Journal of Advanced Zoology

ISSN: 0253-7214

*Volume **45** Issue **01 Year 2024** Page **11:20***

Evaluation and Diversity of Aphids on Two Tomato Crops in Tizi-Ouzou (North Algeria), and First Report of *Semiaphis Dauci* (Fabricius, 1775) (Hemiptera: Aphididae) in Algeria

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Article History

Received: 16 February 2023
Revised: 25 August 2023
Accepted:11September 2023

Abstract

Aphids are among the phytophagous insects causing the greatest economic losses. This study was carried out to evaluate the diversity and abundance of aphids in two tomato crops grown in an open field in two localities situated at Tizi-Ouzou (North Algeria). The aphid's inventory was carried out using yellow traps. 926 winged aphids were trapped, representing 55 species. The aphid fauna recorded was divided into 4 subfamilies, 6 tribes and 31 genera. The aphid's diversity trapped in Zahra variety field was higher with 41 species, compared to 29 species in Zin 45 variety field, with one species recorded for the first time in Algeria, namely Semiaphis dauci (Fabricius, 1775). The density and diversity of aphids differed from one field to another depending on climatic factors and the availability of host plants. Direct observations on plants allowed the identification of three aphid species, namely Aphis fabae Scopoli, 1763 Aphis gossypii Glover, 1877 and Myzus persicae (Sulzer, 1776).

Keywords: *Diversity, Aphids, Tomato, Tizi-Ouzou, Semiaphis Dauci.*

1. Introduction

The tomato Solanum lycopersicum L. is one of the most widely grown vegetables in the world (Polston and Anderson, 1999) and the most widely consumed after the potato. It is the second most important food resource after cereals (Causse et al., 2000). Several pests can affect this crop either in the field or under the greenhouse. According to Blancard (2012), more than 200 pest species can attack a tomato during its vegetative cycle. Among them, whiteflies, aphids, leafminers and some lepidopteran species are particularly important.

Aphids are the most dangerous because the vast majority of viruses affecting tomatoes are transmitted by them. More than 90 aphid species can acquire and transmit Cucumber Mosaic Virus (CMV) (Blancard, 2012). Since aphids are the main vectors of most plant viruses, any factor that increases aphid abundance is likely to increase the spread of the virus and the potential for a virus epidemic (Madden et al., 2000; Hull, 2002; Jeger et al., 2004). For example, the abundance of winged aphids is

positively correlated with the incidence of beet mosaic virus in sugar beet, Beta vulgaris (L.) (Dusi et al., 2000), and with the incidence of potato virus Y and potato leafroll virus in potatoes Solanum tuberosum (Basky 2002). In addition, the aphids cause direct damage by removing sap, thus weakening the plant. Aphids secrete honeydew which can cause severe damage (Blackman and Eastop, 2000; 2006). On this sugary liquid, a sooty mold fungus develops on the surface of the leaves, obstructing the respiratory stomata, which reduces the regularity of the plants' respiratory processes (Capinera, 2001). It also decreases photosynthesis and reduces crop yields (Jazzar and Hammad, 2003).

In Algeria, the diversity of aphids associated with the cultivated environment is very little studied. To our knowledge, no study has evaluated the diversity or abundance of aphids associated with tomato cultivation in Algeria, hence the interest of the present work. The main aim of this work is to evaluate the abundance and diversity of aphids in two tomato fields cultivated in the open field in Tizi-Ouzou (Northern Algeria).

2. Materials And Methods

The Study Region

This study was carried out in two localities of Tizi-Ouzou (Figure 1) on tomato crops: The first, variety Zin 45, transplanted on 25 April 2019, is located in Tizi-Ouzou Centre (GPS coordinates: 36.748548°, 4.007935°) at 47 m altitude. The second, variety Zahra, transplanted on 20th April 2019, is located in Tizi-Ouzou (GPS coordinates: 36.735110°, 3.984249°) at 54 m altitude.

The tomato crops were sampled from 13th May to 29th July 2019 for the variety Zin 45, and from 15th May to 30th July 2019 for the variety Zahra. The experimental protocol followed for trapping winged aphids and visual monitoring of aphids was that described by Atesebeha et al. (2009). Two methods were combined for surveillance of the aphids.

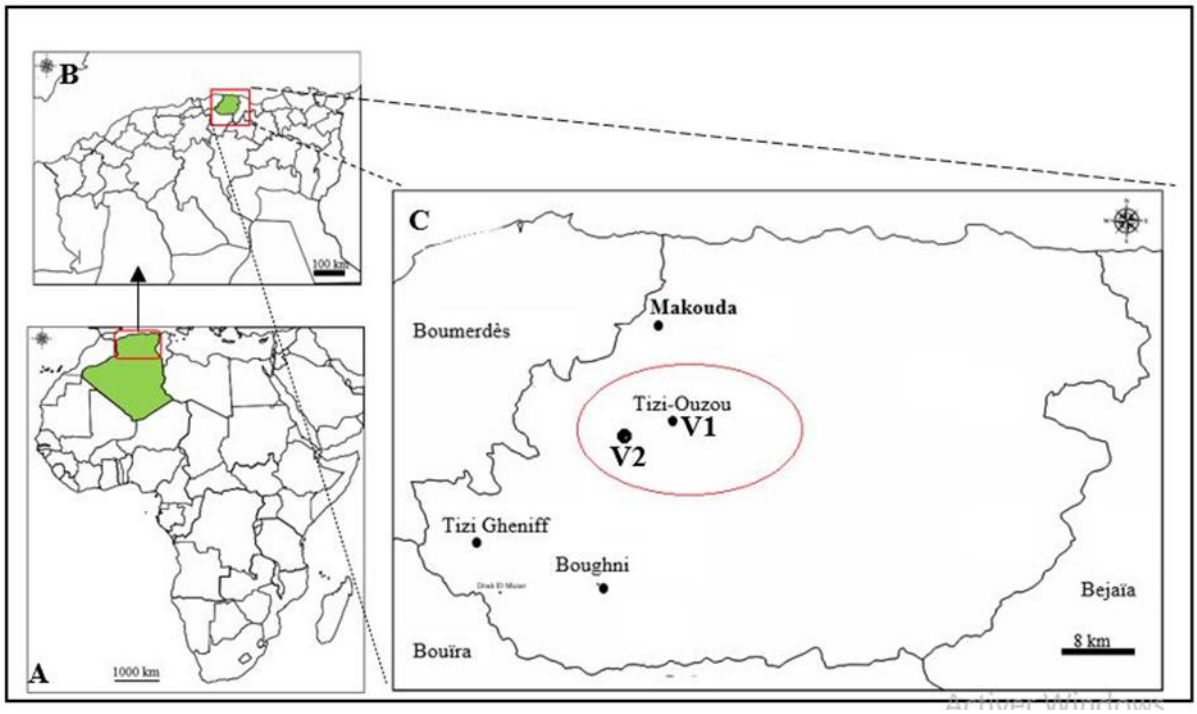

Figure 1: Aphid research site maps. **A**: Africa map. **B**: North Algeria showing Tizi-Ouzou. **C**: Tizi-Ouzou with the research sites, **V1**: Zin 45 Variety. **V2**: Zahra Variety.

Trapping of Winged Aphids

To carry out this study, each field was divided into 9 blocks. In the middle of each block, one yellow Von Moerik trap (Ɵ:27 cm, h: 10 cm) was placed, filled with water and a few drops of detergent (washing-up liquid). The attraction of aphids to the yellow color has long been known. This color tends to land these insects (Yattara et al., 2013). Changing the contents of the container is necessary for optimal performance (EDES, 2011). Aphids caught in yellow traps are removed once a week with a fine brush and kept in tubes filled with 70% ethanol.

Visual Observation of Aphids on Tomato Leaves

Once a week, in each block, one plant was selected and all aphids found on tomato leaves were collected in a tube filled with 70% ethanol, using a fine brush. The aphids trapped and collected from the plants are sorted and identified into species. According to Lascaux (2010), aphid identification is carried out by observing certain morphological characteristics of the aphid, including antennae, frontal tubercles, tarsi, cauda, color and sphincter shape, abdomen and wing pigmentation and venation. Identification was based on the identification keys of Stroyan (1961), Jacky and Bouchery (1982), Autrique & Ntahimpera (1994), Remaudière et al. (1985), and Leclant (1999) and Blackman & Eastop, (2000; 2006).

Exploitation of Results

In this present study, the ecological index of composition (the total richness and centesimal frequency) and the ecological indices of structures (Shannon index and the equitability E) had been exploited.

Ecological Composition Indices

Centesimal Frequency

According to Dajoz (1971), the centesimal frequency is the percentage of individuals of a species (ni) by contribution to the total number of individuals (N).

$F(\%) = ni \times 100/N$

ni: is the number of individuals of species taken into consideration.

N: is the number total of all individuals' confused species.

Ecological Indices of Structure

The two ecological indexes of structure used in our study are the Shannon index and the sign of equitability **E**.

Shannon Diversity Index

According to Barbault (2008), this index is considered as the best medium indicating diversity. Shannon diversity index is given by the following formulation (Ramade, 1984): **$H' = -\Sigma qi \log 2 qi$**

H': Shannon diversity index expressed by bits.

qi: is equal to **ni / N** which **ni** is the number of individuals of species i**. N**: is the total number of individuals. A community will be more diversified than the Shannon diversity index **H'** will be big (Blondel, 1979).

Equidistribution or Equitability Index

The equitability is the specific diversity report to the maximal diversity (Blondel, 1979), it is calculated by the following formulation: **$E = H' / H' max$**

H': is the sign of the observed diversity

H' max: is expressed by bits.

$H' max = \log 2 S$

S: is the total richness. It is equal to the total number of present species. It is obtained from the total number of the picked-up ones (Ramade, 1984).

3. Results and Discussion

During this study carried out on tomato aphids in Tizi-Ouzou (Algeria), the trapping of winged aphids with yellow traps installed in two tomato fields made it possible to establish a list of 55 species (Table

1). These species belong to four subfamilies, Aphidinae, Chaitophorinae, Pemphiginae and Calaphidinae, 6 tribes and 31 genera.

The most abundant subfamily from a qualitative point of view is the Aphidinae, which includes two tribes, the Aphidini and the Macrosiphini. The latter is the most dominant. In the Zahra variety plot, 41 species were caught belonging to 25 genera, 5 tribes and 4 subfamilies. On the other hand, in the Zin 45 variety plot, 29 species were observed. These species are divided into 20 genera, five tribes and three subfamilies.

This present study also made it possible to record a new species that has never been recorded in Algeria, namely *Semiaphis dauci* captured in the yellow traps installed in the plot of variety Zin 45.

Table 1: List of aphids recorded on two tomato varieties.

Subfamilies	Tribes	Genera	Species	Zin 45	Zahra
Aphidinae	Aphidini	*Aphis*	*A. coreopsidis* (Thomas,1878)	+	-
			A. craccivora Koch, 1854	+	+
			A. fabae Scopoli, 1763	+	+
			A. gossypii Glover, 1877	+	+
			A. idaei van der Goot, 1912	+	+
			A. illinoisensis Shimer, 1866	-	+
			A. nerii Boyer de Fonscolombe, 1841	-	+
			A. pomi De Geer, 1773	-	+
			A. spiraecola Patch, 1914	-	+
			Aphis sp.	+	+
		Hyalopterus	*H. pruni* (Geoffroy 1762)	+	+
		Melanaphis	*M. donacis* (Passerini, 1862)	+	-
		Rhopalosiphum	*R. insertum* (Walker, 1849)	-	+
			R. maidis (Fitch, 1856)	+	+
			R. padi (Linnaeus, 1758)	+	+
			R. rufiabdominale (Sasaki, 1899)	-	+
		Schizaphis	*S. graminum* (Rondani, 1852)	-	+
		Toxoptera	*T. aurantii* (Boyer de Fonscolombe, 1841)	-	+
	Macrosiphini	*Acyrthosiphon*	*A. pisum* (Harris, 1776)	+	+
		Amphorophora	*A. rubi* (Kaltenbach, 1843)	-	+
		Aulacorthum	*A. solani* (Kaltenbach, 1843)	+	+
		Brachycaudus	*B. cardui* (Linnaeus, 1758)	+	-
			B. helichrysi (Kaltenbach, 1843)	+	-
			B. rumexicolens (Patch, 1917)	+	-
		Brevicoryne	*B. brassicae* (Linnaeus, 1758)	-	+
		Cavariella	*C. aegopodii* (Scopoli, 1763)	-	+
			C. theobaldi (Gillette et Bragg, 1918)	-	+
		Capitophorus	*C. hippophae* (Walker, 1852)	+	-
			Capitophorus sp.	+	-
		Diuraphis	*D. noxia* (Mordvilko, 1913)	+	-
		Dysaphis	*D. apiifolia* (Theobald, 1923)	+	-
			D. foeniculus (Theobald, 1923)	+	+
			D. plantaginea (Passerini, 1860)	+	+
		Hyadaphis	*H. foeniculi* (Passerini, 1860)	-	+

		Hyperomyzus	*H. lactucae* (Linnaeus, 1758) *Hyperomyzus* sp.	+ +	+ -
		Lipaphis	*L. erysimi* (Kaltenbach, 1843)	+	+
		Macrosiphum	*M. euphorbiae* Thomas, 1878 *M. rosae* Linnaeus,1758	+ +	+ +
		Megoura	*M. viciae* Buckton, 1876	-	+
		Myzus	*M. ascalonicus* Doncaster,1946 *M. cerasi* (Fabricius, 1775) *M. ornatus* Laing, 1932 *M. persicae* (Sulzer, 1776) *Myzus* sp.	- - - + +	+ + + + -
		Phorodon	*P. humuli* (Schrank, 1801)	-	+
		Rhopalosiphonimus	*R. staphyleae* (Koch, 1854)	-	+
		Semiaphis	*S. dauci* Fabricius, 1775	+	-
		Sitobion	*S. avenae* (Fabricius, 1775)	+	+
		Uroleucon	*U. sonchi* (Linnaeus, 1767)	-	+
		Wahlgreniella	*W. nervata* (Gillette, 1908)	+	+
Chaitophorinae	Atheroidini	*Sipha*	*S. maydis* Passerini 1860	+	-
	Chaitophorini	*Chaitophorus*	*C. populeti* (Panzer, 1801)	-	+
Pemphiginae	Pemphigini	*Pemphigus*	*P. bursarius* (Linnaeus, 1758) *Pemphigus* sp.	- +	+ -
Calaphidinae	Panaphidini	*Therioaphis*	*T. trifolii* (Monell, 1882)	+	+
04	**06**	**31**	**55**	**29**	**41**

Percent Frequency or Relative Abundance (%)

During the sampling period, 926 aphids were caught in two study fields (Table 2). In the Zahra variety field, *H. lactucae* was the most represented species with 80 individuals corresponding to a frequency of 15.80% followed by *M. persicae* observed with 52 individuals corresponding to a frequency of 10.20%. In the second variety, *A. gossypii* was the most dominant species with 134 individuals representing a frequency of 31.90% followed by *A. fabae* with 34 individuals representing a frequency of 8.1%.

The frequencies of occurrence of the aphidian species represent variable values. Two species are regular (*A. gossypii and H. lactucae*), 12 accessory species and 20 accidental species in the Zin 45 variety. In the Zahra field, four species are regular, namely *A. fabae*, *R. padi*, *A. gossypii* and *H. lactucae*.

Table 2: Frequencies and relative abundances (%) of aphids caught by trapping in the two study plots.

Variety	**Zin 45**				**Zahra**			
Species	**ni**	**Fi %**	**Consistency**	**Category**	**ni**	**Fi %**	**Consistency**	**Category**
A. craccivora	21	5	33.33	Incidental	25	5	41.66	Incidental
A. coreopsidis	11	2.62	16.66	Accidental	/	/	/	/
A. fabae	34	8.1	41.66	Incidental	30	5.90	50	Regular
A. gossypii	134	31.9	50	Regular	47	9.20	41.66	Incidental
A. idaei	3	0.70	8.33	Accidental	13	2.60	41.66	Incidental
A. illinoisensis	/	/	/	/	2	0.40	8.33	Accidental
A. nerii	/	/	/	/	18	3.5	41.66	Incidental
A. pomi	/	/	/	/	19	3.7	25	Incidental
A. spiraecola	/	/	/	/	21	4.10	41.66	Incidental
Aphis sp.	14	3.33	33.33	Incidental	5	1	16.66	Accidental
H. pruni	1	0.23	8.33	Accidental	3	0.60	8.33	Accidental
M. donacis	5	1.20	16.66	Accidental	/	/	/	/
R. insertum	/	/	/	/	6	1.20	16.66	Accidental
R. maidis	32	7.60	33.33	Incidental	30	5.90	33.33	Incidental
R. padi	15	3.60	41.66	Incidental	41	8.10	50	Regular
R. rufiabdominale	/	/	/	/	4	0.80	8.33	Accidental
S. graminum	/	/	/	/	6	1.20	33.33	Incidental
T. aurantii	/	/	/	/	5	1	8.33	Accidental
A. rubi	2	0.47	8.33	Accidental	3	0.60	16.66	Accidental
A. pisum	/	/	/	/	5	1	25	Incidental
A. solani	5	1.20	25	Incidental	5	1	25	Incidental
B. cardui	3	0.70	25	Incidental	/	/	/	/
B. helichrysi	7	1.67	25	Incidental	/	/	/	/

B. rumexicolens	2	0.50	16.66	Accidental	/	/	/	/
B. brassicae	/	/	/	/	8	1.60	41.66	Incidental
C. aegopodii	/	/	/	/	3	0.60	16.66	Accidental
C. theobaldi	/	/	/	/	3	0.60	25	Incidental
C. hippophae	3	0.70	16.66	Accidental	/	/	/	/
Capitophorus sp.	1	0.23	8.33	Accidental	/	/	/	/
D. noxia	2	0.50	8.33	Accidental	/	/	/	/
D. apiifolia	2	0.50	8.33	Accidental	/	/	/	/
D. foeniculus	2	0.50	8.33	Accidental	3	0.60	8.33	Accidental
D. plantaginea	3	0.70	8.33	Accidental	3	0.60	25	Incidental
H. foeniculi	/	/	/	/	7	1.40	25	Incidental
H. lactucae	29	6.90	50	Regular	80	15.80	50	Regular
Hyperomyzus sp.	1	0.23	8.33	Accidental	/	/	/	/
L. erysimi	4	0.95	25	Incidental	1	0.20	8.33	Accidental
M. euphorbiae	14	3.33	33.33	Incidental	9	1.80	16.66	Accidental
M. rosae	4	0.95	16.66	Accidental	2	0.40	16.66	Accidental
M. viciae	/	/	/	/	2	0.40	16.66	Accidental
M. ascalonicus	/	/	/	/	5	1	25	Incidental
M. cerasi	/	/	/	/	3	0.60	16.66	Accidental
M. ornatus	/	/	/	/	4	0.80	16.66	Accidental
M. persicae	26	6.20	41.66	Incidental	52	10.20	50	Regular
Myzus sp.	2	0.50	8.33	Accidental	/	/	/	/
P. humuli	/	/	/	/	1	0.20	8.33	Accidental
R. staphyleae	/	/	/	/	4	0.80	16.66	Accidental
S. dauci	3	0.70	16.66	Accidental	/	/	/	/
S. avenae	3	0.70	16.66	Accidental	11	2.20	25	Incidental
U. sonchi	/	/	/	/	5	1	25	Incidental
W. nervata	4	0.95	16.66	Accidental	2	0.40	8.33	Accidental
S. maydis	7	1.65	16.66	Accidental	/	/	/	/
C. populeti	/	/	/	/	2	0.40	8.33	Accidental
P. bursarius	/	/	/	/	5	1	25	Incidental
Pemphigus sp.	18	4.30	41.66	Incidental	/	/	/	/
T. trifolii	3	0.70	16.66	Accidental	3	0.60	16.67	Accidental
Total	**420**	**100**	**/**	**/**	**506**	**100**	**/**	**/**

ni : Number of individuals ; **Fi%** : Relative abundances.

Ecological indices structure

The results of the ecological structure indices show that the highest Shannon diversity index value (H'= 4.56 bits) is observed in the Zahra variety. The equitability calculated in the two plots is close, the highest being recorded in the variety Zahra (0,83).

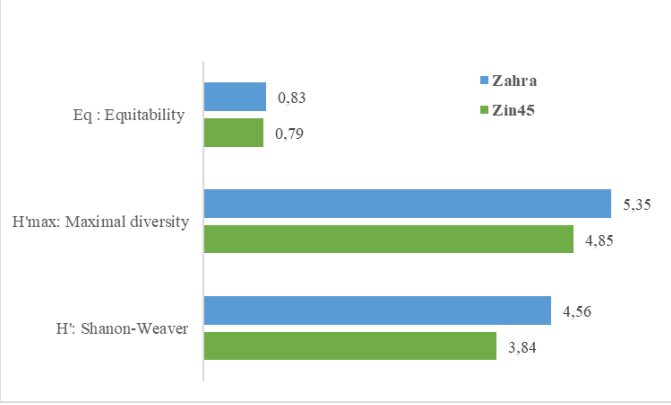

Figure 2: Shannon index value for two tomato variety

Visual observation of aphids on tomato leaves

Direct observations on the plant leaves of both varieties revealed three aphid species, on the leaves of variety Zin 45, we have found three species, they are *A. fabae*, *A. gossypii* and *M. persicae*, the latter being dominant with 406 individuals. On the other hand, on the Zahra variety leaves, only *M. persicae* was found in the form of colonies.

Table 3: Diversity of aphid species found on the leaves of the two tomato varieties.

Variety Species	Zin 45		Zahra	
	Number of Aphids	Frequency %	Number of Aphids	Frequency %
A. fabae	102	15	-	-
A. gossypii	176	25,84	-	-
M. persicae	403	59,2	569	100
Total	**681**	**100%**	**569**	**100%**

The analysis of the Aphididae population composition revealed the presence of 55 species. In Zahra variety field, 41 species were caught, while in Zin 45 variety, 29 species were observed. Ait Amar and Benoufella-Kitous (2021) on potatoes grown in Tizi-Ouzou recorded 65 species, and Ait Amar et al. (2021), in Makouda (Tizi-Ouzou, Algeria) recorded 48 species. Under greenhouse Ait Amar et al. (2022) were identified 26 species on pepper, aubergine and tomato. The difference in the richness of the aphidian species recorded on the two varieties can be explained by the different climatic conditions on the one hand, and on the other hand by the floristic richness of the species which has a direct consequence on the richness of the aphidian species. Indeed, the floristic richness observed around Zahra variety field was higher than that observed in the Zin 45 field. Remaudière and Autrique (1984), reported that wild plants are the source of winged aphids that are installed in the crops. Hullé et al (1999) affirmed that many different plant families can host many aphid species. The results also show that Zin 45 field, *A. gossypii* and *A. fabae* are the species most caught in the yellow traps, while in the Zahra field, *H. lactucae* and *M. persicae* are the most observed. These species are very polyphagous and can attack several trees, vegetable crops and weeds. According to Hullé et al (1999), the black aphid *A. fabae* has more than 200 host plants, *M. persicae* can attack more than 50 botanical families including Solanaceae, Asteraceae, Brassicaceae, Apiaceae and Cucurbitaceae, several species belonging to these families are present in the two study fields. The presence of *H. lactucae* in abundance in the field of the Zahra variety is due to the presence of its secondary host plants which belong to the Asteraceae family such as lettuce and sow thistle (*Sonchus asper* L., *Sonchus arvensis* L. *Sonchus oleraceus* L.).

It also apereas from this inventory that the frequencies of occurrence of different species have a variable value, two species are regular for the Zahra variety, they are *A. gossypii* and *H. lactucae*, for the Zin 45 variety, and four species are regular: *A. fabae*, *R. padi*, *A. gossypii* and *H. lactucae*. The high frequency can be explained by the fact that these species are very polyphagous on the one hand and by the presence of their secondary hosts such as lettuce, chili, pepper, zucchini, tomato and Gramineae. The regular presence of *R. padi* species in the field of the variety Zin 45 is explained by the presence of several Poaceae species and cereals. Maize was planted around the tomato field.

Our study allowed us to record the species *S. dauci* for the first time in Algeria. *S. dauci* species was Eurosiberian originally, but now is widely distributed in Europe, Turkey, Siberia and Central Asia (Heie, 1992). It has also been recorded in the Middle East (Blackman and Eastop, 2000, 2006). In South America, previous notes on the occurrence of this species were made by Delfino (2005) on carrot *Daucus carota* L., and in Brazil by Ide et al. (2011) on arracacha *Arracacia xanthorrhiza* Bancr. *S. dauci* has been recorded in Tunisia by Boukhris-Bouhachem et al. (2007), in yellow traps installed in the potato crop. *S. dauci* is generally found on wild and cultivated *Daucus carota* (Blackman and Eastop, 2000; Holman (2009), but it has also been reported on *Aegopodium podagraria* by Mifsud et al. (2011). The Apiaceae family was represented in the tomato field (variety Zin 45) by several species, which could explain the presence of this species in the traps. The Shannon diversity index calculated for the two study fields is 3.84 and 4.56 bits. In the present study, species richness and plant diversity provide favorable conditions for the establishment of aphids. According to Blondel (1975), in a given environment, when the living conditions are favorable many species are found, in which case diversity is high. Our results are in agreement with those of Bouabida et al., (2021), where the Shannon diversity index calculated in four food legume fields varies from 3.66 to

4.38 bits. The equitability tends to be 1 for both cultivated varieties. This indicates that the numbers of species tend to be in balance with other species.

Direct observations on the leaves have made it possible to find 3 species installed on tomato leaves, these are *A. fabae*, *A. gossypii* and *M. persicae*. According to Blackman and Eastop (2000; 2006), these three species are among the most frequent species of tomato. The study carried out in the United States by Coppler et al, (2007) on the Florina tomato variety showed the existence of 6 aphid species, namely *A. fabae*, *A. gossypii*, *M. euphorbia*, *A. solani*, *M. persicae* and *Uroleucon* spp. In India, Ghosh (2017), noted the presence of *A. gossypii* on tomato leaves.

4. Conclusion

The preliminary study carried out on tomato aphids in Tizi-Ouzou revealed the presence of 55 species, among them *S. dauci* species are recorded for the first time in Algeria. In both study fields, several weeds and fruit trees are present, which explains the abundance of these insects. The latter are mostly present in the area. Visual observation of aphid populations on tomato leaves revealed three species: *A. fabae*, *A. gossypii* and *M. persicae*.

Acknowledgments

We would like to thank Nicols Pérez-Hidalgo, a researcher at the University of Valencia, Spain, for the identification of *S. dauci* and the confirmation of other species.

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