doi:10.14720/aas.2023.119.1.2679 Original research article / izvirni znanstveni članek

Invertebrate's diversity on persimmon crop (*Diospyros kaki* Thunb.) at low altitude in Mechtras region, North Algeria

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Received May 08, 2022; accepted February 07, 2023.
Delo je prispelo 8. maja 2022, sprejeto 7. februarja 2023

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Abstract: The inventory of invertebrates on persimmon cultivation using two methods of sampling, Barber traps and colored traps in Mechtras region (Tizi-Ouzou) Algeria, allowed us to collect 115 species divided into 58 families, belonging to 13 orders and 6 classes. The values of the centesimal frequencies applied to invertebrates orders identified in the studied plot vary from one type of trapping to another, each sampling method relates to a representative order group. The diets of insects are extremely diverse, due to the structures and function of the mouthparts, the structural and functional division of the digestive tract; we have established 8 trophic classes. Shannon-Weaver diversity index values are quite high in the study plot. The fairness obtained for each type tend towards 1, which reflects a balance between the species.

Key words: inventory; invertebrates; persimmon; Mechtras; Algeria

Raznolikost nevretenčarjev v nasadih kakija (*Diospyros kaki* Thunb.) v nižinskih predelih območja Mechtras, severna Alžirija

Izvleček: S popisom nevretenčarjev v nasadih kakija z uporabo dveh metod vzorčenja, Barberjevih talnih in barvnih zračnih pasti, na območju Mechtras (Tizi-Ouzou) v Alžiriji, je bilo ugotovljenih 115 vrst iz 58 družin, ki pripadajo 13 redom in 6 razredom. Vrednosti centezimalnih frekvenc, ki so se uporabljale za identifikacijo vrst nevretenčarjev na preučevanem območju, se razlikujejo od ene vrste pasti do druge, vsaka metoda vzorčenja pa se nanaša na reprezentativno redovno skupino. Prehrana žuželk je izjemno raznolika, kot posledica zgradbe in delovanja ustnega aparata in prebavnega trakta. V tej zvezi smo vzpostavili 8 trofičnih razredov. Vrednosti Shannon-Weaverjevega indeksa pestrosti na preučevani ploskvi so bile precej velike. Vrednost indeksa je za vsako ploskev blizu 1, kar odraža ravnotežje med vrstami.

Ključne besede: popis; nevretenčarji; kaki; Mechtras; Alžirija

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1 INTRODUCTION

Fruit arboriculture is an integral part of the economic and social life of Algeria. This large country, due to its geographical position and its various pedoclimatic conditions, indeed has the privilege of cultivating several fruit species and to produce fresh fruit all year round.

The persimmon, like any fruit tree, is attacked by several insects which occupy a very special place in the ecosystem; in addition, they are good biological indicators, in addition, they are good biological indicators, because they are the main food of many vertebrates and are essential pollinators for the farmer (Clere et Bretagnolle, 2001).

According to Bouktir (2003), insects by their diversity abundance, but also their occupation of very diverse ecological niches, they can be useful such as parasitoids and predators. However, insects can be harmful and play various epidemiological roles, which make them a major public health problem (Jolivet, 1980).

The preservation of biodiversity represents an indisputable ecological stake in the functioning of agroecosystems, but also economical for society (Tscharntke and *al*., 2015). In this context, we carried out an inventory of the invertebrates fauna associated with persimmon tree cultivation in Tizi-Ouzou area (Kabylie), with the aim of improving our knowledge of biodiversity invertebrates and their classification according to the different trophic regimes.

2 MATERIALS AND METHODS

The study was realized in a *Diospyros kaki* 'Tipo' ochard which is located in Mechtras area (36° 32′ 41″ Nord, 4° 0′ 18″ East) situated at an altitude of 389 meters, with sub-humid climate and temperate winter (Fig. 1).

The orchard represents an appropriate environment and an extraordinary ecosystem whose biological functions bring together ecological conditions conducive to installation and the multiplication of various invertebrates. So, various sampling methods have been addressed in Mechtras region from December 2019 until November 2020.

2.1 IN THE FIELD

We used two trapping methods (Fig. 2), namely Barber pots or terrestrial traps as well as colored aerial traps, at the rate of one outing per month, from December 2019 until November 2020.

We installed Barber pots with 9 traps 7 cm deep and 15 cm in diameter, filled to 2/3 of their content with soapy water; which are visited once per week. The content was collected and put in jars with labels on which were indicated the date of collection and the trap concerned.

We installed colored pots with 9 traps, placed on tree branches at a height of one meter exceeds the natural vegetation. The pots are filled to 2/3 of their volume with water added with a few drops of detergent. This reduces the surface tension of water and promotes the drowning of species that come into contact with the liquid.

2.2 LABORATORY WORKING METHODS

After each trip, after a week, and according to the different capture methods used, the samples obtained are placed in Petri dishes with indicating the date and the trap.

2.2.1 Identification

The identification of individuals of listed invertebrates is carried out using the different determination keys treating on morphology and chetotaxis (Perrier, 1961; Piham, 1986; Delvare and Aberlenic, 1989; Chinery, 1988 and Seguy, 1651).

2.2.2 Trophic diet

After identification of the invertebrate species captured by the different sampling methods, their trophic regimes are determined after bibliographic research.

2.3 RESULTS TREATMENT

The results obtained are evaluated by several ecological indices.

The total wealth represents the total number of species that includes the population considered in an ecosystem (Ramade, 2003).

The Relative abundance (centesimal frequency) Fc (%) was also evaluated; it gives the percentage of individuals of a species Ni relative to the total number of individuals N (Dajoz, 1971).

$Fc = Ni \times 100 / N$

We have also used Shannon-Weaver index which is calculated by the following formula:

$H' = - qi \log_2 qi$

*H'***:** diversity index expressed in bits units

qi: the probability of encountering the species i

The evenness index is the ratio of observed diversity H' to the maximum diversity' max**:** E = H'/H' max (Blondel, 1979). Knowing that H' max is calculated using the following formula:

H' max = Log 2 S

S: total wealth

H'max: is expressed in bits

3 RESULTS

In our study about invertebrates fauna associated to persimmon trees, we have caught 115 species, distributed in 57 families belonging to 13 orders and 6 classes.

3.1 TOTAL WEALTH AND CENTESIMAL FREQUENCY

We were able to identify 115 species of captured invertebrates on persimmon plot using colored traps and Barber pots. Table 1 represents total wealth of invertebrate, which were 63 species for colored traps and 66 species for Barber pots.

Invertebrates orders collected on persimmon plot according to their centesimal frequency are shown in Figure 3 for colored traps and Figure 4 for Barber pots. Table 2 represent relative abundance of species identified according to the order, and family.

We have noticed that Hymenoptera is the most dominant order recorded for colored traps is with centesimal frequency equal to 29.8 %, and Coleoptera is the most dominant order recorded for Barber pots with centesimal frequency equal to 30.98 %.

Figure 1: Situation of the study region in Algeria (Google maps, 2021)

Table 1: Total wealth of species caught

	Colored traps	Barber Pots
Total wealth	63	66

Figure 2: Different sampling methods used: a: Yellow plastic bins serving as an aerial trap, b: Barber pots buried in the ground (Original, 2020)

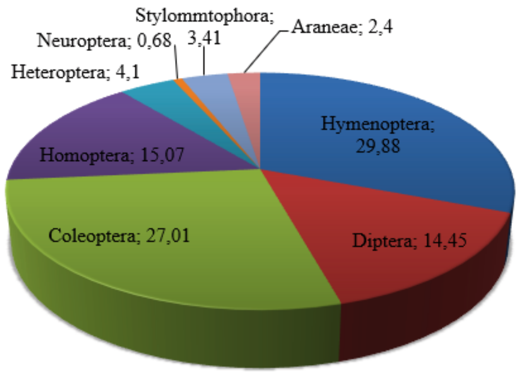

Figure 3: Relative abundance of invertebrate species caught using colored traps

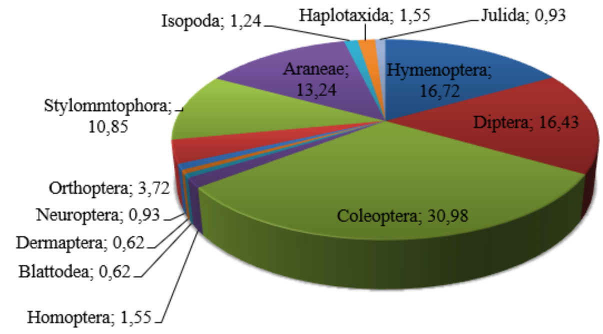

Figure 4: Relative abundance of invertebrate species caught using Barber pots

Table 2: Relative abundance of invertebrates' species caught on persimmon crop

Classes	Orders	Famillies	Species	Colored Trap	Barber Trap
–Insecta	Hymenoptera	Apidae	Apis m–ellifera (Linnée, 1758)	13,7	0,93
		Formicidae	Messor barbarus (Linnée, 1767)	-	5,88
			Messor structor (Latreille, 1798)	-	1,24
			Pheidol pallidula (Nylander, 1849)	1,71	0,31
			Cataglyphis cursor (Fonscolombe, 1846)	-	0,93
			Cataglyphis bicolor (Fabricius, 1793)	-	0,62
			Cataglyphis viatica (Fabricius, 1787)	0,68	4,33
		Braconidae	Aphidius colemani (Viereck, 1912)	0,68	-
		Ichneumonidae	Netelia testacea (Gravenhorst, 1829)	1,13	-
			Ichneumonidae (Latreille, 1802)	1,71	-
		Halictidae	Halictus quadricinctus (Fabricius, 1776)	3,08	-
			Lasioglossum calceatum (Scopoli, 1763)	1,71	-
		Vespidae	Polistes nimpha (Christ, 1791)	1,03	-
			Vespula germanica (Fabricius, 1793)	1,37	0,62
		Pompilidae	Priocnemis confusor (Wahis, 2006)	-	0,93
		Pteromalidae	Systasis angustula (Graham, 1969)	0,68	-
			Coruna clavata (Walker, 1833)	1,37	-
		Megachilidae	Megachile centuncularis (Linnée, 1758)	-	0,93
			Megachile fertoni (Pérez, 1895)	1,03	-
	Diptera	Tephritidae	Xyphosia miliaria (Schrank, 1781)	-	2,17
			Tephritidae (Schrank, 1781)	1,03	-
			Ceratitis capitata (Wiedemann, 1826)	7,53	-
		Muscidae	Graphomya maculata (Scopoli, 1763)	-	0,62
			Musca sp. (Linnée, 1758)	-	0,31
			Musca domestica (Linnée, 1758)	-	1,55
		Sepsidae	Sepsis fulgens (Linnée, 1758)	-	0,62
		Syrphidae	Episyrphus balteatus (De Geer, 1776)	1,71	-
		Stratiomyidae	Chorisops tibialis (Meigen, 1820)	1,71	-

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	Lauxaniidae	Lauxaniidae (Meigen, 1820)	0,68	-
	Sciaridae	Zygoneura sp. (Billberg, 1820)	0,34	-
	Psychodidae	Phlebotomus sp. (Loew, 1845)	-	0,62
	Agromyzidae	Agromyzidae (Fallen, 1823)	0,34	-
	Tipulidae	Tipula oleracea (Linnée, 1758)	-	1,24
	Mydidae	Mydas clavatus (Drury, 1773)	-	1,86
	Calliphoridae	Calliphora vomitoria (Linnée, 1758)	-	2,79
		Calliphora vicina (Robineau-Desvoidy, 1830)	1,03	2,48
		Calliphoridae (Hough, 1899)	-	0,62
		Lucilia caesar (Linnée, 1758)	-	1,55
	Culicidae	Culiseta annulata (Schrank, 1776)	1,03	-
		Aedes albopictus (Skuse, 1894)	0,34	-
		Culex pipiens (Linnée, 1758)	1,71	-
Coleoptera	Staphylinidae	Staphylinus caesareus (Cederhjelm, 1798)	-	0,31
		Creophilus maxillosus (Linnée, 1758)	0,68	0,93
		Philonthus marginatus (O.F. Muller, 1764)	0,68	-
		Ocypus olens (O.F. Muller, 1764)	-	10,84
	Scarabaeidae	Rhizotrogus aestivus (Olivier, 1789)	-	0,62
		Rhizotrogus maculicollis (Villa et Villa, 1833)	-	1,55
		Anisoplia floricola (Fabricius, 1787)	1,71	-
		Oxythyrea funesta (Poda, 1761)	3,42	-
	Apioidae	Apion pomonae (Fabricius, 1798)	1,37	-
	Coccinellidae	Oenopia conglobata (Linnée, 1758)	-	0,93
	Dermestidae	Attagenus fasciatus (Thunberg, 1795)	1,03	-
		Dermestes sp. (Linnée, 1758)	0,68	-
	Curculionidae	Liparus glabrirostris (Kuster, 1849)	1,03	-
		Liparus coronatus (Goeze, 1777)	0,34	-
		Phyllobius oblongus (Linnée, 1758)	-	0,62
		Lixus penctiventris (Boheman, 1835)	2,05	-
		Phyllobius pomaceus (Gyllenhal, 1834)	0,34	-
		Polydrusus sp. (Germar, 1822)	-	1,24
		Polydrusus marginatus (Stephens, 1831)	1,71	-
		Polydrusus impersifron (Gyllenhal, 1834)	0,68	-
		Otiorhynchus sp. (Germar, 1822)	0,68	-
	Elateridae	Elateridae (Leach, 1815)	-	0,31
	Chrysomelidae	Bruchus rufimanus (Boheman, 1833)	7,88	-
	Buprestidae	Anthaxia cadens (Panzer, 1792)	0,68	-
	Cleridae	Trichodes alvearius (Fabricius, 1792)	1,37	-
	Carabidae	Macrothorax morbillosus (Fabricius, 1792)	-	0,93
		Brachinus crepitans (Linnée, 1758)	0,68	-
		Bembidion atripes (Latreilles, 1802)	-	0,93
		Clivina collaris (Herbst, 1784)	-	0,62

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			Carabus auratus (Linnée, 1758)	-	0,62
			Carabus violaceus (O.F. Muller, 1764)	-	0,93
			Harpalus paratus (Casey, 1924)	-	9,6
	Homoptera	Aphididae	Dysaphis plantaginea (Passerini, 1860)	1,03	-
			Aphis nerii (Fonscolombe, 1841)	1,03	-
			Aphis fabae (Scopoli, 1763)	3,08	0,31
		Cicadellidae	Amblysellus curtisii (Fitch, 1851)	5,48	-
			Helochara communis (Fitch, 1851)	1,03	0,62
			Cicadella viridis (Linnée, 1758)	1,03	0,62
			Graphocephala fennahi (Young, 1977)	0,68	-
			Amblysellus sp. (Glover, 1877)	1,71	-
	Heteroptera	Lygaeidae	Lygaeus saxatilis (Scopoli, 1763)	1,37	-
			Nysius helveticus (Herrich-Schaffer, 1850)	1,03	-
			Nysius senecionis (Schilling, 1829)	0,68	-
		Triozidae	Trioza urticae (Linnée, 1758)	0,68	-
		Miridae	Deraeocoris ruber (Linnée, 1758)	0,34	-
	Blattodea	Blattidae	Blatta orientalis (Linnée, 1758)	-	0,62
	Dermapteta	Forficulidae	Forficula auricularia (Linnée, 1758)	-	0,62
	Neuroptera	Myrmeleontidae	Myrmeleontidae (Latreille, 1802)	-	0,93
		Chrysopidae	Chrysoperla carnea (Stephens, 1836)	0,68	-
	Orthoptera	Gryllidae	Gryllus campestris (Linnée, 1758)	-	0,93
			Acheta domestica (Linnée, 1758)	-	0,93
		Tetrigidae	Tetrix undulata (Sowerby, 1806)	-	1,24
			Tetrix subulata (Linnée, 1758)	-	0,62
Gasteropoda	Stylommtophora	Subulinidae	Rumina decollata (Linnée, 1758)	-	1,86
		Hygromiidae	Ganula flava (Tryon, 1866)	-	1,86
			Cernuella virgata (Da Costa, 1778)	0,68	3,41
		Helicidae	Theba pisana (O.F. Muller, 1774)	0,68	-
			Helix aperta (Born, 1778)	0,68	-
			Helix aspersa (O.F. Muller, 1774)	1,37	0,62
			Massylaea vermiculata (OF Muller, 1774)	-	0,62
		Geomitridae	Xerotricha conspurcata (Draparnaud, 1801)	-	0,62
			Cochlicella acuta (O.F. Muller, 1774)	-	0,62
			Cochlicella barbara (Linnée, 1758)	-	1,24
Arachnida	Araneae	Phalangiidae	Phalangium opilio (Linnée, 1758)	-	0,62
		Dysderidae	Dysdera erythrina (Walcknaer, 1802)	-	1,24
		Thomisidae	Thomisus sp. (Walcknaer, 1802)	0,34	2,17
			Synema globosum (Fabricius, 1775)	1,03	0,93
		Salticidae	Heliophans sp. (C.L. Koch, 1833)	1,03	0,31
		Lycosidae	Lycosa narbonensis (Latreille, 1806)	-	5,8
			Lycosidae (Sundevall, 1833)	-	2,79

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Malacostraca	Isopoda	Armadillidiidae	Armadillidium vulgare (Latreille, 1804)	-	0,62
		Oniscidae	Oniscus sp. (Linnée, 1758)	-	0,62
Clitellata	Haplotaxida	Lumbricidae	Eisenia fetida (Savigny, 1826)	-	1,55
Diplopoda	Julida	Julidae	Tachypodoiulus albipes (C.L. Koch, 1838)	-	0,93
6	14	57	115	100	100

Using colored traps we have collected 63 species, represented mainly by *Apis mellifera* with 13.70 %, followed by *Bruchus rufimanus* with centesimal frequency of 7.8 %. The species *Aedes albopictus, Zygoneura* sp., *Liparus coronatus, Phyllobius pomaceux, Thomisus* sp. and *Deraeocoris ruber* presented a low relative abundance equal to 0.34 %.

Using Barber traps, we have caught 66 species, represented mainly by *Ocypus olens* and *Harpalus paratus* with centesimal frequency of 10.84 % and 9.60 % respectively, which are natural predators of various pests. The lowest relative abundance was recorded for the species *Aphis fabae, Pheidol pallidula, Musca* sp., Elateridae, *Staphilinus caesareus,* and Salticidae with 0.31 %.

3.2 RELATIVE ABUNDANCE OF SPECIES DEPENDING ON THEIR TROPHIC RELATIONSHIPS

The centesimal frequency get for species depending on their trophic relationships is shown for colored traps (Fig. 5) and for barber pots (Fig. 6).

Pests represent a large part in invertebrate caught using colored traps and Barber traps with respectively 55.88 % and 37.88 %, whereas the least abundant group for colored traps is necrophagous with only 1.47 % and for Barber traps is omnivorous with only 1.52 %.

Reported pest species attack persimmon, mostly fruit; others attack the trunk by being xylophageous, or to foliage by being phyllophagous. We still find those who suck the sap can seriously affect the proper functioning tree photosynthesis.

3.3 SHANNON DIVERSITY INDEX AND EVENNESS INDEX (E)

Shannon diversity index (H '), maximum diversity (H'max.) and equitability (E) applied to species trapped by the different sampling techniques are presented in Figure 7.

We have registered high value for Shannon diversity index, it is equal to H' = 5.39 bits; with H max = 6.07 bits for colored traps and H' = 5.32 bits; with H max = 6 bits for Barber pots. The evenness values are E = 0.88 for colored traps and Barber pots, this value approaches of 1 which reflects a balance between the middle of species.

4 DISCUSSIONS AND CONCLUSION

In our study about invertebrates fauna associated to persimmon trees, we have caught 115 species, distributed in 57 families belonging to 13 orders and 6 classes.

Chafaa et al. (2019) confirmed in their study on apricot orchards, 125 species belonging to 54 families and 9 orders, in Batna region of North-East Algeria. Vasquez

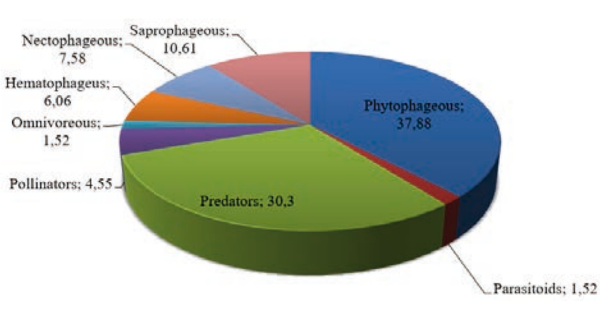

Figure 5: Centesimal frequency of species captured using colored traps according their diet

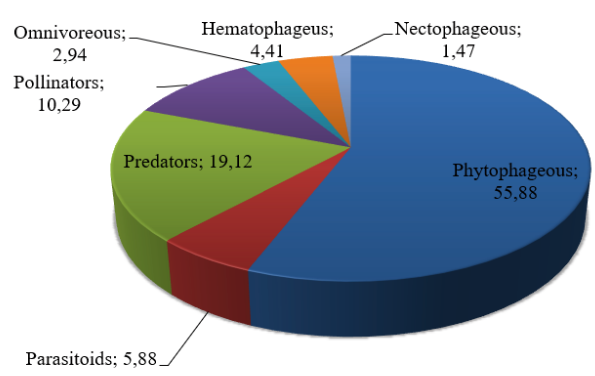

Figure 6: Centesimal frequency of species captured using barber traps according their diet

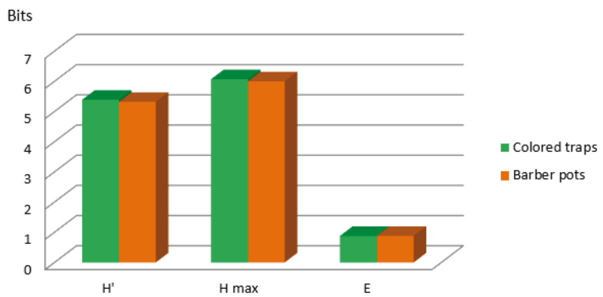

Figure 7: Shannon diversity values H' and evenness of species caught

et al. (2002) in the Peruvian Amazon have counted 36 insect species associated with guava cultivation.

Guermah et al. (2019) reported similar results about 113 species distributed in 64 families belonging to 10 orders in their evaluation of arthropods diversity on apple crop in Tizi-Ouzou. Guermah et al. (2019) collected 42 species divided into 29 families, belonging to 7 orders in their inventory of entomofauna in Tadmait on apple crop.

The total wealth of invertebrate reported were 63 species for colored traps and 66 species for Barber pots.

Chouiet et al. (2012) during a study on the biodiversity of the arthropod fauna of the cultivated areas of the Ghardaia region noted a total richness of 188 species, which is 133 species captured using Barber pots and 124 species using yellow traps. Fritas (2012) estimated total wealth at S = 64 on cereal crops in the Batna region, while Merabet (2014) estimated total wealth at S = 74 by using Barber pots at Agni N Smen.

We have noticed that Hymenoptera is the most dominant order recorded for colored traps is with centesimal frequency equal to 29.8 %, and Coleoptera is the most dominant order recorded for Barber pots with centesimal frequency equal to 30.98 %.

Guermah et al. (2019) registered the most dominant order recorded for sweep net and colored traps which is Hymenoptera with relative abundance of 36.38 % and 37.13 % respectively; for Barber pots, the most dominant order is Coleoptera with relative abundance equal to 50.35 %. Gull et al. (2019) noted that the order of beetles largely dominates with a percentage equal to 89%, followed by Hemiptera with 7% and Lepidoptera with only 3%. Mezani et al. (2016) found dominance about Coleoptera and Hymenoptera with a percentage equal to 23.80% and 23.38%, respectively, by applying the Barber pots. Djetti et al. (2015) in a study on the arthropod fauna of corn cultivation noted that Hymenoptera dominate in the region with a subhumid bioclimatic tier (El Harrach) with a relative abundance equal to 55 %. On the other hand in the region with semi-arid bioclimatic tier, the Coleoptera are best represented with a centesimal frequency equal to 50 %.

Pests represent a large part in invertebrate caught using colored traps and Barber traps with respectively 55.88 % and 37.88 %, whereas the least abundant group for colored traps is necrophagous with only 1.47 % and for Barber traps is omnivorous with only 1.52 %.

Diab and Deghiche (2014) indicated a dominance of phytophages with 53 %, followed by predators with 35 %, then polyphages with 12 % in an olive crop in the Sahara region. According to Beamont and Cassier (1983), in a given area, 40 to 50 % of insect species are phytophagous.

We have registered high value for Shannon diversity index, it is equal to H' = 5.39 bits; with H max = 6.07 bits for colored traps and H' = 5.32 bits; with H max = 6 bits for Barber pots. The evenness values are E = 0.88 for colored traps and Barber pots, this value approaches of 1 which reflects a balance between the middle of species.

Guermah et al. (2019) reported a diversity of Shannon-Weaver values for the various species caught by trapping methods. They are equal to H' = 5.90 bits; H max = 6.40 bits for sweep net; H' = 5.58 bits; H max = 6 bits for colored traps and H' = 5.33 bits; H max = 5.95 bits for Barber pots. Using Barber pot technique for the study of arthropod biodiversity at 3 steppes in the region of Djelfa, Guerzou et al. (2014) reported variations in the diversity values of Shannon between 1.9 and 3.7 bits in Taicha, 3.02 and 3.5 bits in El Khayzar, 3.6 and 4.0 bits in Guayaza.

The variations in the values of the Shannon index are explained by N'zala et al. (1997), who have pointed out that if the living conditions in a given environment are favorable, there are many species and each of them is represented by a small number of individuals. If the conditions are unfavorable, one finds only a small number of species each of them is represented by a large number of individuals. According to Blondel (1979), a community is even more diversified as the index of diversity is higher.

Guermah and Medjdoub-Bensaad (2016) rated fairness at 0.65. In a study on the arthropod fauna of corn cultivation, Djetti et al. (2015) estimated the fairness at E = 0.77 in the region with a subhumid bioclimatic tier (El Harrach) and E = 0.88 in the region with a semi-arid bioclimatic tier. The Pielou's evenness index showed by Gull et al. (2019) varies from 0.62 to 0.87.

In order to consider protection of persimmon crop against possible pests attacks, it is essential to identify the invertebrates cloning this crop and to better understand the interspecific relationship that connects them in this agroecosystem.

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