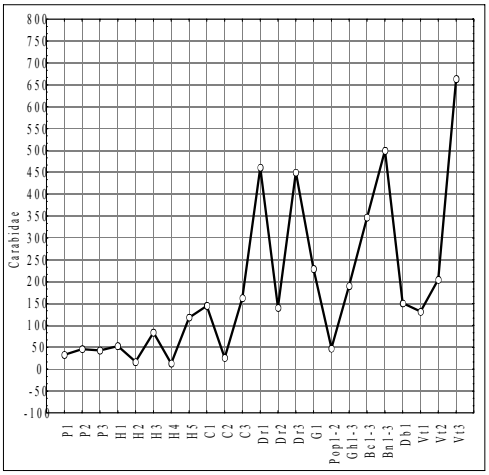

Figura 3 - Relative abundance of Carabidae species in oak forests infested by defolioators in the spring of 2002

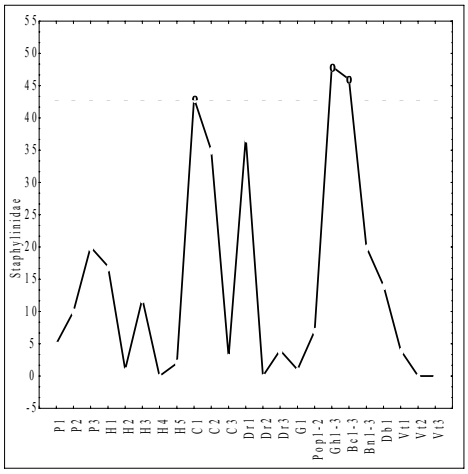

Figura 4 - Relativ abundance of Staphylinidae species in oak forests infested by defoliators in the spring 2002

Gheorghitoaia-Podul Iloaiei and 50,3% in the forest Guranda-Trusesti). The accumulation of predators in those forest ecosystems is one of the reasons of not quite frequent outbreak of defoliators.

The differences appear clearly, especially regarding the most important predators from Carabidae family (dominance of 1,9-2,4% in soil fauna from Trotus Valley forests and 7,2-23,4% in oak forests from Iasi, Vaslui and Botosani regions) and from order Aranea (1,5-6,4% on Trotus Valley and 2,2-20,9% in the other forests).

Distribution of the main predator groups of soil fauna regarding relative abundance in studied forests, graphically represented in the figures 1-5, confirms also the things mentioned above.

Figura 5 - Relativ abundance of the main predators species from soil fauna in oak forests infested by defoliators in the spring of 2002

P,1-3 - Barber traps bateries in the forest Paltinata; H,1-5 - Barber traps bateries in the forest Heltiu
C,1-3 - Barber traps bateries in the forest Cornatel; Dr,1-3 - Barber traps bateries in the forest Dracsani
G,1 - Barber traps bateries in the forest Guranda; Pop,1-2 - Barber traps bateries in the forest Popesti
Gh,1-3 - Barber traps bateries in the forest Gheorghitoaia;
Bc,1-3 - Barber traps bateries in the forest Bacalu ; Bn,1-3 - Barber traps bateries in the forest Bunesti;
Db,1 - Barber traps bateries in the forest Dobrina ; Vt,1-3 - Barber traps bateries in the forest Valea Teiului

Thus, in the figure 1 we can observe that spiders from order Aranea are less abundant in the forest frequently treated against defoliators (Paltinata and Heltiu from forest district Caiuti, Valea Teiului from forest district Husi, Guranda from forest district Trusesti).

Red mites from the genus Eutrombidium are more abundant in the forest infested by Apethymus filiformis from forest district Caiuti (figure 2) and less abundant in the forests infested by caterpillars.

The species of Carabidae seem to be very sensitive at the action of pollution and chemical treatments from the forests Paltinata and Heltiu and their abundance (fi-gure 3) obviously increases in the forests untreated in the last 4-5 years.

Table 3. The community similarity index Jaccard for predators carabides, defoliator caterpillars and himenoptere larvae from oak forests

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Abax ater		75,0	67,8	66,7	82,7	64,3	29,6	66,7	51,8	71,4	79,3	41,3	39,3	46,4	29,6	86,7
Abax ovalis			57,1	55,5	61,3	48,3	23,1	55,5	46,1	60,7	69,0	31,0	38,5	52,0	18,5	76,7
Calosoma inquisitor				60,0	77,8	64,0	30,4	53,8	50,0	72,0	54,0	33,3	36,0	38,5	15,4	70,0
Carabus cancelatus					58,6	69,6	21,7	46,1	61,9	70,8	73,1	30,8	39,1	47,8	12,0	63,3
Carabus coriaceus						62,1	28,6	53,3	50,0	69,0	71,0	44,8	33,3	44,8	33,3	90,0
Carabus excelens							31,8	44,4	59,0	68,0	76,9	29,6	37,5	40,0	7,4	66,7
Carabus violaceus								21,7	20,0	19,2	34,6	20,0	29,4	20,0	5,9	30,0
Harpalus calceatus									47,8	64,0	50,0	32,0	23,1	36,0	26,9	63,3
Harpalus griseus										68,2	51,8	36,3	27,3	36,3	14,3	50,0
Harpalus pubescens											65,5	42,3	40,0	48,0	24,0	73,0
Molops piceus												36,7	44,4	46,4	16,7	86,7
Notiophilus sp													40,0	25,0	33,3	50,0
Pterostichus madens														55,5	10,0	43,3
Pterostichus oblongopunctatus															20,0	50,0
Apethymus larvae																30,0
Defoliator caterpillars																

Staphylinidae species shows the same sensitivity against pesticides. Thus, in the forest Valea Teiului, where pirethroid Sumi-Alpha ULV was used in the spring of 2002, the abundance of staphilinids is very low (0-4 specimens/battery). In the forests Paltinata and Heltiu, after 2 years from the control of Apethymus larvae using chitin inhibitors like Dimilin and Rimon, staphilinids populations start to increase numerically (figure 4) and in untreated forests these insects have evident higher values of the abundance (forests Cornatel, Dracsani, Popesti, Bacalu).

We can see from the figure 5 that predator populations generally present a high sensitivity to pesticides.

The species of Formicidae, with omnivorous food diet, but with a high predator potential, are more frequent in the forest from Trotus Valley (3,4-63,8%), than in the other studied forests (0,7-63,8%), probably due to a greater resistance to pollutant factors.

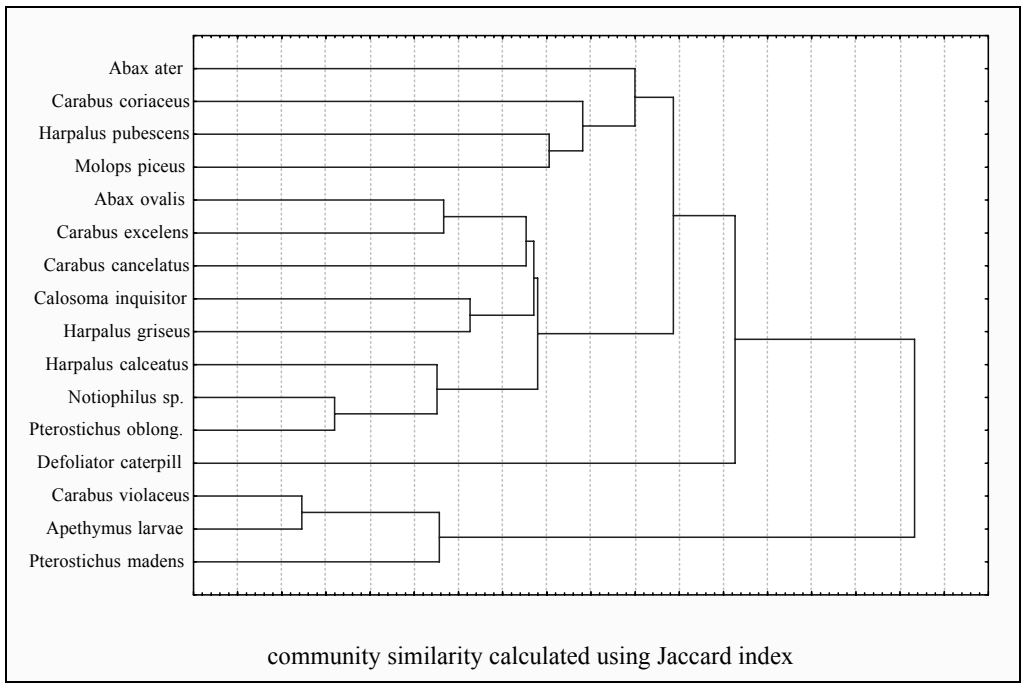

Figure 6. Tree dendrogam for predator carbides species (Coleoptera, Carabidae) and some defoliator larvae identified in soil fauna collected at Barber traps in the studied oak forests

Community similarity of predator Carabidae species and main oak defoliators

The similarity between species of soil fauna was established using Jaccard index :

$$q=cx100/a+b-c$$

where,

a = number of samples with the species A;
b = number of samples with the species B;
c = number of samples with common species A and B.

The values of community similarity index established for the main species of predator carabids (characteristical for the ecosystems of the 11 analyzed forests - index of ecological specificity W>5%) are presented synthetically in the table 3.

The index was, also, calculated for the species of Lepidoptera (Geometridae and Noctuidae) and Hymenoptera (Apethymus filiformis), collected at Barber traps.

The dendrogram obtained on the basis of these values (figure 6) emphasizes the community similarity between carabids species and between these and defoliator caterpillars (larvae), showing the important role of predators in maintaining of biocenotical balance in these forests.

From the graphic we can observe 3 groups of carabids vis-a vis of their ecological exigences.

The first one is composed from the species Abax ater, Carabus coriaceus, Harpalus

pubescens and Molops piceus; these species can be met together in oak forest habitats.

The second group is composed from the species Abax ovalis, Carabus excelens, Calosoma inquisitor, Harpalus griseus, H. calceatus, Notiophilus sp. and Pterostichus oblongopunctatus.

Caterpillars of Geometridae and Noctuidae are strongly correlated with two groups of carabids (q>50%); this shows a low impact of predators on such defoliators at the soil level .

The third group of carabids is composed of the species Carabus violacedus and Pterostichus madens, closer cenotically and probably with a higher influence on the Lepidoptera caterpillars (q=30%, respectively 43,3%).

Apethymus larvae are tied with all the three carabids groups, the low values of Jaccard index (q=5,9-33,3%) confirming that the majority of species have an important role in diminishing of defoliator populations.

CONCLUSIONS

The study of soil fauna was undertook in the spring of 2002 in 11 oak forests from the basin of Siret river infested by defoliators (Tortrix viridana, Geometridae, Apethymus filiformis, Noctuidae).

The researches emphasized that the most important predator groups from studied forests are coleopters from the families Carabidae and Staphylinidae and spiders and mites from orders Aranea and Acarina (genus Eutrombidium).

Carabids species with a high impact on oak defoliators are Abax ater, A.ovalis, Carabus coriaceus, C.excelens, C. violaceus, Harpalus pubescens, H.griseus, H. calceatus, Calosoma inquisitor, Molops piceus, Pterostichus oblongopunctatus, Notiophilus sp.

Predator soil fauna evidently reacts at the impact with stress factors like chemical treatments, showing a high sensitivity to their direct and indirect action (diminishing of available food). Thus, spiders (Aranea) and species of Carabidae and Staphylinidae are less abundant in very frequent treated forests (Paltinata and Heltiu from forest district Caiuti, Guranda from forest district Trusesti and Valea Teiului from forest district Husi).

The species from the genus Eutrombidium (red mites) are more frequent and abundant in the forests infested of Apethymus filiformis (forest district Caiuti) and less frequent in the forests infested with lepidopters species and seems to be an important factor in maintaining these defoliators at low density level

REFERENCES

DANILA, A., VARVARA, M., 1999, - Contributions to the knowledge of some coenoses of edaphic Coleoptera (Insecta, Coleptera) to the forest ecosystems in the Republic of Moldavia, Analele St. ale Univ. A.I.Cuza - Iasi, Biol. Anim., XLIV-XLV, 93-103

SOLOMON, L.,VARVARA, 1983, - The structure of carabid coenosis from the romanian Eastern Carpathians. Anuarul Muzeului jud. Suceava, ST.Naturii VII, 159 - 179

H.U.THIELE , 1977, - Carabid beetles in their environments. A study on habitat selection by adaptations in physiology and behavior. Springer Verlag, Berlin - Heidelberg - New York, 18 - 25

VARVARA, M., VARVARA V., 1991, - Contributii la cunoasterea cenozei de Carabidae din padurea Bârnova - Iasi. Anuarul Muzeului Bucovinei, XI, Suceava, 57 - 68

VARVARA M., OLARIU,L., FLOCEA F.,1997, - Aspects of knowledge of the fauna of Carabidae in the Dornelor Basin, Suceava County. Anuarul Muzeului National al Bucovinei, 52 - 72.

VARVARA,M., 2000, - Laufkäfer in den Heuwiesen von Rumanien Mitt. Dtsch.Ges.Angew.Ent.12, 405-409.

VARVARA, M.,SERBAN,M., 2002, - Taxonomical structure of the coenosis of Carabidae in the Dobrina - Husi forest, Vaslui county. Analele St.Univ.”Alex.I.Cuza” Iasi Biol.Anim. 1-5.

VARVARA, M., 2002, - Diversity of the Carabidae family (Col.Carabidae) in the deciduous forests of Moldavia. Studia Universitatis Babes - Bolyai. Suplement. 1-7