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Entomological diversity associated with tomato cultivation under organic shelter in the El-Outaya Region, Biskra (Algeria)

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Abstract. The aim of the present work is to determine harmful and beneficial insects associated with tomato greenhouse cultivation in the arid region of El-Outaya (Biskra, Algeria). Insect trapping was conducted using yellow water plates and yellow glue traps. Faunistic data have revealed the presence of 2754 individuals distributed on seven orders, 33 families and 38 species of insects. From specific point of view, the majority of these insects were represented by potential insect pests with sixteen phytophagous species amongst them three species attacking tomatoes. Whereas nine species are predators and two pollinators. Our results can be used to plan strategies for the management of harmful pests and beneficial insects associated with the tomato greenhouse crops in this locality.

Keywords: Entomofauna, inventory, tomato, greenhouse, arid.

Introduction

Greenhouse tomato production offers an opportunity for growers to produce a marketable product at times when supplies are low. Greenhouse tomatoes are not an easy crop to grow profitably. Besides growing time, temperatures, pollination, irrigation, fertilization, weeds in a soil system, diseases and pests require different management techniques than outdoor crops (Rutledge, 2015). Although growing tomato is labour intensive, greenhouse production of tomato is getting increasingly popular. Even though greenhouse can control the growing environment of tomato, problem such as pests and diseases build-up, can occur (Sainju and Dris, 2014). In Algeria greenhouse tomato production reaches 129 0829.7tonnes during 2014-2015a gricultural campaign (MADRP, 2016). Although Biskra province (South east Algeria) is famous for date cultivation that represents the principal agricol product in Algeria, in the mid of the 1980's, greenhouses have appeared on Biskra's oases marges, opening the way to new agricol dynamics (Amichi *et al*., 2015). This region is the largest producer of greenhouse tomato at the national level with a production reaching more than 91300 tonnes (MADR, 2009), which represents more than 50% of the total national production. Despite this importance, few studies tackled the total load greenhouse plants fauna in Biskra region. While in Algeria, previous studies have often targeted a-well-defined species in order to estimate its damage and / or to know its life cycle (Houamel, 2013; Yahoui, 2015; Badaoui, 2018; Ourchene, 2019). Meanwhile numerous studies worldwide (*e.g.* Tonessia *et al*., 2018; Son *et al*., 2018; Patouma *et al*., 2020) focused on this subject. Hence, our article aims to identify the insect diversity and abundance by listing different orders, families, genus and species of tomato greenhouse cultivation under Bio-conditions in El-Outaya (Biskra, Algeria).

Material and Methods

Study area

This study was conducted at CRSTRA's Bio-Ressources Experimental Station in El-Outaya (Plaine, north-east of Biskra; 34 ° 55'41 73 "N, 5 ° 38'59 86" E, 263 m). The arid climate of this region is characterized by low rainfall and high evapo-transpiration.

Tomato (*Solanum lycopersicum* L., 1753) seedlings aged of 48 days of the Tofanea standard, large and vigorous hybrid variety (Chenafi *et al*., 2020; Assassi *et al*., 2017) were sown on 12/09/2017, irrigated and monitored daily in the nursery of the station, they were transplanted on 29/10/2017 in two different semi-closed greenhouses of an area of at least 200 m2 (20 × 10), on 8 lines (at the rate of 384 and 372 plants in the two half-greenhouses). Irrigation is done by a drip system at frequencies depending on the soil situation which is of the loam-clay type. The farming technics used are plowing, mulching and weeding. No chemical fertilisers neither phytosanitary treatment were used during the whole period of the test.

Sampling methods

The inventory of the entomological fauna took place in the two half-greenhouses during the period between September 2017 and April 2018. At ground level a yellow water plate is used and a yellow glue trap is installed at a height of 30 cm above of culture in each half-greenhouse. Insect trapping was done from the transplanting stage to fruiting and maturity of the first fruits while the sampling frequency is one week. Identification of the harvested specimens is made possible by specialized books and keys (Chinery, 1988; D'Aguilar and Fraval, 2004; Tolman and Lewington, 1999; Wolfgang and Werner, 2009).

Temperature and humidity were recorded during the experiment in both half greenhouses to check their effect on insect's diversity.

Diversity evaluation

Family diversity was evaluated by Shannon-Weaver index. This index permits to evaluate taxa diversity (in our case the family) of each half greenhouse is calculated (Magurran, 2004), of which formula is as follows:

$$H' = \sum p_i \ln p_i.$$

With ***H'***: Shannon biodiversity index; ***i***: a species from the study environment; ***Pi***: the relative frequency of the species.

The ratio of the number of species common to two districts to the total number of species collected in the two districts together reported by Jaccard (1912) as coefficient of community (Number of species common to the two districts / Total number of species in the two districts * 100); is used to evaluate similarity between the two half greenhouse with the formula:

$$\text{Jaccard index} = Nc/(N_1+N_2-Nc)$$

With Nc: Common number of taxons (in our case the family) between two half greenhouses, N1 and N2 taxon numbers present respectively in the half greenhouse G1 and G2.

Results

Diversity of insect species associated to tomato growing under greenhouse

The identification revealed sequence presences in 33 families and 38 genera and species of insects with significant species richness in the order of Diptera (Tab. 1).

Table 1. Different families, genera and species of insects inventoriedin Biskra, Algeria.

Order	Families	Species
Coleoptera	Meloidae	*Lytta vesicatoria*
	Chrysomelidae	*Phyllotreta* sp.
	Coccinellidae	*Coccinella septempunctata*
	Buprestidae	*Acmaeodera* sp.
	Cryptophagidae	*Cryptophagus* sp.
	Staphylinidae	*Anotylus tetracarinatus*
Diptera	Syrphidae	*Sphaerophoria philanthus*
		Episyrphus sp.
		Lapposyrphus lapponicus
	Agromyzidae	*Liriomyza bryoniae*
	Calliphoridae	*Lucilia* sp.
	Muscidae	*Musca domestica*
	Chironomidae	*Chironomus* sp.
	Culicidae	*Culex* sp.
	Sciaridae	*Neociara* sp.
	Tephritidae	*Rhagoletis* sp.
	Simuliidae	*Simulium* sp.
Hemiptera	Aphididae	*Macrosiphum euphorbiae*
		Aphis sp.
		Myzuspercicae
	Cicadellidae	*Cicadella* sp.
	Delphacidae	*Laodelphax* sp.
	Psyllidae	*Cacopsylla* sp.
Hymenoptera	Microgastrinae	*Cotesia glomerata*
	Opiinae	*Opius* sp.
	Pemphredonidae	*Diodontus* sp.
	Cryptidae	*Dichrogaster aestivalis*
	Bauchinae	*Exetastes syriacus*
	Andrenidae	*Andrena* sp.
	Apidae	*Apis mellifera*
Lepidoptera	Guelechiidae	*Tuta absoluta*
	Nymphalidae	*Cynthia (=Vanessa) cardui*
Neuroptera	Chrysopidae	*Chrysoperla carnea*
	Hemerobiidae	*Hemerobius* sp.
Thysanoptera	Aeolothripidae	*Aeolothrips intermeduis*
	Melanthripidae	*Melanthrips fuscus*
	Thripidae	*Frankliniella occidentalis*
		Odontothrips confusus

The Diptera was richest order (nine families), followed by Hymenoptera (seven families) and Coleoptera (six families). The richest suborder Brachycerea with five families, followed by the suborder Nematocerea with four families; however, the richest families were determined to be Syrphidae and Aphididae, both with three genera and species. Thus, 16 species or genera are phytophagous. Consisting of *Lytta vesicatoria* (Linnaeus, 1758) (Coleoptera: Meloidae), *Phyllotreta* sp., *Acmaeodera* sp., *Liriomyza bryoniae* (Kaltenbach, 1858) (Diptera: Agromyzidae), *Rhagoletis* sp., *Macrosiphum euphorbia* (Thomas, 1878) (Hemiptera: Aphididae), *Aphis* sp., *Myzus percicae* (Sulzer, 1776) (Hemiptera: Aphididae), *Cicadella* sp., *Laodelphax* sp., *Cacopsylla* sp., *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), *Cynthia cardui* (Linnaeus, 1758) (Lepidoptera: Nymphalidae), *Melanthrips fuscus* (Sulzer, 1776) (Thysanoptera: Melanthripidae), *Frankliniella occidentalis* (Pergnade, 1895) (Thysanoptera: Thripidae) and *Odontothrips confusus* (Priesner, 1926)(Thysanoptera: Thripidae).

Abundance of individuals, families and species

Samples taken during our experiment captured a total of 2745 insects including 1697 insects in the yellow plates and 1048 in the glue traps their distribution and Shannon Index among orders are shown in (Tab. 2).

Table 2. Number of individuals, families and Shannon Index per orders.

Orders	**Greenhouse1**		**Greenhouse 2**		**Total**		
	Ind* (Water traps)	Ind (Glue traps)	Ind. (Water traps)	Ind. (Glue traps)	Ind	Fam*	Spc*
Coleoptera	14	3	2	2	21	6	6
Diptera	602	322	699	534	2157	9	11
Hemiptera	205	6	46	10	267	4	6
Hymenoptera	13	6	26	22	67	7	7
Lepidoptera	3	2	11	1	17	2	2
Neuroptera	0	1	0	2	3	2	2
Thysanoptera	58	53	18	84	213	3	4
Total	895	393	802	655	2754	33	38
Shannon index	**0.927**	**0.640**	**0.553**	**0.652**	**0.781**		

Legend: Ind: number of individuals, Fam: number of families, spc: number of species.

The captured insects belong to the orders Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Neuroptera and Thysanoptera. The Diptera is the largest order with 2157 captured specimens. It is followed respectively by

Hemiptera (267 individuals), Thysanoptera (213 individuals), Hymenoptera (67 individuals), Coleoptera (21 individuals), and Lepidoptera (17 individuals), whereas, the order Neuroptera was determined as the least captured insects (3 individuals).

The Shannon index is similar in the two half-greenhouses G1 and G2 (0.64 and 0.65 respectively) for the glue traps while it varies slightly in the two half-greenhouses G1 and G2 (0.92 and 0.55 respectively) for the water traps. The Jaccard similarity index showed that the tow half-greenhouses are strongly similar for the glue traps (1) while it is dissimilar for the water traps (0.81).

The results showed that the population of Diptera captured by yellow water plates was dominant in both half-greenhouses G1 and G2 (67.26% and 87.16% respectively), followed by Hemiptera in both half-greenhouses G1 and G2 (22.91% and 5.74% respectively), Thysanoptera in the half-greenhouse G1 (6.48%), Hymenoptera in the half-greenhouse G2 (3.24%), Coleoptera in the half-greenhouse G1 (1.56%) and Thysanoptera in the half-greenhouse G2 (2.24%). Then Hymenoptera in the half-greenhouse G1 (1.45%) and Lepidoptera in the half-greenhouse G2 (1. 37%). However, Lepidoptera and Coleoptera did not reach 1% in both half-greenhouses G1 and G2 correspondingly (0.34% and 0.25% respectively). What is reported is the absence of the order of the Neuroptera in both half greenhouses G1 and G2 in the yellow plates (Fig.1).

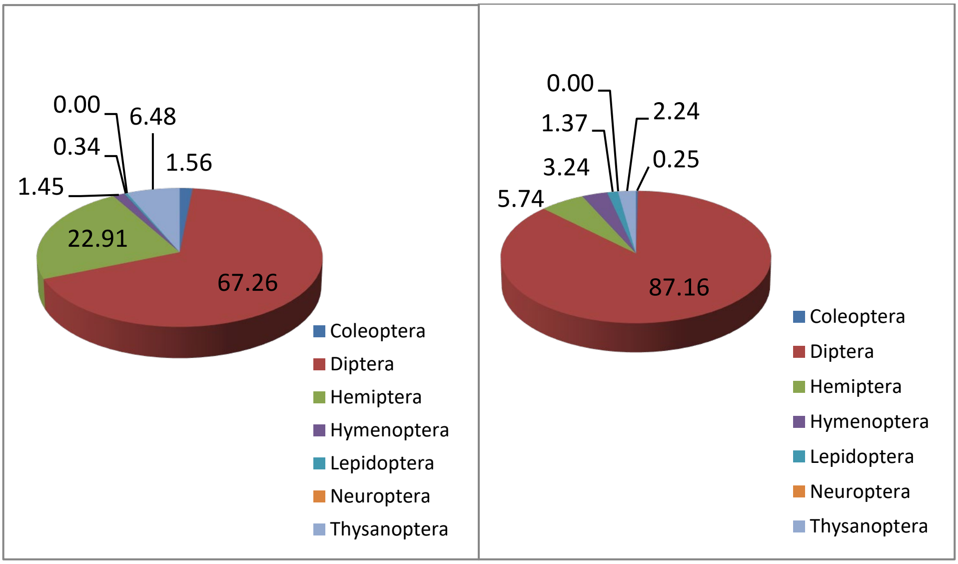

Figure 1. Relative abundance of different orders in water traps (G1 on the left and G2 on the right).

Diptera also dominate in glue traps (Fig.2) in both half-greenhouses G1 and G2 (81.93% and 81.53% respectively) followed by Thysanoptera (13.49% and 12,82% respectively), Hymenoptera and Hemiptera in the half-greenhouse G1 (1.53% for each order) while in thehalf-greenhouse G2 Hymenoptera followed by Hemiptera (3.36% and 1.53% respectively). Meanwhile, Coleoptera, Lepidoptera and Neuroptera did not reach 1% in both half-greenhouses G1 and G2 (0.76%; 0.51%; 0.25% and 0.31%; 0.15%; 0.31% respectively).

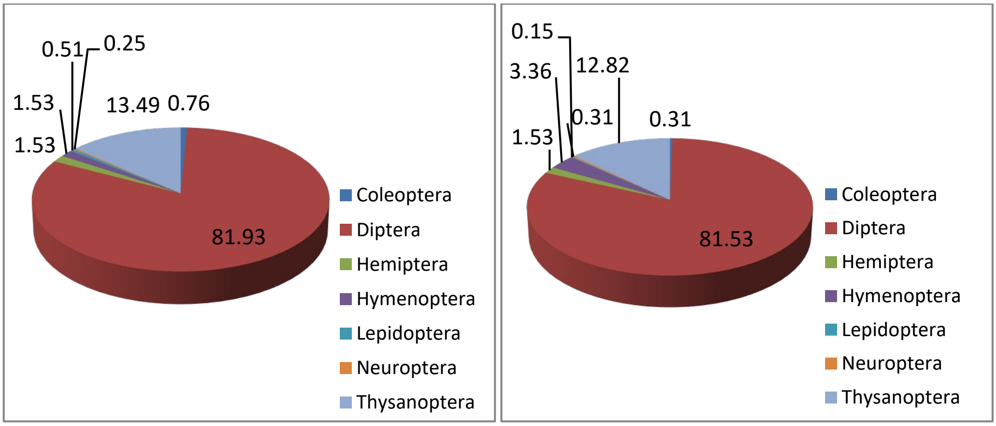

Figure 2. Relative abundance of different orders in glue traps (G1 on the left and G2 on the right).

Beneficial insects inventoried

The insect inventory has identified beneficial species that belong to five orders and are divided into seven families including four predatory species, three parasitoids and two pollinators (Tab. 3).

Table 3. Beneficial insects encountered in the two half-greenhouses of the El-Outaya bio-resources station.

Orders	Families	Genera and species	Prey or host
Coleoptera	Coccinellidae	*Coccinella septempunctata*	White flies and aphids
Diptera	Syrphidae	*Sphaerophoria philanthus* *Lapposyrphus lapponicus*	Aphid and mite eggs.
Hymenoptera	Andrenidae	*Apis mellifera* *Andrena* sp.	Pollinator. Pollinator.
	Braconidae	*Cotesia glomerata*	Cabbage mothlarvae.

Orders	**Families**	**Genera and species**	**Prey or host**
		Opius sp. *Diodontus* sp.	Diptera. Thysanoptera and Collembola.
Neuroptera	Chrysopidae Hemerobiidae	*Chrysoperla carnea* *Hemerobius* sp.	Mites, aphids and white flies.
Thysanoptera	Aeolothripidae	*Aeolothrips intermedius*	Thrips.

Temperature and humidity records

During the experiment the G1 recorded higher means of temperature than G2 with a highest value of 46°C. Meanwhile G2 recorded higher levels of humidity than G1with a highest value of 65% (Fig. 3).

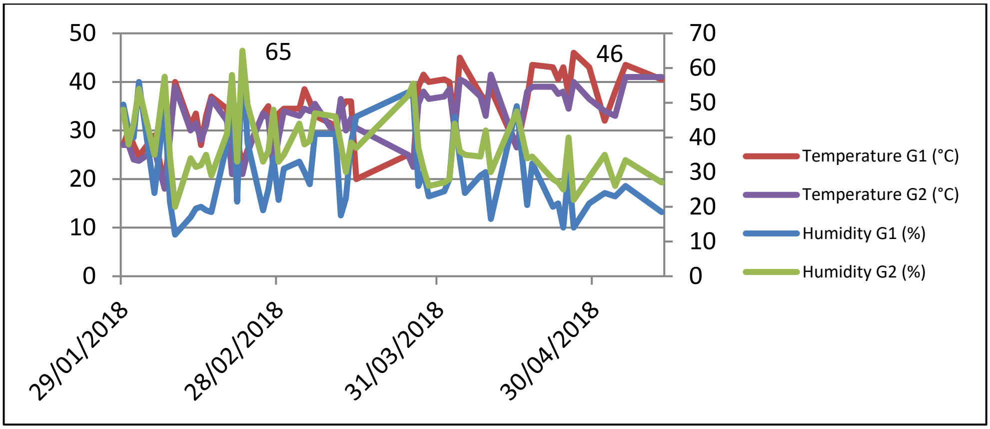

Figure 3. Temperature and humidity means recorded in the two half greenhouses

Discussion

Sixteen species are phytophagous, thus *Lytta vesicatoria* adults are reported as phytophagous (Binon*et al.*, 2015), *Acmaeodera* sp. being a jewel beetles (Coleoptera: Buprestidae) thus, mostly are xylophagous species, although a few buprestids mine leaves (Evans *et al.*, 2007). *Rhagoletis* sp. is also reported as Phytophagous (Bush,1992), as well as *Cacopsylla*sp. (Hemiptera: Psyllidae) are phloem feeding insects (Sagar andBalikai, 2013). Three aphid species that found in this study have been already reported in the region of Biskra by Laamari *et al.* (2010). Though, past studies have identified 18 species of aphids attacking tomato in open-field agriculture and greenhouses. However an in-depth review of the literature reveals only two species, *Macrosiphum euphorbiae* and *Myzuspersicae*, as frequent and common aphid pests of tomato throughout the world (Perring, 2018). The leafhoppers of the genus *Cicadella* (Hemiptera: Cicadellidae) usually feed on different plants sap and are considered as agricultural pests while some leafhoppers are the vector of many plant viruses (SHAH*et al.* 2019). The planthoppers of the genus *Laodelphax* (Hemiptera: Delphacidae)was reported as vectors of plant pathogens (O'Brien and Wilson, 1985). *Cynthia cardui*is a polyphagous species, with a clear host plant preference (Stefanescu, 1994). *Melanthrips fuscus*, *Odontothrips confusus* and *Frankliniella occidentalis* are phytophagous thrips already identified on faba beans in this site (Bengouga, 2018).

Thus, the most interesting species attacking tomatoes are *Phyllotreta* sp. which serves as minor insect pests causing damage to tomatoes (Brust *et al*., 2018). The tomato leaf miner, *Liriomyza bryoniae* (Kaltenbach, 1858)(Diptera: Agromyzidae) can cause severe infestations in protected tomato production (Srinivasan and Manickam, 2018). Meanwhile, the tomato pinworm, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Guelechiidae) is among the most harmful pests encountered on greenhouse tomato cultivation, whose larva can cause serious damage at all stages of the culture by digging galleries in the leaves, stems, buds, flower buds as well as in the fruits during formation or maturity (Aprel *et al.,* 2017). This pest has been observed in several Mediterranean countries, which was reported from Spain in 2006 and from Tunisia in 2008 (Lebdi *et al*., 2011). Similarly in Algeria this pest was reported in 2008 by Guenaoui (2008) in Mostaganem located north / west of Algeria. The precise identification of this micro-Lepidoptera has been confirmed by the study of its genitalia. (Badaoui and Berkani, 2011). Similarly, Belhadi (2008) reported that some greenhouse gardeners in Tolga a commune of Biskra reported the presence of an insect attacking their tomato plants; this insect has been identified as *T. absoluta* by a team from the CRSTRA El-Outaya Bio-Ressources station who reported that this pest first appeared, at Zab Elgharbi (West of Biskra), then at Zab Echargui (East of Biskra) with a lag of one and a half to two months between these two major ecological entities of the Ziban. The recrudescences of this pest at the Bio-Ressources station of El-Outaya have been studied by Berrjouh *et al*. (2016), who reported that the evolution of adult catches of tomato leafminer increases from one month to another to reach the peak during the month of April. This increase is influenced by the rise in temperatures in the greenhouse.

Similarly, *Frankliniella occidentalis* is a significant and the most destructive thrips of greenhouse crops. It causes direct damage on foliage and flowers, and indirect damage as vector viruses (Cloyd, 2010).

Meanwhile, the presence of auxiliaries; *Coccinellasepemt punctata* (Linnaeus) (Coleoptera: Coccinellidae), *Sphaerophoria philanthus* (Meigen) (Diptera: Syrphidae), *Lapposyrphus lapponicus* (Zetterstedt) (Diptera: Syrphidae), *Opius* sp., *Diodontus* sp., *Chrysoperla carne* (Stephens) (Neuroptera: Chrysopidae), *Hemerobius* sp. and *Aeolothrips intermedui*s (Bagnall) (Thysanopera: Aeolothripidae) is useful for suppressing harmful pests this ascertainment is consolidated by Naika *et al*. (2005) and the presence of pollinators; *Apis mellifera* (Linnaeus) (Hymenoptera: Apidae) and *Andrena* sp. (Hymenoptera: Andrenidae) also ensures better fruiting.

From the quantitative point of view,our results are similar to those of Choudourou *et al*. (2012) even they performed their work on two open fields, of three tomato varieties in Benin and identified 37 species of insects belonging to nine orders and 26 families from May to July. Similarly, Lahmar (2008) identified 44 genera and species of insects distributed in eight orders and 23 families on tomato cultivation under greenhouse in Ouarglaby the Barber pots collection method. From the qualitative point of view, Sid-Rouhou (2014) also reported that the most represented order in a tomato greenhouse over eight months from November to June is Diptera followed by Hymenoptera, Lepidoptera, Homoptera and Coleoptera. Similarly, Imine (2011) recorded six insect orders on greenhouse tomato cultivation with 21 families and 22 species with Dipterian order dominance. The dominance of Diptera can be attributed of being ubiquitous and widely distributed insects most families of Diptera are nearly worldwide in distribution (Vockeroth, 1993). Indeed, our inventory of insects took place during the period between September 2017 and April 2018, where climate factor covers humidity, rainfall and temperature are optimal for dipteran larval development. Emantis (2017) reported that factors of humidity and rainfall have positive correlation with the abundance of dipteran larvae. Meanwhile, temperature factor has negative correlation.

Using the same methods adopted in our work (yellow plates with water and glue traps); in Burkina-Faso; on a total trial area of 691.2 m2 (Kere, 2016); reported the capture of 13525 insects in tomato field that belong to 10 orders divided into 83 families. Where the Hemiptera was more abundant followed respectively by the orders of the Diptera, Hymenoptera, Heteroptera, Coleoptera, Orthoptera, Thysanoptera, Lepidoptera, Trichoptera, and Neuroptera. In comparison with our results the difference in the number of specimens as well as the number of orders and families can be justified by the combination of certain factors including, capture on open field, the area being larger as well as climatic conditions of the experimentation site which took place in Bobo-dioulassour (Burkina-Faso) characterized by a tropical savanna climate compared to our experiment conditions, capture under greenhouse, small area and arid climate.

In addition, with the method of Barber pot in a farm of which 5 ha reserved for tomato cultivation of the variety Tavira in open field during 4 months of study (June-September) and which was treated by several phytosanitary products; 23 species of insects represented by 245 individuals were recorded (Bissaad*et al*., 2016).

By comparing the two trapping methods; similar observations have been made by Sid-Rouhou (2014) about the dominance of Diptera, however the abundance of other orders is different. While Lahmar (2008) using the Barber pots on greenhouse tomato cultivation in the region of Hassi Ben Abdallah in Ouargla (Algeria); found that Hymenoptera was the most numerous order followed by Coleoptera and Diptera. These differences can be explained by pedo-climatic differences and differences in cultural techniquesand in type of trap “Barber pots” that capture crawling insects by the underground traps.

While Sid-Amar (2011) using the yellow plates recorded 8 orders of insects under greenhouse sheltering different market gardening including the tomato in the station Mouley Nadjem and 7 orders in the station Sbaihi. It is noted in our experiment that Thysanoptera pre-date Hemiptera and that Neuroptera are present in glue traps; this can be explained by the difference in the size and shape of the wings between the different orders.

The similarity in Shannon and Jaccard Indices indicate that the two half-green houses are colonized by approximately the same number of insect families. Thus, the slight differences can be attributed to climatic conditions and position of each green house that the halhf-greenhouse2 is more exposed to wind so it recorded low temperatures than the half-greenhouse1, at the same time more insects are captured in the glue traps. The difference of the Shannon index between the two-half greenhouse can be attributed to temperature and humidity differences recorded in the two half greenhouses (Figure3) according to Bale et al. (2002) temperature is identified as the dominant abiotic factor directly affecting insect abundance.

Conclusion

The inventory showed that the insects that are subservient to tomato cultivation under greenhouse bio conditions in the El Outaya Bio-resource Station vary in abundance and diversity. A total of 38 genera and species of insects were registered. These insects belong to seven orders and 33 families. Although the majority of these insects are pests in tomato cultivation, there are some predators, parasitoids and pollinators. The collected data provide a basis for preliminary knowledge of tomato crop entomofauna in the El-Outayaplain and can thus be used to design pest management strategies in this region.

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