Arthropods associated with Aleppo pine (*Pinus halepensis* Mill. 1768) in the Bouchaoui forest, Algeria

Artrópodes associados ao pinheiro de Alepo (*Pinus halepensis* Mill. 1768) na floresta de Bouchaoui, Argélia

Artrópodos asociados al pino carrasco (*Pinus halepensis* Mill. 1768) en el bosque de Bouchaoui, Argelia

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ABSTRACT

This study was carried out in an area of Aleppo pine reforestation located at La Croix Blanche, in the heart of the Bouchaoui-Algeria forest. The region has an annual rainfall of 752.61 mm and belongs to the subhumid to temperate winter bioclimatic zone. Two sampling methods were used between February and May 2022 : the Barber pot method and the yellow trap method. The two trapping techniques identified a total of 88 species, divided between 59 species for the yellow traps and 29 species for the Barber pots. These species belonged to 5 classes, 15 orders and 58 families, with a marked predominance of insects, which numbered 9 orders and 48 families. The most represented orders are Hymenoptera and Diptera, each with 11 and 17 families respectively, totalling 21 species each. Coleoptera follows with 8 families and 20 species, then Hemiptera with 5

families and 8 species. The average species richness in the Barber pots ranged from 0.87 to 3.75 species, while in the yellow traps it was 0.62 species in April and 0.44 species in February 2022.

Keywords: arthropods, Aleppo pine, barber pots, yellow traps, Bouchaoui-Algeria forest.

RESUMO
Este estudo foi realizado numa zona de reflorestação de pinheiro de Alepo situada em La Croix Blanche, no coração da floresta de Bouchaoui-Algeria. A região tem uma precipitação anual de 752,61 mm e pertence à zona bioclimática sub-húmida a temperada de inverno. Foram utilizados dois métodos de amostragem entre fevereiro e maio de 2022 : o método do pote Barber e o método da armadilha amarela. As duas técnicas de armadilhagem identificaram um total de 88 espécies, repartidas entre 59 espécies para as armadilhas amarelas e 29 espécies para os potes Barber. Estas espécies pertenciam a 5 classes, 15 ordens e 58 famílias, com um predomínio acentuado dos insectos, que representavam 9 ordens e 48 famílias. As ordens mais representadas são Hymenoptera e Diptera, cada uma com 11 e 17 famílias respetivamente, totalizando 21 espécies cada. Seguem-se os Coleoptera, com 8 famílias e 20 espécies, e os Hemiptera, com 5 famílias e 8 espécies. A riqueza média de espécies nos vasos Barber variou entre 0,87 e 3,75 espécies, enquanto nas armadilhas amarelas foi de 0,62 espécies em abril e 0,44 espécies em fevereiro de 2022.

Palavras-chave: artrópodes, pinheiro de Alepo, potes de madeira, armadilhas amarelas, floresta de Bouchaoui-Algeria.

RESUMEN
Este estudio se llevó a cabo en una zona de repoblación de pino carrasco situada en La Croix Blanche, en el corazón del bosque de Bouchaoui-Argelia. La región tiene una pluviometría anual de 752,61 mm y pertenece a la zona bioclimática subhúmeda a templada invernal. Entre febrero y mayo de 2022 se utilizaron dos métodos de muestreo: el método de la maceta de Barber y el método de la trampa amarilla. Las dos técnicas de trampeo identificaron un total de 88 especies, desglosadas en 59 especies para las trampas amarillas y 29 especies para las macetas Barber. Estas especies pertenecían a 5 clases, 15 órdenes y 58 familias, con un marcado predominio de los insectos, que representaban 9 órdenes y 48 familias. Los órdenes más representados son los Hymenoptera y Diptera, con 11 y 17 familias respectivamente, totalizando 21 especies cada uno. Le siguen los Coleópteros, con 8 familias y 20 especies, y los Hemípteros, con 5 familias y 8 especies. La riqueza media de especies en las macetas Barber osciló entre 0,87 y 3,75 especies, mientras que en las trampas amarillas fue de 0,62 especies en abril y de 0,44 especies en febrero de 2022.

Palabras clave: artrópodos, pino carrasco, macetas de madera, trampas amarillas, bosque de Bouchaoui-Argelia.

1 INTRODUCTION

Aleppo pine (*Pinus halepensis*) forests are valuable ecosystems that provide numerous ecological, economic and social benefits, both worldwide and in Algeria (Abbas *and al*., 1985 ; Nichane *and* Khelil, 2014 ; Chandioux *and* Chomel, 2015 ; Talbi, 2019 ; Guit *and* Nedjimi, 2020). Studying the diversity of arthropods in Aleppo pine forests is crucial for a number of reasons, including their global importance. Firstly, their ecological importance, as arthropods play a key role in ecosystems, notably as pollinators, decomposers and natural predators. They are also indicators

of ecosystem health, as the diversity of arthropods is an important indicator of the health and stability of forest ecosystems. They also contribute to biodiversity, as arthropods account for a large proportion of the world's biodiversity, and studying them helps us to understand the dynamics of global biodiversity.

In Algeria, they are important for conservation and management, as understanding the diversity of arthropods in Aleppo pine forests helps to formulate conservation and sustainable forest management strategies (Nichane *and* Khelil, 2014 ; Souttou *and al*. 2015 ; Belkheiri *and* Zerrouki, 2018 ; Aissani, 2000 ; Bouzar-ESSAIDI, 2021 ; Ghersallah *and* Souici, 2023). They also combat pests, because arthropods include beneficial species that control pest populations, reducing the need for chemical pesticides. Finally, they play a part in maintaining the ecological balance of forests, which is crucial in preventing desertification and protecting soils. In short, studying the diversity of arthropods in Aleppo pine forests is essential for biodiversity conservation, sustainable forest management and ecosystem protection, both worldwide and in Algeria.

In the light of the above data, this study is structured around the following problem : to identify all the arthropods that thrive in Aleppo pine forests in Algeria.

2 MATERIALS AND METHODS

This work focuses on the study of the diversity of arthropods associated with Aleppo pine (*Pinus halepensis* Mill. 1768) in a specific plot, called the Croix Blanche, located in the centre of the Bouchaoui forest in Algeria, about 20 kilometres from Algiers, in Staouéli. The study covers the period from February to May 2022. The region recorded a rainfall of 752.61 mm and is located in a sub-humid bioclimatic zone with temperate winters.

To achieve the objective of this study, two types of sampling methods were used in the field : the Barber pot method and the yellow trap method (Benkhelil, 1991 ; Nichane *and* Khelil, 2014 ; Bendoumia *and al*. 2016)Yellow traps and Barber pots are effective methods for sampling and identifying arthropods in Aleppo pine forests. The importance of each of these methods is explained below :

2.1 YELLOW TRAPS

1. **Visual attraction:** Yellow traps exploit the tendency of arthropods, particularly flying insects, to be attracted by bright colours. This makes it possible to capture a wide variety of species, including those that would not necessarily be present on the ground.

2. **Effectiveness for flying insects:** They are particularly effective at capturing flying insects such as Diptera, Hymenoptera and Coleoptera. This makes it possible to obtain a representative sample of the insects flying around trees.

3. **Easy to set up:** Yellow traps are simple to set up and monitor. They can be hung at different heights to target different strata of vegetation.

4. **Ecological indicators:** Insects caught by yellow traps can be used as indicators of the health and biodiversity of forest ecosystems.

2.2 BARBER JARS

1. **Ground trapping:** Barber pots are ground traps for capturing non-flying arthropods and those that move mainly on the ground, such as beetles, spiders and millipedes.

2. **Soil biodiversity:** These are essential for assessing the biodiversity of soil arthropods, which play a crucial role in decomposing organic matter and maintaining soil health.

3. **Standardisation:** The method is well standardised, allowing direct comparisons between different studies and sites.

4. **Long-term effectiveness:** Barber pots can be left in place for extended periods, capturing a wide range of species over an extended period of time, allowing a more comprehensive assessment of biodiversity.

2.3 COMBINED IMPORTANCE OF THE TWO METHODS

1. **Complementarity:** By using both yellow traps and Barber jars, researchers can obtain a more complete picture of arthropod diversity, by capturing both flying and terrestrial species.

2. **Biodiversity assessment:** The combination of the two methods provides a better assessment of the biodiversity and abundance of arthropod species in Aleppo pine forests.

3. **Ecological monitoring:** These methods are useful for ecological monitoring and forest management, providing data on changes in arthropod populations in response to environmental variations and forest management practices.

In short, the use of yellow traps and Barber pots is essential for an in-depth and comprehensive study of arthropods in forest ecosystems, providing a better understanding of their diversity and ecological role.

3 RESULTS

3.1 INVENTORY OF SPECIES CAUGHT IN BARBER POTS IN THE BOUCHAOUI FOREST

Analysis of the Barber pots collected in the Bouchaoui forest shows the presence of 29 species and 63 individuals divided into 5 classes, 10 orders and 19 families (Tab.1).

Tab. 1 - Inventory of arthropods trapped in Barber jars in the Bouchaoui forest

Class	Order	Family	Genre	Species	ni
insecta	coleoptera	curculionoidae	Ips	*Ips sp*	1
			Hylesinus	*H.oleiperda*	1
			hylurgus	*Hylurgus sp*	1
			Hylastes	*Hylastes ater*	3
		Latridiidae	Enicmus	*E.transversus*	1
		Staphylinidae	Athela	*Atheta sp*	1
	diptera	Muscidae	Hydrotaea	*Hydrotaea sp*	1
		Sciaridae	Bradysia	*Bradysia sp*	6
		Phoridae	Phora	*Phora sp*	4
		Calliphoridae	Calliphoridae	*Calliphora vicina*	1
	hymenoptera	Apidae	Apis	*Apis mellifera*	2
		Formicidae	Aphaenogaster	*A.Testaceopilosa*	2
			Tetramorium	*T.biskrense*	11
			Tetramorium	*T.semilaeve*	4
			Plagiolepis	*P.barbara*	2
			Monomorium	*M.pharanois*	3
			Crematogaster	*C.auberti*	1
			Pheidole	*P.pollidula*	1
			Aphaenogaster	*Aphaenogaster crocea*	3
			scolitus	*scolitus sp*	1
		Scolytidae	Aphis	*Aphis fabae*	1
	hemiptera	Aphididae	Gnaphosa	*Gnaphosa sp*	1
Arachnida	Araneae	Gnaphosidae	Aranea	*Aranea sp*	1
		Araneidae	Gonatium	*G.biimpressum*	1
		Linyphiidae	Acari	*Acari sp*	1
	Acaridae	Ixodidae	Armadillidium	*Armadillidium sp*	1
Malacostraca	Isopoda	Armadillidiidae	Brachyiulus	*Brachyiulus pusillus*	1
Diplopoda	Julida	Julidae	Podura	*Podura sp*	1
Collembola	Poduromorpha	Poduridae	Entomobrya	*Entomobrya sp*	5
	Entomobryomorpha	Entomobryidae	29	29	63
5	10	19			

ni = number of individuals. Source: Prepared by the authors (2024).

3.1.1 Inventory of arthropods by class of species caught using the Barber jar method in the Bouchaoui forest

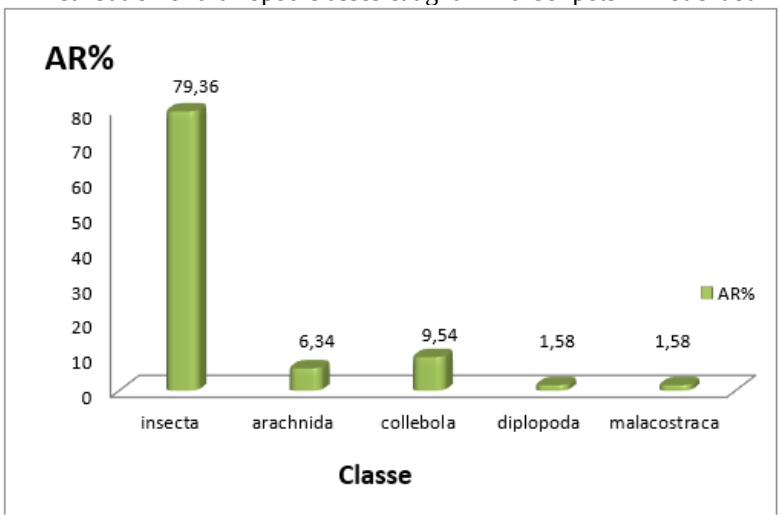
The species captured in the Barber jars belong to 5 classes. These are Insecta, Arachnida, Malacostra, Diplopoda and Collembola. The Insecta class is the largest with 79.36%, followed by the Collembola class with 9.52% and then the Arachnida class with 6.34%. The other classes are poorly represented with 1.58 % for the Dilopoda and malacostra (Fig.2 and Tab.2).

Tab. 2 - Relative abundance of arthropod classes of species caught in Barber jars

Class	Insecta	Arachnida	Collembola	Diplopoda	Malacostraca
AR%	79.36	6.34	9.52	1.58	1.58

AR% : Relative abundance. Source: Prepared by the authors (2024).

Fig. 2 - Distribution of arthropod classes caught in Barber pots in Bouchaoui forest



Source: Prepared by the authors (2024).

3.1.2 Inventory of the orders of Insecta captured in Barber pots in the Bouchaoui forest

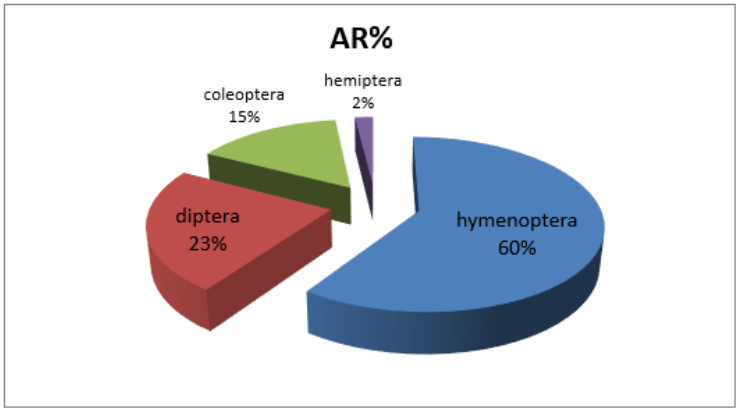
The Insecta trapped in the Barber jars were divided into 4 orders (Coleoptera, Diptera, Hymenoptera, Hemiptera). The most represented order was the Hymenoptera (60%) with the species Tetramorium biskrense (11 individuals), followed by the Diptera (23%) with the species Bradysia sp. (6 individuals), then the Coleoptera (15%) with the species Hylastes ater (3 individuals) and the Hemiptera (2%) (Fig. 3 and Tab. 3).

Tab. 3 - Relative abundances of orders of Insecta captured in Barber pots in the Bouchaoui forest

Order	Hymenoptera	Diptera	Coleoptera	Hemiptera
AR%	62	24	16	2

AR% = Relative abundance. Source: Prepared by the authors (2024).

Fig. 3 - Distribution of orders of Insecta captured in Barber pots in the Bouchaoui forest



Source: Prepared by the authors (2024).

3.1.3 Inventory of Arachnid orders captured in Barber pots in the Bouchaoui forest

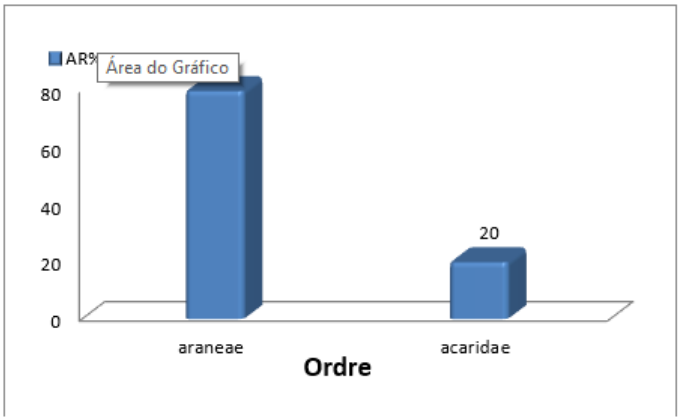
The arachnids trapped in the Barber jars were divided into 2 orders (Araneae and Acaridae). The most represented order is Araneae with 80%, followed by Acaridae with 20% (Tab.4 and Fig.4).

Tab. 4 - Relative abundances of orders of arachnids caught in Barber pots in the Bouchaoui forest

Order	Araneae	Acaridae
AR%	80	20

Source: Prepared by the authors (2024).

Fig. 4 - Distribution of Arachnid orders caught in Barber pots in Bouchaoui forest



Source: Prepared by the authors (2024).

3.1.4 Inventory of Collembola orders captured in Barber jars in the Bouchaoui forest

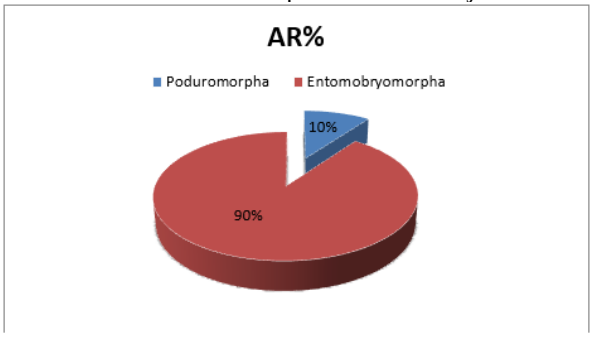
The springtails trapped in the Barber jars were divided into 2 orders (Poduromorpha and Entomobryomorpha). The most represented order is Entomobryomorpha with 90%, followed by Poduromorpha with 10% (Fig.5 and Tab.5).

Tab. 5 - Relative abundances of orders of springtails caught in Barber pots in the Bouchaoui forest

Order	Entomobryomorpha	Poduromorpha
AR%	90	10

Source: Prepared by the authors (2024).

Fig. 5 - Distribution of insect orders captured in Barber jars in Bouchaoui forest



Source: Prepared by the authors (2024).

3.2 INVENTORY OF SPECIES CAUGHT IN YELLOW TRAPS IN THE BOUCHAOUI FOREST

Arthropods trapped in yellow traps revealed the presence of 59 species with 206 individuals divided into 3 classes, 12 orders and 51 families (Tab.6).

Tab. 6 - Inventory of arthropods trapped by yellow traps in the Bouchaoui forest

Class	Order	Family	Genre	Species	ni
Insecta	Diptera	Sciaridae	*Bradysia*	*Bradysia sp*	64
		Phoridae	*Phora*	*Phora sp*	16
			Megaselia	*megaselia sp*	1
		Agromyzidae	*Napomyza*	*Napomyza lateralis*	1
		Hybotidae	*Platypalpus*	*Platypalpus sp*	1
		Chironomidae	*Chironomus* (male)	*Chironomus sp*	1
		Scotopsidae	*Scotopse*	*Scotopse sp*	7
		Drosophilidae	*Drosophila*	*Drosophila sp*	1
		Dolichopodidae	*Medetera*	*Medetera diadema*	1
		Muscidae	*Muscina*	*Muscina stabulans*	2
		Sphaeroceridae	*Leptocera*	*Leptocera nigra*	1
		Cecidomyiidae	*Cécidomyie*	*Cécidomyie sp*	3
		Mycetophilidae	*Mycetophila*	*Mycetophila fugorum*	1
		Psychodidae	*Psychoda*	*Psychoda alternata*	1
		Psilidae	*Psila*	*Psilida loxocera*	1
		Calliphoridae	*Calliphora*	*Calliphora sp*	1
		Syrphidae	*Paragus*	*Paragus sp*	2
		Chloropidae	*Punctatus*	*Paunctatus chloropidae sp*	1
			Platypalpus	*Platypalpus sp*	1
			Chloropidae	*Chloropidae sp*	2
	Coleoptera	Cantharidae	*Malthinus*	*Malthinus punctatus*	10
		Cryptophagidae	*Cryptophagus*	*Cryptophagus sp*	1
		Cleridae	*Trichodes*	*Trichodes alvearius*	1
		Staphylinidae	*Atheta*	*Atheta sp*	2
			Anotylus	*Anotylus sp*	2
			Tachyporus	*Tachyporus sp*	1
		Corylophidae	*Corylophus*	*Corylophus sp*	2
		Cerambycidae			1
			Scolytide	*Scolytides sp*	1
			Hylastes	*hylastes sp*	1
			Sitophilus	*Sitophilus zeamais*	1
			Taphrorycus	*Taphrorycus bicolor*	1
			Hylastes	*Hylastes sp*	2
			Lixus	*Lixus algerus*	1
			Hylesinus	*Hylesinus varius*	2
			Ips	*Ips sp*	1
		Tenebrionidae	*Euboeus boieldieu*	*Probaticus anthracinus (Pélozinus)*	1
		Scarabbaeidae	*Hoplia*	*Hoplia africana*	2
	Homoptera	Coccidae	*Phylloxera*	*Phylloxera vitifolii*	1
	Hymenoptera	Apidae	*Apis*	*Apis mellifera*	13
			Crematogaster	*Crematogaster auberti*	2
			Crematogaster	*Crematogaster scutellaris*	2
			Monomorium	*Monomorium pharaonis*	6
		Trichogrammatidae	*Trichogramma*	*Trichogramma sp*	2
		Platygastridae	*Trissolcus*	*Trissolcus sp*	1
		Diapriinae	*Basalys*	*Basalys sp*	1

		Braconidae	*Habrobracon*	*Habrobracon hebetor*	1
		Scoliidae	*Scoliidae*	*Scoliidae sp*	1
		Scarabeidae	*Scoliidae*	*Scoliidae sp*	1
		Crabronidae	*Spilomena*	*Spilomena sp*	1
			Diadegma	*Diadegma sp*	2
			Orthocentrus	*Orthocentrus sp*	1
				Anomaloninae	1
	Psocoptera		*Elipsocus*	*Elipsocus sp*	1
		Elipsocidae	*Psocoptera*	*Psocoptera sp*	3
	Hemiptera	Miridae	*Camptozygum*	*Camptozygum sp*	2
			Phytocoris	*Phytocoris tiliae*	1
		Aphididae	*Myzus*	*Myzus persicae*	4
			Aphis	*Aphis fabae*	1
		Issidae	*Issis*	*Issis sp*	1
			Issus	*Issus sp*	1
		Cicadellidae			2
		Anthocoridae	*Orius*	*Orius niger*	2
	Blattaria	Blattelida	*Ectobius*	*Ectobius pallidus*	1
	Lepidoptera	Arctiidae	*Coscinia*	*Coscinia sp*	1
	Zygentoma	Lepismatidae	*Lepisma*	*Lepisma sp*	1
Collembola	Poduromorpha	Poduridae	*Podura*		1
	Entomobryomorpha	Entomobryiade			1
Arachnida	Araneae	Salticidae	*Salticidae*	*Salticidae sp*	2
		Lycosidae	*Lycosidae*	*Lycosidae sp*	2
		Gnaphosidae	*Gnaphosidae*	*Gnaphosidae sp*	1
Total : 3	**12**	**51**	**59**	**59**	**206**

ni = number of individuals. Source: Prepared by the authors (2024).

3.2.1 Inventory of arthropods by class of species caught using the yellow trap method in the Bouchaoui forest

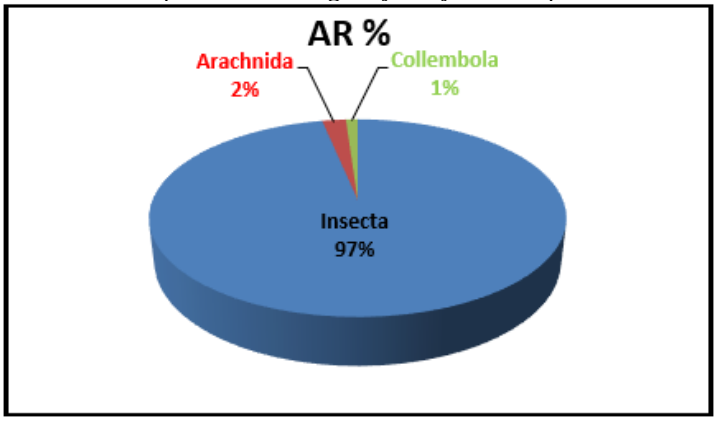
The species caught by the yellow traps belong to 3 classes. These are Insecta, Collembola and Arachnida. The Insecta class is in the majority with 96.70%, followed by Arachnida with 2.19% and Collembola with 1.09%.

Tab. 7 - Relative abundance of arthropod classes caught in yellow traps in Bouchaoui forest

Class	**Insecta**	**Arachnida**	**Collembola**
AR %	96.60%	2.42%	0.97%

AR % : Relative abundance. Source : Prepared by the authors (2024).

Fig. 6 - Distribution of arthropod classes caught by the yellow trap method in Bouchaoui forest



Source: Prepared by the authors (2024).

3.2.2 Inventory of insect orders caught by yellow traps in Bouchaoui forest

The insects caught in the yellow traps are divided into 12 orders (Diptera, Coleoptera, Hemiptera, Homoptera, Hymenoptera, Psocoptera, Blattaria, lepidoptera, Zygentoma, Poduromorpha, Entomobryomorpha, Araneae).

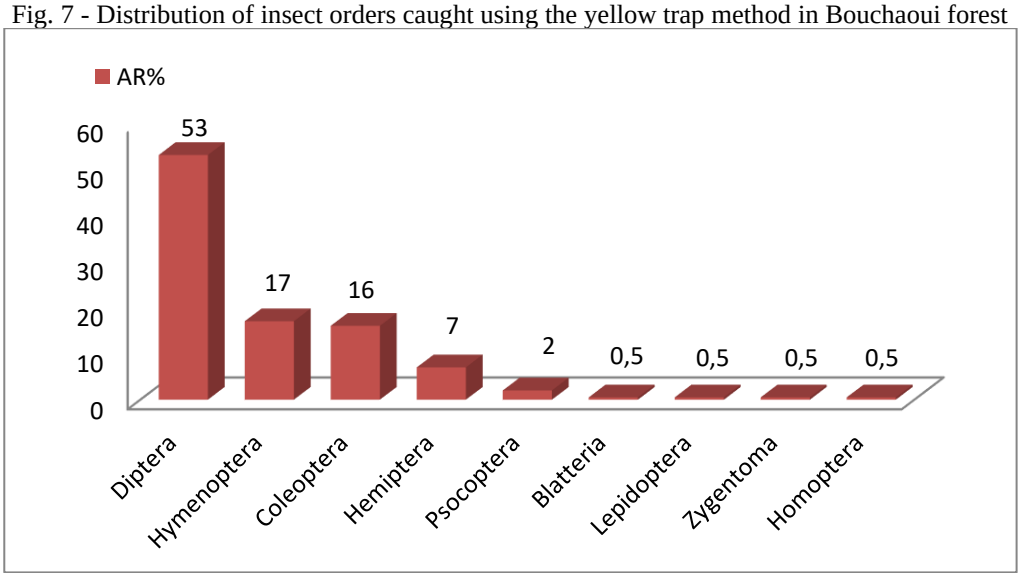
The most represented order is the Diptera with 53%, followed by the Hymenoptera with 17%, then the Coleoptera with 16%, then 7% for the Hemiptera, and only 2% for thePsocoptera, while the other orders are poorly represented (Tab.8 and Fig.7). The families most frequently encountered among the Diptera are the Sciaridae with Bradysia sp (64 individuals), the Phoridae with Phora sp (16 individuals) and the Scotopsidae with Scotopse sp (7 individuals). The Hymenoptera stand out with the Apidae and the species Apis mellifera (13 individuals). The Coleoptera are dominated by the Cantharidae with Malthinus punctatus (10 individuals).

Tab. 8 - Relative abundances of insect orders caught in yellow traps

Order	Diptera	Hymenoptera	Coleoptera	Hemiptera	Psocoptera	Blatteria	Lepidoptera	Zygentoma	Homoptera
AR%	53	17	16	7	2	0.5	0.5	0.5	0.5

AR**%**: Relative abundance. Source : Prepared by the authors (2024).

Fig. 7 - Distribution of insect orders caught using the yellow trap method in Bouchaoui forest



Source: Prepared by the authors (2024).

3.3 ECOLOGICAL COMPOSITION INDICES APPLIED TO SPECIES INVENTORIED USING THE BARBER POT AND YELLOW TRAP METHODS IN THE BOUCHAOUI FOREST

The results of the inventory of arthropods obtained from Barber pots and yellow traps in the Bouchaoui forest are used for composition indices such as total and average richness and relative abundance.

3.3.1 Total and average richness of species caught by the two sampling methods

The total and average richness values inventoried in the Barber pots and yellow traps are presented in Table 9.

Tab. 9 - Total richness (S) and mean richness (Sm) of species caught in Barber pots and yellow traps in Bouchaoui forest

Traps/Month 2022		February	March	April
Barber jars	**S**	6	13	15
	Sm	0.87	3.12	3.75
Yellow traps	**S**	22	29	31
	Sm	0.44	0.58	0.62

Source: Prepared by the authors (2024).

The highest total richness was observed in the Barber pots in April, with 15 species, and again in April, with 31 species in the yellow traps. On the other hand, the lowest total richness was observed in February with 6 species in the Barber pots and 22 species in the yellow traps.

The highest average richness values were found in the Barber pots, where they ranged from 0.87 species in February to 3.75 species in April. On the other hand, in the yellow traps, the highest average richness was reported in April with 0.62 species, and the lowest in February with 0.44 species.

3.3.2 Relative abundance of species caught in Barber pots and yellow traps in Bouchaoui forest

The results for the relative abundances of the main species present in the Barber pots and yellow traps are shown in Table 10.

Tab. 10 - Relative abundances of the main species trapped in Barber pots and yellow traps in the Bouchaoui forest

Relative abundance %							
Barber pots				**yellow traps**			
Species	**February**	**March**	**April**	**Species**	**February**	**March**	**April**
Bradysia sp	0	24	0	*Bradysia sp.*	6.66	50.64	27.50
Phora sp	0	8	5	*Phora sp.*	6.66	11.68	5
T.biskrense	0	0	0	*Apis mellifera*	20	0	5
T.semilaeve	14.28	12	0	*Malthinus punctatus*	13.33	3.89	1.25
M.pharanois	0	0	7.5	*Monomorium pharanois*	0	0	7.5
A.crocea	0	0	7.5	*Scotopse sp.*	13.33	1.29	0
Entomobrya sp	0	20	0	*Psocoptera sp.*	0	2.59	1.25

Source: Prepared by the authors (2024).

According to Table 3.10, in the Barber pots, the most abundant species are Bradysia sp. with (24%) in March. Tetramorium semilaeve (14.28%) in February and Entomobrya sp (20%) and Tetramorium semilaeve. (12%) in March, the least abundant being Phora sp. With (5%) in April.

In the yellow traps, the most abundant species are *Bradysia* sp. with (50.64%) in March, *Malthinus punctatus* with (13.33%) in February. The least abundant species are found in February with (1.25%) each of *Malthinus punctatus* and *Psocoptera* sp.

3.4 ECOLOGICAL INDICES OF STRUCTURE APPLIED TO SPECIES INVENTORIED BY THE BARBER POT AND YELLOW TRAP METHODS IN THE BOUCHAOUI FOREST BARBER POTS AND YELLOW TRAPS IN THE BOUCHAOUI FOREST

The ecological indices of structure can be summarised as the Shannon-Weaver index (H'), the maximum diversity (H'max) and the equitability index (E). The Shannon-Weaver diversity (H'), maximum diversity (H'max) and equitability (E) values for the species caught in the Barber pots and yellow traps are given in Table 11.

Tab. 11 - Diversity (H), maximum diversity (H'max) and equitability (E) of species caught in Barber pots and yellow traps in Bouchaoui forest

		February	March	April
Barber pots	**N**	7	25	31
	H'	0.39	0.30	0.53
	H'max	1.81	3.91	4.52
	E	0.22	0.08	0.12
yellow traps	**N**	50	83	73
	H'	0.26	0.28	0.29
	H'max	6.62	8.73	9.33
	E	0.04	0.03	0.03

N: Number of individuals. Source: Prepared by the authors (2024).

H‘ (bits): Shannon-Weaver diversity index

H'max (bits): Maximum diversity

E: Equitability index

The Shannon-Weaver diversity index calculated for species caught in Barber pots shows a high value of H' in April with 0.53 bits, the lowest value is reported in March with 0.30 bits. For species caught in yellow traps, the highest value is noted in April with 0.29 bits; however, the lowest value is also found in February with 0.26 bits.

The highest maximum diversity for Barber pots was recorded in April (4.52 bits), while the lowest was in February (1.81 bits). For yellow traps, a high value was noted in April (9.33 bits) compared with (6.62 bits) in February.

The equitability indices (E) calculated for the species trapped in the Barber pots during the months sampled show a value close to o for all the months (February, March and April), which proves an imbalance between the species inventoried. This can be explained by the dominance of a

few species: *Entomobrya* sp and *Bradysia* sp in March, and *Tetramorium biskrense* and *Monomorium pharanois* in April.

The calculation of the equitability (E) for the species trapped in the yellow traps shows a value of E which tends towards 0 for the three months (February, March, April) which proves the dominance of certain species during these different periods, these are Bradysia sp with 39 individuals in March and 22 individuals in April as well as Phora sp with 9 individuals in February.

4 DISCUSSION

The overall inventory of arthropods inventoried at the white cross station in the Bouchaoui forest using two types of trap, Barber traps and yellow traps, revealed the presence of 269 individuals belonging to 78 species, divided into 14 orders and 56 families. At the same station, Selmane (2012), in his study of Aleppo pine and pinion pine during the period from May to October, noted the presence of 452 individuals divided between 12 orders, 46 families and 71 species. This difference is due to various factors such as climatic factors, the period and duration of the study, and the type and number of traps used.

Analysis of the Barber pots collected in the Bouchaoui forest revealed the presence of 63 individuals belonging to 29 species, divided into 5 classes, 10 orders and 19 families. The Insecta class is the most important with 79.36%, divided into 4 orders (Hymenoptera, Diptera, Coleoptera and Hemiptera). Hymenoptera dominate with the species Tetramorium biskrense (60%), followed by Diptera with the species Bradysia sp (23%), Coleoptera (15%) and Hemiptera (2%). The Collembola class was also noted (9.54%). The Diplopoda and Malacostaca followed with 1.58%.

Zaarir and Zidane in 2020 in the Hamma test garden (English garden and systematic square) noted the dominance of Malacostraca (98.4%), including Gammarus sp. (205 individuals) and Armadillidium vulgare (96 individuals). Whereas Nadji *and al.* (2016) reported that the class most represented in the trap pots was Insecta with 92.4% at Crescia and 89.1% at Zéralda.

In the present study, among the insects trapped in Barber jars, the order Hymenoptera dominated** with 59%, followed by Diptera with 23%. The same applies to Djetti *and al.* (2014) in the eastern part of the Mitidja, where they found that, among the insects, Hymenoptera dominated with 54.8%, followed by Coleoptera. In the Séhary Guebly pine grove near Djelfa, Souttou *and al.* (2010) found that 476 of the 614 invertebrates were Hymenoptera, ranking first. While Aissani (2000) notes in a pine grove near Cherchell, that of the 12 orders, the one most represented is Coleoptera. These authors point out that Diptera rates fluctuate (5%<A.R.% = 49.4%). At the same time, Coleoptera peaks in March (A.R. % = 21.5%).

Arthropods trapped in yellow traps revealed the presence of 59 species (206 individuals) divided into 3 classes, 12 orders and 51 families. The Insecta class was in the majority with 96.60%, followed by the Arachnida with 2.42%, and the Collembola with 0.97%. The same is true for Zaarir and Zidane in 2020, who note that the Insecta class dominates with 98.8%, followed by the Arachnida (1.2%). Aissani (2000), Bensaada *and al.* (2010) in an Aleppo pine forest near Cherchell report 348 individuals divided between 6 classes, of which the Insecta is the best represented.

In a holm oak forest near Larbâa Nath Irathen, Fernane *and al.* (2010) report the presence of 525 individuals in 16 orders and 6 classes (Arachnida, Diplopoda, Chilopoda, Crustacea, Podurata and Insecta). According to the same authors, the Insecta class is the largest in terms of number of individuals (A.R. % = 90.7%), followed by the Arachnida.

The insects caught by the yellow trap method are divided into 9 orders, the best represented order being the Diptera (53%) with the Sciaridae (Bradysia sp.) (63 individuals), the Phoridae (Phora sp) (16 individuals). This result corroborates that of Dajoz (1980), who notes that the larvae of phytophagous or saprophagous soil Diptera consume a great deal of litter, which they actively mix with the mineral part of the soil, so that Diptera dominate in a forest environment (Dajoz 1998). In second place are the Hymenoptera with 17%, then the Coleoptera with 16% and only 7% for the Hemiptera and 2% Psocoptera. In contrast to our results, Fernane *and al.* (2010), in an undergrowth of holm oak (Quercus ilex) b b in Larbaa Nath Irathen (Tizi-Ouzou), note the dominance of Hymenoptera with 46.5%. In the same region of Tizi-Ouzou, Fernane (2012) in a cork oak (*Quercus suber*) forest noted the dominance of Hymenoptera with 43.8%, followed by Coleoptera with 12.9%.

The highest total richness (S) was observed in April, with 15 species in the Barber pots and 31 species in the yellow traps. On the other hand, the lowest total richness was noted in February with 6 species in the Barber pots and 22 species in February also in the yellow traps. In a forest of the same type near Cherchell Aissani (2000) found total richness varying between 19 species in November and 6 species in March. The same author in another station near Cherchell noted that the values of total richness varied between 18 species in October and 4 species in March.

In the Bouchaoui forest, the highest average richness values were found in the Barber pots, where they varied between 0.87 species in February and 3.75 species in April. On the other hand, in the yellow traps, the highest average richness was reported in April with 0.62 species, and the lowest in February with 0.44 species. Aissani (2000), reports an average richness of between 2.6 species in September and 5 species in February in a pine grove near Cherchell.

Concerning the relative abundances of the species caught, in the Barber pots, the most abundant species were *Bradysia* sp with (24%) and *Entomobrya* sp with (20%), *Tetramorium semilaeve* with (12%) in March and *Tetramorium semilaeve* with (14.28%) in February. For yellow

traps, the most abundant species are *Bradysia* sp with 50.64% in March, *Malthinus punctatus* and *Scotopse* sp with 13.33% in February. Zaarir and Zidane (2020), report that the most abundant species is *Gammarus* sp. (67%) followed by *Armadillidium vulgare* (31.4%).

The Shannon-Weaver diversity index calculated for species caught in Barber pots shows a high value of H' in April with 0.53 bits, the lowest value is reported in March with 0.30 bits. For species caught in yellow traps, the highest value is noted in April with 0.29 bits ; however, the lowest value is found in February with 0.26 bits. Aissani (2000) reports highly variable H‘ values depending on the month, with the lowest value noted in July and the highest in September (1.7bits<H’< 3.6 bits). According to Souttou *and al.* (2010) in a pine grove near El Mesrane, the Shannon-Weaver diversity index H' varies between 2.6 bits in June and 3.4 bits in April.

The equitability indices (E) calculated for the species trapped in the Barber pots during the months sampled show a value close to 0 for the three months of February, March and April - an imbalance between the species inventoried. This can be explained by the dominance of some species: *Tetramorium biskrense* with 11 individuals, *Bradysia* sp with 6 individuals in March. However, Aissani (2000) notes that equitability is low during July and increases during the other months.

The calculation of equitability (E) for the species trapped in the yellow traps shows a value of E close to 0 in February, March and April, which also proves the dominance of certain species during these periods, namely *Apis mellifera* with 07 individuals in February and *Bradysia* sp with 32 individuals in March and 43 individuals in April. However, none of the authors cited above used this sampling technique. It is therefore not possible to make a comparison.

5 CONCLUSION AND OUTLOOK

From these results, we can deduce that the Bouchaoui forest in Algeria is very rich in arthropods. The trapping method using yellow traps (59 species and 206 individuals) proved more effective than that using Barber pots (29 species and 63 individuals). This difference is attributed to more intense use of the environment (the Bouchaoui forest) by the population, leading to the destruction of the traps, as well as to the evaporation of water from the traps. The number of outings and traps needs to be increased in order to improve sampling quality.

In the future, it would be desirable to increase the number of arthropod trapping methods, and to spread the duration of the experiment over a long period, especially during the Aleppo pine flowering period, in order to improve the quality of the sampling and correct the limitations of the trapping methods. The inventory will provide us with a better understanding of arthropods and, more specifically, of the entomofauna associated with Aleppo pine, as well as knowledge of the

auxiliary species that can contribute to the implementation of biological control for better management of the fauna.

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REFERENCES

ABBAS H., BARBÉRO M., LOISEL R. et QUÉZEL P., 1985 - Les forêts de pin d'Alep dans le sud-est méditerranéen français analyses éco-dendrométriques. *Forêt méditerranéenne*, t. VII, na 2, 123-130.

AISSANI R., 2000 - *Contribution à l'étude des insectes du pin d'Alep dans les forêts de la région de Cherchell (Tipaza*). Mémoire Ingénieur, Inst. nati. agro., El Harrach, 79 p.

BELKHEIRI N. et ZERROUKI D., 2018 - *Etude Dendrométrique et Floristique Dans La Forêt Naturelle A pin D'Alep de Djellal Chergui «Wilaya de Djelfa* ». Mémoire de Master. Univ. ZIANE Achour-Djelfa, 62p.

BENDOUMIA H., TERGOU S. and DOUMANDJI S., 2016 - Influence of the absence of irrigation water on the Arthropod complex in a lucerne (*Medicago sativa* Linné) in Mitidja (Algeria). *Adv. environ. biol.*, 10 (12) : 84 - 88.

BENKHELIL M., 1991 - *Les techniques de récoltes et de piégeages utilisées en entomologie terrestres.* Ed. Office des Publications Universitaires (O.P.U), Alger, 68p.

BENSAADA F., DERDOUKH W., DOUMANDJI S. et KALOUA B., 2010 - Contribution à l'étude de la biodiversité de l'entomofaune de deux forêts de pin d'Alep dans la région de Gouraya. Journées nati. Zool. agri. for., 19-21 avril 2010, Dép. zool. for., Ecole nati. sup. agro., El Harrach, p. 114.

BOUZAR-ESSAIDI K., 2021 - *Les populations de la processionnaire du pin (Thaumetopoea pityocampa shiff, Lepidoptere : Thaumetopoeidae) dans la frange littorale ouest algérienne : incidence des essences forestières et du parasitisme.* Thèse de Doctorat. Univ. Blida. 172p.

CHANDIOUX O. et CHOMEL F., 2015 - *La valorisation bois d'œuvre du Pin d'Alep, source d'économie et d'emploi pour la forêt méditerranéenne ; Fiches de lecture.* Ed. Alcina – France Forêt PACA. 168p.

DAJOZ R, 1980 - *Ecologie des Insectes forestiers*. Édition : Bordas, Paris 489p.

DAJOZ R., 1998 - *Les insectes et les forêts*. Edition : Lavoisier, Paris 594p.

DJETTI T., HAMMACHE M. et DOUMANDJI S., 2014 - *L'arthropodofaune associée à la culture de maïs dans la station expérimentale de l'E.n.s.a*. d'El- Harrach. Séminaire nati., Biodiv. faunist., 7-9 décembre 2014, Dép. zool. agri. for., Ecole nati. sup. agro., El Harrach.

FERNANE A., 2012 - *Biodiversité des insectes en milieu forestier : cas de la région de Tizi-Ouzou (Algérie).* 3 ème Congrès franco-maghrébin de Zoologie et d'Ichtyologie, 6-10 novembre, Marrakech, p. 65.

FERNANE A., DOUMANDJI S. et DOUMANDJI-MITICHE B., 2010 - Etude de la biodiversité entomofaunistiquue dans la région de Larbâa Nath Irathen (Tizi-Ouzou). *Journées nati. Zool. agri. for., 19-21 avril 2010, Dép. zool. for., Ecole nati. sup. agro., El Harrach, p. 106.*

GHERSALLAH M. et SOUICI N., 2023 - Evaluation des infestations de la chenille processionnaire du pin : *Thaumetopoea pityocampa* (Lepidoptera : Denis & Shiffermuller, 1775) dans quelques biotopes forestiers de la région de Bordj Bou Arreridj. Mémoire de Master. Univ. Mohammed El Bachir El Ibrahimi de Bordj Bou Arreridj. 29p.

GUIT B. et NEDJIMI B., 2020 - Croissance radiale du pin d'Alep (*Pinus halepensis* Mill.) en fonction des paramètres stationnels dans les massifs forestiers naturels de l'Atlas saharien algérien. *Bois et Forêts des Tropiques n*° 345, *Vol*. 345. 3-11.

NADJI F.Z., MARNICHE F. et DOUMANDJI S., 2016 - Ant's trophic status *Cataglyphis viatica* (Fabricius, 1787) (Hymenoptera, Formicidae) in agricultural and forest environment in Algiers Sahel. Advances Environm. Biol., 10 (9) :146 - 152.

NICHANE M. et KHELIL M.A., 2014 - Arthropodofaune recensée par la méthode des pots barber dans la forêt de Tamerchalet (Marsa Ben M'Hidi-Tlemcen). *Rev. Ivoir. Sci. Technol.,* 24 : 93-111.

SELMANE F., 2012 - *Contribution à l'inventaire d'arthropodologie intervenant sur le dépérissement de pin d'alep et de pin pignon sur le littoral Algérois.* Mémoire d'ingénieur d'état d'agronomie. Univ. Mouloud Mammeri.79P

SOUTTOU K., BAKOUKA F., DOUMANDJI S., SEKOUR M. et GUEZOUL O., 2010 - Analyses écologiques des arthropodes capturés par la technique des pots Barber dans une pineraie à Séhary Guebly (Djelfa). *Journées nati. Zool. agri. for., 19-21 avril 2010, Dép. zool. for., Ecole nati. sup. agro., El Harrach, p. 106.*

SOUTTOU K., CHOUKRI K., SEKOUR M., GUEZOUL O., ABABSA L. et DOUMANDJI S., 2015 - Ecologie des arthropodes en zone reboisée de Pin d'Alep dans une région présaharienne à Chbika (Djlefa, Algérie). *Entomologie Faunistique – Faunistic Entomology* : 68, 159-172.

TALBI S., 2019 - *Contribution à l'étude du dépérissement du pin d'Alep Pinus halepensis Mill. (Symptôme, cause et traitement) cas de la forêt de Draa El-Aoud à Mecheria (Wilaya de Naâma)*. Mémoire de Master. Univ. Tlemcen. 66p.

ZAARIR F., et ZIDANE M., 2020 - *Place des arthropodes dans un jardin botanique*. Diplôme en master en phytopharmacie et protection des végétaux. Université de Saad Dahleb. 59P.