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RESEARCH ON THE INVERTEBRATE FAUNA OF SOME GOJI (*LYCIUM BARBARUM*) PLANTATIONS IN THE 2023 AND THE CALCULATION OF THE ALPHA BIODIVERSITY INDICES

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Abstract
The research carried out in the Aroneanu stationary, in 2023, in Iasi County, followed the appearance, abundance and dynamics of the existing invertebrate species in the goji culture, with a special reference to the most important and widespread pests identified during the period of observations.
With the help of Barber traps, individuals of different species can be continuously collected, regardless of the biotope. After collecting and identifying the species, assess the specific composition of the biocenosis, the seasonal variation and their cenotic preferences.
Sticky traps can be used both for monitoring pests and for their actual control. The use of this method of pests control and monitoring comes with certain advantages, they are ecological; they are easy to mount and use; does not leave residues or residues in the crop or on the fruit; reduce the number of treatments with insecticides; etc.
The research aimed to accurately identify the pests that impact or could potentially impact goji crops in the northeastern region of Moldova, as well as to calculate alpha biodiversity for comparing the biodiversity of various geographical areas or biological communities.

Keywords: goji, indices, invertebrates, pests, trap.

1. INTRODUCTION

Lycium barbarum L. is a shrub native to Asia whose fruits are harvested and marketed as health food and for use in traditional medicine. China is the world's leading producer and supplier of *L. barbarum* goji berries (Ke-Long et al., 2020).
In Europe, goji culture is expanding rapidly to meet the increased demand of the functional food market, with effects in the treatment of chronic diseases (cancer, diabetes, atherosclerosis, etc.). Romania has become in recent years one of the most important growers of goji berries, especially for organic production, because the species is quite resistant to the main pests and diseases (Ciceoi et al., 2021).
Goji culture is important from several perspectives due to its nutritional value, health benefits, and economic impact (Clapa et al., 2021). Here are some aspects that highlight the importance of Goji culture: Goji berries, known for their high nutritional value, are packed with essential nutrients, including vitamins, minerals, and antioxidants.They contain significant amounts of vitamin C, vitamin A, iron, zinc, and fiber, contributing to a healthy lifestyle and preventing conditions such as heart disease and cancer.

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Health benefits: Regular consumption of goji can have many beneficial health effects, including improving the immune system, protecting vision, maintaining healthy skin and the cardiovascular system, as well as reducing blood sugar and cholesterol levels (Altintas et al., 2006). Adaptability to different growing environments: Goji is a hardy plant that can grow in a variety of soil and climate conditions. This makes goji culture accessible in many regions of the world, contributing to food diversification and security (Clapa et al., 2013).
Economic potential: The cultivation and marketing of goji berries can represent an important source of income for farmers and producers in different countries. Goji berries are increasingly popular in the global market, being used in food, dietary supplements, cosmetics, and traditional medicine. Sustainability and environmental protection: Goji is a perennial crop that can help protect the soil and local ecosystems. Also, goji production can stimulate sustainable and ecological agricultural practices, reducing reliance on pesticides and chemical fertilizers (Clapa et al., 2013).
In conclusion, goji culture plays an important role in promoting human health, in agricultural diversification, in stimulating the local economy, and in protecting the environment (Clapa et al., 2021).

2. MATERIALS AND METHODS

The research was conducted at a station located in Aroneanu commune, Iasi County, following the experimental technique protocol, which, based on research methods, helps us identify both beneficial and harmful fauna in goji crops.

Collection of entomological material with the help of Barber-type ground traps.

The taxonomic study, distribution, and ecological requirements were carried out on the material collected from the field with the help of Barber traps.
In 2023, six harvests were made in the goji culture: 30.05, 10.06, 24.06, 02.07, 26.07, and 07.08.
Different species of arthropods are captured by this method, but millipedes, molluscs, amphibians, small reptiles, and even rodent mammals are also accidentally collected. With the help of Barber traps, individuals of different species can be continuously collected, regardless of the biotope. After collecting and identifying the species, it is possible to assess the specific composition of the biocenosis, the seasonal variation, and their cenotic preferences. Barber traps are 500-ml plastic boxes that are buried at ground level so that insects can easily enter (Figure 1).
The presence of the liquid excludes cannibalism between individuals captured in the trap and reduces the probability of their escape. The fixing liquid must have good preservative qualities to prevent the maceration of the collected individuals. Formalin and a concentrated NaCl solution were used as fixing liquids.
By placing 10–12 traps, all categories of species can be collected to establish dominance in a biotope, because in the case of a temperate climate, we have two groups: species with large numbers (dominant, constant), and species with small numbers (sporadic). Therefore, the dominant species will always be collected. Through a small number of collections, only the abundant species (eudominant and dominant) will be captured. Through a larger number of samples, both the number of individuals and the collected species will be closer to the real number of herds in nature. The number of Barber traps used to obtain as many real observations as possible was determined according to the collection site, varying between 18 and 24. (Jiaoa et al, 2020).
The contents of each box were put on a sieve to separate the insects from the fixative liquid, and then the contents were stored in plastic containers on which the following information was written on the label: the resident, the culture, the date of collection, and the trap number.

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Figure. 1. Location of Barber soil traps

Calculation of alpha diversity indices

When assessing alpha diversity, two factors are considered: species richness and the evenness of species abundances (the even distribution of species according to their abundance in the community). It must be taken into account that not all species help in the same way for diversity to exist in the area. From an ecological perspective, the different dimensions of biodiversity are represented by the number of trophic levels and the variety of life cycles that contribute differentially (IUCN France, 2014).

An important measure of alpha diversity is the species richness index (Margalef species richness index, Menhinik species richness index, etc.). The main potential applications of diversity indices are conservation and monitoring.

The use of diversity assessments in these areas is based on two assumptions:

1) Communities rich in species are more stable than those poor in species;

2) The level of pollution is associated with a decrease in diversity and a change in the nature of species abundance. At the same time, species richness indicators are commonly used in nature protection, and species abundance indices and models are used in environmental monitoring (Knapp et al., 2008).

Shannon diversity index

The Shannon index, or Shannon-Weaver index, is commonly used to measure specific biodiversity. It is represented by an H', and the index values vary only between positive numbers. In most ecosystems, the indices are rated between 2 and 4.

Values below 2 are considered to have relatively low diversity, such as in desert ecosystems. On the other hand, values greater than 3 indicate a high level of diversity, such as a forest, tropical climate, or reef.

To calculate the value of this index, the number of species, which we call richness, and their relative number, which we call abundance, are taken into account. The maximum value of the index is usually close to 5, and the minimum value is 0, which is where there are only species, meaning no diversity. An ecosystem with a Shannon index of 0 can be a monoculture (Marcon and Morneau,

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2014). To estimate the specific diversity, the Shannon function was applied, which has the expression: H = -Σ pilog2 pi, where:
pi is the proportion of individuals by which species i is present in the biocenosis (dominance); it derives from the ratio nIN, where n is the number of individuals of the species.
and N is the total number of individuals of all species in the analyzed sample.
The real (observed) diversity - H(S) will be calculated applying the Shannon calculation relation, modified by Mac Arthur, corrected by Lloyd, and the maximum (hypothetical) diversity - H(S)max = K log10S.
where K = 3.321928, and S (total number of species) and relative diversity (equity) = Hr (Hr = H(S)÷H(S)max x 100%).

Simpson Diversity Index

Simpson's index is the one represented by the letter D, and it estimates the probability that two individuals chosen at random from a sample belong to the same species or to another taxonomic category.
In the same way, the Simpson diversity index is expressed as 1–DD. Then the values are between 0 and 1, and, contrary to the previous index, it expresses the probability that two randomly chosen individuals belong to different species (Madani and Sayeh, 2002).
Another way to state it is by means of a reciprocal index, which is represented as 1/D. In this way, the value of 1 expresses the existence of a community that has only one species. If the value increases, it is an indication that there is more diversity.

$$1-\sum_{i=1}^{k}\frac{n_i(n_i-1)}{n(n-1)}$$

Although the Shannon and Simpson indices are the most commonly used in the ecological literature, there are others, such as the Margalef, McIntosh, and Pielou indices, among others.

Dominance index. A dominance index is a statistical measure used in ecology to quantify the biodiversity of a habitat. It represents the degree to which a species dominates in a given ecological community. The index is calculated based on the relative abundance of different species within the community (Giannetti et al., 2020).A high dominance index indicates that one or a few species dominate the community, while a low dominance index suggests a more even distribution of species.

$$\boldsymbol{D=\frac{N(N-1)}{\sum n(n-1)}}$$

Menhinick index. The Menhinick index is a simple measure useful for the purpose of measuring diversity. The index is only applicable to categorical data where all observations can be classified into a finite number of categories (species, types, etc.).

$$I=\frac{S}{\sqrt{N}}$$

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The Menhinick index given by I Mn is defined as the index that is based on the ratio of the number of species (S) to the square root of the total number of individuals (N). Written as IMn=S/√N or DMn = S/√N. Menhinick's index calculator is used to compare samples of different sizes and reduce the effect of the number of individuals. However, the index is not independent of the sample size (Benchrik and Lakhdari, 2002).

Buzas and Gibson index. It is an evenness index and has a maximum value of 1. For a simple estimate of diversity based on species richness (*S*), the Margalef index is often used.

$$EGB\ \frac{e^{-\sum_i(\frac{ni}{N}\ln\ \ \ (\frac{ni}{N}))}}{S}$$

For a simple estimate of diversity based on species richness (*S*), the Margalef index is often used, which is expressed as:

$$\frac{S-1}{\ln N}$$

3. RESULTS AND DISCUSSIONS

In 2023, six harvests were made in the goji culture: 30.05, 10.06, 24.06, 02.07, 26.07, and 07.08.

Goji berries are particularly susceptible to pests and diseases due to their high sugar content, especially aphids and mites. Statistics show that every year, aphid damage reduces the production of goji berries by 1/4 and significantly lowers the quality.

In 2023, in the goji culture, a number of 78 species or groups of invertebrates were collected with the help of Barber-type soil traps, totaling 3278 specimens (Table 1).

The Coleoptera order is the most representative, with 63 species totaling 1722 specimens. The species *Harpalus distinguendus*, a harmful species, has an abundance of 1091 specimens (Figure 2).

Table 1. Invertebrate fauna collected in the goji crop in 2023

Class/ The order	Invertebrate species/group	No. trap						Total specimens
		1	2	3	4	5	6	
Arachnida	Dust Mites	13	18	16	36	58	53	194
	Arachnids	24	23	31	17	23	28	146
Coleoptera	*Actobius cinerascens*				1			1
	Acupalpus brunnipes	1			2	1	1	5
	Acupalpus dorsalis	6		1	2	2	1	12
	Acupalpus luteatus					1	5	6
	Acupalpus saturalis			1	2	1		4
	Agriotes ustulatus		1			1		2
	Amara familiaris		1			2		3
	Anthichus floralis	1		1	1	1	5	9
	Aphthona euphorbiae	3		1	1	1	5	11
	Apion fuscirostre		1					1
	Apion violaceum	3						3
	Atomaria gutta	1						1
	Atomaria prolixa		1					1
	Bembidion levigatum		1					1
	Bembidion properans						1	1

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	Cardiophorus rufipes	1	1					2
	Cartodere elongata			2				2
	Cartodere ruficollis		2					2
	Ceutorhynchus troglodytes	1					1	2
	Invertebrate species/group	No. trap						Total specimens
		1	2	3	4	5	6	
	Clanoptilus marginellus		1					1
	Coccinella 11 punctata	1						1
	Coccinella 14 punctata				1			1
	Coccinella 5 punctata		1					1
	Coccinella 6 pustulata				1			1
	Coccinella 7 punctata	2			2			4
	Coccinella 9 punctata			1				1
	Colodera aethiops			2				2
	Colodera nigrita		1					1
	Corticaria crenulata		1					1
	Cryptobium fracticorne		1	1				2
	Dermestes laniarius	3		1				4
	Drasterius bimaculatus		2	6	4	2	2	16
	Elater praeustus				2		1	3
	Formicomus pedestris		2	5	3		5	15
	Haltica oleracea	1					1	2
	Harpalus calceatus	26	25	93	52	62	54	312
	Harpalus distinguendus	213	306	141	154	106	171	1091
	Harpalus griseus					1		1
	Harpalus nigrita			3				3
	Harpalus pubescens	22		48		15		85
	Harpalus smaragdinus	1					2	3
	Harpalus tardus		2					2
	Heterostomas villiger					1		1
	Hister merdarius	2		1	2	2	2	9
	Hister stercorarius					1	2	3
	Ityochara rubens	3	1		2			6
	Longitarsus brunneus					1	2	3
	Micraspis 12 punctata	2						2
	Micraspis sedecimpunctata				1			1
	Microlester maurus				3	2	4	9
	Monotoma picipes		2	2		1		5
	Mycetoporus brunneus	1				1		2
	Onthophagus ovatus		1		2			3
	Opatrum sabulosum	5	11	2	9	1	3	31
	Paramecosoma melanocephalum	1			1	1		3
	Phyllotretta nemorum			1			1	2
	Phylonthus pulus	2			1			3
	Polydrosus amoenus			1	1		1	3
	Pteryngium crenatum					1		1
	Rizophagus nitidulus	2					1	3
	Tachyporus abdominalis		3				1	4
	Tachyporus hypnorus					1		1
	Sapintus fulvipes	3			2			5
Total coleopters 63 species		1722 specimens						

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Hemiptera	Cicads	11	6	7	19	12	11	66
	Campylosteira verna			1				1
	Stephanitis pyri		1			1		2
	Aphids	9	39	10	7	9		74
	Invertebrate species/group	No. trap						Total specimens
		1	2	3	4	5	6	
	Heteroptera sp.	4	18	9	3	16	8	58
Myriapods	Miriapods	3	3	3			1	10
Neuropters	*Chrysopa melanopa*			1				1
Lepidopters	Lepidopters			3				3
Dipteras	Dipters	25	23	6	13	17	21	105
Hymenopters	Ants	104	155	96	132	96	185	768
	Bees	1		5	2	1		9
	Wasps	13			5		7	25
	Parasitic Wasps	28	39	19	11	14	24	135
Orthopters	*Gryllus campestris*	4	14	31	12	10	12	83
	Grasshopper			1				1
TOTAL		546	707	553	509	466	622	3403

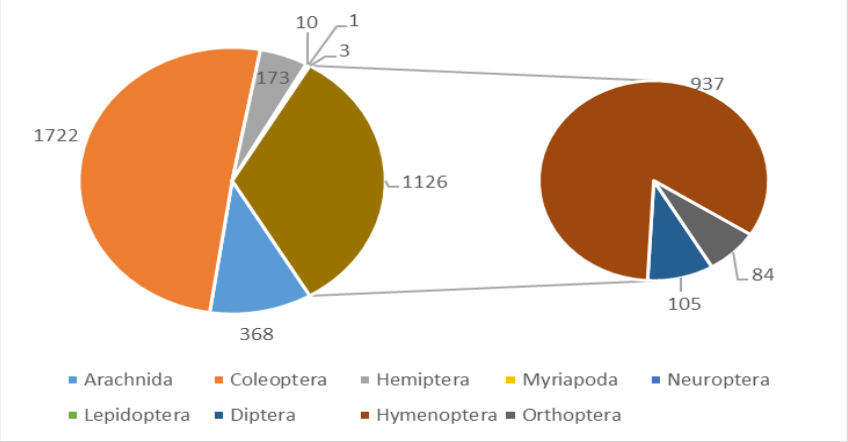

Figure 2. Graphic representation of the invertebrate fauna collected in the year 2023 in the goji culture

Indices of alpha biodiversity of invertebrates collected in Goji culture

In 2023, 81 taxa with 3403 specimens were collected, and the alpha biodiversity index recorded the following values: The Shannon index, or Shannon-Weaver index, is commonly used to measure specific biodiversity. In the goji culture, during the research period, its value was 3.461, which indicates the existence of a high level of diversity (Table 2).

Tabel 2. Calculation of alpha diversity indices in goji culture

Total specimens collected		3403
Index Simpson	$1-\sum_{i=1}^{k}\frac{n_i(n_i-1)}{n(n-1)}$	0.1719

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Dominance index	$D = \frac{N(N-1)}{\sum n(n-1)}$	0.8281
Shannon index	$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$	3.461
Shannon index	$H = -\sum Pi * logPi$	2.399
Shannon index	$\sum_i (\frac{ni}{N} \log 10(\frac{ni}{N}))$	-1.042
Menhinick index	$\frac{S}{\sqrt{\sum_i ni}}$	1.389
Buzas and Gibbson index	$\frac{e^{-\sum_i (\frac{ni}{N} \ln (\frac{ni}{N}))}}{S}$	0.136
The equity index	$\frac{\sum_i (\frac{ni}{N} 1n (\frac{ni}{N}))}{\ln N}$	0.5459
The Berger-Parker dominance index	$\frac{n_{max}}{N}$	0.3206
Margalef index	$\frac{S-1}{\ln N}$	9.837

Then the values are between 0 and 1 and, inversely to the previous index, express the probability that two randomly chosen individuals belong to different species or taxons.
The index is calculated based on the relative abundance of different species within the community. A low dominance index of 0.8281 suggests a more even distribution.
The Preston diagram (Figure 2) shows that there are 22 taxa with abundance 1; 13 taxa with abundance 2; 17 taxa with abundance 2-4; 5 taxa with abundance 4-8; 9 taxa with abundance 8-16; 3 taxa with abundance 16-32; 2 taxa with abundance 32-64; 4 taxa with abundance 64-128; 3 taxa with abundance 128-256; 1 taxon with abundance 256-512; 1 taxon with abundance 512-1024; and 1 taxon with abundance 1024-2048.

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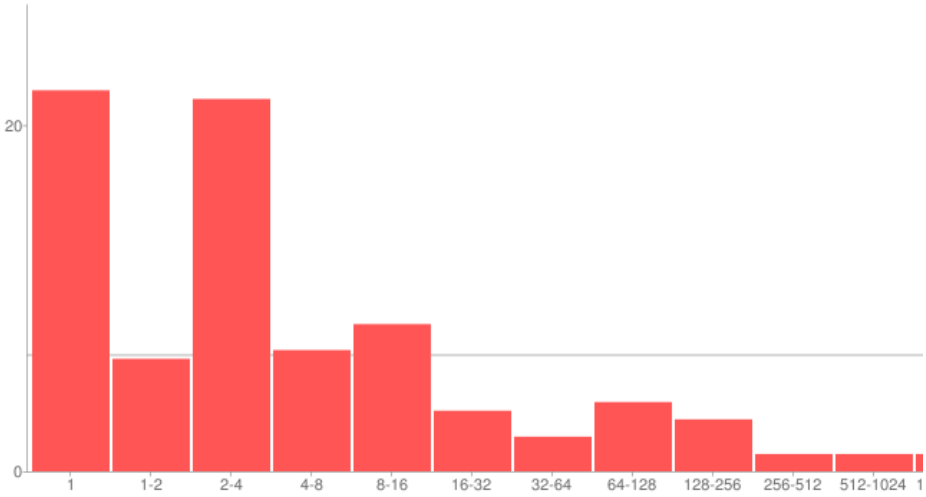

Figure. 2. Preston diagram for the fauna collected in goji culture

The Lorenz curve (Figure 3) is a graphical representation developed by the American economist Max O. Lorenz in 1905 to measure inequality within a population.
For the fauna collected in the goji crop in 2023, this indicates high levels of inequality.

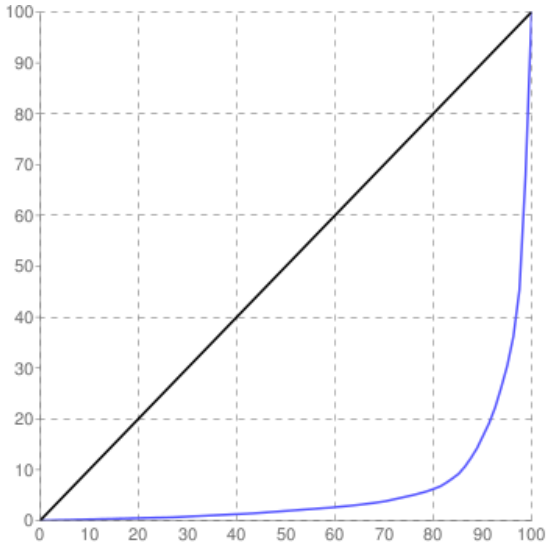

Figure 3. Lorenz curve for the fauna collected in goji culture in 2023

4. CONCLUSIONS

In 2023, six harvests of invertebrate species were conducted in the goji culture using Barber-type soil traps, with the number of specimens collected ranging from 349 to 748 per harvest, all belonging to the Order Arthropoda.

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Biodiversity indices revealed significant variation, with values such as the Simpson Index at 0,1719, the Shannon Index (H') at 3,461, and the Margalef Index showing a slight decrease from 9,909 in 2022 to 9,837 in 2023, reflecting changes in arthropod diversity over time.
The Preston diagram indicated an uneven distribution of species, with most taxa showing low abundance, while a few dominant taxa exhibited very high abundance (up to 1024–2048 samples).
The Lorenz curve analysis showed a significant deviation from the diagonal line, highlighting pronounced inequality in the distribution of species within the entomofauna of the goji crop in 2023.

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