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AN ECOLOGICAL ANALYSIS OF COLEOPTERAN FAUNA OF CEREALS CROPS

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Abstract. The present article reports the biodiversity indices of beetles which spread wheat agrocenoses and natural cenoses in winter. An ecological analysis of coleopteran fauna in grain cenoses was carried out for the first time in Azerbaijan. Therefore, results are new and show the outcome of original research. For assessing the biodiversity of coleopteran fauna in the grain cenoses we calculated Simpson's dominance index (D'), Shannon's diversity index (J'), Margalef's richness index (M) and Pielou's evennes index (e) for both type of cenoses. For comparing, two cenoses have been used in Jaccard's similarity index. The obtained results show that, no outbreak in mass development, as well as disturbance of ecological balance was noted in both types of cenoses. Compared with agrocenoses the relatively greater species' richness was noted in natural cenoses, and evenly distribution of species was recorded in agrocenoses.

Keywords: *biodiversity indices, grain cenoses, beetles, Azerbaijan, Simpson's dominance index, Pielou's evennes index, Margalef's richness index, Jaccard's similarity index.*

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1. Introduction

Diversity constitutes one of the most important characteristics of community organization. Several indices are being used to measure diversity of communities. Diversity indices have been applied to compare the communites in time and space, successional stages in the ecosystem, vertical diversity of a forest and many other areas in ecology. Indices aim to describe general properties of communities that allow us to compare different regions, taxa, and trophic levels (Kathryn *et al*., 2014; Thukral, 2010).

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In entomology this type of researches has been curiously welcomed and have ecologically significant importance (Ajayi, *et al*., 2018; Ashrith, *et al*., 2017; Bukejs & Balalaikins, 2008; José, 2014; Suprakash, 2017).

Despite the fact that, biodiversity is the key factor for the structure and function of ecosystems, the biodiversity indices of beetles in grain cenoses have not been investigated so far in Azerbaijan. An ecological analysis of coleopteran fauna in grain cenoses was carried out for the first time in Azerbaijan. Therefore, results are new and show the outcome of original research.

2. Materials and methods

The research was carried out in winter wheat agrocenoses and natural cenoses, which mainly consist of *Bromus japonicus* Thunb., *Aegilops cylindrica* Host, *Aegilops briuncialis* L., *Trisetum flavescens* L. P. Beauv., *Hordeum murinum* L. and so on. The area of each selected winter wheat agrocenoses is 5-7 hectares, and according to entomological methods the area of natural cenoses for comparison also was approximately in the same size. The samples of various beetles, mainly harmful beetles were collected in spring and in the first-half of summer. The larvae and pupae of harmful beetles were gathered in winter and early spring, and all samples were brought to the laboratory. Then the development of these samples has been monitored in the laboratory condition. The observation in the field, collection of samples, preparing them for the determination etc. were based on general – entomological methodology (Fasulati, 1971).

For assessing the biodiversity of beetles in the grain cenoses we calculated Simpson's dominance index (D'), Shannon's diversity index (J'), Margalef's richness index (M) and Pielou's evennes index (e) for both types of cenoses. All indices were calculated on the basis of number of species and samples spread in both cenoses.

Simpson's dominance index (D'). This index is a dominance index, because it gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity. The value of Simpson's dominance index ranges between 0 and 1. If the value of D' gives 0, it means infinite diversity, but if the value of D' gives 1, it means there is no diversity. That is, the bigger the value the lower the diversity (Simpson, 1946).

$$D' = 1 - \sum_{i=1}^{S} p_i^2$$

where,

p_i – the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N),

s – the number of species,

Σ – the sum of calculations.

Margalef's richness index. This index is based on the total number of species and individuals in the sample. If it is possible to distinguish all the species in the sample successfully, these types of indices would be an appropriate method for estimating of richness (Margalef, 1958). A large number of samples containing the species studied indicates a large number of those species in the study area.

$$D = \frac{(S-1)}{lnN}$$

where,

S – the total number of species,

N – the total number of individuals in sample,

ln – the natural log.

Shannon's diversity index. This index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. The index is related to the living organism, the size, the distribution of living organisms in the studied area, and characterizes diversity of the species in the communities. The index indicated the quantity, allotment and species' composition of living beings, mainly described the diversity of species in sample (Zhang *et al*., 2012).

$$H = -\sum_{i=1}^{S} lnp_i$$

where,

p – the proportion (n/N) of individuals of one particular species found (n) divided by the total number individuals found (N)

ln – the natural log

Σ – the sum of the calculations

S – the number of species.

Pielou's evennes index. This index is the most widely used in ecology. The value of Pielou's index ranges from 0 to 1, with largest values representing more even distributions in abundance among species. This index is calculated according to Shannon diversity index (Pielou, 1966).

$$J' = \frac{H'}{\ln(S)}$$

where,

H' – Shannon diversity index,

S – total number of individuals in sample,

ln – natural log.

Jaccard's similarity index. An intuitive measure of similarity between two samples can summarize the fraction of species they share. Jaccard's index is the simplest summary of this, taking the following form (Magurran, 2004).

$$J = \frac{S_c}{S_a + S_b + S_c}$$

where,

S_a – the numbers of species unique to samples a,

S_b – the numbers of species unique to samples b,

S_c – the number of species common to the two samples.

Shannon's diversity, Simpson's Diversity and Margaleff richness indices were calculated by using Biodiversity pro-2.

3. Results and discussion

The research was carried out on the grain cenoses of the Ganja-Gazakh region, Azerbaijan. As a result, 54 species of beetle families (*Coleoptera*) which belong to 10 families, 22 subfamilies and 42 genera were identified. Among them, 10 species are first time recorded for the fauna of Azerbaijan, and 26 species for the Ganja-Gazakh region (Table 1).

The total number of species in natural cenoses were 47 and samples 704; and the total number of species in agrocenoses was 37 and samples 513.6 species were found in agrocenoses only, 17 species in natural cenoses only, but 31 species were common in both types of cenoses.

The Simpson index was 0.21 in natural cenoses, and 0.13 in agrocenoses. It means that there is no any outbreak and any dominant species among identified species. The low value of Simpson index, even not reaching 0.5 is explained by the fact that the ecological balance is not disturbed in both types of cenoses.

Table 1. Spreading of species in the study area

No	Families and species	Presence on cenoses		
		Agro cenoses	Natural cenoses	Both types of cenoses
	Family: Carabidae			
1	*Pterostichus niger* Shaller 1783	-	-	+
2	*Zabrus tenebrioides longulus* Reiche & Saulcy 1855	-	-	+
3	*Zabrus morio morio* Ménetries 1832	-	-	+
4	*Harpalus froelichii* Sturm 1818	-	-	+
5	*Harpalus tardus* Panzer 1797	-	-	+
6	*Harpalus griseus* Panzer 1797	-	-	+
7	*Harpalus rufipes* De Geer 1774	-	-	+
8	*Harpalus calceatus* Duftschmid 1812	-	-	+
9	*Cryptophonus melancholicus melancholicus* Dejean 1829	-	-	+
10	*Acinopus picipes* Oliver 1795	-	-	+
11	*Dixus obscurus* Dejean1825	-	-	+
12	*Scarites cylindronotus* Faldermann 1836	-	-	+
13	*Sphodrus leucophthalmus* Linnaeus 1758	-	-	+
14	*Calathus ambiguus ambiguus* Paykull 1790	-	-	+
15	*Calathus longicollis* Motschulsky 1865	-	-	+
16	*Nebria picicornis luteipes* Chaudoir 1850	-	+	-
17	*Broscus semistriatus* Dejean 1828	-	+	-
18	Family: Chrysomelidae *Oulema melanopus* Linnaeus 1758	+	-	-
19	*Chaetocnema hortensis* Geoffroy 1785	+	-	-
20	*Galeruca pomonae* Scopoli 1763	-	-	+
21	*Luperus longicornis*Fabricius 1781	-	+	-
22	*Clytra valeriana*Ménétries 1832	-	+	-
23	*Chilotoma musciformis* Goeze 1777	-	+	-
24	*Labidostomis humeralis* Schneider 1792	-	+	-
25	*Chrysolina chalcites*Germar 1824	-	+	-
26	*Chrysolina limbata* Fabricius 1775	-	+	-
27	*Gastrophysa polygoni* Linnaeus 1758	-	+	-
28	*Linaeidea aenea* Linnaeus 1758	+	-	-
29	*Colaphus hoefti* Ménétries 1832	-	+	-
	Family: Scarabaeidae			
30	*Anisoplia austriaca* Herbst 1783	-	-	+
31	*Anisoplia austriaca major* Reitter 1889	-	-	+
32	*Anisoplia farraria* Erichson 1847	-	-	+
33	*Brancoplia leucaspis* Laporte de Castelnau 1840	-	-	+
34	*Blitopertha nigripennis* Reitter1888	-	-	+
35	*Oxythyrea cinctella* Schaum 1841	-	-	+
36	*Epicometis sp.*	-	+	-
37	*Pentodon idiota* Herbst 1789	+	-	-
38	*Gymnopleurus mopsus* Pallas 1781	-	+	-

	Family: Melyridae			
39	*Enicopus hirtus* Linnaeus 1767	-	-	+
	Family: Elateridae			
40	*Agriotes lineatus* Linnaeus 1767	+	-	-
	Family: Silphidae			
41	*Silpha obscura* Linnaeus 1758	+	-	-
	Family: Curculionidae			
42	*Hypera postica* Gyllenhal 1813	-	+	-
	Family: Coccinelidae			
43	*Coccinella septempunctata* Linnaeus 1758	-	-	+
44	*Hippodamia variegata* Goeze 1777	-	-	+
45	*Bulaea lichatschovi Hummler 1827*	-	+	-
	Family: Tenebrionidae			
46	*Podonta daghestanica* Reitter 1885	-	-	+
47	*Podonta elongata* Ménétries 1832	-	+	-
48	*Omophlus proteus* Kirsch 1869	-	-	+
49	*Omophlus flavipennis* Küstter 1850	-	-	+
50	*Opatrum sabulosum* Linnaeus 1761	-	-	+
51	*Blaps halophila* Fischer de Waldheim 1820	-	-	+
52	*Blaps lethifera* Marsham 1802	-	-	+
	Family: Cantharidae			
53	*Rhagonycha fulva Scopoli 1763*	-	+	-
54	*Cantharis livida* Linnaeus 1758	-	+	-
	Total:	6	17	31

Table 2. Indices of coleopteran diversity in cereal cenoses

No	Indices	Values of indices in natural cenoses	Values of indices in agrocenoses
1	Simpson's dominance index (D')	0.21	0.13
2	Shannon's diversity index (J`)	0.65	0.75
3	Margalef's richness index (M)	16.14	13.33
4	Pielou's evennes index (*e*)	0.39	0.48
5	Jaccard's similarity index	0.57	

The value of Shannon diversity index was 0.65 in natural cenoses, and 0.75in agrocenoses. It shows that the species diversity is evenly distributed in agrocenoses where the value of Shannon's index is higher than it is in natural cenoses. The reason for this result can be shown the monodominant vegetation of agrocenoses. The main reason for this circumctance is the single-species planting in agroecosystems.

The Margalef index was 16.14 on natural cenoses, and 13.33on agrocenoses; The Pielu index was 0.39 on natural cenoses, 0.48 on agrocenoses. The obtained results show that, as well as disturbance of ecological balance was noted in both types of biocenoses. Compared with agrocenoses the relatively greater species' richness was noted in natural cenoses, and equal distribution of species in agrocenoses (Table 2).

For comparing two cenoses we used Jaccard's similarity index. The table 1 shows all established species and their presence on the cenoses. As the table 1 shows, 6 species were found in agrocenoses only, 17 species in natural cenoses only, but 31 species were common in both types of cenoses. The value of the index of species' similarity for the natural and agricultural cenoses was J=0.57.

The obtained results show that, no outbreak in mass development, as well as disturbance of ecological balance were noted in both types of cenoses. Compared with agrocenoses the relatively greater species' richness was noted in natural cenoses, and evenly distribution of species was recorded in agrocenoses. In a word, a more stable ecosystem or environmental change is less likely to be damaging to the ecosystem as a whole.

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