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Diversity of aphids and their natural enemies on peach orchards, *Prunus persica* (L.) Batsch, in Lakhdaria at Bouira (Algeria)

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ABSTRACT Few insects that live on peach, *Prunus persica* (L.) Batsch, were considered pests. Aphids were one of the major pests there. To change the product to organic, we should know more about the pests and their natural enemies to use better organic decisions. The monitoring was conducted from March to May 2019 in a peach orchard in Lakhdaria at Bouira. Six species of aphids were considered important pests on peach trees. aphids attacked the peach orchard, and they were feeding on the young leaves, causing stunted growth. Natural enemies of aphids were essential agents in balancing their populations and an alternative to using insecticides to control these pests. Six predator species were identified: three ladybugs (Coleoptera Coccinellidae), two hoverflies (Diptera Syrphidae), one species of Neuroptera (Chrysopidae) and three parasitoids (Braconidae).

KEY WORDS Aphids; Lakhdaria; natural enemies; parasitoids; Peach.

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INTRODUCTION

Arboricultural was a good niche for production and land conservation in mountainous areas par excellence. In Bouira (Algeria), arboriculture occupied a total area of 30,979 hectares. Stone and pome fruit trees represented 3,278 hectares and 90 hectares respectively. Their production arrives at 78,629 Qx and 3,971 Qx in Bouira and Lakhdaria, respectively in 2017/2018 (D.S.A, 2019).

Peach trees were the most variable of all the fruit trees species; they differ in their fruit, seed, flower in the tree's growth habit, leaf, bud, environmental condition, and resistance to various diseases (Faust & Timon, 1995; Mezerdi & Farhi, 2022).

Peach, *Prunus persica* (L.) Batsch, is the most crucial fruit economically. It is a deciduous tree that belonged to the family of Rosaceae. Peach varieties are classified into four groups based on skin and pit characters, peaches (fluffy skinned), nectarines (smooth-skinned), and clingstone (flat peaches) (Maqbool et al., 2018).

Within each of these groups, there are white-fleshed and yellow-fleshed fruits. Peaches and nectarines were table fruits (Cantín et al., 2009).

The knowledge of the impact of the host plant factor, temperature on the development of aphids and the relationship between the pest and its host plant under the effect of the physical factors of the environment was a way to consider effective control strategies at the right time, improve yields and protect tree productions, primarily (Mezerdi, 2011, 2015; Khaliq et al., 2014; Mezerdi et al., 2015, 2017, 2021).

This study aimed to identify the biodiversity of aphids and their natural enemies present in peach orchards.

MATERIAL AND METHODS

Experimental orchard

Experiments were carried out in Lakhdaria, whose geographical coordinates were 36°33'37''

North latitude and 3°36'11'' East longitude. Altitude: 136 m.

The sampling was conducted from March to May 2019; a peach orchard was selected, with an area of 0.06 hectares, and there were 50 trees, with an average age of approximately eight years.

This study aimed to identify the species of aphids and their natural enemies present in the peach orchard and observe the efficiency of capturing different sampling methods. We followed the visual analysis and yellow traps and yellow sticky trap in collecting samples (Gacem, 2019). Experiments were customarily performed weekly, and the orchard was not treated with any chemical control during the study period.

The flight phase in aphids plays a vital role in the dispersion of species, the search for host plants, and the transmission of viral diseases. To control these phenomena it was necessary to sample the aerial environment by capturing winged aphids, which move freely.

Collected leaves by hand

The aphids collected five leaves from the trees, which are distributed at the top middle, and bottom. The samples were taken from ten trees taken casually. Fifty leaves were sampled in a peach orchard and followed the protocol for three months; once a week, the samples were transported in plastic bags with a label where the sampling date was noted.

We collected the aphids and their natural enemies with a fine brush, forceps and then put in micro-tubes containing 70% alcohol. On these we noted the date, location of collection, and host trees.

Yellow traps

We placed ten circular yellow plastic traps on ten trees selected each week randomly. Adult aphids and their natural enemies were collected once a week. Soapy water filled to 2/3 of the traps was renewed after each harvest (Gacem et al., 2022).

In the laboratory, the trapped aphids and their natural enemies were poured into micro-tubes for conservation, identification, and counted under the binocular magnifying glass (Gacem et al., 2021).

Yellow Sticky Plastic Sheet Traps (YSPST)

The yellow sticky trap was made of plastic (10 × 20 cm), sealed with a thin transparent plastic cover, and smeared with sticky glue (Saljoqi et al., 2009; Mezerdi & Gacem, 2022).). During the weekly experiments, the only trap was hung about 1 m above the soils, and could be adjusted vertically. The aphids and their natural enemies stuck to these traps were counted at weekly intervals, they were collected for identifications.

Data analysis

Different biodiversity indices were used to describe the data: species richness, relative abundance, two indices of diversity (Shannon and Simpson) and two indices of equitability (Pélou and Simpson) (Hlaoui et al., 2020).

Ecological indices of diversity

Shannon's diversity indices:

$$H' = -\sum_{i=1}^{S} (pi\ ln\ pi)$$

Pi was the proportion of *i* species among all collected samples, and *S* was the total number of species in the community (Matintarangson, 2018).

Simpson's diversity indices:

$$D = 1 - \left(\frac{\sum_{i=1}^{s} ni(ni-1)}{N(N-1)}\right)$$

Where D: Simpson's index, *ni*: the number of individuals of particular species.

N: total number of individuals in all collected species (Russell et al., 2016).

The probability that any two randomly selected species from the sample will be different (0= low diversity, 1= high diversity).

Pélou's evenness index (J'):

$$EH = \frac{H'}{Ln(S)}$$

Where *S* was the total number of species in the community (richness) and *H'* was Shannon's diversity index (Anggraini et al., 2021).

Simpson's equitability (evenness):

$$ED = \frac{D}{Dmax} = \frac{1}{\sum_{i=1}^{S} Pi^2} * \frac{1}{S}$$

The Pélou 's and Simpson's indices were used to calculate the evenness of aphids and their natural enemies communities (Mirfakhraie & Saeidi, 2017).

RESULTS AND DISCUSSION

Aphid population

The aphid associated with peaches orchards in the Lakhdaria includes six species that colonize the trees, which were: *Hyalopterus pruni* (Geoffroy), *Brachycaudus helichrysi* (Kaltenbach), *Myzus persicae* (Sulzer), *Myzus varians* (Davidson), *Brachycaudus schwartzi* (Börner) and *Brachycaudus persicae* (Passerini). These species attack the leaves, which were in order of importance: *Hyalopterus pruni* with a relative abundance of 61.25% individuals, followed by *Myzus persicae* with 26.46%, *Brachycaudus helychrysi* with 4.85% and three other species with few relative frequency (Table 1).

The number of *Hyalopterus pruni* increased throughout the season from the beginning of April until it reached the highest abundance at the end of May 2019. The rest of the species increased successively until the end of April, when the number of these species was high and then began to decline gradually (Fig. 1).

Andreev & Vasilev (2017) conducted a similar study on the species of aphids that attacked peach orchards in Bulgaria, eight species of aphids were found. They also pointed out that the most dangerous species for orchards belong to the genus *Myzus*. They are widespread and cause strong infestations on the shoots.

Ecological indices of aphid species in the peach orchard

N: Total number of individual, H': Shannon's Index, E.H.: Shannon's equitability, D: Simpson's index, E.D.: Simpson's equitability.

Order	Family	Aphid species	ni	RA (%)
Hemiptera	Aphididae	*Hyalopterus pruni* (Geoffroy, 1762)	3875	61.25
		Myzus persicae (Sulzer, 1776)	1674	26.46
		Brachycaudus helychrysi (Kaltenbach, 1843)	307	4.85
		Myzus varians (Davidson, 1912)	255	4.03
		Brachycaudus schwartzi (Börner, 1931)	139	2.20
		Brachycaudus persicae (Passerini, 1860)	77	1.22
Total number of all species combined: N			6327	100
Total Richness: S		6		

Table 1. Relative abundance (%) of aphid species found in the peach orchard.

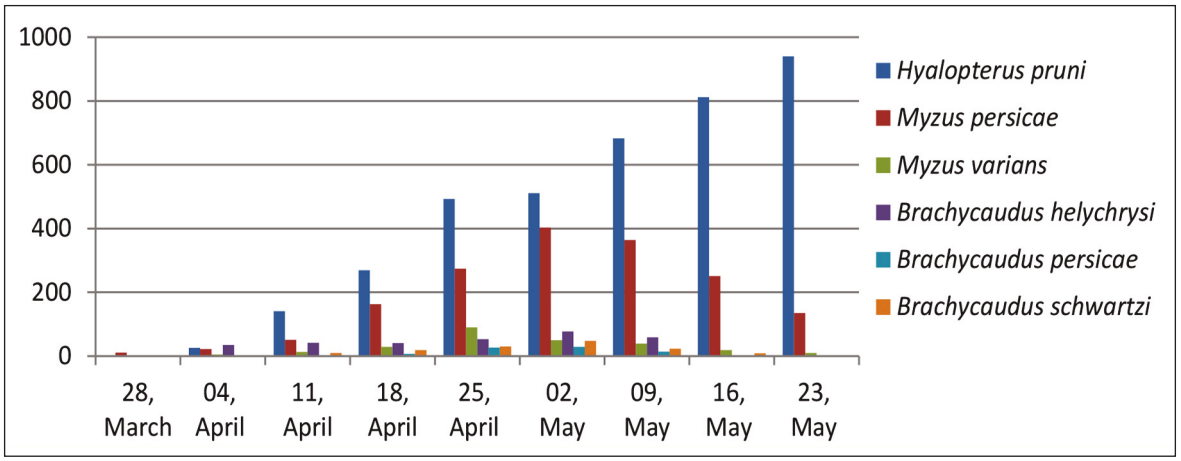

Figure 1. Evolution of the fluctuations of the different aphid species installed in the peach orchard.

Diversity indices	28, March	04, April	11, April	18, April	25, April	02, May	09, May	16, May	23, May	Total
N	11	88	257	528	967	1118	1182	1091	1085	6327
H'	0	1.24	1.22	1.24	1.29	1.28	1.07	0.67	0.43	1.07
EH	0	0.69	0.68	0.69	0.72	0.71	0.60	0.37	0.24	0.59
D	0	0.70	0.63	0.64	0.65	0.65	0.57	0.39	0.23	0.55
ED	0.17	0.54	0.45	0.46	0.47	0.48	0.39	0.27	0.22	0.37

Table 2. Diversity indices of aphid's community at different time intervals in the peach orchard of Lakhdaria in 2019.

In 2019, the highest Shannon's index of aphids was calculated on 25 April (1.29), followed by May second (1.28); however, for Simpson's index, the highest aphids diversity index was reported on 04 April (0.70).

Generally, diversity indices of aphids in April were higher than in May 2019 (Table 2).

Natural enemies of aphids

The results reported indicate that ladybugs dominate in peach orchards compared to hoverflies and green lacewing. The Coccinellidae represent the vast majority, *Coccinella algerica* comes first with frequencies of 25.19%, followed by the other species *Harmonia axyridis* and *Hippodamia variegata* in the peach orchard but at low abundances. Then comes the Syrphidae family, represented by the dominant species *Eupeodes corollae* with 11.11%. As for as, the parasitoid *Aphidius colemani* represented with 23.70% on the peach orchard (Table 3).

Description of predators of aphid species

We found eight species of natural enemies in the peach orchard; three ladybugs (Coleoptera, Coccinellidae) represented by the species: *Coccinella algerica* (Kovar), *Harmonia axyridis* (Pallas), and *Hippodamia variegata* (Goeze), also two hoverflies were mentioned *Episyrphus balteatus* (De Geer), *Eupeodes corollae* (Fabricius) (Diptera: Syrphidae) and one species *Chrysoperla carnea* (Stephens) harvested in this study (Figs. 2–6).

Moreover, three parasitoids of aphids have been identified: *Aphidius colemani* (Viereck), *Aphidius matricariae* (Haliday) and *Lysiphlebus fabarum* (Marshall).

Order	Families	species of natural enemies	ni	RA (%)
Coleoptera	Coccinellidae	*Coccinella algerica* (Kovar, 1977)	34	25.19
		Harmonia axyridis (Pallas, 1773)	3	2.22
		Hippodamia variegata (Goeze, 1777)	6	4.44
Diptera	Syrphidae	*Episyrphus balteatus* (De Geer, 1776)	5	3.70
		Eupeodes corollae (Fabricius, 1794)	15	11.11
Neuroptera	Chrysopidae	*Chrysoperla carnea* (Stephens, 1836)	11	8.15
Hymenoptera	Braconidae	*Aphidius colemani* (Viereck, 1912)	32	23.70
		Aphidius matricariae (Haliday, 1834)	12	8.89
		Lysiphlebus fabarum (Marshall, 1896)	17	12.59
Total number of all species combined: N			135	100
Total Richness: S		8		

Table 3. Relative abundance (%) of the natural enemies of aphid species in the peach orchard.

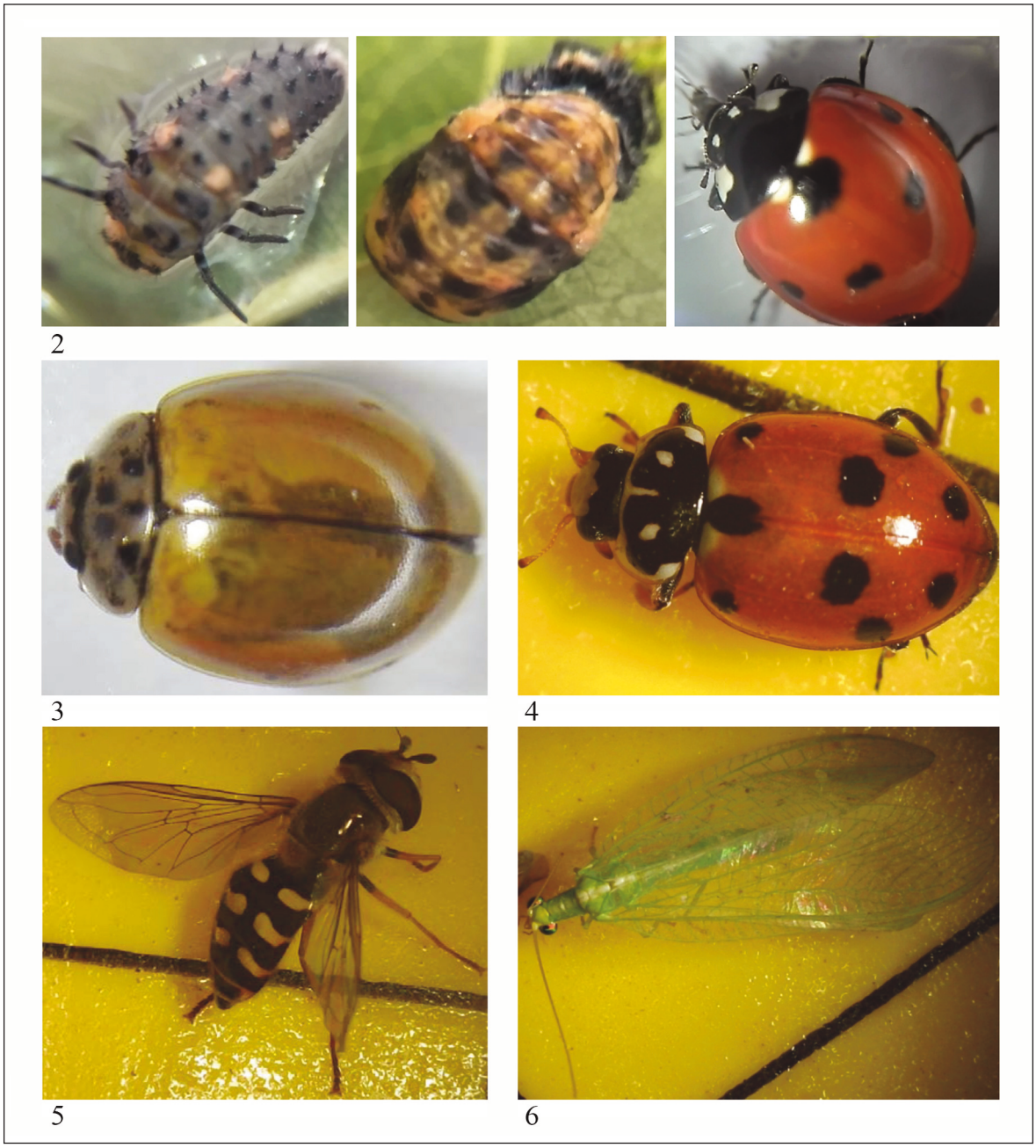

Figure 2. Larva, nymph and adult of *Coccinella algerica.* Figure 3. Adult of *Harmonia axyridis.* Figure 4. Adult of *Hippodamia variegata.* Figure 5. Adult of *Eupeodes corollae.* Figure 6. Adult of *Chrysoperla carnea.*

Fluctuation of the different natural enemies of aphids identified

The natural enemies appeared in April, we counted eight species during period. The activity of the predators decreased at the end of May.

The frequency of the different predators identified in the peach orchard as shown in our findings indicated that there was a large population of the natural enemies. The presence of high ladybird species in the peach was because pesticides did not spray the orchard. However, the results showed that ladybird populations were decreased significantly at the end of the sampling period in May 2019 (Fig. 7). The abundance of natural enemies decreased due to their migration to other shelters,

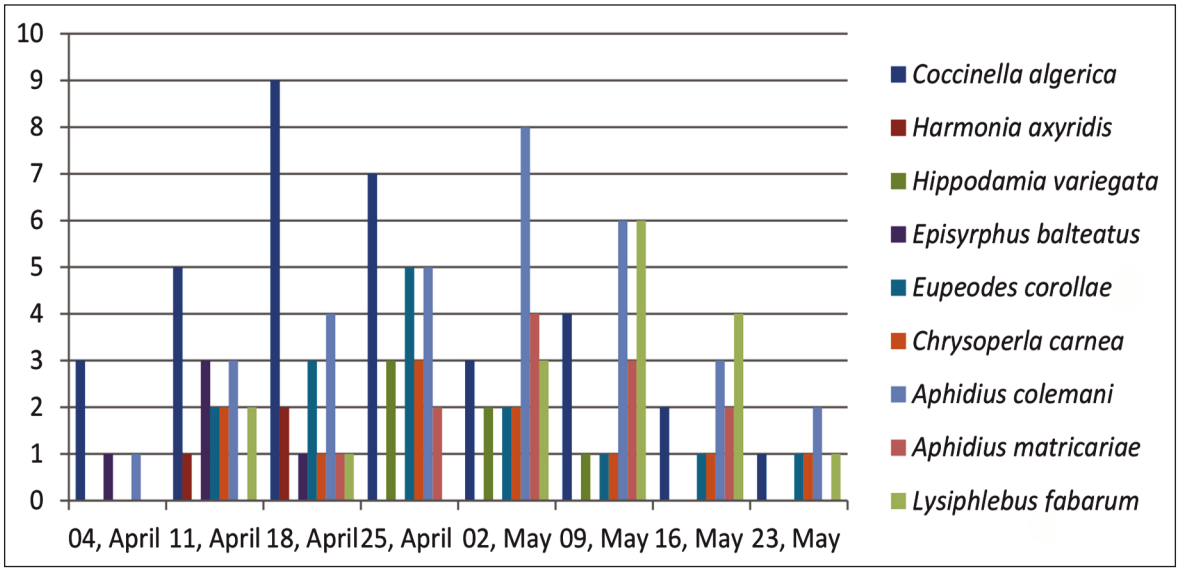

Figure 7. Relative abundance (%) of the natural enemies of aphids found in a peach orchard.

especially in summer. It is worth mentioning that the number of natural enemies increased in the spring when the surrounding landscape and shrubs were green and the semi-urban area, unlike those areas with more annual crops. Therefore, regular spots around orchards, landscape composition and heterogeneity influence the efficacy of these biological control agents.

Ecological indices of natural enemies of aphid species in the peach orchard

In our study, Shannon's index's value for the natural enemies community was 1.96.

Diversity indices of natural enemies of aphids were higher in April than in May.

The Simpson's index of aphids in 2019 was 0.84, which suggests that the possibility of selecting two different species of aphids randomly in the checked orchard in 2019 was 84%. For natural enemies, Simpson's equitability was 0.75 for 2019. The low species diversity index (Simpson) could be due to the uniform distribution of individuals among species (Table 4).

Zhao et al. (2013) stated that abundance, species richness, and diversity increased with increasing plant diversity and landscape complexity, the structure of landscapes examined that expected to decrease the richness of the aphids and natural enemies.

Diversity indices depend not only on species richness but also on the evenness, or equitability,

Diversity indices	04, April	11, April	18, April	25, April	02, May	09, May	16, May	23, May	Total
N	5	18	22	25	24	22	13	6	135
H'	0.95	1.85	1.73	1.71	1.81	1.71	1.67	1.56	1.96
EH	0.46	0.89	0.83	0.82	0.87	0.82	0.80	0.75	0.94
D	0.70	0.88	0.80	0.84	0.84	0.83	0.86	0.93	0.84
ED	0.28	0.72	0.53	0.65	0.65	0.61	0.60	0.56	0.75

Table 4. Diversity indices of the natural enemies of aphid at different time intervals in the peach orchard of Lakhdaria during 2019. N: Total number of individual, H': Shannon's Index, E.H.: Shannon's equitability, D: Simpson's index, E.D.: Simpson's equitability.

with which individuals were distributed among the different species(Okpiliya, 2012).

Shayesteh et al. (2015) mentioned important details about abundance and diversity of aphids and ladybirds population in wheat fields of Urmia, northwestern of Iran.

Yellow sticky plastic traps were found to be a good management technique in suppressing the aphid population. Our results can be supported by (Saljoqi & Van Emden, 2003), who demonstrated that they were helpful in suppressing aphid populations in the potato berseem mixed cropping plots. (Webb et al., 1994) also found yellow traps to be very effective against aphids.

CONCLUSIONS

The main objective of our study was to highlight the population dynamics of aphids and their natural enemies in the experimental orchard of Lakhdaria.

The results of this work have made it possible to establish the first inventory of aphids and their natural enemies infested with fruit trees in this region.

In the experimental orchard, the aphid activity was very intense in April, but two flight periods were observed.

The study of the biodiversity of aphid populations in peach orchard allowed us to undertake a new approach relative to its relationship with natural enemies. However, the study of the population dynamics of the pest was a crucial element in understanding the biological phenomena that govern the evolution of the problem and better define the control techniques to adopt.

The absence or ineffectiveness of awareness for this type of pest in this region and the lack of information among farmers may leave the field open for rapid and formidable development of these insects. In light of the results obtained, it is desirable in the future to continue the study.

Particularly, insects predators and parasitoids may be an alternative to chemical control, as often practiced in the region of Lakhdaria, especially in fruit farming. In this directive, it can help the selection of varieties of fruit trees resistant to aphid attacks. All these results were obtained through scientific research and applications in the orchard.

In the future, it would be necessary to confirm experimentally the effect of natural enemies on the growth of aphids to limit phytosanitary problems.

On the other hand, a study on the infestation of orchards and other fruit trees by the various pests was also necessary to have more information on the sensitivity and resistance of these crops in the region of Lakhdaria.

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