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Arthropods Diversity Associated with the Fig Tree (*Ficus carica*, Linnaeus, 1753) in Tigzirt (Tizi-Ouzou, Algeria)

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ABSTRACT

Background: This study concerns a qualitative and quantitative inventory of fig tree (*Ficus carica* L.) invertebrates in the Tigzirt region (Tizi-Ouzou, Algeria), the aim of which is to identify the species associated with the fig tree, their abundance and their ecological role.

Methods: Three sampling methods were used; Barber pots, yellow traps and the Japanese umbrella. The work is carried out over one year (October 2022 to September 2023).

Result: 505 individuals were captured, divided into 78 species belonging to 4 zoological classes. A total richness of 58 species obtained with the Barber pots, 39 with the yellow traps and 15 with the Japanese umbrella. The shannon indices obtained are 4.559 bits for Barber pots, 4.437 bits for the yellow traps and 3.584 bits for the Japanese umbrella. The equitability is 0.774 for Barber pots, 0.835 for aerial traps and 0.913 for the Japanese umbrella. 7 trophic behaviors were observed in invertebrates captured with the use of Barber pots where predators are best represented with 29%, with aerial traps and the Japanese umbrella, 6 trophic behaviors are noted for each where pollinators are best represented with 51% and 40% respectively.

Key words: Arthropods, Diversity, Fig tree, Tigzirt, Tizi-ouzou, Trophic regime.

INTRODUCTION

The fig tree *Ficus carica* L. (Moraceae) is one of the oldest cultivated fruit species in the world with approximately 1400 species grouped into 40 genera (Watson and Dallwitz, 1992). The fig tree is a diploid species which includes the male fig tree or caprifig (caprificus) presenting two to three generations and the female fig tree (domestica) which has one or two generations (uniferous or biferous fig tree) (Fateh and Ali, 2009). Algeria is among the largest producers of figs in the world, with a production reaching 112.3 thousand tons in 2022, ranking third in the world behind Egypt and Turkey. 60% of this production comes from the wilayas; Bejaia, Tizi Ouzou and Sétif (Bourayou *et al*., 2005). The invertebrates that interact with the fig tree play a varied ecological role. Some species are beneficial, participating in its pollination and balance, while others are harmful, causing damage. In order to define the impact of invertebrates and their interactions with the fig tree, we carried out an inventory of the invertebrate species present in a fig orchard. The results obtained will allow us to establish ecological management to maintain the balance of these interactions by preserving useful species such as pollinators and adopting integrated pest management techniques to combat harmful species and thus ensure the sustainability of fig cultivation.

MATERIALS AND METHODS

The study was conducted over a one year period (2022-2023) in a fig orchard located in the Tigzirt region, approximately 35 km from Tizi-ouzou Province, in North-central Algeria (Kabylia) and 2 km from the Mediterranean Sea (Fig 1).

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The geographic coordinates are 36°53′35″ North latitude and 4°07′21″ East longitude.

Sampling methods

Three sampling techniques were used to conduct the inventory. The Barber pot method is widely used as a trapping technique for collecting invertebrates (Benkhelil, 1992). It provides information on arthropods circulating on the ground. Nine Barber pots were used for the study. These pots are filled to about one-third of their capacity with water containing a wetting liquid to prevent evaporation and fix the trapped species. Harvesting is done weekly by renewing the water in the traps. The yellow traps are used to sample flying invertebrates living in the foliage. They are

attracted partly by their color and partly by the presence of water, which is the vital element. The yellow traps are placed on a tree branch at eye height, containing water and a few drops of wetting liquid. The Japanese umbrella is used to capture invertebrate species that have a preference for the leaves of certain trees. Invertebrates hiding in the foliage are surprised by the beating and collected on the canvas (Benkhelil, 1992).

Laboratory methods

Once the samples were collected, a thorough analysis was carried out at the Laboratory of Production, Conservation of Threatened Species and Crops and Impact of Climate Variations, Department of Biology, Faculty of Biological and Agricultural Sciences, Mouloud Mammeri University of Tizi-Ouzou. This analysis involved sorting the specimens into different zoological classes, then by order and finally by family, in order to obtain a more precise identification, down to the species level whenever possible.

The identification of invertebrates was performed by Dr. Guermah D. Research Professor at Mouloud Mammeri University of Tizi-Ouzou, using the identification keys of Perrier (1961) and Chinery (1988). After identification, their trophic regimes were determined through a bibliographic search.

Processing the results using ecological indices

The ecological indices used in this study are composition and structure indices.

Total richness (S) and relative abundance (RA) are the ecological indices of composition used in this work.

The total richness of a given ecosystem, represented by S, is the total number of species present in the population considered (Ramade, 2003).

Relative abundance RA% refers to the percentage of individuals of a given species (ni) out of the total number of individuals (N). The relative abundance index, on the other hand, measures the number of individuals belonging to each species (Blondel, 1979).

$$RA = \frac{ni}{N}$$

RA: was calculated for each species (percentage of the species (Ni) in the total number of all species combined (N) (Magurran, 2004).

Ecological structural indices

The shannon index (Dajoz, 1971) was calculated to assess species diversity on each sampling method. The Evenness Index (E) was also calculated (ratio between the Shannon index and the maximum diversity (H'max) (Ramade, 2003).

$$H' = -\sum pi \log_2 pi$$

RESULTS AND DISCUSSION

The results of the inventory carried out in the fig grove (*F. carica*) using three sampling methods are presented in (Table 1). The arthropods inventory associated to the fig tree made it possible to capture 78 species divided into 51 families, 18 orders and 4 classes of invertebrates which are Diplopoda, Arachnida, Collembola and Insecta.

The results obtained are evaluated by ecological indices of composition and structure.

Processing the results using ecological indices

Examination of the results using ecological composition indices.

The results obtained are analyzed using ecological composition indices, namely total richness and relative abundance.

Total richness of species captured

The total species richness captured using the three sampling methods is expressed in Table 2.

Relative abundance (RA %) applied to the orders of species captured according to the capture techniques used

The results obtained from the relative abundances of the orders of arthropod species captured by the use of Barber pots in the fig tree are illustrated in Fig 2.

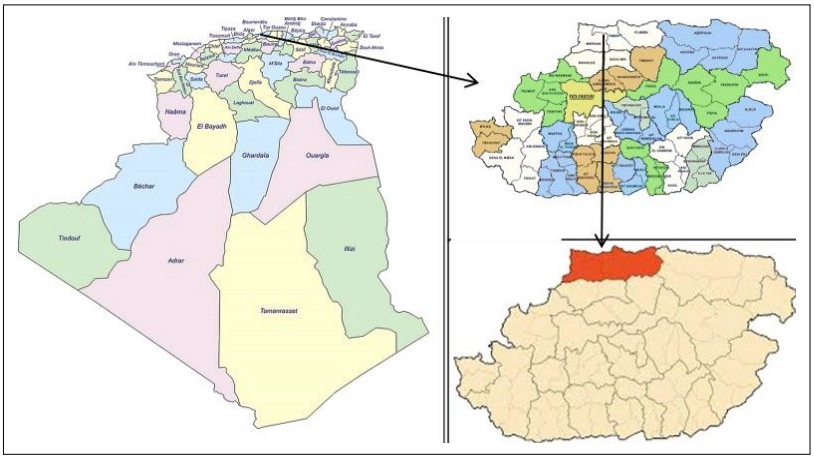


Fig 1: Tigzirt region localization (Tizi-Ouzou).

Table 1: Results of the inventory carried out in the fig grove (*F. carica*) using three sampling methods.

Classes	Orders	Families	Especies	BP	YT	JU
Diplopoda	Glomerida	Glomeridae	*Glomeris* sp.	3		
	Julida	Julidae	*Tachypodoiulusalbipes*	1		
Arachnida	Scorpiones	Buthidae	*Androctonusamoreuxi*	4		
	Opiliones	Phalangiidae	*Phalangiumopilio*	8		3
	Araneae	Clubionidae	*Clubiona* sp.	5		
		Liocranidae	*paratus* sp.	1		
		Lycosidae	*Lycosidae* sp.	3		
			Lycosanarbonensis	2	1	
		Nemesiidae	*Nemesia* sp.	4		
		Thomisidae	*Thomisus* sp.	1		
		Salticidae	*Salticus* sp.		1	7
	Trombidiformae	microtrombidiidae	*Eutrombidium* sp.	1		6
Collembola	Entomobryomorpha	Entomobryidae	*Entomobryidae* sp.	1		
			Entomobrya nivalis	2		
Insecta	Blattodea	Blattidae	*Blatta oxydantalis*	1		
	Orthoptera	Acrididae	*Anacridium aegyptium*	4		
			Acrida sp.	1		
		Tetrigidae	*Tettrixundulata*		2	
		Tettigoniidae	*Ephippigeraephippigera*	1		
	Mantodea	Mantidae	*Mantis religiosa*	1		
	Hemiptera	Aphididae	*Aphis fabae*		2	3
			Aphis citricola		1	
		Cicadellidae	*Cicadella* sp.	1		1
		Pentatomidae	*Rhaphigaster nebulosa*		1	3
	Neoptera	Staphylinidae	*Philonthus marginatus*	1		
	Coleoptera	Brentidae	*Apion* sp.	1	1	
		Buprestidae	*Buprestidae* sp.		1	
			Capnodis tenebrionis		2	
		Cantharidae	*Malthinus flaveolus*	8		3
		Carabidae	*Carabus* sp.	1		
			Carabidae sp.		1	
			Harpalus sp.	1		
			Harpalus paratus	3		
			Harpalus affinis	1	1	
		Coccinellidae	*Coccinela algerica*	2	13	4
		Curculionidae	*Curculionidae* sp.	1		
			Phyllobius sp.	6		
			Otiorhynchus sp.	1		3
			Lixus penctiveutris	1		
			Lixus sp.		2	
		Lampyridae	*Lampyris noctiluca*	1		
		Meloidae	*Lyttavesicatoria*		1	5
		Scarabaeidae	*Netocia morio*	2		
			Scarabaeidae sp.	2		
			Scarabaeus sp.	2		
			Tropinotasqualida	2	17	
			Oxythyriafunesta	4	6	
		Silphidae	*Silphaolivieri*	1		
		Staphylinidae	*Ocypus olens*	7		

Table 1: Continue....

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	Neuroptera	Chrisopidae	*Chrysoperla carnea*	1	1	
	Heteroptera	Pyrrhocoridae	*Pyrrhocoris* sp.	1		
			Pyrrhocoris apterus	4	2	
	Lepidoptera	Notodontidae	*Thaumetopoea pityocampa*	1		
	Diptera	Calliophoridae	*Luciliaceasar*		3	
		Chironomidae	*Chironomusplumosus*		9	2
		Culicidae	*Culex sp*		1	
			Culex pipiens	6	3	1
		Drosophilidae	*Drosophilasp*	1		5
			Drosophilafunebris	2	8	
		Empididae	*Empisgrisea*		1	
		Lauxaniidae	*Lauxaniidaesp*		2	
		Sciaridae	*Zygoneurasp*	3	13	
		stratiomyidae	*Chloromyiaformosa*	1	1	
	Hymenoptera	Apidae	*Apis mellifera*	8	20	
			Longicornissp		1	
		Formicidae	*Componotusvagus*	25	19	15
			Componotuslateralis	9	1	
			Componotussp		1	
			Messorbarbarus	42	2	5
			Messorstructor	15	2	
			Cataglyphisviaticus	54	5	
		Halictidae	*Lasioglossumcalceatum*	1	14	
		Ichneumonidae	*Dimophoralongicornis*		3	
		Megachilidae	*Megachilesp*	1		
		Scoliidae	*Dasyscaliaciliata*		1	
		Pompilidae	*Pompilidae* sp.	1		
		Vespidae	*Polistes* sp.		3	
			Vespula vulgaris	1		
4	18	51	78	270	169	66

(BP: Barber Pots; YT: Yellow Traps; JU: Japeness Umbrella).

Table 2: Total richness of arthropods species captured.

Capture methods	Barber pots	Yellow traps	Japanese umbrella
Total richness	58	39	15
Total of species		78	

The results show that the order best represented by the Barber pots is Hymenoptera with 58%, followed by Coleoptera with 17%, then Araneae with 6%, Diptera 5%, Opiliones 3%, Orthoptera and Heteroptera with 2% each, the remaining orders are the least represented with relative abundances below 2%.

The results obtained for the relative abundances of the orders of invertebrate species captured using the colored yellow traps in the fig tree are illustrated in Fig 3.

The order best represented by the use of aerial yellow traps is that of Hymenoptera with 43% followed by Coleoptera 27% and Diptera 24%, then Hemiptera 2% and the least represented are Araneae, Orthoptera, Neuroptera and Heteroptera which have relative abundances lower than 2%.

The results obtained from the relative abundances of the orders of invertebrate species captured by the use of the Japanese umbrella in the fig tree are illustrated in Fig 4.

The order best represented by the use of the Japanese umbrella is Hymenoptera with 30%, followed by Coleoptera 23% and Diptera 12%, then Araneae and Hemiptera with 11% each. The least represented orders are Trombidiformae 9% and Opiliones 4%.

Exploitation of results using ecological structure indices

The results obtained are exploited using ecological structure indices, including shannon diversity and equitability indices.

The results relating to the Shannon diversity indices (H'), maximum diversity (H max) and evenness (E) applied to the invertebrate species captured by the different sampling techniques are presented in Fig 5.

The Shannon index values are quite high, they are represented by H'= 4.56 bits for terrestrial traps with a maximum diversity H max= 5.884 bits, for yellow traps the diversity is H′= 4.437 bits with a maximum diversity Hmax= 5.31 bits and for the Japanese umbrella the diversity is H′= 3.58 bits with a maximum diversity Hmax= 3.92 bits.

Exploitation of inventory results using equitability indices

The equitability obtained for each trap type tends towards 1, with 0.774 for ground traps, 0.835 for aerial traps and 0.913 for the Japanese umbrella, which suggests that the species present in the fig orchard tend to be in balance with each other.

Trophic behaviors of invertebrate species captured in the fig grove

The relative abundances related to the trophic behaviors of invertebrates captured using Barber pots are presented in Fig 6.

Seven trophic behaviors were observed, with predators 39% and pollinators 22% being the most represented. This was followed by phytophages 18%, scavengers 17%, omnivores 11%, then detritivores 2% and coprophages 1%.

The relative abundances related to trophic behaviors of invertebrates captured using yellow traps are presented in Fig 7.

The results show the presence of six trophic levels, where pollinators are most represented 51%, followed by predators 17%, followed by phytophagous 11%, omnivores 10% and scavengers 9% and lastly, xylophages 2%.

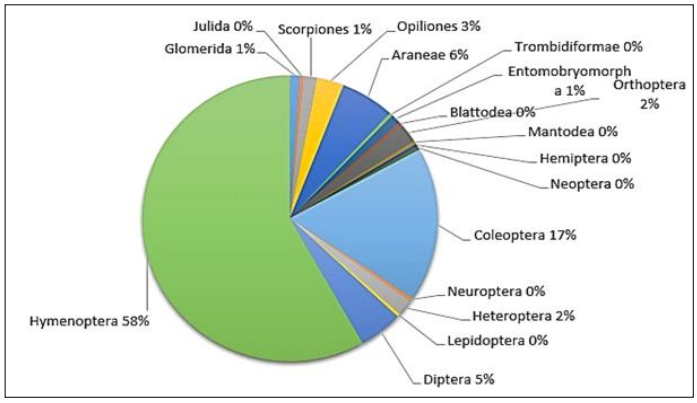


Fig 2: Relative abundances of invertebrate orders captured using terrestrial traps.

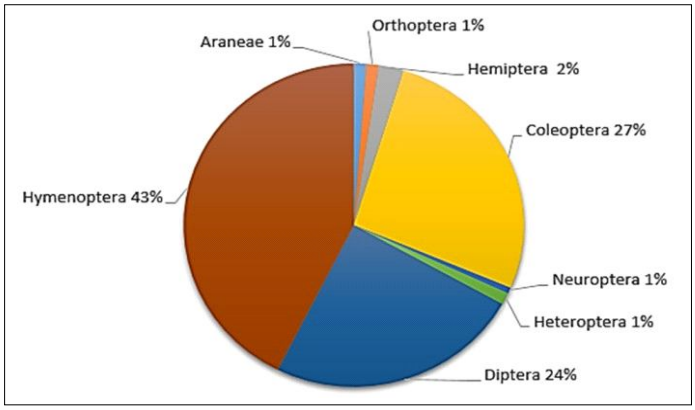


Fig 3: Relative abundances of invertebrate orders captured using color traps.

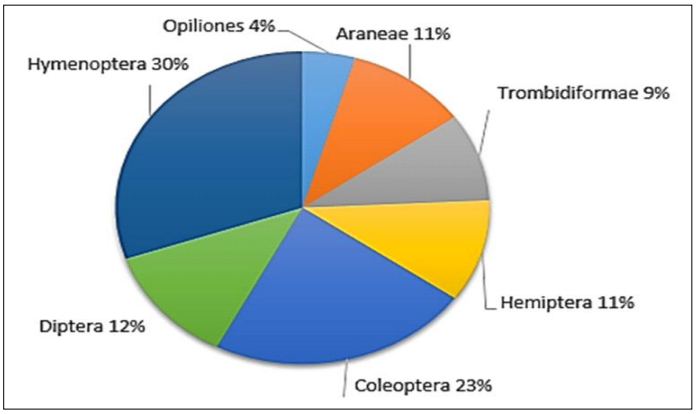


Fig 4: Relative abundances of invertebrate orders captured using Japanese umbrella.

The relative abundances related to the trophic behaviors of invertebrates captured using the Japanese umbrella are presented in Fig 8.

The inventory of arthropods carried out in the fig orchard (*Ficus carica* L.) located in the region of Tigzirt (Tizi-Ouzou), made it possible to identify a total of 505 individuals belonging to 78 arthropods species, thanks to the use of 3 capture techniques. 4 zoological classes are to be noted, that of insects dominates with 64 species and 11 orders among them, the order of Hymenoptera is more abundant, with 15 species. It is followed by Coleoptera which count with 24 species, then by Diptera, represented by 10 species. Beddiaf *et al*. (2014) in a study carried out on the arthropodological fauna in the Djanet region, report that the order Hymenoptera is the best represented with a relative abundance equal to 78.6%. Frah *et al*. (2015) during their study on the arthropodological fauna in Sefiane (Batna) with a total richness of 71 species using Barber pots, colored traps and sweep nets. Our results corroborate those of Souttou *et al*. (2006), who captured 70 species of arthropods in a palm grove in Biskra, belonging to 3 classes, with a very large majority of insects which are represented by 69 species, grouped into 36 families and 8 orders using the Barber pots technique. Although the two environments differ, the dominance of insects is constant, which demonstrates their strong adaptability. At the Lovely Professional University Research Farm, Punjab, Longkumer *et al.* (2025) recorded 913 insects belonging to 56 species and 8 orders (Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, Orthoptera and Thysanoptera), along with 9 spider species. In that study, Hemiptera, Lepidoptera and Coleoptera showed the highest species abundance, whereas Hymenoptera was the least represented. The relative abundance values by taxonomic order, depending on the capture techniques used, reveal variations in the specific composition of arthropods. Using Barber pots, the order Hymenoptera dominates with 58%, followed by Coleoptera 17% and Araneae 6%. Using yellow traps, the order Hymenoptera dominates with 43% followed by Coleoptera 27% and Diptera 24%. Using Japanese umbrellas, the order Hymenoptera dominates with an abundance of 30%, followed by Coleoptera 23% and Diptera 12%. The fig tree attracts a significant diversity of Hymenoptera (Formicidae,

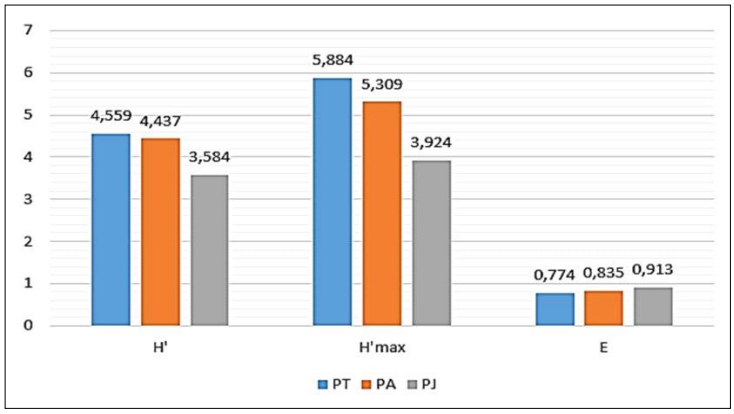


Fig 5: Diversity index (H'), maximum diversity (H max) and evenness (E) applied to invertebrate species captured with the different sampling techniques.

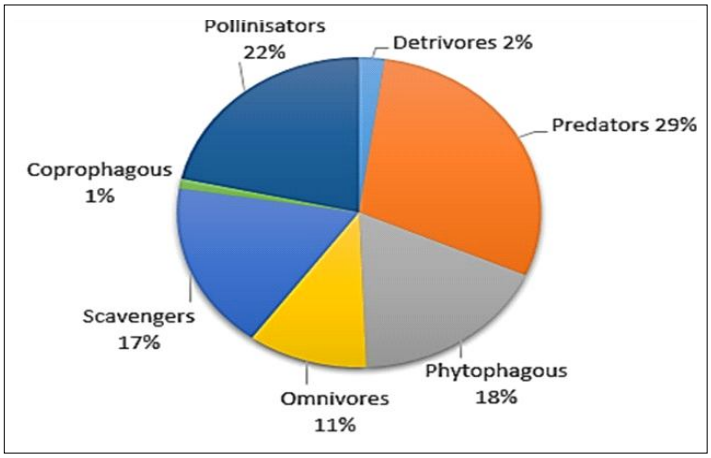


Fig 6: Relative abundances related to trophic behaviors of invertebrates captured using Barber pots.

Apidae and Halictidae) which could justify their dominance particularly in terrestrial traps. The functional analysis of captured arthropods highlighted 6 to 7 trophic behaviors depending on the capture method used. With the use of Barber pots 7 trophic behaviors were identified, predators are the best represented with 29%, followed by pollinators 22% then phytophages 18% and scavengers 17%. With aerial traps 6 trophic behaviors are noted pollinators are the best represented with 51%, then predators 17% and phytophages 11%. With the Japanese umbrella 6 trophic behaviors are noted pollinators are the best represented with 40% followed by predators 21% and phytophages 17%. Our results are close to those obtained by Ali Ahmed (1996) in a fig orchard in the Sidi Naâmane region (Tizi-Ouzou) where many of the species recorded are common, such as *Clubiona* sp., *Salticus* sp., *Lycosanarbonensis*, *Nemesia* sp., *Thomisus* sp. and *Mantis religiosa*, whose regular presence suggests their role in regulating phytophagous populations. It is worth noting the presence of saprophages and necrophages, such as *Luciliacaesar*, *Drosophila funebris* or *Silphaolivieri*, reflecting a fine exploitation of the ecological niches offered by organic debris or fallen fruits. Furthermore, the high representation of nectarivorous and pollinating insects such as *Apis mellifera*, *Lasioglossum calceatum* or *Chironomus plumosus* reinforces the idea that the fig tree constitutes an important floral resource, particularly during the flowering period. Similarly, in Gazipur, Bangladesh, Amin Ruhul *et al.* (2021) recorded 30 insect species associated with cucumber plants during a study on pollinator impact on fruit set, with relative abundances ranging from 0.4% to 13.7%. These comprised 10 pests, 10 predators, 4 pollinators and 6 occasional visitors. The introduction of pollinating insects significantly increased yields, emphasizing the importance of pollinator conservation.

The Shannon index (H') values reveal notable differences between the three capture methods used. The Barber pots present the greatest diversity with a value of H'= 4.559 bits, reflecting a high species richness and a relatively homogeneous distribution of individuals between the species. The yellow traps follow with H'= 4.437 bits. On the other hand, the lowest diversity is recorded with the

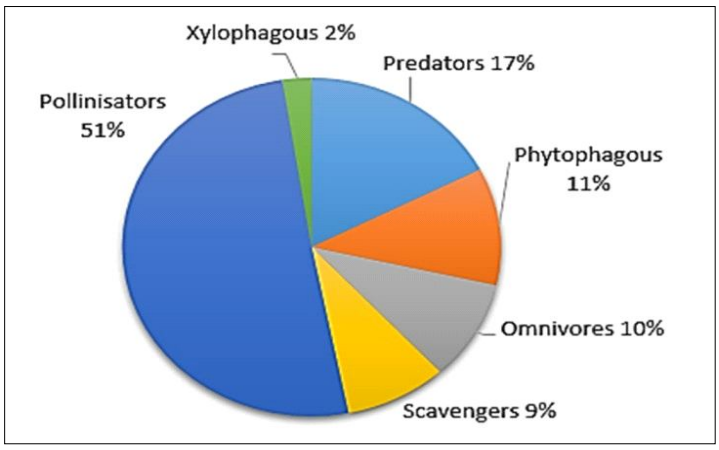
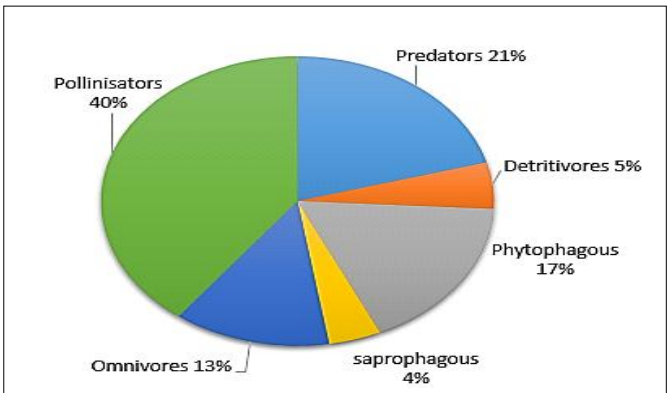


Fig 7: Relative abundances related to trophic behaviors of invertebrates captured using yellow traps.



Six trophic behaviors are observed, pollinators are in the lead with 40%, followed by predators 21%, phytophagous 17%, omnivores 13%, lastly detritivores 5% and saprophages 4%.

Fig 8: Relative abundances related to trophic behaviors of invertebrates captured using Japanese umbrella.

Japanese umbrella, H'= 3.584 bits. Chougar *et al*. (2024) who found 3.73 Bits for yellow traps and 5.01 Bits for Barber pots. The evenness (E), is E= 0.913 for the Japanese umbrella, 0.774 for the Barber pots and 0.835 for the yellow traps. These values are close to 1 which denotes a balance between the different species in the stand. Our results are close to those of Guermah *et al.* (2021) for equitability close to 1 in the prickly pear orchard 0.91 for colored traps and E= 0.93 for Barber pots.

CONCLUSION

The study carried out following a quantitative and qualitative assessment of invertebrates during the year 2022/2023 in a fig grove in the Tigzirt region with three sampling methods allowed the capture of 505 individuals belonging to 78 species, divided into 18 orders and 4 zoological classes. 58 species were recorded using Barber pots, 39 species with yellow traps and only 15 species with the Japanese umbrella. The results showed that each capture method targets different taxonomic groups, which highlights the need to use other capture methods for a better assessment of the arthropodological fauna. Invertebrates associated with the fig tree play a varied ecological role, ranging from mutualism to various forms of phytophagy, parasitism and predation. These beneficial or harmful interactions influence the reproduction of the fig tree and contribute to the balance of the ecosystem, the ecological study orchard influences the repair of these species which proliferate freely in a healthy environment.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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