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SURVEY OF THE ENTOMOFAUNA ON THE SOIL SURFACE IN AN ORGANIC APPLE ORCHARD

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Abstract

The ecological aspect of organic farming refers to the ability to maintain the resilience of agroecosystems. This paper aims at investigating the species diversity of entomofauna (harmful and beneficial) on the soil surface in an organic apple orchard under the conditions of ecological management approaches. The organic orchard is located on the land of the village of Vodenichane, Yambol region, Bulgaria. Field surveys of entomofauna on the soil surface in the apple orchard were carried out in 2018 and 2019 with monthly reporting of 'pitfall trap' (soil traps) placed in a checkerboard pattern under the crowns of selectd trees. The Dominance index was higher in 2018 in comparison with the dominance index reported in 2019 and showed the capacity of taxons of higher ecological plasticity to increase their number in return for other taxons in the agrocenosis under survey. The other ecological index is the Equitability index, which expresses the uniformity in the distribution of the total number among the separate species and shows a tendency towards striving for achieving optimal development. Equitability was higher in 2018 as compared to the equitability in 2019, which means that the taxons in the complex were more evenly distributed from a systematic point of view.

Key words: *agroecosystem, biodiversity, entomofauna on the soil surface, organic apple orchard.*

INTRODUCTION

Organic farming is one of the forms of sustainable agriculture, in which the care for environmental protection is intertwined with the production of ecologically clean food (Leksono, 2017). The ecological aspect of organic farming refers to the ability to maintain the resilience of agroecosystems (Semos, 2002). Leksono (2017) cites Altieri & Nicholls, (2000) according to whom the concept of organic agriculture is closely related to the concept of agroecology. The concept of agroecosystems is based on the understanding that it is an ecosystem that operates on the basis of complementary relationships between living organisms and their environment, limited within certain limits, which maintain a stable dynamic balance in time and space (Kostadinova et al., 2003; Rusch et al., 2010; Ghosh, 2011). Kostadinova (2017) cites Vandermeer & Perfecto (1995), according to whom there are two main components distinguished in agroecosystems, namely the planned biodiversity of plants and animals, which are purposefully included by the farmer in the agroecosystem, and the associated biodiversity, which includes soil flora and fauna, herbivores, reducers, etc., which are colonized by the environment in the agroecosystem and develop over time depending on its management. It is well known that agriculture can support biodiversity and biodiversity can support agriculture (Bàrberi et al., 2010), yet the importance of balancing these two approaches is rarely taken into account (Altieri, 2004; Bàrberi, 2015). Montañez & Amarillo-Suárez (2014) point out that according to Hole et al. (2005) a dramatic decline was reported in the abundance of several species associated with farms in Europe during the last quarter century. In organic farming, weeds have a positive role in protecting the soil from erosion; most of the flowering weeds (*T. officinale, C. intybus, M. chamomilla*) are honey plants and are a habitat for predators and parasites of the enemies of cultivated plants. In this way they increase biodiversity and help the biological control of the natural enemies of pests (Clements et al., 1994; Rusch et al., 2010; Ghosh, 2011; Diekötter et al., 2016). A number of authors (Franke et al., 2009; Médiène et al., 2011) have pointed out the ecological role of weeds in the agroecosystem, as some of them play the role of a 'buffer' for the development of a large number of aphidophages- predatory species, syrphid flies and others. Weeds are considered an element of pest control because they attract natural predators (Biala et al., 2006; Gaba et al., 2014). Weeds compete with crops for light, water and nutrients, and when they pass a certain level (Economic injury level), there is a reduction in yields, difficulty in harvesting, as some weeds are hosts-source of phytopathogens and pests of crops. Cover crops between rows spacing of perennials are perceived as competition of the main crop in terms of water, light and nutrients (Weibel & Häseli, 2003; Crews, 2005; Moore et al., 2019) as a shelter for the natural enemies of pests (Irvin, 2009; Rodriguez-Saona, 2012; O'Neal, 2014; Snydera, 2019). Kostadinova (2017) cites a number of authors (Vogt & Weigl, 1999; Fitzgerald & Solomon, 2004) who point out that cover crops are attractants of beneficial entomofauna. Many authors (Hooks & Johnson, 2003; Gurr et al., 2004; Poveda et al., 2008; Ratnadass et al., 2012) indicate that the increase in natural pests as a result of the increasing plant species diversity contributes to the biological control in cultivated plants. The maintenance of the soil surface also affects the predatory insects that inhabit the soil surface (Miñarro & Dapena, 2003; Mathews et al., 2004). Kostadinova (2017) cites (Matthey et al., 1990; Steinborn & Heydemann, 1990) who indicate that species from the *Carabidae* family are considered indicative of the habitat quality (Diekötter et al., 2016). As predatory beetles - runners are polyphagous, the species of the genera *Calosoma*, *Carabus* perform natural regulation of many plant pests (Harizanov et al., 2010). Kostadinova (2017) reports that biological diversity and abundance in the biological agrocenosis are the most tangible for species (the families *Carabidae*, *Staphylinidae*, and *Coccinellidae*) known for their benefits for agroecosystems. Pfiffner and Niggli (1996) point out that arthropods are characterized not only by greater diversity and abundance, but also by the fact that they are more evenly distributed. A number of researchers (Harizanov et al., 1996; Andreev, 2012; Harizanov et al., 2010) point out that the family *Coccinellidae* is widespread in biocenoses. In terms of food specialization, ladybugs are divided into 3 groups- phytophagous, mycophages, and zoophages. Species in the group of zoophagous use for food insects with a delicate body (aphids, thrips, cicadas, young larvae of butterflies and beetles, whiteflies) and mites. Though characterized with extensive polyphagia, zoophages have a known preference for certain groups of preys, such as aphids, whiteflies, mites, and others. Arachnids can be used as suitable indicators to monitor the impact of agricultural practices on biodiversity (Mazzia et al. 2015; Kostadinava, 2017). Beneficial species that inhabit the soil surface have a very important role in regulating the density of various pests (Luff, 1983; Nyffeler & Benz, 1987; Mudgal et al., 2010). Birds, mammals, arthropods and plants benefit from organic crop production, which also exhibits better pest control by maintaining natural enemies and pollinators (Hole et al. 2005; Garratt et al., 2011). The Shannon (entropy) index is often used in environmental studies (Townsend et al., 2002; Mouillot et al., 2005; Petrova et al., 2012, Kostadinova et al., 2017). The index of individual species diversity (Shannon H') is one of the most frequently used structural parameters and the most important of all structural indicators. When the ecosystem under survey is in its optimal condition, Shannon H' is high (i.e. there is a large number of species, and a relatively small number of specimens for each species, which is sufficiently aligned in all species) and vice versa (Hristov, 2014). This paper aims at investigating the species diversity of entomofauna (harmful and beneficial) on the soil surface in an organic apple orchard under the conditions of ecological management approaches.

MATERIALS AND METHODS

Location of the study. The orchard is located on the land of the village of Vodenichane, Yambol Region, at an altitude of 117 m. The area, on which the organic fruit orchard has been created, used to be common pasture. The orchard was established in 2008. It has an arable area of 180 dka, including apples of the Aidered variety, Golden Delicious. The rows with a length of 200 meters have a north- south orientation, as the distance between the trees is 90 cm and the formation is free. The distance between the rows is 3.20 meters, and the distances between rows are naturally grassed and periodically mowed.

Organic fertilizers were applied during vegetation- poultry manure and livestock manure, in concentration of 0.6% nitrogen, 0.2% P_2O_5 and 0.6% K_2O, at the following phases of fruit growth - formation of fruitfulness, fruit filling and 60% fruit ripening. The principles of organic fruit-growing were applied in the fruit orchard in conformity with the legislation of the Republic of Bulgaria- Regulation (EC) No 889/2008. Funguran OH 50WP- 0.3; NeemAzal T/S- 0.3%; Madex- 0.01%; Pirethrum- 0.05% were used to fight against pests and diseases.

Soil and climatic characteristics. The soils in this area are Chernozem and are suitable for growing perennial fruits. The typical Chernozem soils are typically micellar-carbonate, with a higher content of humus and carbonates, respectively in the surface and subsurface horizon (Koynov et al., 1998). The climate is continental with Mediterranean influence. Summers are dry and hot, and winters are mild. Rainfalls are unevenly distributed throughout the months. Two maximums are typical (May-June; November-December) and two minimums (August and February) of rainfalls. Figures 1 and 2 present the data regarding the average monthly values of air temperature, and the amount of rainfalls 2018 and 2019. Meteorological conditions are very favorable both for the development of fruit species and for entomofauna, which is an indicator in the agroecosystem under survey.

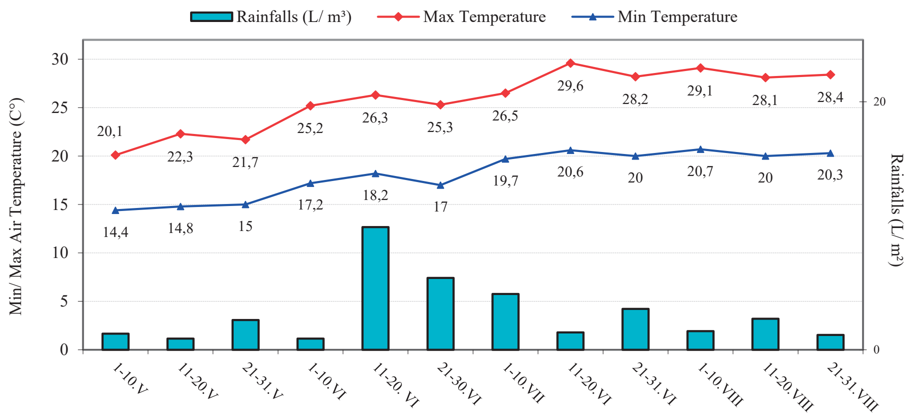

Figure 1. Climatic region characteristics for V-VIII, 2018

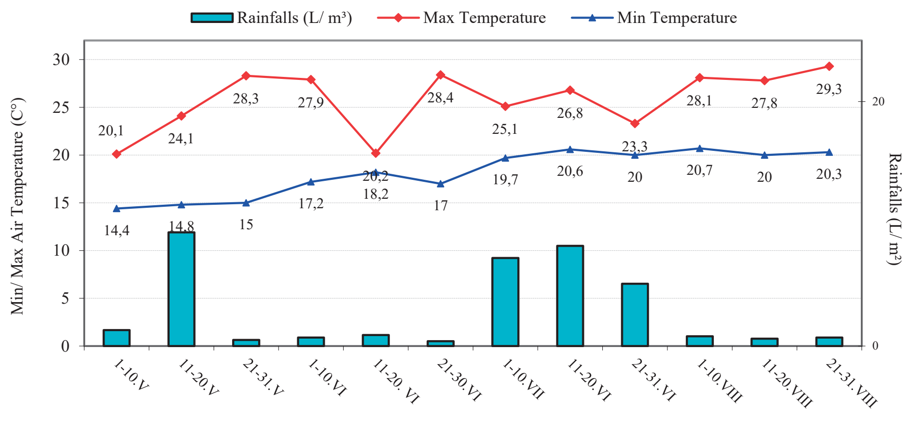

Figure 2. Climatic region characteristics for V- VIII, 2019

Field surveys of entomofauna on the soil surface. Field surveys of entomofauna (harmful and beneficial) on the soil surface in the apple orchard were carried out in 2018 and 2019 with monthly reporting of 'pitfall trap' (soil traps) placed in a checkerboard pattern under the crowns of selected trees. The method of 'pitfall trap' consists in digging plastic cups (with dimensions of d = 9 cm, h = 12 cm) at ground level, in which 100 ml of formalin solution are placed. In order to limit the evaporation of formalin and filling the plastic cups with rainwater, lids are placed 3 cm above the plastic cups. The reports have been prepared on a monthly basis (May, June, July, August) but the presentation of the number of entomofauna has been merged in four months. Specimens are determined to the lowest possible taxons- Family and Order. Ecological indices are calculated using specialized software for statistical analysis Paleontological Statistics, Version 2.15 'PAST' (Hammer et al., 2001). In the surveyed fruit agrocenosis the reported entomofauna is determined by main ecological indicators (total number of species attributed to a family). Some of the indicators for the species structure of the communities recommended by Odum (1975) were used in the study- Shannon, diversity index- H' and Simpson, dominance index- 1-D). The nomenclature of entomofauna is represented by Fauna Europaea [http://www.faunaeur.org.].

RESULTS AND DISCUSSIONS

The results from the survey of the entomofauna on the soil surface from the organic apple agrocenosis in 2018 showed that a total of 108 insect species have been identified in the samples, which are relate to twelve Families and one Order. The results presented in Figure 3 show that the Order *Araneae* is dominant, both quantitatively (23 the number of insects) and in percentage (21%). The other more widespread family in the study was the Family *Tenthredinidae* (17%), followed by the Family *Coccinellidae* (11%) and the Family *Vespidae* (11%). Species from these families definitely play a key role in the agroecosystem. The species from the other reported families (*Cicadelidae*, *Cicadidae*, and *Carabidae*) are less represented, but this does not diminish their role in the agrocenosis. Popov et al., (2017) point out reprentatives of Family *Carabidae* (*Calosoma sycophanta, Carabus convexus dilatatus, Calathus metallicus*), Order *Coleoptera,* which inhabit the soul surface and are beneficial arthropods. According to authors ground beetles are deemed important indicators for the quality of habitats and as such show the sustainability of agroecosystems. Arachnida from Order *Araneae* are polyphagia and are important predatory animals in the regulation of pests in agricultural areas.

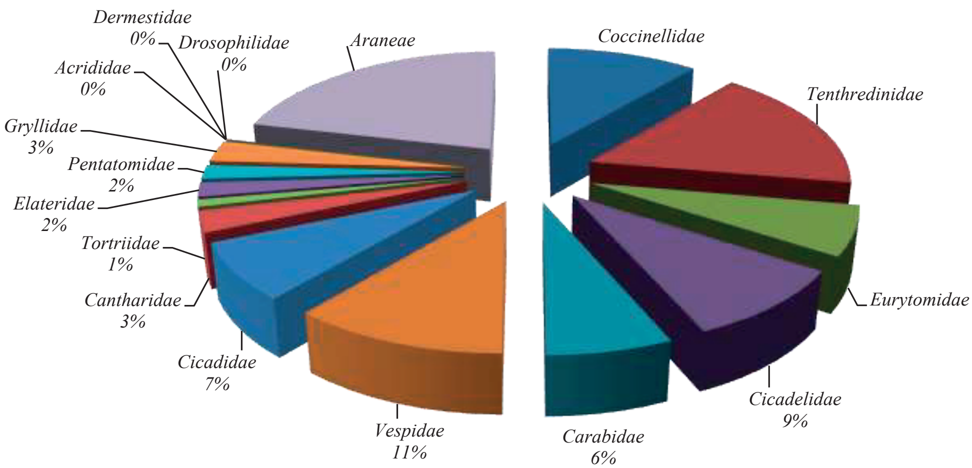

Figure 3. Reporting of entomofauna in V-VIII (2018)
Source: Own survey

The data from the survey on entomofauna conducted in 2019 are presented in Fig. 4, as a total of 124 insects were identified and assigned to fifteen Families and one Order. Figure 4 shows the percentage of families and the Order *Araneae*.

It is noted that the Order *Araneae* and the *Vespidae* Family are equally dominant, both in terms of quantity (19 insects) and percentage (15%). The families *Coccinellidae* (14%) and *Cicadelidae* (10%) are presented in the sample. In this case, the representatives of the family *Carabidae* (7%) are less represented, but their positive role in the agrocenosis has been pointed out by many authors (Kromp, 1989; Andreev, 2012; Harizanov et al., 2010; Kostadinova et al., 2015; Kostadinova et al., 2016; Kostadinova, 2017; Popov et al., 2017; Popov et al., 2018). The other reported families are represented by a smaller number of insects.

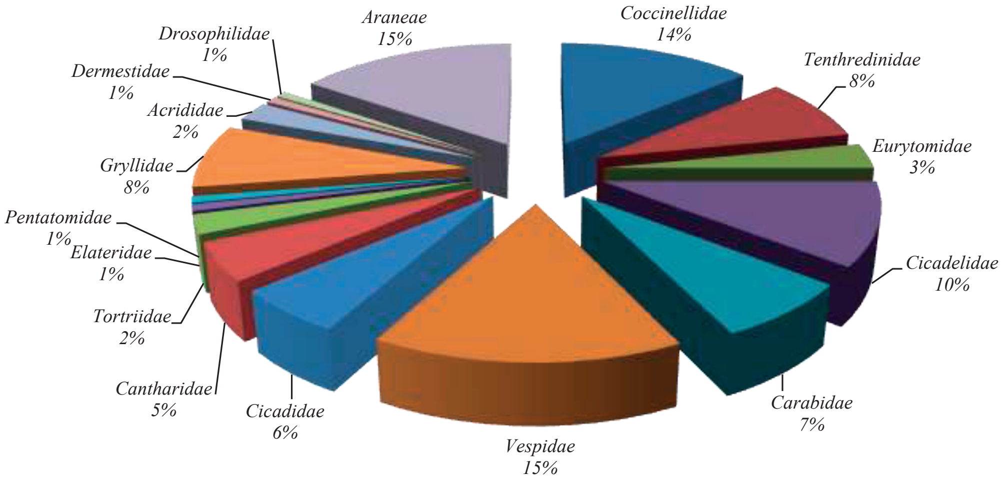

Figure 4. Reporting of entomofauna in V-VIII (2019), Source: Own survey

The survey data obtained during the two-year period have been processed with a specialized software with a calculation of the ecological indices presented in Table 1. In 2018 the Dominance index (D) had a value close to zero (0.123), which means that the number of individuals, which represent the separate taxa in the respective complex, is similar as there are one or two taxons with a predominant number of species. It is noted that in 2019 the Dominance index had a lower value (0.103) as compared to the one reported in the preceding year. The Dominance index (D) definitely demonstrates the capacity of taxons with higher ecological plasticity to increase their number (i.e. to dominate) in return for other taxons in the surveyed agrocenosis. The species characterized with proven, established ecological plasticity in 2018 were the Order *Araneae*, the Family *Tenthredinidae*, the Family *Coccinellidae*, and the Family *Vespidae*. The higher values of the Dominance index established from the results obtained for the year of 2018 show higher dominance or changed conditions in the agroecosystem towards aggravation under the impact of the anthropogenic interference, fluctuation of abiotic factors, etc. There is a situation that is described in the specialized literature as a phenomenon due to the so-called double stress in biocenoses, which is caused by repeated stress of relatively poor in species composition coenoses, such as agrocenosis (Markova & Chardakova, 2009). According to Odum (1975) in case of repeated stress, most often the result is a reduction in the number of the main species, which leads to greater evenness of the species.

The Equitability index (E), expresses the uniformity in the distribution of the total number among the separate species and shows a tendency towards striving for achieving optimal development. The values of the Equitability index (E) are below 1 and vary from 0.887 in 2018 to 0.878 in 2019. It has been established that the equitability was higher in 2018 as compared to the equitability in 2019, which means that the taxa in the complex were more evenly distributed from a systematic point of view. Simpson's index (1-D) and Shannon's index (H) give a more detailed evaluation of the diversity of subspecies in the organic fruit agrocenosis, thus confirming the higher diversity of species from the complex of taxons in 2019 with a value of 0.897 for the Simpson's index, as compared to the value of 0.877 reported in 2018. The higher the value the greater the diversity. This also became clear for the values of the Shannon's index (H), which were 2.435 in 2019 and respectively 2.274 in 2018.

Table 1. Ecological indices

Index	**2018**	**2019**
Taxons	13	16
Individuals	108	124
Dominance (D)	0.123	0.103
Simpson (1-D)	0.877	0.897
Shannon (H)	2.274	2.435
Simpson Evenness	0.748	0.714
Equitability (J)	0.887	0.878

Source: Own survey

Biodiversity in species may be used to characterize the "biological health" of a given habitat. However, the values of biodiversity should be interpreted carefully. Some habitats are filled with tension and therefore less organisms adapt to the life there, as all adapted animals are unique. Such habitats are important even if characterized with low diversity. The higher species diversity is conductive to a more stable agroecosystem due to the availability of more ecological niches and the less chance for the environment to be unfavorable, as the combined food networks also contribute to the environmental stability. It is less probable that the potential change of the environment causes any damage to the ecosystem as a whole.

CONCLUSIONS

The Dominance index was higher in 2018 in comparison with the dominance index reported in 2019 and showed the capacity of taxons of higher ecological plasticity to increase their number in return for other taxons in the agrocenosis under survey. The other ecological index is the Equitability index, which expresses the uniformity in the distribution of the total number among the separate species and shows a tendency towards striving for achieving optimal development. Equitability was higher in 2018 as compared to the equitability in 2019, which means that the taxons in the complex were more evenly distributed from a systematic point of view. Biodiversity should be related to the functional features of the agricultural ecosystems. The high level of biodiversity, for example through higher species abundance, does not necessarily mean a high level of functionality of agroecosystems. It is therefore necessary to identify the key functions of biodiversity in agroecosystems and the mechanisms for biodiversity to help the management of organic farming systems.

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