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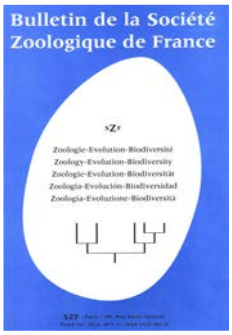

Entomofaunal diversity of insects in loquat (*Eriobotrya japonica* Lindl.) orchard in Lakhdaria at Bouira (Algeria)

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Abstract	The objective of our research is to study the entomofauna of loquat; we are also interested in finding pests and their natural enemies. We conducted sampling with yellow soapy water traps, and placed yellow sticky traps in the loquat orchard (*Eriobotrya japonica* Lindl.), for three months, from March to May 2019 in the region of Lakhdaria (Bouira). Temporal and spatial monitoring, with both sampling methods, showed the presence of six orders, Hemiptera is the most abundant. We identified 20 families, Aphididae is the most represented. The sampling allowed us to count 34 species distributed in 702 individuals. This entomofauna includes pests that attack the loquat tree, auxiliary insects represented mainly by hoverflies, ladybugs, lacewings, pollinating insects, and useful insects.
Keywords:	Loquat, orchard, yellow traps, Lakhdaria, entomofauna, insect.

Diversité entomofaunique des insectes dans le verger de néflier du Japon (*Eriobotrya japonica* Lindl.) à Lakhdaria à Bouira (Algérie)

Résumé	L'objectif de notre recherche est d'étudier l'entomofaune du néflier du Japon. Nous nous intéressons également à la recherche des ravageurs et de leurs ennemis naturels. Nous avons effectué des échantillonnages par des pièges jaunes à l'eau savonneuse, et placé des pièges jaunes collants dans le verger de bibacier (*Eriobotrya japonica* Lindl.) pendant trois mois, de mars à mai 2019, dans la région de Lakhdaria (Bouira). Le suivi temporel et spatial, avec les deux méthodes d'échantillonnage, a montré la présence de six ordres, l'Hémiptères est la plus abondante. Nous avons identifié 20 familles, l'Aphididae est la plus représentée. L'échantillonnage nous a permis de dénombrer 34 espèces réparties en 702 individus. Cette entomofaune comprend des ravageurs qui s'attaquent au bibacier, des insectes auxiliaires représentés principalement par des syrphes, des coccinelles, des chrysopes, des insectes polinisateurs et des insectes utiles.
Mots-clés	Bibacier, verger, pièges jaunes, Lakhdaria, entomofaune, insecte.

Introduction

Arboricultural is a good niche for production and land conservation in mountainous areas par excellence. In Bouira, arboriculture occupies a total area of 30 979 hectares. Stone and pome fruit trees represent 3 278 hectares and 90 hectares respectively in 2017/2018 (GACEM, 2019).

Loquat (*Eriobotrya japonica*) is a fruit tree species native to Asia. The tree is grown worldwide as an ornamental tree with edible fruits, widely planted in Africa, Europe, the Mediterranean and the Americas. Besides its fruits, the loquat is a prized landscape tree in many countries because of its lush evergreen foliage and remarkable environmental adaptability. In its native Asia, loquat is a vital nectar source for apiculture and is widely used by other insects (ZHENG *et al.*, 2019).

In orchards, various types of insects are present. Some are beneficial, and some may be harmful.

Generally, farmers are not aware of it. Predators (friends of the farmers) which feed on pests are not easy to observe in arboriculture orchards. Insect concepts can be helpful to enhance farmers' skills to identify beneficial and harmful

insects. In this method, insects are collected in plastic tubes with a brush and brought to the laboratory.
Each insect is placed inside a plastic tube to observe and determine whether it is a pest (feeds on the plant) or a predator (feeds on other insects) (PRISCHMANN-VOLDSETH *et al.,* 2021).

Identifying the number of pests and beneficial insects helps the farmers to make appropriate traps (MAHAMAN *et al.*, 2003).

Visual counts are performed to estimate the numbers of pests and defenders. This can vary depending on the feeding potential of the natural enemy and the type of pest.

Material and methods

Experimental orchard

The loquat trees are located in Lakhdaria (36°33'37" N, 3°36'15" E); it rises to an altitude of 270 m. It is more than ten years old and comprises 70 trees, 5 m apart.

Our study aimed to identify the insects of loquat orchards present in the Lakhdaria and captured them with two yellow traps sampling methods. The study of the entomofauna was carried out between March and May 2019.

We performed Experiments weekly, and the loquat orchard was not treated with any chemical control during the study period.

Yellow traps

Water traps (aerial)

We used ten yellow plastic traps, and we filled it up with 3/4 of water mixed with a pinch of detergent.

The detergent acts on the lipid layer covering the insects, which prevents them from escaping. These traps are attractive because reflected light attracts insects that fly nearby, and drown in them. They are also convenient, require slight handling, and are inexpensive. On the other hand, they are ineffective in bad weather when insects are not flying (GACEM *et al.,* 2022).

This method makes it possible to specify the fluctuation of different species according to time and during a year or a season.

Yellow sticky trap

We placed one yellow trap sticky with a 25 x 10 cm on both sides, it captured flying insects. The grid visible on the trap allows us to identify, count, monitor, and control the insects present in the loquat orchard. We renewed it every week, and one trap must be enough for a hectare.

Data analysis

Specific richness (S)

According to REMINI & MOULAÏ (2015), we distinguish the total richness S, the total number of species represented in a given ecosystem. Species richness corresponds to the total number of species that determine the overall structure in an ecological community.

It is ultimately one of the fundamental parameters characteristic of the study and is the most frequently used measure of biodiversity.

Centesimal frequency (FC %) or relative abundance (AR %)

The centesimal frequency (A.R. %) is the percentage of individuals of a species (ni) compared to the total of individuals (N) (GUERMAH *et al.,* 2019).

Its formula is as follows: AR% = ni x100 /N

AR %: is the relative abundance.

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

N: is the total number of individuals (BENOUFELLA-KITOUS & MEDJDOUB-BENSAAD, 2016).

Ecological indices of biodiversity

Shannon's Diversity Index

The quantitative study of the diversity can be carried out according to various approaches, which are based on the use of the index of diversity whose formulation is more or less complex.

According to ZHAO *et al.* (2010), the Shannon-Weaver diversity index evaluates a stand in a biotope. It is calculated by the following formula: $H' = -\sum_{i=1}^{S} (pi \ln pi)$
H': Shannon-Weaver diversity index expressed in bits ;
pi = ni/N: Ratio of species i to the total number of individuals sampled of all species ;
ni: Number of individuals of species I ;
N: Total number of individuals.

If a community will be more diversified, the index H' will be more significant.

Maximum diversity

According to TRIPATHI & SHANKAR, (2014), the maximum diversity corresponds to the highest possible value of the stand, calculated based on an equal density for all species present. The maximum diversity H' max is represented by the following formula: H' max= ln S S: total richness.

Equitability index or equipartition

Although it is an essential element in describing the structure of a stand, species richness is not sufficient to characterize it satisfactorily. Equitability is very important in the characterization of diversity. It allows comparison between two species with different species richness.

The index of equipartition is the ratio between the compelling diversity of the community and its maximum theoretical diversity. It is given by the following formula: E = H'/H' max.

Results and discussion

This sampling deals with the insects of the study Loquat fruits (*Eriobotrya japonica* L.) grove, which we revealed with the yellow traps technique. First, we used the inventory results. Then, we exploited the results and calculated the

ecological indices of composition and diversity (Figure 1), (Table 1).

Total richness S

We determined that the total richness S is equal to 34 species.

Relative abundance or centesimal frequency

We performed an inventory of insects in the study area, and we showed it in Table 1 with species numbers (ni), and relative abundances (A.R. %) depending on the species.

At first, we collected a total of 702 individuals in yellow traps at Loquat (*Eriobotrya japonica*) orchard of Lakhdaria during the study period. These individuals are distributed in 6 orders. We noted that the order of the Hemiptera is the most dominant with a frequency of 58.55% (411 individuals), followed by the Diptera with a frequency of 17.81% (125 individuals). Then, the Coleoptera comes with 15.10% (106 individuals).

1. *Lytta vesicatoria*

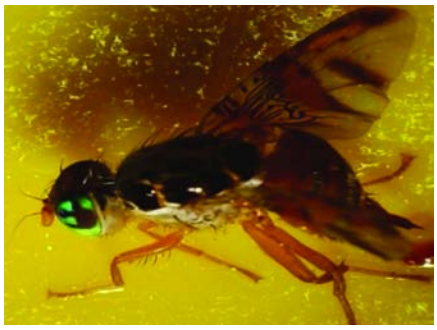
2. *Oxythyrea funesta*

3. *Coccinella algerica*

4. Adonia variegata

5. *Thanasimus formicarius*

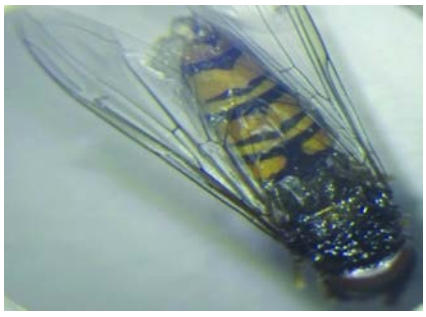
6. *Lucilia cuprina*



7. *Ceratitis capitata*

8. *Megaselia ruficornis*

9. *Eupeodes corollae*



10. *Episyrphus balteatus*

11. *Thaumatomyia notata*

12. *Chrysoperla carnea*

Figure 1

Some species determined in the laboratory.
Quelques espèces déterminées au laboratoire.

Table I

Relative abundances (A.R. %) of the species captured in the Loquat (*Eriobotrya japonica* L.) fruits grove of Lakhdaria.
*Abondances relatives (A.R. %) des espèces capturées dans le verger de Loquat (*Eriobotrya japonica *L.) de Lakhdaria.*

Order	ni	AR%	Family	ni	AR%	Species	ni	AR%
Coleoptera	106	15.10	Meloïdae	13	1.85	*Lytta vesicatoria* (Linnaeus, 1758)	13	1.85
			Cantharidae	9	1.28	*Malthinus scriptus* (Kiesenwetter, 1852)	4	0.57
						Cantharis rufa (Linnaeus, 1758)	5	0.71
			Staphilinidae	2	0.28	*Oxytelus* sp. (Gravenhorst, 1802)	2	0.28
			Cetoniidae	8	1.14	*Oxythyrea funesta* (Poda, 1761)	8	1.14
			Coccinellidae	70	9.97	*coccinella algerica* (Kovar 1977)	40	5.70
						Harmonia axyridis (Pallas, 1773)	13	1.85
						Adonia variegata (Goeze, 1777)	17	2.42
			Chrysomelidae	3	0.43	*Labidostomis humeralis* (Schneider, 1792)	3	0.43
			Cleridae	1	0.14	*Thanasimus formicarius* (Linnaeus, 1758)	1	0.14
Diptera	125	17.81	Calliphoridae	2	0.28	*Lucilia cuprina* (Wiedemann, 1830)	2	0.28
			Tephritidae	42	4.27	*Ceratitis capitata* (Wiedemann, 1824)	42	5.98
			Empididae	28	3.99	Tachydromia *pallidiventris* (Meigen, 1822)	15	2.14
						Hilara sp. ind	1	0.14
						Musca domestica (Linnaeus, 1758)	7	1.00
						Megaselia ruficornis (Meigen, 1830)	5	0.71
			Sciaridae	18	2.56	*Sciara hispida* (Winnertz, 1871)	10	1.42
						Sciara pusilla (Meigen, 1818)	8	1.14
			Syrphidae	30	4.27	*Eupeodes corollae* (Fabricius, 1794)	19	2.71
						Episyrphus balteatus (De Geer, 1776)	11	1.57
			Chloropidae	5	0.71	*Thaumatomyia notata* (Meigen, 1830)	5	0.71
Hymenoptera	25	3.56	Formicidae	10	1.42	*Lasius niger* (Linnaeus, 1758)	7	1.00
						Pheidole pallidula (Nylander, 1849)	3	0.43
			Bethylidae	3	0.43	*Cephalonomia* sp. ind	2	0.28
						Bethylus cephalotes (Förster, 1860)	1	0.14
			Vespidae	6	0.85	Polistes *gallicus* (Linnaeus, 1767)	4	0.57
						Vespula germanica (Fabricius, 1793)	2	0.28
			Apidae	6	0.85	*Apis mellifera* (Linnaeus, 1758)	6	0.85
Hemiptera	411	58.55	Aphididae	411	58.55	*Myzus persicae* (Sulzer, 1776)	61	8.69
						Aphis spiraecola (Patch, 1914)	350	49.86
Orthoptera	1	0.14	Acrididae	1	0.14	*Acrotylus patruelis* (Herrich-Schäffer, 1838)	1	0.14
Nevroptera	34	4.84	Chrysopidae	34	4.84	*Chrysoperla carnea* (Stephens, 1836)	33	4.70
						Chrysoperla affinis (Stephens, 1836)	1	0.14
Total	**702**	**100**	**20**	**702**	**100**	**34**	**702**	**100**

Sp.ind: undetermined species. **ni**: number of species i, **A.R.** %: relative abundance.

The other orders have low frequencies; the Orthoptera is the least important (0.14%).

The table shows that we captured 20 families of insects; Aphididae is the most abundant, with 411 individuals with a frequency of 58.55%. In the second position comes the family Coccinellidae, with a frequency of 9.97%. Then the family of Tephritidae comes with an abundance of 5.98%. The families Chrysopidae, Syrphidae represent 4.84% and 4.27% respectively of the sampled insects.

Some families of Coccinellidae, Chrysopidae and Syrphidae identified in the study, despite their limited average abundance, play an essential role in the regulation of pest species, and also reduce the frequency of Aphididae because they are predators of them.

Finally, we observed the rest of the families with a low abundance.

In north-western Algeria, GUERROUCHE *et al.* (2021) obtained similar results on a pear orchard (*Pyrus communis* l.). The 797 individuals sampled have highlighted 91 species, 46 families, and nine orders.

We also compared our data with the results of DEGHICHE-DIAB *et al.* (2015); Their study was conducted

at five stations in the oasis of Ziban, located in Biskra; The most represented insect orders were Coleoptera (44.42%), Hymenoptera (20.86%), and Lepidoptera (7.87%). ZAKARIA *et al.* (2021) studied the diversity and species richness of insects at the palm grove of El Ghrous. They collected 44 insect species. Their inventory shows a predominance of Coleoptera with 6 families, 13 species and 241 individuals, followed by Hemiptera with 5 families, 7 species and 111 individuals, and Orthoptera with 2 families, 7 species and 54 individuals.

In Ouled Si Slimane, Batna, CHAFAA *et al.* (2019) conducted a similar study in apricot orchards, *Prunus armeniaca* L. (Rosales Rosaceae); they identified a total of 125 species divided into nine orders and 54 families.

DJEBARA *et al.* (2018) used the same sampling method in greenhouse-grown tomatoes in North Algeria. The authors note 1449 individuals belonging to 46 different taxons, distributed among eight orders and 26 families. Our data are also comparable with the results of (JOSHI *et al.,* 2016) (AIDOO *et al.,* 2016) (MOHAMMEDI *et al.,* 2019).

Shannon-Weaver diversity index, maximum diversity, and equitability index

The results obtained concerning the indices of Shannon-Weaver diversity (H'), of maximum diversity and of equitability applied to the species of the insects sampled are consigned in Table 2.

The Shannon diversity index ranges from a value of 0 to 1. Note that lower values indicate more diversity while higher values indicate less diversity. Specifically, an index value of 1 means that all groups have the same frequency (BUREL *et al.,* 1998; WILSEY & STIRLING, 2007).

According to Table 2, the value of the Shannon-Weaver index is 0.58 bits. This value is low, so we can say that this environment is slightly diverse in species caught in the study station during the three months. The maximum diversity index is 3.53 bits. As for the equitability is 0.17. The numbers of species are in disequilibrium with each other.

MOHAMMEDI *et al.* (2019) conducted a similar study in order to determine Insect North-West of Algeria. Samples were taken regularly in the field. They identified nine (09) taxonomic orders of insects; Coleoptera and Orthoptera were the most represented in terms of both species and numbers. Entomofaunal diversity was more important in un-cultivated fields (diversity index = 4.15 bits, equitability = 0.89) than in arable fields (index ranging from 1.68 to 2.87 and an equitability between 0.41 and 0.72).

Table 2

Values of the Shannon-Weaver index (H'), maximum diversity (H' max), and equitability index of species captured with yellow traps in the study area during the three months (March, April, and May).

Valeurs de l'indice de Shannon-Weaver (H'), de la diversité maximale (H' max) et de l'indice d'équitabilité des espèces capturées avec des pièges jaunes dans la zone d'étude au cours des trois mois (mars, avril et mai)

Ecological index	Values
H'	0.58
H' max	3.53
E	0.17

H': Shannon-Weaver diversity index expressed in bits. **H' max**: maximum diversity index expressed in bits, **E**: the equitability index.

Many studies previously conducted on fruit trees in general and few researches on bibacier have shown the original bioenvironmental. His world is home to a variety of animals and plants that have an environmental and ecological role in population control Harmful, this world still hides secrets that must be discovered to restore balance ecosystems in general and agricultural systems in particular Further studies should be conducted to help Expanding the list of beneficial insects for crops, which is a promising method crop protection and environmental preservation.

Conclusion

The entomofauna inventory reveals a procession of insects with harmful and valuable species. The knowledge of the predators including the ladybugs, hoverflies, and green lacewing in the loquat grove is of great importance in not to resort hastily to the use of pesticides. It would be interesting in the future to combine several sampling methods to broaden our knowledge of the entomofauna of the fruit arboriculture, and perhaps identify new species of interest for biological control.

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