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MALAISE TRAP INVESTIGATIONS IN INUNDATION, SODIC AND SANDY AREAS II. QUANTITATIVE RELATIONS

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Abstract

In five different areas 38 thousand insect specimens were collected by Malaise trap from 1972 to 1980 in 35 time periods. From the order Hymenoptera the most important group superfamily is Ichneumonoidea at all localities. In the inundation meadow Tenthredinoidea and on the sandy and sodic grasslands Sphecoidea, Pompiloidea and Apoidea are also important. From Lepidoptera families dominant groups are: Noctuidae, Hesperidae and Lycaenidae in inundation area, Satyridae and Pieridae in sandy areas, Satyridae, Noctuidae and Nymphalidae in sodic areas. Among Cicadinea families Cicadellidae, Delphacidae and Cercopidae are important. In the sodic area Cixiidae is frequent, too. Coccinellidae is the dominant group at all localities from the 21 Coleoptera families collected. In addition to it Curculionidae in autumn, Melolonthidae and Chrysomelidae in spring are important. According to Renkonen's index Hymenoptera communities of inundation and sodic areas are most specific in spring. In summer the identity indices of species dominance are similar. In the sandy areas Lepidoptera species characteristic to seasons are more important than elsewhere. Seasonal differences in the Lepidoptera fauna are least in the sodic area. The biotop specificity of Cicadinea fauna is high according to Renkonen's indices. The differences between Coleoptera communities of the sites investigated are highest in spring. Order Hymenoptera has the highest species diversity because of the great number of them. The eveness of Hymenoptera population is highest on sodic meadow. The diversity and species richness of Lepidoptera is high in woody areas. The eveness is higher in summer in the inundation area and in spring in sodic and sandy areas. The diversity of Cicadinea living in grasslands is higher than in woodlands. The diversity and eveness of Coleoptera are nearly identical at all localities.

Introduction

No paper has been found conserning total material collected by Malaise trap and there are only very few authors who elaborated even some details of Malaise trap materials (MARSTON, 1965; CHANTER, 1965; MÓCZÁR, 1967; GEIJSKES, 1968; MATTHEWS and MATTHEWS, 1970, 1971). The whole collected material cannot be evaluated in the frame of one paper, so we have separately published the qualitative relations of the flying insect communities of the areas investigated (MÓCZÁR and GYÖRFFY, (1981). Present paper discusses the quantitative relations and seasonal diversity of these populations. The investigations were made in 5 different sites being natural and conserved areas. The most important areas are: inundation area (Körtvélyes), sodic meadow (Kiskundorozsma=D) and a sandy woodland (Ásotthalom). Additional investigations were performed: sandy grassland (Bugacpuszta), a pasture with loess and sodic soil (Fülöpháza) (MÓCZÁR and GYÖRFFY, 1981).

Methods

The sampling program and periods are described in MÓCZÁR and GYÖRFFY (1981). Malaise trap (Malaise, 1937) improved by MÓCZÁR (1967) was used in three periods yearly from 1972 to 1978. Samples were taken altogether 35 times. The exact sample program was detailed in the previous paper (MÓCZÁR and GYÖRFFY, 1981).

Analysing the fauna of areas and time periods from quantitative points of view we investigated in the p.c. dominance of families and Renkonen's index of similarity:

$$PS = \sum_i \min (p_{1i}\ p_{2i})$$

where PS is the similarity between the communities being analysed, p_{ji} is the p.c. ratio of the ith species in the jth sample.

Shannon-Weawer formula was used to estimate species diversity

$$H = -\sum_i p_i \ln p_i,$$

where H is the diversity, p_i is the proportion of the number of individuals of the ith species in the community.

Results

Hymenoptera

From the Hymenoptera superfamilies (Fig. 1) Ichneumonoidea has the highest number because of the considerable species richness of this group. This was also established by MÓCZÁR (1967). Superfamilies Chalcidoidea and Proctotrupoidea having otherwise also many species represent only a very low ratio in the Malaise collection because of their small size and unfrequent flying activity. The same was found in wet biotops of inundation area and in summer and autumn period in sodic meadow, as well. On sandy grassland the high number of Apoidea species was also remarkable. The majority of Ichneumonoidea among Hymenoptera speciments collected at Fülöpháza is caused by the heterogeneous environment and not by the sandy soil.

Comparing the quantity of Hymenoptera families of 3 area types it can be concluded that in addition to Ichneumonoidea the amount of Tenthredinoidea specimens is also big in the wet inundation meadow with dense vegetation. In relation to other superfamilies the number of Apoidea and Sphecoidea species was increased by the dense flower layer in spring and summer. This considerable number of species strongly decreased after flowering.

The number of parasite Ichneumonoides is has become dominant only in sodic areas, the role of Tenthredinoidea is minimal because of the open and drier character of the biotop. The number of Pompiloidea and Sphecoidea increased because of the low vegetation and flowers but they were outnumbered by flower visiting Apoidea in spring and summer. In autumn only Ichneumonoides were predominant and also Vespides were more frequently captured than earlier because their number had increased owing to the social way of life.

In sandy areas Aculeata, especially Apoidea and Formicoidea were dominant, Ichneumonoidea are subdominant as parasites of the former groups. Relations are similar in summer. In autumn Apoidea species were dominant owing to the fact men-

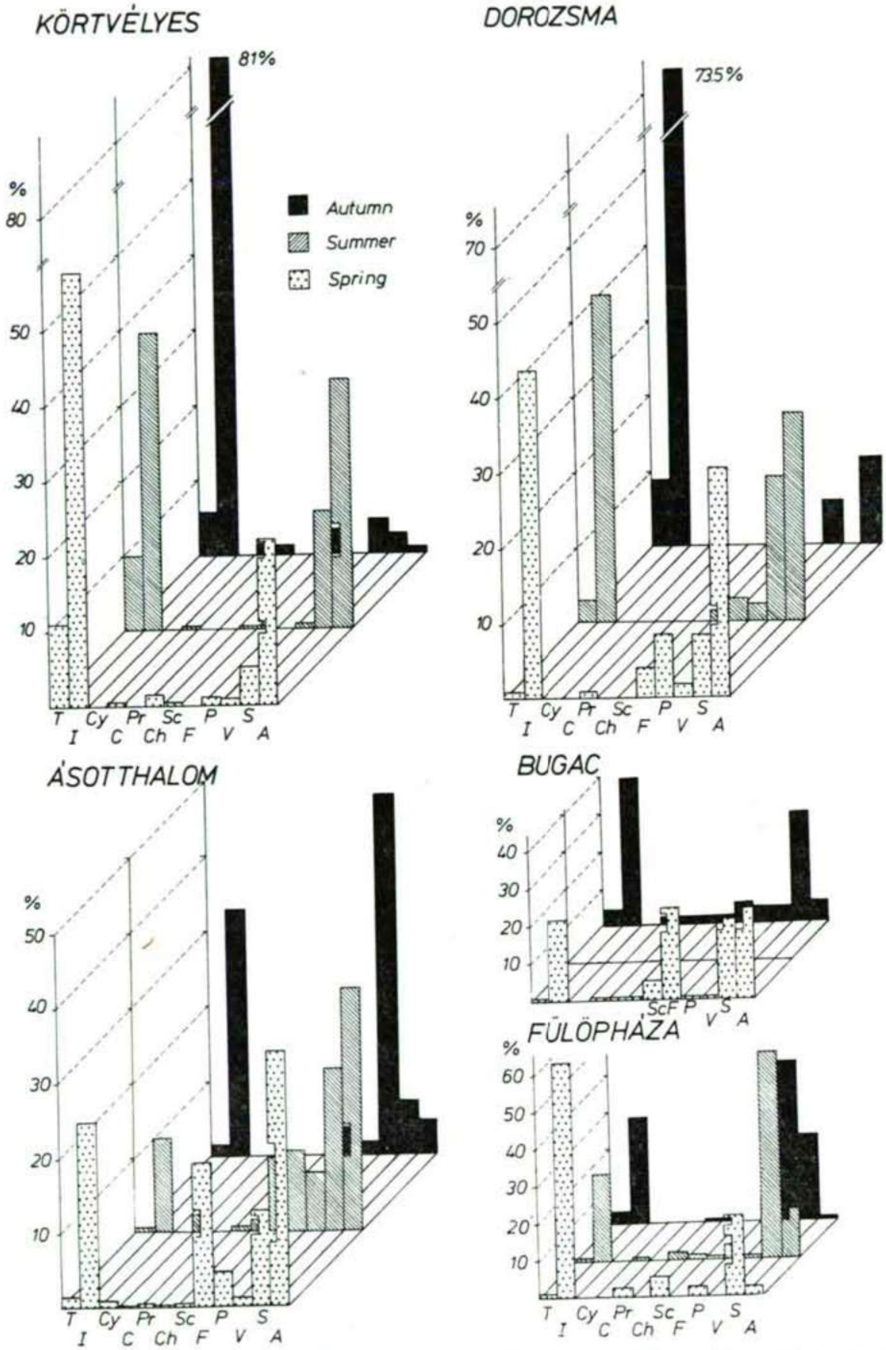

Fig. 1. Quantitative distribution of Hymenoptera superfamilies according to time periods. T=Tenthredinoidea, I=Ichneumonoidea, Cy=Cynipoidea, C=Chalcidoidea, Pr=Proctotrupoidea, Ch=Chrysidoidea, Sc=Scolioidea, F=Formicoidea, P=Pompiloidea, V=Vespoidea, S=Sphecoidea, A=Apoidea.

Table 1. Values of Renkonen's similarity indices of Hymenoptera species according to aspects and areas

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	16.52	7.19	10.29			6.86			0.00			4.79		Sp	K
	100	4.58		11.21			8.55			5.25				Su	
		100			0.00			2.67			0.00		0.89	Au	
			100	7.84	1.33	14.36			0.00			3.46		Sp	D
				100	6.86		8.05			12.18				Su	
					100			0.00			0.00		3.84	Au	
						100	22.79	5.20	1.19			17.87		Sp	Á
							100	9.83		18.15				Su	
								100			0.00		3.32	Au	
									100	16.66	25.00	2.32		Sp	F
										100	17.48			Su	
											100		0.00	Au	
												100	2.71	Sp	B
														Su	
													100	Au	

tioned above, Ichneumonoides were subdominant and the species of other families became rare.

The similarity of species dominance (Renkonen's index) is several times higher than Jaccard index (MÓCZÁR and GYÖRFFY, 1981) between different periods in the same areas (Table 1). So the dominant species have probably more than one generations, social way of life or longer life span. Dominance similarity is highest between spring and summer least between spring and autumn, for instance in sandy areas similarity between spring and summer is 23 p.c., between summer and autumn 10 p.c. and between spring and autumn 5 p.c.

Comparing different areas it can be experienced that the similarity of species dominance (Table 2) is generally twice as high as species similarity.

Table 2. Values of Renkonen's indices of Hymenoptera species according to areas in annual relations.

Table 3. Values of Renonen's index of similarity in the Macrolepidoptera species according to time periods in annual relations

Table 2

K	D	Á	F	B	
100	12.71	10.67	3.09	6.98	K
	100	14.71	8.84	10.84	D
		100	16.98	19.07	Á
			100	18.20	F
				100	B

Table 3

K	D	Á	F	B	
100	35.04	23.38	10.80	4.53	K
	100	27.21	9.27	4.09	D
		100	10.55	5.45	Á
			100	11.49	F
				100	B

Investigating in this in different periods (Table 1) it can be established there are common species only in the fauna of the flood and sandy areas in autumn and it is only 3 p.c., so the quantitative similarity and Renkonen's index are very low. It is about the same in summer period. In spring the fauna of flood area is most differentiated and it is followed by sodic and sandy areas respectively.

Lepidoptera

Investigating in the quantitative relations only of Macrolepidoptera families by collection areas and time periods (Fig. 2) it emerges that in spring family Satyridae is predominant in sandy and sodic sites (40 p.c.), while in the flood area Pieridae has the highest ratio (39 p.c.) closely followed by Noctuidae (35 p.c.). Besides the two dominant families, Noctuidae and Satyridae, Geometridae is also important in sandy areas, while in inundation and sodic areas Pieridae is the most important family. In the sandy area at Ásotthalom the ratio of Satyridae increases from 41 to 65 p.c. during season, it decreases in the flood and sodic areas. In the inundation area Hesperidae is the dominant and Lycaenidae is subdominant in summer. This is the most diversified aspect when six families have important role comparing the other areas' with maximum four.

In the sodic area Nymphalidae has also certain role (6 p.c.) but Noctuidae and Satyridae are the most important families here as well. In the sandy area Pieridae is also important in summer (15 p.c.) but neither in spring nor in autumn. The autumn aspect like summer ones do differ from each other. In the inundation area Noctuidae, in sodic area Pieridae and in sandy area Satyridae are dominant in autumn.

Besides quantitative relations of families comparing the faunas of different periods or areas we got the following results. Between different aspects of the same areas Ta ble 4) Renkonen's index is higher than Jaccard's index in the inundation and sodic

Table 4. Values of Renkonen's indices of Lepidoptera species according to areas and time periods

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	24.02	0.00	42.39			23.80			0.00			4.76		Sp	K
	100	0.00		19.40			18.10			11.52				Su	
		100			0.00			0.00			0.00		0.00	Au	
			100	37.57	30.36	27.60			0.00			4.76		Sp	D
				100	13.63		14.31			7.72				Su	
					100			15.60			0.00		0.00	Au	
						100	14.82	22.19	1.19			4.76		Sp	Á
							100	12.30		4.81				Su	
								100			7.57		9.29	Au	
									100	16.02	12.04	4.76		Sp	F
										100	10.65			Su	
											100		22.32	Au	
												100	2.32	Sp	B
														Su	
													100	Au	

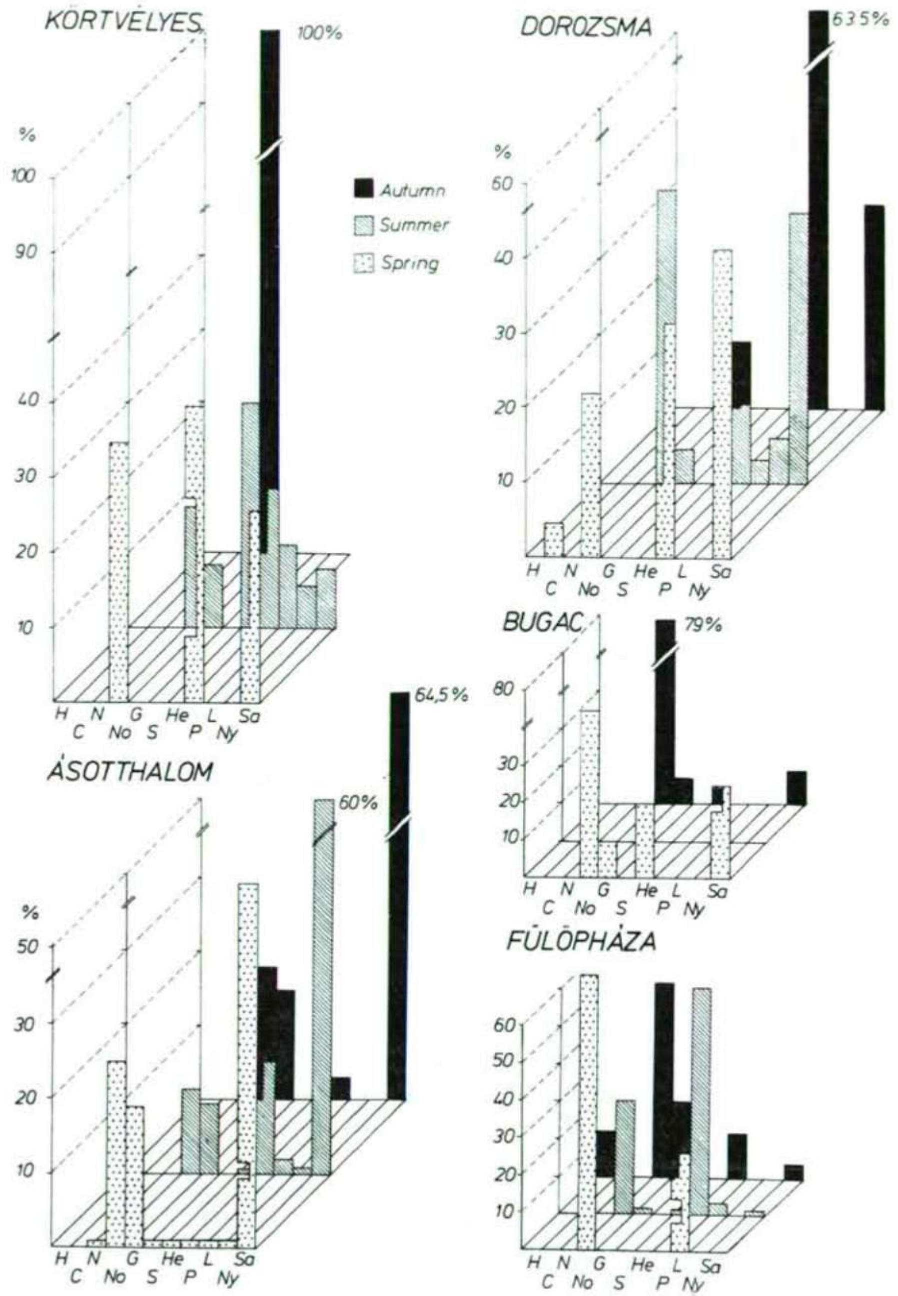

Fig. 2. Quantitative distribution of Lepidoptera families according to time periods. H = Hepialidae, C = Cossidae, N = Notodontidae, No = Noctuidae, G = Geometridae, S = Sphingidae, He = Hesperidae, P = Pieridae, L = Lycaenidae, Ny = Nymphalidae, Sa = Satyridae.

areas, but in sandy sites (Ásotthalom, Fülöpháza) Renkonen's index is lower in spring and summer relation. So in the latter case the importance of the populations characterising the spring aspect (and not in common) is higher than in other areas. The aspect divergence is least in the fauna of sodic area.

Comparing the different areas' annual relations (Table 3) Renkonen's index is almost twice as high as species similarity in the three most important areas, so the common species have a considerable proportion everywhere. According to present investigations the biotop specificity of Macrolepidoptera species is relatively low. In seasonal relation (Table 4) this specificity is the least in spring. The 42 p.c. similarity between inundation and sodic areas is apperent. The differences are highest in autumn.

Cicadinea

Investigating in the quantitative distribution of Cicadinea families (Table 5) Cicadellidae is dominant everywhere and in some areas Delphacidae is subdominant. Cercopidae is important in spring and autumn and the higher ratio of Cixiidae at Dorozsma can also be mentioned.

Table 5. Quantitative distribution of Cicadinea families

Familia %	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au
1. Achilidae	—	—	—	—	—	—	0.78	0.91	—	—	—	—	—	
2. Cercopidae	1.15	0.62	3.33	2.94	0.80	12.50	9.37	0.45	1.92	6.66	5.88	—	0.51	11.11
3. Cicadellidae	98.46	95.00	93.33	70.58	80.64	75.00	32.81	90.36	92.30	93.33	76.47	16.66	97.61	66.66
4. Cixiidae	—	1.25	3.33	11.76	13.70	—	0.78	—	—	—	11.76	—	—	—
5. Delphacidae	0.38	3.12	—	11.76	4.83	12.50	48.43	8.25	5.76	—	5.88	83.33	1.87	22.22
6. Dictyopharidae	—	—	—	2.94	—	—	—	—	—	—	—	—	—	—
Sum total: %	100	100	100	100	100	100	100	100	100	100	100	1 00	100	100

Renkonen's indices of the different aspects within an area are higher than Jaccard's indices almost everywhere (Table 6) except the inundation area. So, in the latter case the spring and summer populations are different while the majority of autumn species occurs already in summer.

The result of the comparison between different areas' annual relations are shown in Table 7. The habitat specificity of Cicadinea group is shown by the fact that the majority of Renkonen's indices is much less than the corresponding Jaccard's indices. This means that the majority of populations of high dominancy is habitat specialist. There are only two exceptions' Ásotthalom—Fülöpháza and Fülöpháza—Dorozsma sodic area relations where the relatively high number of common sandy and sodic species increased the degree of similarity. On this basis comparing qualitative and quantitative relations the inundation and sodic areas have the most specific Cicadinea communities. The other areas have also high fauna specificity except sandy areas of Fülöpháza.

Table 6. Values of Renkonen's indices of Cicadinea according to time periods in annual relations

	Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au
Sp	100	9.97	12.92	100	34.24	20.58	100	32.22	19.69	100	17.64	0.00	100	1.70
Su		100	72.70		100	14.49		100	17.64		100	0.00		
Au			100			100			100			100		100

Table 7. Values of Renkonen's indices of Cicadinea species according to areas in annual relations

Table 8. Values of Renkonen's indices of Coleoptera species according to areas in annual relations

Table 7

K	D	Á	F	B	
100	11.61	3.15	8.16	2.81	K
	100	7.77	37.29	3.27	D
		100	21.42	3.57	Á
			100	3.00	F
				100	B

Table 8

K	D	Á	F	B	
100	42.47	15.40	25.00	14.62	K
	100	17.72	34.85	17.18	D
		100	39.63	18.85	Á
			100	19.24	F
				100	B

Coleoptera

Coccinellidae is the only family that is dominant in all habitats. It is important in summer in the flood area, in all aspects in sodic and sandy areas, in the sandy area at Fülöpháza in summer and autumn and at Bugac in autumn (Fig. 3).

Curculionidae, Melolonthidae and Chrysomelidae are characteristic of three areas each in considerable proportion. Curculionidae is predominant in autumn Melolonthidae and Chrysomelidae in spring.

Carabidae and Cantharidae are predominant in two habitats. Cantharidae is characteristic of the spring period of the flood and sodic areas and Carabidae is typical in autumn at Bugac and in the flood area.

Five families were restricted to only one habitat: Alleculidae and Oedomeridae to sandy areas in spring and summer, Elateridae to flood area in spring and summer, Mordellidae and Lagriidae to Fülöpháza in spring and summer.

Differences between Renkonen's and Jaccard's indices can already be seen in annual relations (Table 8). Renkonen's index shows greater differences between areas. On the basis of Jaccard's index the degree of similarity is twice as high as in the case of Renkonen's index, so besides Macrolepidoptera, Coleoptera seems to be the second group with least habitat specificity.

It is also shown by the detailed data of aspects (Table 9) that the Coleoptera fauna of sandy areas differs from that of inundation and sodic areas in quantitative relations, but their similarity increased in summer by 5 p.c. The autumn differences increased. The similarity of Coleoptera fauna of sodic areas being quantitatively most

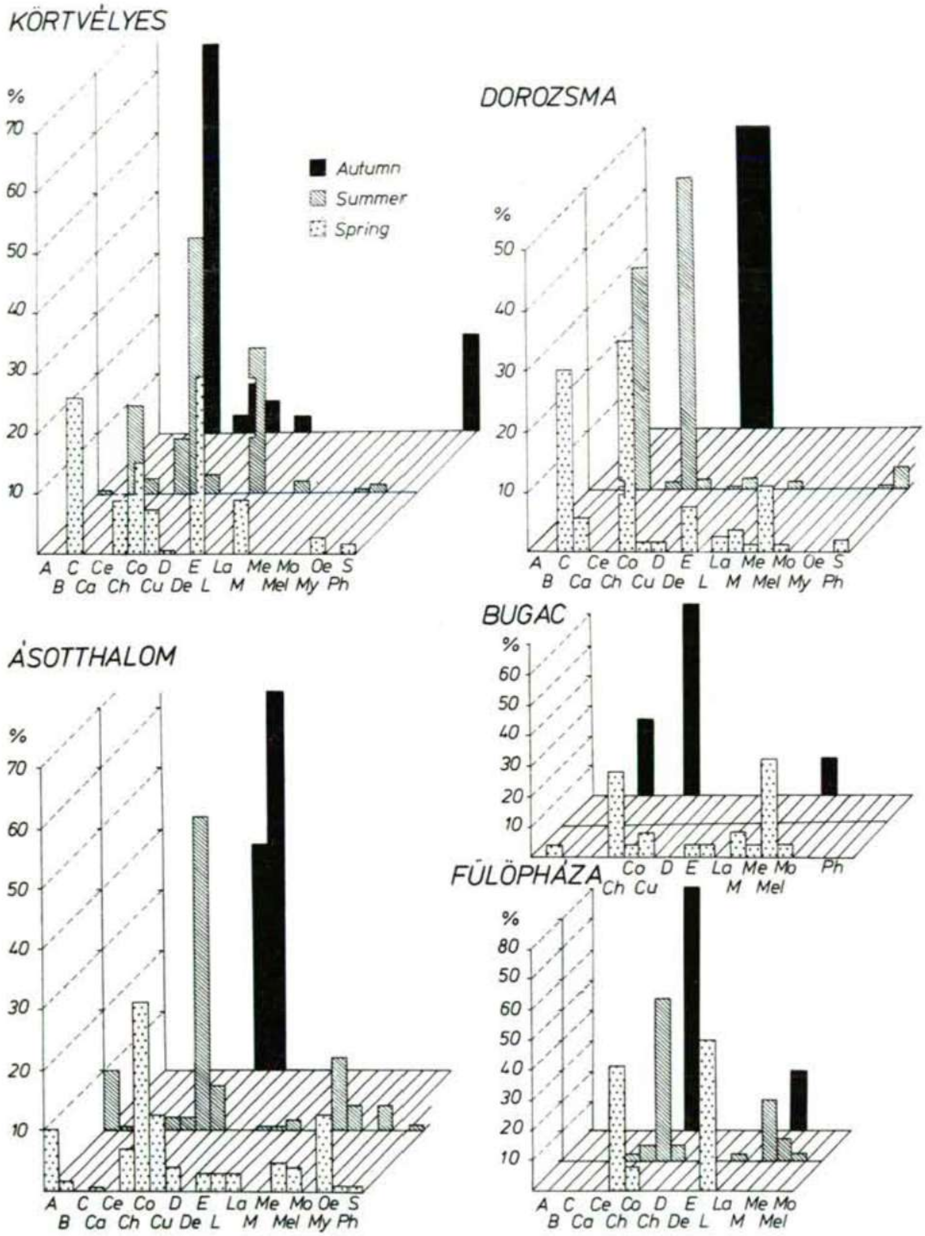

Fig. 3. Quantitative distribution of Coleoptera families according to aspects. A = Alleculidae, B = Buprestidae, C = Cantharidae, Ca = Carabidae, Ce = Cerambycidae, Ch = Chrysomelidae, Co = Coccinellidae, Cu = Curculionidae, D = Dasytidae, De = Dermestidae, E = Elateridae, L = Lagriidae, La = Lampyridae, M = Malachidae, Me = Meloidae, Mel = Melolothidae, Mo = Mordellidae, My = Mylabridae, Oe = Oedemeridae, Ph = Phalacriidae, S = Staphylinidae.

Table 9. Values of Renkonen's index of Coleoptera species

Körtvélyes			Dorozsma			Ásotthalom			Fülöpháza			Bugac			
Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au	Sp	Au		
100	54.73	8.83	30.54			7.12			0.68			4.67		Sp	K
	100	9.36		31.62			19.09			36.77				Su	
		100			8.10			5.40			8.10		0.00	Au	
			100	27.41	6.45	10.32			4.03			10.48		Sp	D
				100	23.31		16.04			39.13				Su	
					100			25.00			45.00		25.00	Au	
						100	53.59	2.36	7.08			10.23		Sp	Á
							100	6.61		25.93				Su	
								100			32.50		25.00	Au	
									100	16.01	8.33	12.33		Sp	F
										100	35.90			Su	
											100		20.00	Au	
												100	4.00	Sp	B
														Su	
													100	Au	

differentiated increased in spring and summer to a great extent. The spring Coleoptera aspect of the inundations area which is the other very differentiated area, approximated sodic areas owing to the high dominance ratio of family Cantharidae. Its summer composition neared the other areas' but it definitely receded in autumn.

Diversity

The index of diversity is the resultant of two components. It depends both on the species richness of the taxonomic group investigated and on the eveness of distribution (Pielou, 1969). The greater the index of diversity is the richer the species composition is or the more evenly the dominancies are distributed. These two factors are not random.

There are relations between floral and faunal diversities. In the case of plants both taxonomic and spatial diversity i.e. spatial distribution of floral structures are equally important (Southwood, Brown and Reader, 1979). In the early period of succession the diversity of insects rather depends on taxonomic diversity and the importance of structural diversity increases near climax (Lawton, 1978). The species richness of herbivor insects depends on the geographical distribution of plant species too. Comparing plant species of similar geographical areas the following sequence can be noticed in the richness of their insect fauna: trees > woody shrubs > perennial herbs > weeds and other annuals > monocots (Lawton and Schröder, 1978). So the struture of plants is also very important as larger and more complex plants ensure more niches (Lawton, 1978). There are also seasonal changes in diversity. It is caused by the changes in chemical properties of plant (chemical hypothesis) and by architectural changes of plant (architecture hypothesis, Lawton, 1978).

On this basis questions can arise whether the investigated insect groups of a more complex habitat are more divers and whether the material of Malaise trap is sufficient to express this. The species diversity of insect groups investigated can be seen in Table 10.

First analysing Lepidoptera and Cicadinea groups including phytophagous populations it can be established that order Lepidoptera fits LAWTON's arrengement, its diversity is the highest in woody areas and less in grasslands, but Cicadinea has greatest diversity in sodic and sandy grasslands and it is least in the woody flood area. The species richness of Macrolepidoptera is similar, that of Cicadinea shows a less eveness in forests than in grasslands.

There are not essential differences between areas in the diversity of Coleoptera, it is a little higher in woody areas. Their species richness is almost the same as well. Perhaps figures would change if we separately studied the trophic groups because plant eaters, predators and decomposers are together in this analysis.

The diversity of Hymenoptera is conspicuously higher than that of the other groups. It is caused by the high number of species without doubt. This is almost identical in sandy and flood area woods but in the sodic grassland it is less than the half of it. The difference in the diversity index is less because the eveness is greater in the sodic grassland area.

Table 10. Diversity of important insect groups (whole year)

	Ásotthalom	Dorozsma	Körtvélyes	Fülöpháza	Bugac
Hymenoptera	5.2343	4.7974	5.2558	3.4593	4.5851
Lepidoptera	3.0210	2.5864	3.0593	2.8030	2.6818
Cicadinea	2.1365	2.7344	1.8023	2.6722	0.5578
Coleoptera	2.9712	2.7477	2.905	2.7078	2.8027

It is also interesting to compare the diversity indices and species richness between taxonomic groups of insects and between areas (Table 11, Fig. 4).

The diversity dynamics of Macrolepidoptera follows the dynamics of species number rather well only in the inundation area (Fig. 4/a). The faunal eveness is the highest here in summer in sodic and sandy areas in spring. The number of Cicadinea

Table 11. Seasonal values of species diversity of important insect groups

	Ásotthalom			Dorozsma			Körtvélyes		
	Sp	Su	Au	Sp	Su	Au	Sp	Su	Au
Hymenoptera	4.9268	4.5501	3.7064	4.0165	4.2660	2.5003	4.6769	4.5260	3.8757
Lepidoptera	2.8202	2.4528	1.7658	2.1818	2.2001	1.1595	2.4998	2.9315	0.00
Cicadinea	2.1814	1.2334	2.1247	2.2457	2.4282	1.6674	1.1270	1.4801	1.4352
Coleoptera	2.7796	2.5852	0.9002	2.6050	2.8982	1.0397	2.4875	2.5086	1.8538

	Fülöpháza			Bugac	
	Sp	Su	Au	Sp	Au
Hymenoptera	1.3862	3.3814	1.5402	4.5424	2.4807
Lepidoptera	1.8343	1.8524	2.8997	2.1738	2.0211
Cicadinea	2.0782	1.9250	0.4505	0.4780	1.6769
Coleoptera	1.3577	2.6249	1.3321	2.5461	2.3630

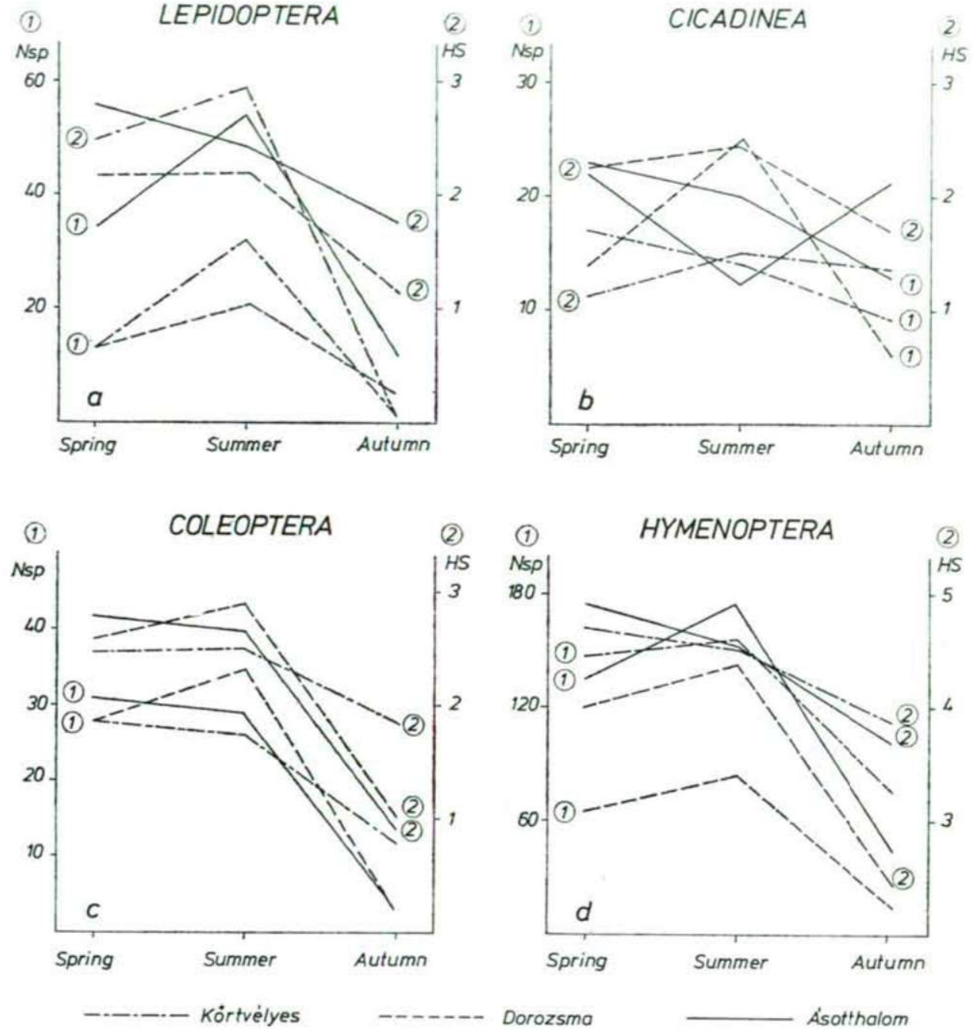

Fig. 4. Seasonal dynamics of species number and species diversity.

species — that are also herbivor groups — is very similar to that of Lepidoptera larvae studied by FEENY (1970). So it is highest in spring and decreases to autumn in woody areas, but a summer maximum was found in sodic areas (Fig. 4/b). Comparing it with dynamics of diversity it is shown that the eveness component changes this situation at Ásotthalom and Körtvélyes. The eveness is very low in sandy areas in summer and in the inundation area in spring which causes a decrease in diversity indices. The changes in the number of Coleoptera species is similar to those of Cicadinea and it is followed by the diversity, so the eveness is almost the same in the single areas. The population eveness of Hymenoptera having highest diversity and species number is similar in inundation and sodic areas, there is no significant difference between the curves of richness and eveness. Although there is a summer maximum in species number in sandy areas, the highest diversity was measured in spring, so the fauna eveness in spring is much higher than in other areas (Fig. 4/d).

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