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Research Article

Evaluation at The Upper Taxon Level of Biological Diversity Parameters of Epigean Species in Mayer Lemon Agro-Ecosystems Used Different Application

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ABSTRACT

This study was carried out to evaluate the biodiversity parameters at the upper taxon level of epigean species in lemon agro-ecosystems with different applications between 2019 and 2022. Field studies were carried out on the land of Çukurova University, Faculty of Agriculture Revolving Fund, on a 50-decare Mayer lemon variety orchard. For this purpose, four parcels were chosen: (i) **Chemical** (herbicide was applied periodically for weed control and weed growth was not allowed), (ii) **Weed cutting** (in-row mulching and inter-row weed cutting applications are made), (iii) **Vetch** (in-row mulching and inter-rows covering the plant with vetch (*Vicia sativa* L. (*Fabaceae: Leguminosae*)), and (iv) **Control** (where conventional agriculture is applied). The pitfall trap sampling method was used to measure the biodiversity parameters at the upper taxon level of the epigean (epigeal) species. Arthropoda, Chordata, Mollusca (3 phylum), and Amphibia, Arachnida, Insecta, Gastropoda, Malacostraca, and Reptilia (6 classes) were sampled over 3 years in the study. When the data were evaluated together with all the study years it was seen that the highest Shannon-Wiener diversity value was calculated in the vetch plot as 1.9981. The dominance value increasing or decreasing inversely with the diversity was calculated highest in the control (0.2746), weed cutting (0.2290), chemical (0.2172), and vetch (0.1686) plots, respectively. It was determined that the habitat with the lowest dominance was the vetch parcel. According to percent similarity, the most similar parcel was found in weed cutting and control parcels, and this similarity rate was calculated as 83.879 %. Vetch parcel was found 71.688 % similar to the group formed by control and weed-cutting parcels. Besides chemical parcel was found %52.04 similar to the group formed by the rest of the study areas. Although vetch and chemical parcels were within the same garden boundaries, they were found to be only 58.012 % similar to each other. According to the results of this study; it can be said that the biodiversity in the agro-ecosystems where cover crops are applied, may have a higher biodiversity value than the diversity of conventional agricultural lands. In addition, when these two different application methods are compared in terms of similarity, the dissimilarity rate may increase due to the difference in epigean species living in those agro-ecosystems.

Keywords: epigean species, conventional agriculture, pesticide application, weed cutting, cover plant, Shannon-Wiener, Simpson diversity, similarity, dominancy

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Evaluation at The Upper Taxon Level of Biological Diversity Parameters of Epigean Species in Mayer Lemon Agro-Ecosystems Used Different Application

Farklı Uygulamalar Kullanılan Mayer Limon Agro-Ekosistemlerinde Epigean Türlerin Biyolojik Çeşitlilik Parametrelerinin üst Takson Seviyesinde Değerlendirilmesi

ÖZ

Bu çalışma, 2019-2022 yılları arasında farklı uygulamaların yapıldığı limon agro-ekosistemlerinde epigean türlerinin biyoçeşitlilik parametrelerinin üst takson seviyesinde değerlendirilmesi amacıyla yapılmıştır. Çalışma alanı olarak Çukurova Üniversitesi, Ziraat Fakültesi Döner Sermaye İşletmesi sınırları içerisinde bulunan 50 dekarlık Mayer limon bahçesi seçilmiştir. Bu amaca ulaşmak için bahçede dört parsel belirlenmiştir. Bunlar; (i) **Kimyasal** (yabancı ot kontrolü için periyodik olarak herbisit uygulanmış ve yabancı ot büyümesine izin verilmemiştir), (ii) **Yabancı ot kesimi** (sıra içi malçlama ve sıra arası yabancı ot kesim uygulamaları yapılmıştır), (iii) **Fiğ** (sıra içi malçlama ve fiğ bitkisi (*Vicia sativa* L. (Fabaceae: Leguminosae) ekimi) ve (iv) **Kontrol** (geleneksel tarımın uygulaması) parselleri olarak belirlenmiştir. Örtücü bitkinin etkinliğini belirlemek amacı ile çukur tuzak örnekleme yöntemi epigean türlerin üst takson seviyesinde değerlendirilmesi amacı için kullanılmıştır. Çalışma süresince Arthropoda, Chordata, Mollusca Şubelerine bağlı Amphibia, Arachnida, Insecta, Gastropoda, Malacostraca ve Reptilia sınıfa ait epigean türler örneklenmiştir. Veriler tüm çalışma yılları ile birlikte değerlendirildiğinde en yüksek Shannon-Wiener çeşitlilik değerinin 1.9981 olarak fiğ parselinde hesaplandığı görülmüştür. Çeşitlilik ile ters orantılı olarak artan veya azalan dominantlık değeri en yüksek sırasıyla kontrol (0.2746), yabancı ot biçme (0.2290), kimyasal (0.2172) ve fiğ (0.1686) parsellerinde hesaplanmıştır. Dominantlığın en düşük olduğu habitatın fiğ parseli olduğu belirlenmiştir. Yüzde benzerliğe göre birbirine en çok benzeyen parsellerin yabancı ot biçme ve kontrol parselleri olduğu ve bu benzerlik oranının % 83.879 olarak hesaplandığı görülmüştür. Fiğ parseli, kontrol ve yabancı ot kesme parsellerinin oluşturduğu gruba % 71.688 oranında benzer bulunmuştur. Ayrıca kimyasal parsel, çalışma alanlarının geri kalanının oluşturduğu gruba % 52.04 oranında benzer olarak hesaplanmıştır. Fiğ ve kimyasal uygulanan parseller aynı bahçe sınırları içinde olmasına rağmen sadece % 58.012 oranında birbirine benzer bulunmuşlardır.

Bu çalışmanın sonuçlarına göre; örtücü bitkilerinin uygulandığı agro-ekosistemlerdeki biyolojik çeşitliliğin, konvansiyonel tarım uygulamasının olduğu agro-ekosistemlere göre daha yüksek bir biyolojik çeşitlilik değerine sahip olduğu ortaya çıkarılmıştır. Ayrıca bu iki farklı uygulama yöntemi benzerlik açısından karşılaştırıldığında, o agro-ekosistemlerde yaşayan epigean türlerinin farklılığından dolayı benzemezlik oranlarının artabileceği söylenebilir.

Anahtar Kelimeler: Epigean türler, geleneksel tarım, pestisit uygulamaları, yabancı ot kesimi, bitki örtüsü, Shannon-Wiener, Simpson çeşitlilik, benzerlik, dominantlık

Introduction

The rapid progress of science and technology in the 19th century, along with industrialization, developed urbanization in an extraordinary way (Ho-Fung & Zhan, 2013). While the developed industrial societies meet most of the energy needs of the growing population from fossil fuels, they have also contributed to the pollution of the environment they live in. While the rate of fossil fuel consumption is increasing, the above-ground resources are rapidly decreasing in order to meet the food needs of people. The destruction of natural resources in this way brings the danger of drought and desertification (Perera, 2017; Mirzabaev et al., 2019). Approximately 5 billion hectares of land in the world are faced with drought and desertification and 1.5 billion people are directly affected by this event (UNCCD., 1995). In recent years, the soil characteristics and climate of our country have changed and the sensitivity to drought and desertification has increased gradually (Kapur et al., 2008). Not to mention the transformation of agricultural lands into urban areas (Unfortunately, agricultural lands are now obtained by the destruction of natural ecosystems). It has become a necessity to fight against drought, desertification, global warming, and the destruction of arable land all over the world. Otherwise, in this context, the planet will eventually become uninhabitable as a result of the increasing natural slaughter all over the world. Negativities such as "the lack of a sustainable agricultural policy", "wrong agricultural practices", “excessive use of pesticides (including increased use of herbicides) and chemical fertilizers”, “mismanagement of land and water resources”, and “inappropriate land use with the increase of mechanized agriculture” in existing agricultural areas disrupt the natural functioning of agro-ecosystems and negatively affect biological diversity (Aktar et al., 2009).

Biodiversity refers to the level of organization of all living species on Earth and the diversity of life. Biological diversity is examined in three different dimensions genetic diversity, species diversity, and ecosystem diversity. Genetic diversity refers to the intraspecific difference between populations that are somehow geographically isolated from each other and between individuals of a population of a species while Species diversity refers to the difference that exists between species in a particular region. Ecosystem diversity encompasses the entirety of interacting organisms as an ecological unit and their physical environment.

The concept of "agricultural biodiversity" refers to biodiversity at all stages of all kinds of agricultural production. Agricultural biodiversity supports the basic functions, structure, food production, and food security of the agro-ecosystem (Aydın, 2021, a, b). The multi-faceted complex network of relationships within the food chain of an ecosystem shows that that ecosystem is very strong in terms of ecological balance, while it is very sensitive to changes (Karaca ve ark., 1993; Aydın & Şen, 2020; Aydın & Demir, 2020).

Ecological deterioration observed in all living organisms living in freshwater, saltwater, and terrestrial ecosystems and even in the inanimate environment adversely affects the species living in these areas and harms biological diversity. Ecological destruction observed in all living organisms living in freshwater, saltwater, and terrestrial ecosystems and even in the inanimate environment adversely affects the species living in these areas and harms biological diversity. There have been many studies conducted abroad on the negative effects of human activities on biodiversity nowadays (Abudulai, et al., 2022; Ballal, et al., 2022; Franson & Tekla, 2022; Markl et al., 2022; Marschalek & Deutschman, 2022; Outhwaite, et al., 2022; Ríos-Touma, et al., 2022; Shane, et al., 2022; Soler, et al., 2022; Storch, et al., 2022). As an example of the studies on "insect biodiversity and investigating the possibilities of using insects as biological indicators in sustainable land use", the first scientific study in our country can be cited as the doctoral thesis of Dr. Gökhan Aydın under the supervision of Prof. Dr. Erdal Şekeroğlu and Prof. Dr. Cengiz Kazak (Çukurova University, Faculty of Agriculture, Department of Plant Protection, Adana) (Aydın, 2006). In our country, from this date to the present many scientific studies have been carried out on "calculation of biodiversity parameters of insects in different habitats", "investigating the possibilities of using insects as bioindicators for habitat description and destruction ", "the use of insects as biological indicators to ensure the sustainability of protected areas", "calculation of biodiversity in cave ecosystems and determination of biological indicator species", "testing predictors of species richness used in biodiversity calculations on the adequacy of sampling methods", etc., but multidisciplinary studies or the studies of different authors have not been encountered frequently (Aydın, Şekeroğlu & Arndt, 2005; Aydın & Kazak, 2007; Aydın & Kazak, 2010; Aydın, 2011; Aydın & Karaca, 2018; Aydın & Demir, 2020; Aydın & Şen, 2020; Aydın, 2021a; Aydın, 2021b; Aydın, 2022).

Citrus, one of the agro-ecosystems, has an important share among the fruits grown in Turkey. The eastern Mediterranean region has a 70% share of citrus cultivation in Turkey. Citrus orchards, as in many agricultural fields, have many negative reasons such as inaccurate agricultural practices, excessive pesticide use, monoculture agriculture without using cover crops, etc. affect negatively human health and nature. There are many scientific types of research supporting organic agriculture or good agricultural practices versus conventional agriculture in Turkey (Ortaç et al., 2015; Aydın & Karaca, 2018; Gülbarış, et al., 2021; Silay, et al., 2021; Aydın, 2022).

Cover plant application is made to increase biological diversity. Advantages of cover crops include nitrogen fixation in the soil, preventing erosion, increasing the amount of organic matter in the soil, protecting soil moisture, creating a habitat for predators and/or parasitoid insects, and controlling weeds. Some of the cover plants used in biodiversity studies in agricultural ecosystems are; *Arachis hypogaea*, *Avena sativa*, *Crotalaria juncea*, *Enchinochloa frumentacea*, *Fagopyrum esculetum*, *Glycine max*, *Hordeum vulgare*, *Lolium multiflorum*, *Mucuna deeringiana*, *Paspalum notatum* cv. *competidor*, *Pennisetum glaucum*, *Pisum sativum arvense*, *Secale cereale*, *Setaria italica*, *Sorghum bicolor* × *Sorghum sudanense*, *Trifolium incarnatum*, *Trifolium repens*, *Trifolium subterraneum*, *Triticum aestivum*, *Vigna unguiculata*, *Visia sativa*, *Visia villosa*. In a habitat, including agricultural areas, plant biodiversity, and insect biodiversity increase or decrease in direct proportion (Aydın, 2011). Insects, especially epigean species (e.g. some species of Carabidae, Scarabaeidae, Tenebrionidae, and Staphylinidae families) have been often used as indicators for habitat identification and habitat degradation purpose of the sustainability of protected areas and/or for improvement of an agro-ecosystem (Aydın, et al., 2005; Arndt, et al., 2005; Aydın & Kazak, 2007; Aydın & Kazak, 2010).

The study was aimed to evaluate the biodiversity parameters at the upper taxon level in Mayer lemon agro-ecosystems, with using and without using cover plants affiliated to Çukurova University, Revolving Fund Management Directorate.

Material and Methods

Study areas

Field studies were carried out between 2019 and 2022 on the land of Çukurova University, Faculty of Agriculture Revolving Fund, on a 50-decare Mayer lemon variety orchard. Mayer lemon orchard was divided into four parcels of 10 decares each with three rows of safety strips between them. The first parcel was chosen as the plot where herbicide applications were made for weed control" (**Chemical**). Chemical plot, herbicide was applied periodically for weed control, and weed growth was not allowed. The second parcel was chosen as "the parcel where in-row mulching and inter-row weed cutting applications are made" (**Weed cutting**) Grasses were mown about 5 cm above the weeds with line mowers. No herbicide application was made in the mentioned plot. The third plot was chosen as "in-row mulching and inter-rows covering plant with vetch, (*Vicia sativa* L. (Fabaceae: Leguminosae)" (**Vetch**). Cover crop, vetch, was inter-row planted by plowing the soil. Vetch is planted twice a year (march and september) as a cover plant and when the vetch is blooming, it was mixed into the soil. The control plot was evaluated as the area where conventional agriculture is applied (**Control**).

Sampling method

The pitfall trap sampling method was used to measure the biodiversity parameters at the upper taxon level of the epigean (epigeal) species, living above the soil, in four different habitats where field studies were carried out. Totally 80 pitfall traps (20 traps for each plots) were placed in the Mayer lemon orchard. Plastic pitfall trap containers, 15 cm in diameter and 20 cm in depth, were buried in the soil in all plots, with 20 pieces at approximately 10 meters intervals, with the open parts at the soil level (New, 1998). Pitfall traps were placed in locations that represent plots. Traps were checked once a week throughout the year. Captured species from each plots were collected with appropriate techniques; counted separately and recorded in the prepared charts and evaluated at the upper taxon level.

In the first year of the study, 2020, it was possible to collect the samples caught with pitfall traps in a healthy way in March, May, June, July, August and September. In 2021, samples were collected between January and July. The epigean species were sampled by pitfall traps between April and August in the last year of the study. Data obtained from pitfall traps were used to calculate biodiversity parameters.

Statistical analysis (Measurement of Biodiversity parametres)

The biodiversity parameters of plots were calculated using the EvenDiv 1.1 program (Heimann, 2004), the parameters used and their calculation methods are given below:
for species diversity;

- Shannon-Wiener diversity index (H')

$$H' = -\sum pi \ln(pi)$$

pi: the importance value of a species as a proportion of all species

ln: the natural logarithm

- Simpson diversity index (S)

$$S = 1 - \sum \mathrm{ni(ni-1)/N(N-1)}$$

i: number of species

ni: the importance value of a species as a proportion of all species

N: s the sum of the number of individuals

for species dominancy;

- Simpson dominance index (Sd)

$$S = \sum \mathrm{ni(ni-1)/N(N-1)}$$

i: number of species

ni: the importance value of a species as a proportion of all species

N: the sum of the number of individuals

for species evenness;

- Shannon Evenness index (EH')

$$EH' = H'/\ln(\mathrm{N})$$

H': Shannon-Wiener diversity

ln: the natural logarithm

N: the sum of the number of individuals

- Simpson Evenness index (ESm)

$$ESm = S/\mathrm{N}$$

S: Simpson diversity

N: the sum of the number of individuals (Magurran, 1988; 2004)

MVSP (Multi Variate Statistical Package) 3.11c program was used to classify selected plots (Kovach, 1999).

for similarity;

- Percentage similarity index (%S)

$$\%S = \sum \mathrm{min(a, b, \dots\dots\dots, x)}$$

∑min: the sum of the smallest values whose percentages are calculated in the habitat with the smallest values in the other habitat whose similarity is calculated (Kreps, 1999).

Results and Discussion

A total of 1287 individuals belonging to 3 phylum (Arthropoda, Chordata, Mollusca) and 6 classes (Amphibia, Arachnida, Insecta, Gastropoda, Malacostraca and Reptilia) were sampled over 3 years in the study.

When the biodiversity results of 2020 in the all pilots are evaluated on a weekly basis; it seen that the expected result from the pitfall traps could not be obtained because of the many reasons such as removal and damage of traps by human and animals, weed cutting, pesticide application, ecological/climatic factors (rain, the wind carries the soil to cover the traps, etc) on 12 and 26 May, 25 June, 16 and 22 July, 6 August, 10, 17, and 24 September and 1, 7, 14, and 21 October in chemical; on 26 May, 4, 11, and 25 June, 9, 16, and 28 July, 13, 20, and 27 August, 10, 17, and 24 September, 1, 7, 14, and 21 October in control; on 18 and 25 June, 6 August, 3 and 10 September, 7 and 14 October in vetch; and on 12, 19, and 26 May, 25 June, 9 July, 3, 10, and 24 September, 1, 7, and 14 October in weed cutting. However, Shannon-Wiener was found with the highest values on 27 March with 1,3322 in Chemical Plot, 13 March with 1,5498 in the control plot, 9 July with 1,7479 in vetch, and 6 March with 1,7046 in the weed cutting plot. Shannon-Wiener diversity value were unexpectedly high in cold period (March) in all experimental areas except cover crop, vetch plot (July, as expected) (Figure 1).

Except when traps were unusable, Shannon-Wiener diversity result showed high and a balanced distribution in Vetch Plot if compared to others. Control and weed cutting sampling areas were seen an increasingly decrease diversity curve on graphs. It was observed that the diversity curve increased even more during the warmer season which the active periods of epigean species in the vetch sampling area (Figure 1).

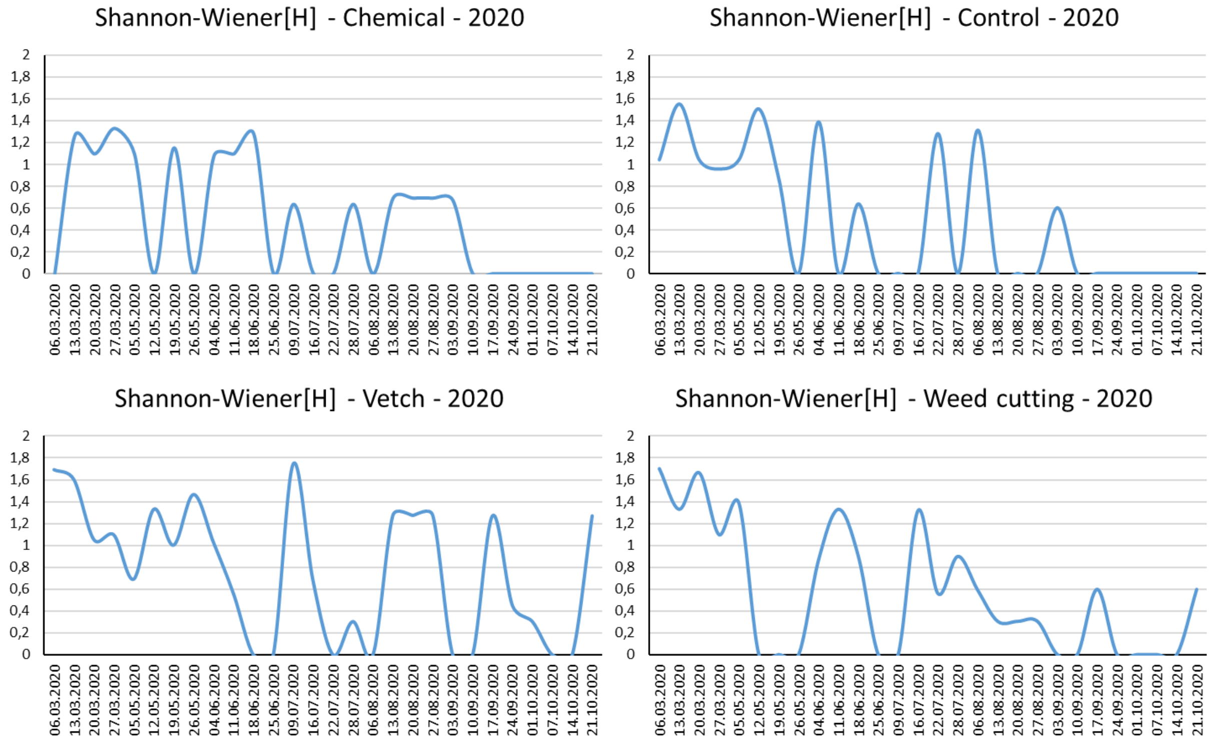

Figure 1. Weekly measured Shannon-Wiener diversity parameter values with the data obtained from the pitfall traps in chemical, control, vetch, and weed cutting areas in 2020.

Due to the reasons stated above, sample cannot be made in some weeks in the study areas. It has been revealed that the biodiversity values are so low that they can hardly be measured in the chemical applied area. Shannon-Wiener diversity result showed that March, May, and

June were the most diverse in Vetch sampling area while only April and May were the most diverse in control and weed cutting areas, respectively. (Figure 2).

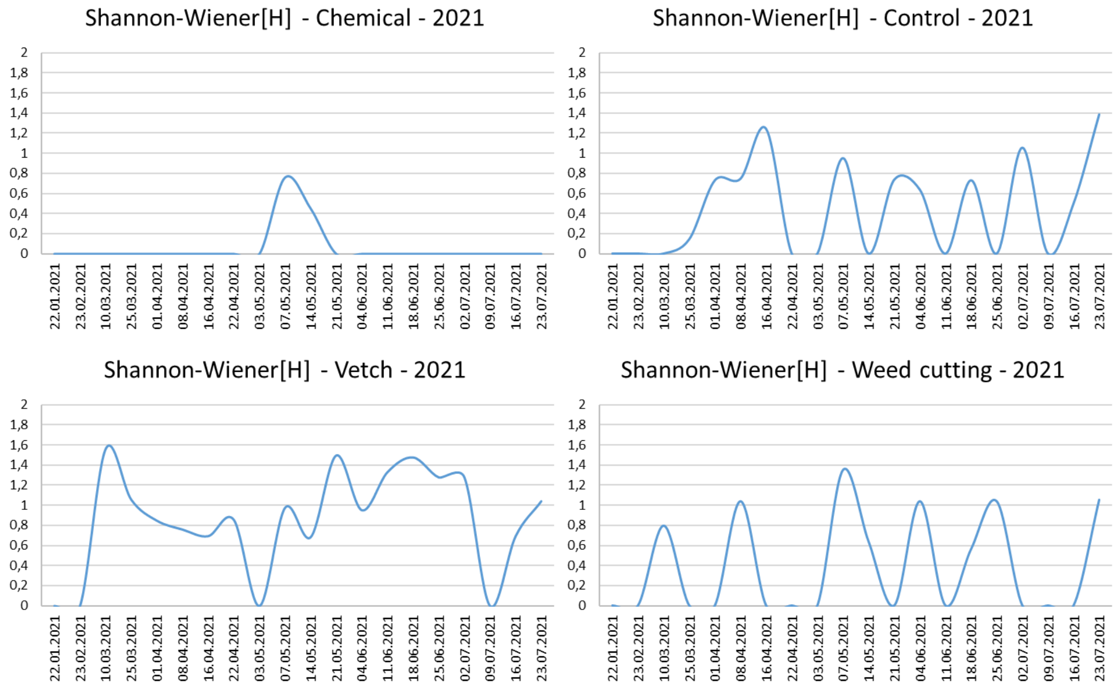

Figure 2. Weekly measured Shannon-Wiener diversity parameter values with the data obtained from the pitfall traps in chemical, control, vetch, and weed cutting areas in 2021.

Based on the data obtained from the pitfall traps set up in the areas where chemicals are applied and cover crops are used, it was seen that the diversity of these areas could be measured between April and June. Biodiversity data obtained in the region with vetch cover crop application during this time period showed that it was more diverse compared with other regions. Average of Shannon-Wiener diversity results from beg. of April to beg. of June were calculated as 0.7545 in the vetch parcel, 0.5452 in the control parcel, 0.2706 in the weed cutting parcel, and 0.2186 in the chemical parcel. Shannon-Wiener diversity results were measured until August, 11 in both control and weed cutting areas. The highest diversity result was found in weed cutting as 1.4328 while the lowest one was found in control at 1.3031 (Figure 3).

It was observed that Shannon-Wiener biodiversity values unexpectedly decreased over time. Biodiversity values were found to be the highest in all plots except the chemical parcel in March, when the activities of Epigean species were just beginning. Although similar curves in chemical parcel observed in March the highest value was calculated on June in mentioned parcel. When the plots were compared with each other in terms of diversity, they were found in vetch (1.9426), weed cutting (1.8467), chemical (1.5858), and control (1.5659) plots, from highest to lowest, respectively (Figure 4).

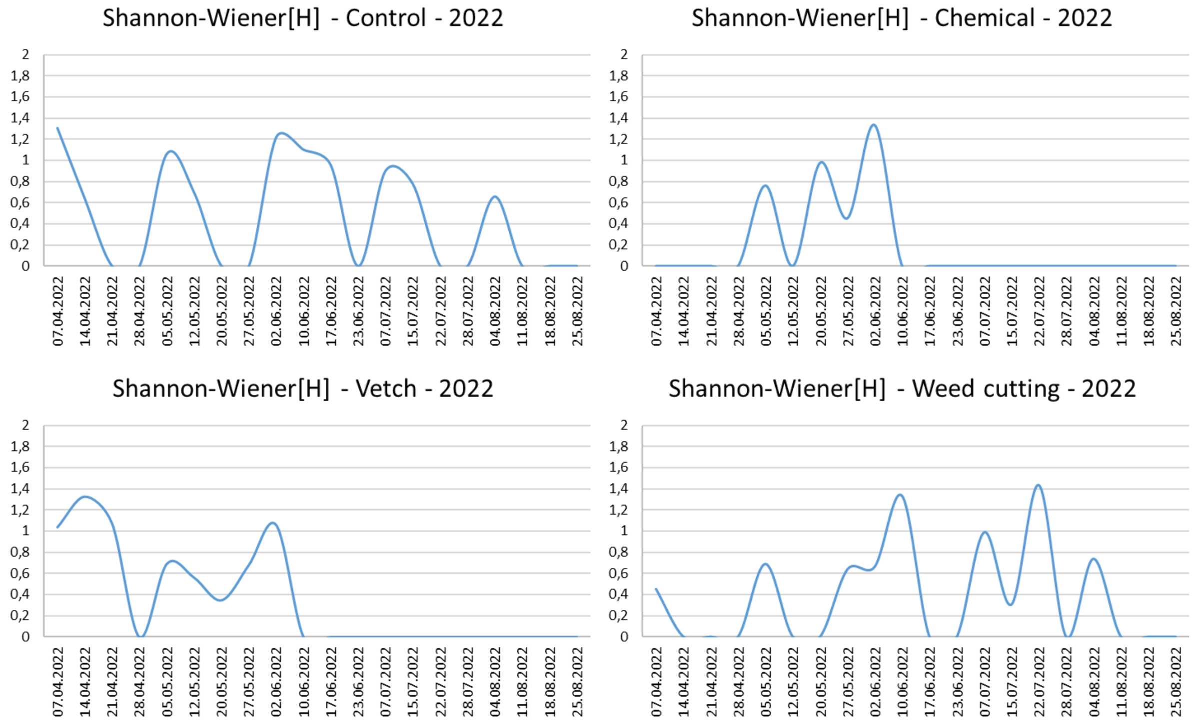

Figure 3. Weekly measured Shannon-Wiener diversity parameter values with the data obtained from the pitfall traps in chemical, control, vetch, and weed cutting areas in 2022.

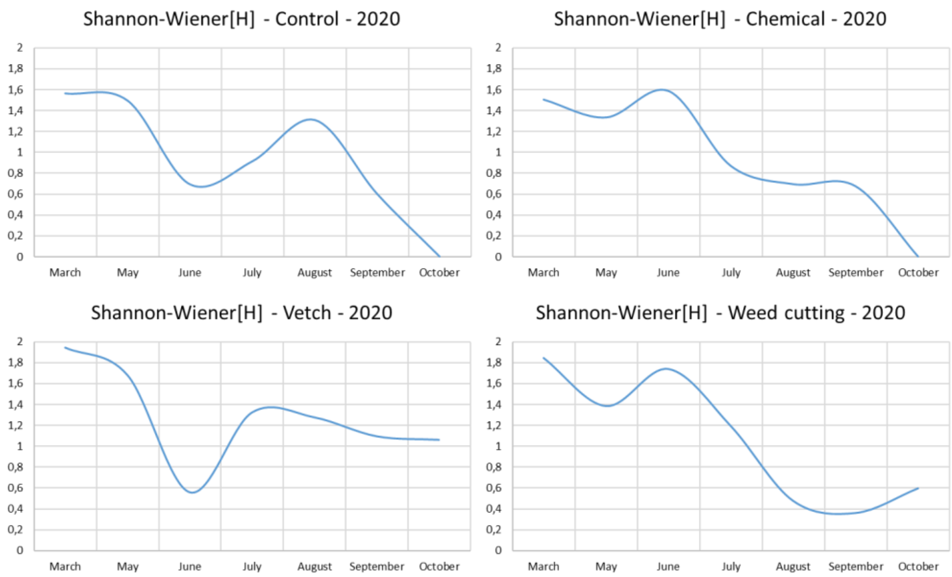

Figure 4. Monthly measured Shannon-Wiener diversity parameter values with the data obtained from the pitfall traps in chemical, control, vetch, and weed cutting areas in 2020.

At the upper taxon level, the most diverse parcel was found in vetch with 1.6731. Shannon-Wiener diversity results were found lowest in chemical parcel with 0.8169. Shannon-Wiener diversity results in weed cutting and control parcels were found between highest and lowest values with 1.5171 and 1.6731, respectively (Figure 5).

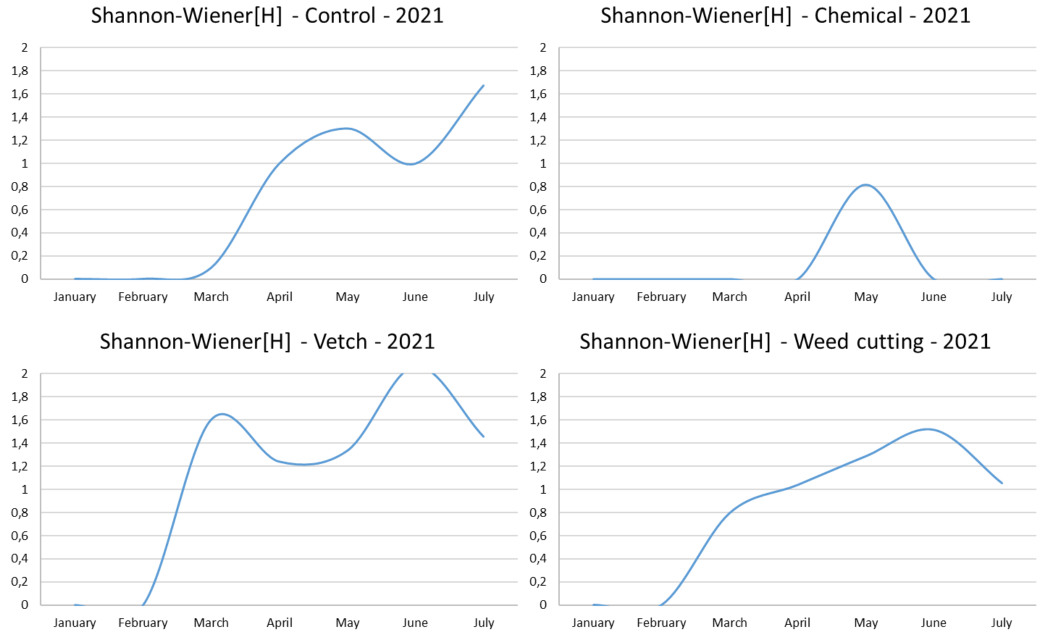

Figure 5. Monthly measured Shannon-Wiener diversity parameter values with the data obtained from the pitfall traps in chemical, control, vetch, and weed cutting areas in 2021.

The highest Shannon-Wiener diversity results were found in both vetch and control parcels in April however a sudden decrease was observed in nearly all parcels thereafter, the except chemical parcel. The biodiversity values in the chemical parcel only showed a rising and falling curve between April and June. The reason for sudden decrease of this curve is thought to be chemical application (Figure 6).

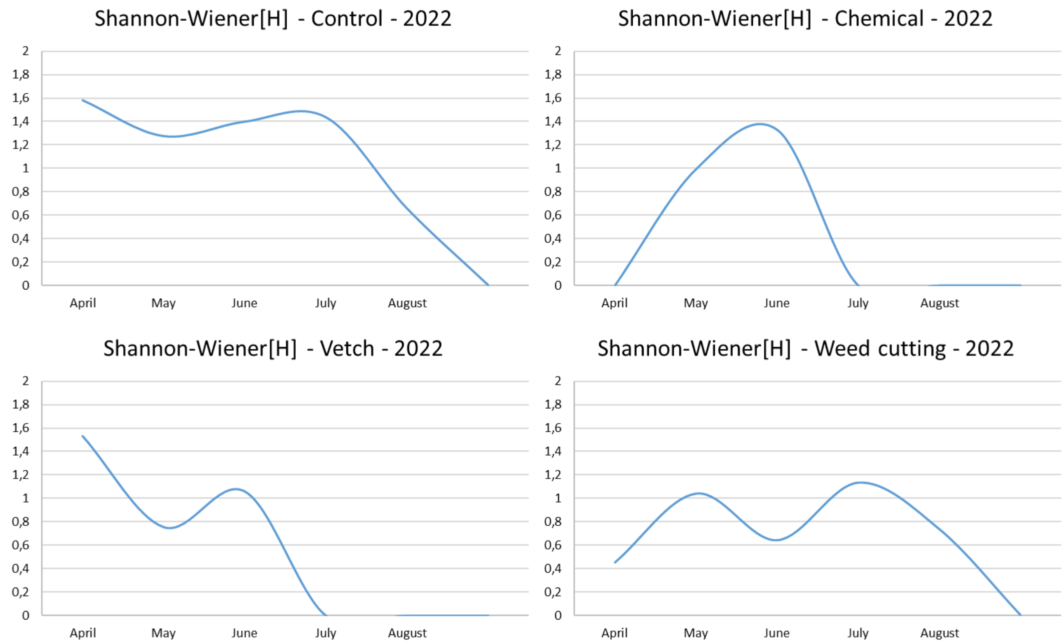

Figure 6. Monthly measured Shannon-Wiener diversity parameter values with the data obtained from the pitfall traps in chemical, control, vetch, and weed cutting areas in 2022.

The Shannon-Wiener biodiversity values calculated with the data obtained from the pitfall trap sampling method differ from each other when compared with each other over the years (Figure 7; upper left; upper right; lower left). However, when the graphic curve showing all the years together was examined seen that the highest Shannon-Wiener diversity value was found in vetch parcel (with 1.9981) (Figure 7; lower right). The lowest diversity value was determined in the control plot with 1.5957. Weed cutting and chemical parcels were calculated between highest and lowest values with 1.8413 and 1.8176, respectively.

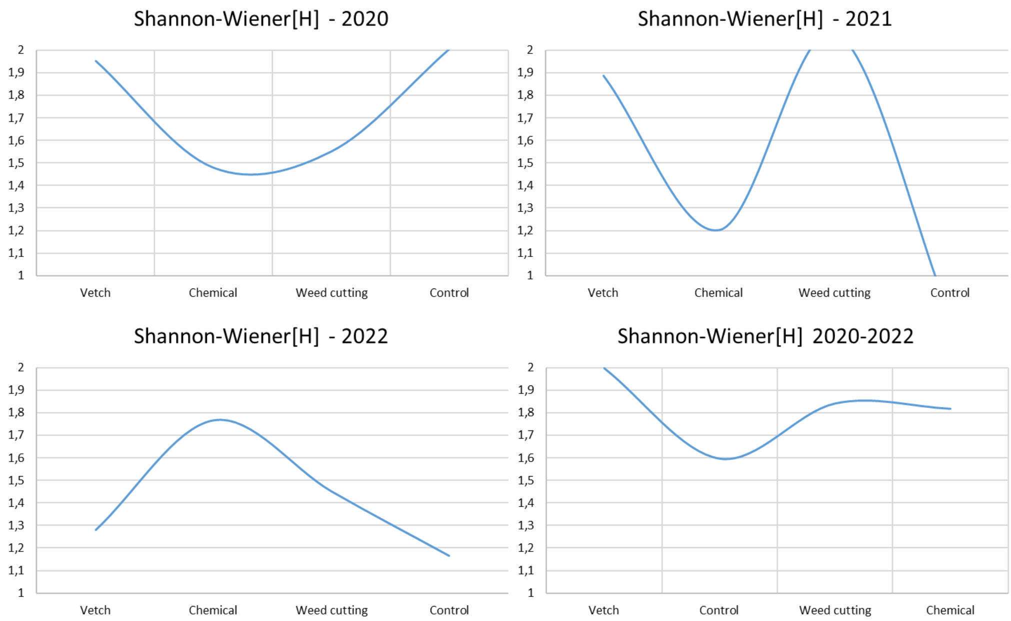

Figure 7. Yearly measured Shannon-Wiener diversity parameter values with the data obtained from the pitfall traps in chemical, control, vetch, and weed cutting areas in 2020 (upper left), 2021 (upper right), 2022 (lower left), and all years/sum of years (lower right).

Table 1 showed that the highest diversity value was found generally in the vetch plot both in 2020 and 2021 although the result of Shannon-Wiener diversity was found almost lowest in mentioned habitat when it compared with others in the year of 2022 (Table 1). Simpson dominance with the highest value were calculated in the control parcel with 2.5476 in 2022. The highest values of Simpson dominancy were calculated in weed cutting and chemical plots in 2020 and 2021, respectively. Vetch plot was never calculated at the highest dominance value in any study year (Table 1).

Table 1. Biological diversity parameter values in vetch, control, weed cutting, and chemical parcels in 2020, 2021, and 2022 (separately).

	2020			
	Vetch	**Control**	**Weed cutting**	**Chemical**
Diversity indices				
Shannon-Wiener[H]	1.9531	1.478	1.5503	2.0047
Simpson Index[D]	0.1877	0.2922	0.3502	0.151
Simpson Diversity[1-D]	0.8123	0.7078	0.6498	0.849
Evenness indices				
Shannon-Evenness[EH]	0.7615	0.7595	0.6733	0.9124

Simpson-Evenness [ESm]	0.4098	0.4889	0.2856	0.7358
	2021			
Diversity indices				
Shannon-Wiener[H]	1.8865	1.2023	2.0764	0.8169
Simpson Index[D]	0.1843	0.4552	0.1769	0.5291
Simpson Diversity[1-D]	0.8157	0.5448	0.8231	0.4709
Evenness indices				
Shannon-Evenness[EH]	0.8193	0.5782	0.8659	0.7436
Simpson-Evenness [ESm]	0.5426	0.2746	0.5139	0.63
	2022			
Diversity indices				
Shannon-Wiener[H]	1.2812	1.7659	1.4521	1.1667
Simpson Index[D]	1.8484	2.5476	2.095	1.6831
Simpson Diversity[1-D]	0.6639	0.7932	0.6919	0.6038
Evenness indices				
Shannon-Evenness[EH]	0.7961	0.8037	0.6983	0.7249
Simpson-Evenness [ESm]	0.5951	0.5373	0.4057	0.5048

When the data were evaluated together with all the study years it was seen that the highest Shannon-Wiener diversity value was calculated in the vetch plot as 1.9981 (Table 2). The dominance value increasing or decreasing inversely with the diversity was calculated highest in the control (0.2746), weed cutting (0.2290), chemical (0.2172), and vetch (0.1686) plots, respectively. It was determined that the habitat with the lowest dominance was the vetch parcel (Table 2)

Table 2. Biological diversity parameter values in vetch, control, weed cutting, and chemical parcels evaluated together in all study years.

	All study years (2020, 2021, and 2022)			
	Vetch	**Control**	**Weed cutting**	**Chemical**
Diversity indices				
Shannon-Wiener[H]	1.9981	1.5957	1.8413	1.8176
Simpson Index[D]	0.1686	0.2746	0.229	0.2172
Simpson Diversity[1-D]	0.8314	0.7254	0.771	0.7828
Evenness Indices				
Shannon-Evenness[EH]	0.7571	0.6655	0.7679	0.8272
Simpson-Evenness [ESm]	0.4237	0.3311	0.397	0.5116

Aydın & Karaca (2018) have compared conventional and organic apple orchards in terms of insect biodiversity. Shannon-Wiener diversity result has showed that the diversity measured in the May period, when insects became active in both years, is found the same in organic and conventional gardens (Shannon-Wiener: 1.8486 organic; 1.8586 conventional). However, it has seen on the manuscript that the biodiversity values measured in the conventional garden suddenly decreased after May in both study years (Shannon-Wiener: 2.2696 organic; 1.6631 conventional). Similar results were obtained in our study, and it was revealed that the diversity was lower in the conventional agriculture and pesticide-applied plots compared to weed cutting and vetch parcels. Šlachta and Vokoun (2011) have studied on impact of an insecticide, application on the non-target insect on one of the agro-ecosystem and declared that there has been no effect of the insecticide treatment on the carabid assemblages. They predicted that pesticide application does not cause toxic effects to the soil and therefore to epigean species by covering the soil surface of ground cover plants. We agree with Šlachta and Vokoun that vetch even weed cutting may protect the epigean species against pesticide application. According to same authors Shannon-Wiener diversity index has calculated as 1.5, and 1.6 before and after the insecticide application, respectively (Šlachta & Vokoun, 2011). We do not agree with this result. Because biological diversity can effect with many biotic and abiotic factor, especially in time. Sometimes a biodiversity result measured too early can mislead you.

The most dissimilar parcel was calculated vetch to the group formed by control, chemical and weed cutting parcels with 0.848 by Sörensen's Coefficient analysis. When examined separately, it was seen that the vetch plot was 0.783 dissimilar to the chemical plot and 0.880 to the weed cut and the control plots (Figure 8).

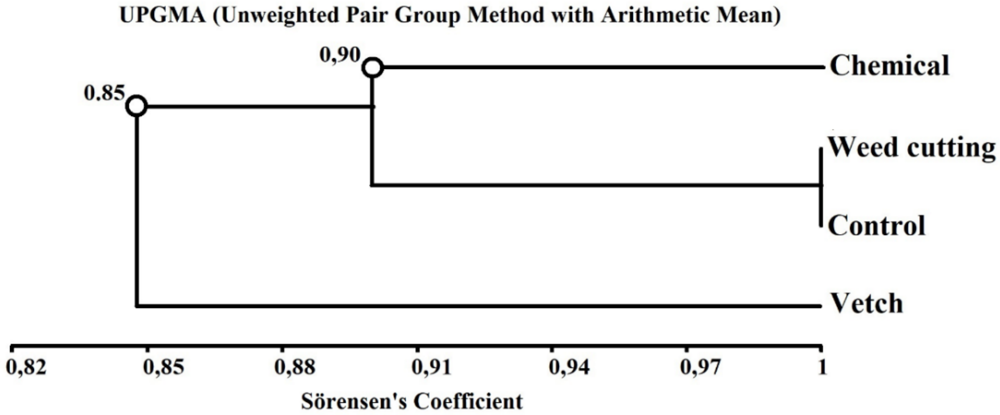

Figure 8. Sörensen's Coefficient analysis calculated considering the epigean species sampled in chemical, control, Vetch, and weed cutting parcels.

According to percent similarity the most similar parcel was found weed cutting and control parcels to each other and this similarity rate was calculated as 83,879 %. Vetch parcel was found 71,688 % similar to the group formed by control and weed cutting parcels. Besides chemical parcel was found %52.04 similar to the group formed by the rest of the study areas. Although vetch and chemical parcels were within the same garden boundaries, they were found to be only 58.012 % similar to each other (Figure 9).

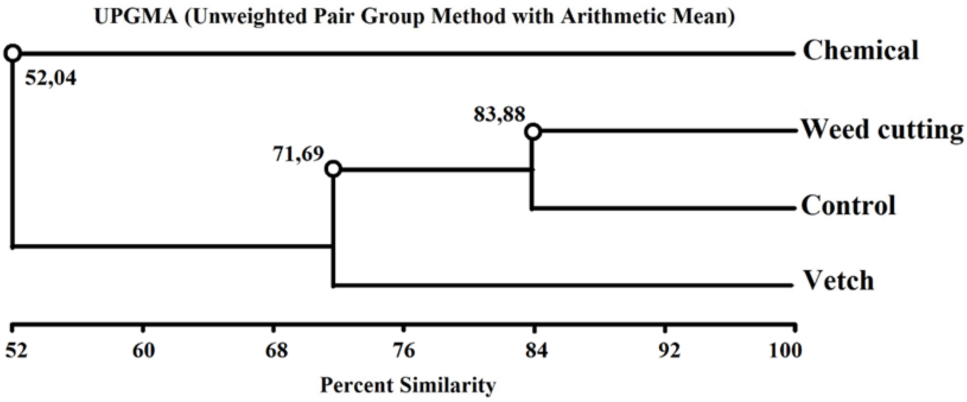

Figure 9. Percent Similarity analysis calculated considering the epigean species sampled in chemical, control, Vetch, and weed cutting parcels.

According to Aydın & Karaca (2018), dendrogram based on a cluster analysis using the Sörenson Coefficient of the carabid assemblages with the pooled data of Organic and conventional apple orchards between 2016 and 2017 has showed that every time a pesticide is applied, the similarity of organic and conventional gardens is negatively affected (Aydın & Karaca, 2018).

Similar to our study result, many scientific studies show that the measured biodiversity values in natural areas are higher than in non-natural areas (Aydin, 2006; Aydın & Kazak, 2007; Aydın & Kazak, 2010; Aydın & Karaca, 2018; Aydın, 2021a; Aydın & Demir, 2020; Aydın, 2022; Ballal et al., 2022; Din. Et al., 2015; Fransson & Tekla, 2022; Karaca et al., 1993; Marschalek & Deutschman, 2022; Outhwaite et al., 2022; Shane et al., 2022; Silay et al., 2021; Storch et al., 2022).

Conclusion

There are numerous studies about the comparison of biodiversity in organic and conventional farming, also include using orchards cover crop. Since the results obtained from some part of the previous studies have been made without considering the time factor, it is quite natural that they do not show similar results to our present study. However, there are large quantity of studies about conventional agriculture reducing biodiversity is quite remarkable. The results obtained from the study are given below:

i) Plant diversity in agricultural areas is effective in terms of increase or decrease in insect biological diversity.

ii) Epigean species that spend their lives on the soil in the pesticide-applied agro-ecosystem can be saved from the toxic effect of the pesticide by the vegetation covering the soil.

iii) Although the upper taxon evaluation is easy to interpret in biological diversity studies, the species-based evaluations will make it easier to find indicator species that are one step ahead of biological diversity.

iv) The results of the study showed that; long-term application of cover plant to an agro-ecosystem may increase biodiversity.

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