ENTOMOLOGY

Aphid diversity in two food legume crops: fava bean and pea in Naciria region, and first record of *Melanaphis sacchari* (Zehntner, 1897) in Algeria

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Abstract

Beans and peas are very important legumes because of their importance in human food and their high protein contents, as well as their role in the supply of atmospheric nitrogen to the soil. However, these crops are subject to various pest outbreaks, reducing their yield. The purpose of this study is to carry out an exhaustive inventory of aphids present on bean (Faba bean and Seville variety) and pea crops (Merveille De Kelvedone and Utrillo variety) in the region of Naciria (Boumerdes), in order to evaluate the diversity and abundance of aphids present in these crops. Sampling of aphid populations has been done using two trapping techniques: Barber pitfall trap and yellow traps. The results obtained express a richness of 48 aphid species, with one *Melanaphis sacchari* species identified for the first time in Algeria. 28 species are inventoried in the pea crop of Utrillo variety, 27 species on the Merveille de Kelvedone variety, 21 species in the bean crop of Seville variety (*Vicia faba major*) and 20 species on the faba bean (*Vicia faba minor*).

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Introduction

Food legumes are the basis of the human diet thanks to their nutritional interests and their high protein content. They also play a role in soil fertility through atmospheric nitrogen fixation (Schneider & Huyghe, 2015). Unfortunately, these crops are infested by aphids causing a decrease in crop yields. They suck their hosts sap and inject saliva that could be phytotoxic causing wilting, yellowing and often death of plants. In addition, aphids are particularly damaging as vectors of plant disease viruses (Brault *et al*., 2010). They excrete a sticky substance "honeydew" on which fumagin develops decreasing the market value of the products (Eaton, 2016). In Algeria, few studies have been developed on aphids infesting food legumes (Laamari & Hebbel, 2006 ; Benoufella-Kitous *et al*., 2014; Benoufella-Kitous & Medjdoub-Bensaad, 2016; Benoufella-Kitous *et al*., 2019). There were no studies on legume aphids in the region of Naciria (Boumerdes). For this reason, an inventory of bean and pea aphids is managed to assess their diversity and abundance in this region.

Materials and methods

Study area

This study was carried out on fields of broad beans of Seville variety (*Vicia faba* var. major) and field bean variety (*Vicia faba* var. *minor*) and fields of peas of the Merveille de Kelvedone and Utrillo varieties during 2017-2018 crop year. The 4 study fields are located at an altitude of 158 m a.s.l. in the region of Naciria (36°44'51''N, 3°49'44''E), part of the province of Boumerdes, around 80 km East of Algiers (Figure 1) where the Mediterranean climate is characterized by a rainy and mild winter and a dry and hot summer. It must be emphasised that the fields did not undergo any phytosanitary treatment during the entire sampling period.

Aphid trapping method

Sampling was carried out over 13 weeks, from 26/01/2018 until the end of the crop on 20/04/2018. Each field was divided into nine

homogeneous quadras. In the centre of each quadra, a Barber pot (20 cm in diameter by 10 cm high) and a yellow trap (20 cm in diameter by 15 cm high) were placed. The yellow traps were placed on stakes 40 cm above the ground. Barber pots were placed in the ground.

The traps were filled with water to which was added a small amount of detergent to act as a wetting agent, reducing water surface tension and preventing trapped insects from escaping once caught (Benkhelil, 1992).

Aphid sampling and recovery were carried out on regular basis during weekly field trips. Collected aphids were preserved in 70% Ethanol, counted and then identified in the laboratory. Aphid identification was carried out based on the determination keys described by Jacky & Bouchery (1982); Remaudière *et al*. (1985); Autrique & Ntahimpera (1994) ; Blackman & Eastop (2000, 2006).

Exploitation of results

Different analyses were applied in order to exploit the results obtained, namely the ecological indices composition (total richness and relative abundance), as well as the ecological indices structure (Shannon and Peilou equitability indices).

Ecological composition indices

Specific richness

The specific wealth is one of the fundamental parameters characteristic of a settlement. The total richness (S) of a biocenosis corresponds to the totality of species that make it up (Ramade, 1984).

Relative abundance or percent frequency

Relative abundance (AR%) is the percentage of the number of individuals of a species (ni) in relation to the total number of individuals (N): AR%=ni x100/N (Faurie *et al*., 1980).

Ecological indices structure

Shannon-Weaver Diversity Index

This index provides information on the diversity of each environment under consideration. It varies both according to the number of species present and the abundance of each of them (Barbault, 2008). It is calculated using the following formula:

$$H' = - \Sigma \, qi \log2 \, qi$$

H': Shannon-Weaver Diversity Index expressed in bit units.
qi: Probability of occurrence of the species (qi= ni/N, where ni is the number of each species in the sample and N is the sum of the ni of all species combined).
Log2: logarithm - base 2.

Peilou equidistribution or equitability index (E)

It is the relationship between real diversity and maximum theoretical diversity (Blondel, 1975).

$$E = H' / H' \text{ max.}$$

H' is Shannon's diversity index expressed in bits.
H' max. is the index of maximum diversity expressed in bits, with H' max. = H' / Log2 where S is the total richness corresponding to the number of species present.

Figure 1. Map of Boumerdes region and location of study site, (A) Map of Algeria showing the study region, (B) the study region.

Results

In this experimental study, trapping winged aphids using the yellow traps resulted in a list of aphids that could infest four field of food legumes.

List of aphids found in the four legume fields: Seville bean, Faba bean, Merveille de Kelvedone pea and Utrillo pea

Aphid fauna analysis in the four studied fields revealed the existence of 48 species of aphids: 28 species of aphids in the Utrillo pea crop and 27 species in the Merveille de Kelvedone variety; in the bean crop, 21 species were identified in the Seville variety field and 20 species in the broad bean variety.

Sampling made it possible to trap a new species that has never been identified in Algeria. It is *M. sacchari* trapped in the Utrillo field (Table 1).

Percent frequency or relative abundance (%)

During the 13 weeks of trapping, 383 individuals were collected representing 48 species belonging to 21 genera, two tribes and a single subfamily, in the four study fields. The relative abundance of these species varied from one crop to another. *A. gossypii* and *M. persicae* were the most present species in the pea crop of Merveille de Kelvedone variety. *A. gossypii* was the most abundant in the Utrillo variety. *A. fabae* and *A. gossypii* were the most frequent in the two bean crops. The other species were poorly represented with frequencies ranging from 1.25% to 8.93% (Table 2).

Ecological indices structure

The results of the ecological structure indices applied to the species caught by different types of traps show that the highest Shannon diversity index value (H'= 4.38 bits) is observed in the Utrillo pea crop. This value varies between 3.66 and 3.92 bits for the other crops (Figure 2).

The maximum diversity H' max varies between 4.32 and 4.81 bits for all cultivated varieties. The equitability obtained tends towards 1 at the level of the 4 cultivated varieties.

Discussion and conclusions

Analysis of the aphid fauna in the four fields used for the study pointed out the presence of 48 aphid species. In Oued-Smar (Algiers, Algeria), Boussad & Doumandji (2004) report that among the insects collected on a bean crop, the Aphididae family is the most representative with a total of 73 specimens. Working in Biskra (Algeria) region, Laamari & Hebbel (2006) identified 16 aphid species in a field of *V. faba.* In 2014, Benoufella-Kitous *et al.* (2014) reported the presence of 27 species of aphids in a bean field in the region of Draâ Ben Khedda (Tizi-Ouzou, Algeria) inclusive of 125 specimens belonging to 25 species in 2008 and 143 specimens attributed to 19 species in 2013. In chickpea and lentil crops situated in Tala Amara (Tizi-Ouzou, Algeria), Benoufella-Kitous & Medjdoub-Bensaad (2016) have identified 55 aphid species. The work of Lopes *et al*. (2012) in Belgium recorded the presence of 37 aphid species in a pea field. Singh *et al*. (2016) in a study on biodiversity of aphids infesting legumes in India, reported the presence of 73 species that could infest these crops. In 2019, Benoufella-Kitous *et al*. (2019) studied the aphid diversity of four food legumes (broad bean, chickpea, pea and lentil) in the region of Tizi-Ouzou. The results obtained by these authors showed the existence of 43 species of aphids.

Aphid species richness characterizing the investigated fields can be justified on the one hand by the climatic conditions favourable to aphid flight and on the other hand by the abundance and diversity of cultivated host plants and weeds likely to attract aphids. Hanski & Cambefort (1991) assert that the richness of a stand depends on the level of available trophic resources and climatic conditions of the investigated biotopes. Indeed, the increase in plant diversity leads to an increase in the diversity of phy-

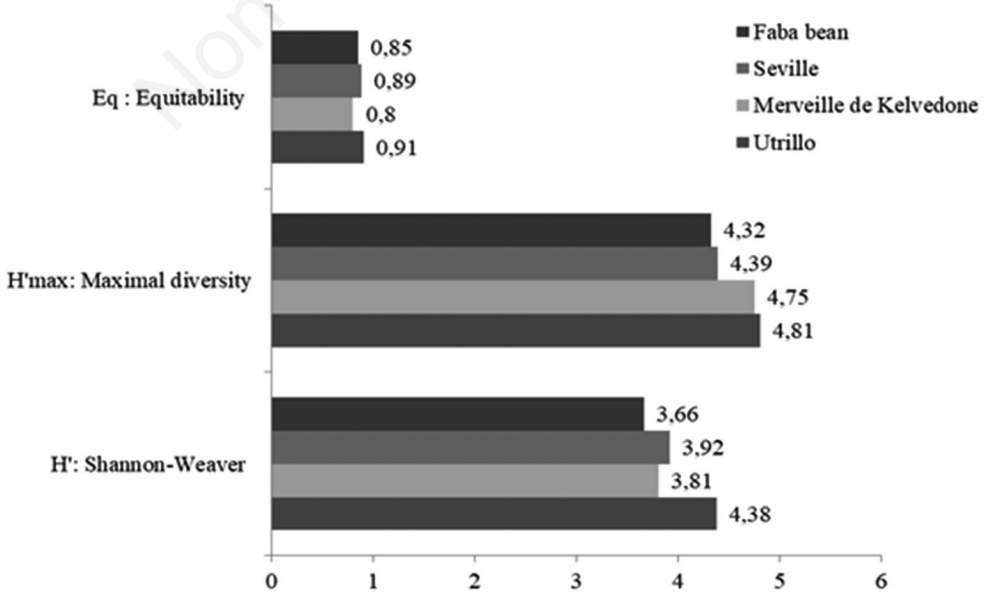

Figure 2. Shannon-Weaver index value for the different trapping techniques used for each cultivated plot.

tophagous plants (Barbault, 1981). Wild plants are very often the additional source of winged aphids that will settle on receptive crops (Remaudière & Autrique, 1984).

The analysis of the surveys shows that *A. gossypii* and *M. persicae* are the most frequent species in the pea field in Merveille de Kelvedone variety. In the Utrillo variety, *A. gossypii* is the most represented. In the two bean crops, two species are abundant: *A. fabae* and *A. gossypii.*

In a bean crop, Benoufella-Kitous *et al*. (2014) noted the presence of *A. gossypii* with a frequency of 9.3% of winged aphid species captured in 2008 and 16.1% in 2013. In Tunisia, this aphid

Table 1. List of aphids detected in the four food legume fields: bean (Seville variety, broad bean variety) and pea (Kelvedone variety, Utrillo variety) fields located in Naciria region (Boumerdes).

Sub-families	Tribes	Genera	Species	F	Fr	M	U
Aphidinae	Aphidini	*Aphis*	*A. spiraecola* Patch, 1914	-	-	+	-
			A. coreopsidis (Thomas,1878)	+	-	+	+
			A. craccivora Koch, 1854	+	+	+	+
			A. fabae Scopoli,1763	+	+	+	+
			A. gossypii Glover, 1877	+	+	+	+
			A. idaei van der Goot, 1912	+	-	+	+
			A. nerii Boyer de Fonscolombe, 1841	+	+	-	+
			A. verbasci Schrank, 1801	-	-	+	+
			Aphis sp.	+	-	+	+
		Melanaphis	*M. sacchari* (Zehntner, 1897)	-	-	-	+
		Rhopalosiphum	*R. oxyacanthae* (Schrank, 1801) (= *insertum* Walker)	-	-	-	+
			R. maidis (Fitch, 1856)	+	+	+	+
			R. padi (Linnaeus, 1758)	+	+	+	+
		Schizaphis	*S. eastopi* (van Harten et Ilharco, 1971)	-	-	+	-
			S. graminum (Rondani, 1852)	-	-	+	+
			S. rotundiventris (Signoret, 1860)	-	-	+	-
			Schizaphis sp.	-	-	+	-
	Macrosiphini	*Acyrthosiphon*	*A. ilka* (Mordvilko, 1914) (= *bidentis* Eastop)	-	+	-	-
			A. pisum (Harris, 1776)	-	+	-	-
		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. pastinaceae* (Linnaeus, 1758)	-	+	-	-
			C. theobaldi (Gillette et Bragg, 1918)	-	-	+	-
			Cavariella sp.	+	-	-	-
		Diuraphis	*D. noxia* (Mordvilko, 1913) ex Kurdjumov, 1913	-	-	+	-
		Dysaphis	*D. apiifolia* (Theobald, 1923)	-	+	+	+
			D. foeniculus (Theobald, 1923)	+	-	-	-
			D. plantaginea (Passerini, 1860)	-	-	+	-
			D. tulipae (Boyer de Fonscolombe, 1814)	+	-	-	-
		Hyadaphis	*H. foeniculi* (Passerini, 1860)	-	-	+	-
		Hyperomyzus	*H. lactucae* (Linnaeus, 1758)	+	+	+	+
		Liosomaphis	*L. berberidis* (Kaltenbach,1843)	-	-	-	+
		Lipaphis	*L. erysimi* (Kaltenbach, 1843)	+	+	-	-
		Macrosiphoniella	*M. artemisiae* Boyer de Fonscolombe, 1841	-	+	-	-
		Macrosiphum	*M. euphorbiae* Thomas, 1878	-	-	+	+
			M. rosae Linnaeus,1758	+	-	+	+
		Metapolophium	*M. festucae* (Theobald,1917)	-	-	+	-
		Myzus	*M.ascalonicus* Doncaster,1946	-	-	-	+
			M. cymbalariae Stroyan,1954	-	-	-	+
			M. langei (Börner, 1933)	-	+	-	-
			M. persicae (Sulzer, 1776)	+	+	+	+
		Nasonovia	*N. ribisnigri* (Mosley, 1841)	-	+	+	-
		Sitobion	*S. fragariae* (Walker, 1848)	-	-	-	+
		Uroleucon	*U. compositae* (Theobald, 1915)	+	-	-	-
			U. sonchi (Linnaeus, 1767)	-	+	-	+
01	02	22	48				

F: Bean Seville variety; **Fr:** Broad bean variety; **K**: Pea Merveille de Kelvedone2; **U:** Pea Utrillo; **+ :** Presence ; **- :** Absence.

Table 2. Values of centesimal frequencies (%) applied to the different aphid species harvested in the crops studied.

Species	Pea Merveille de Kelvedone		Pea Utrillo		Bean Seville variety		Broad bean variety	
	ni	AR%	ni	AR%	ni	AR%	ni	AR%
A. craccivora	9	4.79	4	5.06	3	5.36	6	10
A. fabae	24	12.77	4	5.06	8	14.29	13	21.66
A. gossypii	41	21.81	11	13.92	6	10.71	12	20
A. verbasci	7	3.72	2	2.53	0	0	0	0
A. spiraecola	3	1.59	0	0	0	0	0	0
A. idaei	1	0.53	1	1.26	1	1.79	0	0
A. solani	8	4.25	3	3.79	1	1.79	2	3.33
Aphis sp.	7	3.72	1	1.26	1	1.79	0	0
A. ilka	0	0	0	0	0	0	3	5
M. ascalonicus	0	0	1	1.26	0	0	0	0
A. pisum	0	0	0	0	0	0	2	3.33
A. nerii	0	0	3	3.79	1	1.79	1	1.66
A. coreopsidis	2	1.06	1	1.26	1	1.79	1	1.66
B.cardui	1	0.53	2	2.53	2	3.57	2	3.33
B. helichrysi	3	1.59	3	3.79	3	5.36	1	1.66
B. rumexicolens	0	0	2	2.53	0	0	0	0
B. brassicae	0	0	0	0	0	0	2	3.33
Cavariella sp.	0	0	0	0	1	1.79	0	0
C. pastinaceae	0	0	0	0	0	0	1	1.66
C. theobaldi	1	0.53	0	0	0	0	0	0
D. apiifolia	4	2.13	3	3.79	0	0	0	0
D. foeniculus	0	0	0	0	1	1.79	0	0
D. tulipae	0	0	0	0	1	1.79	0	0
D. plantaginea	2	1.06	0	0	0	0	0	0
D. noxia	1	0.53	0	0	0	0	0	0
H. lactucae	11	5.85	8	10.12	5	8.93	2	3.33
H. foeniculi	0	0	0	0	1	1.79	0	0
M. persicae	29	15.41	9	11.39	7	12.5	5	8.33
M. langei	0	0	0	0	0	0	1	1.66
M.euphorbiae	2	1.06	3	3.79	0	0	0	0
M. rosae	6	3.19	3	3.79	1	1.79	0	0
M. festucae	1	0.53	0	0	0	0	0	0
M. sacchari	0	0	1	1.26	0	0	0	0
M. cymbalariae	0	0	1	1.26	0	0	0	0
N. ribisnigri	1	0.53	0	0	0	0	1	1.66
R. padi	13	6.91	3	3.79	5	8.93	0	0
R. maidis	5	2.67	3	3.79	5	8.93	2	3.33
R. oxyacanthae	0	0	3	3.79	0	0	0	0
L. erysimi	0	0	0	0	1	1.79	1	1.66
L. berberidis	0	0	1	1.26	0	0	0	0
S.rotundiventris	1	0.53	0	0	0	0	0	0
*Schizaphis*sp	1	0.53	0	0	0		0	0
S. eastopi	1	0.53	0	0	0	0	0	0
S. graminum	3	1.59	1	1.26	0	0	0	0
S. fragariae	0	0	1	1.26	0	0	0	0
M. artemisiae	0	0	0	0	0	0	1	1.66
U. sonchi	0	0	1	1.26	0	0	1	1.66
U. compositae	0	0	0	0	1	1.79	0	0
Total	188	100	79	100	56	100	60	100

ni: Number of individuals; **AR**: Relative abundances.

is identified by Ben Halima-Kamel & Ben Hamouda (1993) on eggplant, chilli pepper, cucumber and melon. This species is also reported by Vayssières *et al*. (2001) on Solanaceae, Cucurbits, Fabaceae and Asteraceae. On courgette crops, *A. gossypii* is in the vast majority with 99 % of aphids identified on this crop (Lopes *et al*. 2012). Benoufella-Kitous (2015) reports the presence of this species in the form of low density colonies, apterous individuals on *Avena sterilis* L. and denser colonies on *Lavatera cretica* L. Sekkat (2015) reports it on Cucurbits, Solanaceae and *Citrus* in Morocco, whereas Singh *et al.* (2016) note the presence of *A. gossypii* on 39 legume species in India.

Mezani *et al*. (2016), in a study of invertebrate assessment on a bean field in the region of Tizi-Ouzou, show that *A. fabae* is the most dominant species in the yellow traps with 48 specimens representing a relative abundance of 17.84%. The study carried out by Medjdoub-Bensaad *et al.* (2014) shows that *A. fabae* is the most represented species with a frequency of 23.1% in a bean field. Kheloul & Medjdoub-Bensaad (2014a) mention that this species only totals 8.2% compared to all aphids trapped in a bean field.

Benoufella-Kitous *et al*. (2019) report that the species *A. fabae* is the most present with a frequency of 23.1% in a broad bean crop. Kheloul & Medjdoub-Bensaad (2014b) highlight the presence of *A. fabae* on *Rumex sp*., *Vicia sicula* (Raf.) Guss., *Sonchus sp*. and *Melilotus officinalis* (L.) Pall. Alhmedi *et al*. (2007) note the presence of this aphid on wheat and peas. Laamari *et al*. (2010) report that this aphid is identified on about 15 plant species.

Myzus persicae has as primary hosts peaches and other Rosaceae of the genus *Prunus* and as secondary hosts Asteraceae, Brassicaceae, Apiaceae and Cucurbitaceae (Hullé *et al*. 1999). Vayssière *et al*. (2001) note it on *Rumex abyssinicus, Euphorbia hirta, Solanum nigrum* L., *Cajanus cajan* Millsp., *Tropaeolum sp.* and *Callistephus sp*. According to Laamari *et al*. (2011), *M. persicae* is identified on 16 plant species. *M. persicae* is caught by Sekkat (2015) on peach, pepper, potato, tomato and several weed species. According to this author, *M. persicae* is among the most feared aphid species and most frequently harmful to crops, requiring specific phytosanitary treatments.

It should be noted that in the present study, one species is identified for the first time in Algeria. It is *Melanaphis sacchari*, which is caught with a very low frequency (1.26%).

The sugarcane aphid, *M. sacchari* is present in many African countries such as Angola, Egypt, Ethiopia, Nigeria, and Uganda. In Mexico, this species was first identified in 2013, in sorghum fields (Maya-Hernandez & Rodriguez-Del-Bosque, 2014). In 2016, this aphid was reported for the first time as a pest on sorghum in North America (Bowling *et al*., 2016). Blackman & Eastop (2000, 2006) report that this pest can also develop on grasses. According to Holman (2009), *M. sacchari* was observed on several species of Poaceae, Rosaceae, but also on Brassicaceae. The latter family was represented in the pea field (Utrillo variety) by a species namely *Sinapis arvensis* L., which could perhaps explain the presence of this species in the trap.

Shannon's diversity varies from one culture to another. In the present study, the specific richness and diversity of the flora provide favourable conditions for the settlement of aphids. In a study carried out by Medjdoub-Bensaad *et al.* (2014), Shannon diversity index calculated from fields of Seville bean and field bean is 0.75 and 0.69 bits respectively. Benoufella-Kitous *et al*. (2019) note that in chickpea, lentil and pea crops, H' values are 3.92, 3.88 and 0.32 bits respectively.

Equitability obtained tends towards 1 for the 4 cultivated varieties. This indicates that the numbers of the species present tend to be in equilibrium with each other.

According to Blondel (1975), when living conditions in an environment are favourable, many species are found. Aphid fauna is therefore diversified in the presence of the flora (Bassino, 1983). The density and diversity of insects are strongly influenced by the environment close to the crop field (Francis *et al*., 2001). Marc (2004) reports that winged specimens contribute in the dissemination of the population at variable distances and ensure the colonization of new habitats to be exploited.

Our study carried out on aphid diversity in four fields of bean and pea food legumes of two different varieties in Naciria region, shows the existence of 48 species of aphids with one species recorded for the first time in Algeria. This rather large number demonstrates the abundance of aphids on these crops. It would be edifying to continue this work for several years and on other crops to improve results.

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