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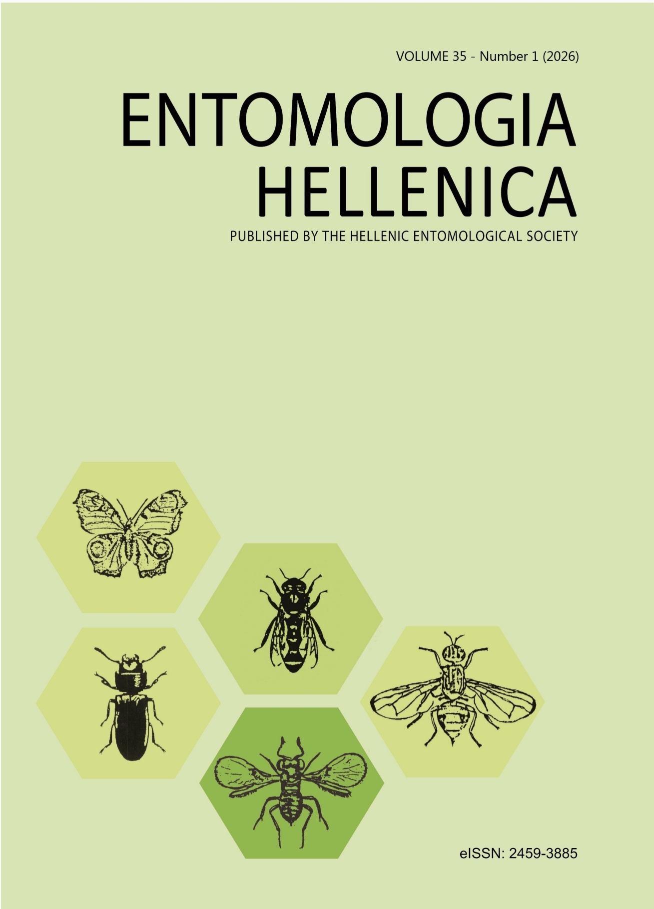

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Biodiversity and categories of insects on lucerne crop at El-Outaya Bio-Resources station (CRSTRA-Biskra, Algeria)

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ABSTRACT

Lucerne (*Medicago sativa* L.) is the main forage crop cultivated in the El-Outaya plain (Biskra, Algeria); however, information on the associated insect community remains limited for the region. Studying insects associated with this crop allows an assessment of their roles and ecological importance within the production system. This study aims to assess insect diversity, functional guild composition, and ecological roles within a pesticide-free lucerne agro-ecosystem. Insects were sampled weekly during the 2018 growing season, using circular yellow water traps, placed in a lucerne field and an adjacent bare-ground control. A total of 4655 insect specimens were collected and found to represent 80 species, 80 genera, 47 families, and seven orders. The main functional groups recorded were phytophagous species (47.5%), entomophagous (27.5%), and pollinators (13.75%), while detritivorous, hematophagous, scavengers, and saprophagous species accounted altogether for 11.25%. Most phytophagous species belonged to the order Hemiptera, whereas beneficial insects were mainly Hymenoptera. The Shannon–Wiener diversity index was higher in lucerne (H′ = 1.415) than in the bare control (H′ = 1.137), indicating the positive effect of crop presence on insect diversity. Long-term lucerne cultivation (approximately 10 years), providing both favourable microclimate and abundant nutritious food, under pesticide-free conditions, likely promoted the establishment of a structurally diverse and functionally balanced insect community consisting mainly of pollinators and phytophagous species, which in turn support predator populations. These findings provide baseline data for integrated pest management strategies and highlight the ecological value of lucerne agro-ecosystems in arid regions.

KEY WORDS: *Medicago sativa*, beneficial insects, entomofauna, phytophagous insects.

Introduction

Lucerne (*Medicago sativa* L.) originated from the regions of Iraq and Iran and is one of the oldest and most widely cultivated crops, with a history of over 3,300 years. This reliable, temperate, deep-rooted legume is well adapted to both irrigated and non-irrigated lands. It produces high levels of dry matter and regrows quickly, allowing multiple cuts and/or grazing. Consequently, lucerne is considered a premier perennial forage legume, providing income for thousands of farmers and ranchers worldwide (Ahlawat 2008, Bates 2015, Lacefield et al. 1997, 2009, Lattimore 2008, McDonald et al. 2003, Pioneer Brand Products 2012, Smith et al. 1999, USAID 2011).

Lucerne provides high-quality forage and can persist for more than 10 years. This extended stand life, despite system disturbances caused by frequent harvests and occasional pesticide applications, offers sufficient temporal stability for the establishment and

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development of a wide diversity of flora and fauna. While, most of these organisms pose little to no threat to the crop, some can inflict considerable damage, leading to significant yield and/or quality losses, often contributing to a shortened productive lifespan of the stand. Therefore, to maximize the benefits of lucerne cultivation, effective weed and pest management is essential at all stages, from paddock selection to the maintenance of established stands. Failure to do so may result in yield losses of 20–40% and reduced stand longevity (Adama 2017, Lacefield et al. 1997, Summers 1998).

This crop has historically been the main forage crop in the Mediterranean basin and is the most grown perennial forage legume in nearly all countries of the region (Annicchiarico 2015). Paradoxically, in the Algerian Sahara, it is the primary fodder (Chaabena 2001), i.e. for the period 1995 to 1997, the area devoted to perennial lucerne in Algeria accounted for 0.37 and 0.71% of the total fodder crop area; compared to herbaceous crops, this area represented between 1.86 and 3.03% over the same period. Thus, Biskra ranked fourth after Ourgla, El Oued, and Gahrdaia among the most productive Saharan provinces in Algeria (Chaabena and Abdelguerfi 2001).

Insects, which represent approximately 80% of all known animal species, play pivotal roles in pollination, decomposition, and food webs. They contribute significantly to nutrient cycling, soil health and the reproduction of many plant species (Kharwal et al. 2024). Previous research has documented insect pests associated with lucerne worldwide, including those by Nikolova (2019) in Bulgaria, Genzhemuratovna and Sherniyazovich (2021) in Karakalpakstan, Aljoboory and Saber (2022) in Baghdad (Iraq), Khalifa and Badawy (2023) in Egypt, Premalatha et al. (2024) in India, and Valverde-Rodríguez et al. (2024) in Peru. Meanwhile, in Algeria earlier studies have focused on inventories of arthropod complexes associated with lucerne. Research conducted in Ouargla, a northern Saharan region, revealed insects as the most abundant arthropods in three cases (one-, two-, and three-year-old stands). Hymenoptera and Collembola were predominantly captured using pitfall traps, whereas Coleoptera, Diptera, and Hemiptera were mainly collected by sweep-net sampling (Kherbouche et al. 2015). In the Mitidja region, Diptera was the most represented order, comprising 21 species, while the Aphididae family was dominant with six species (Bendoumia et al. 2016).

Meanwhile, few studies have addressed insect communities associated with lucerne in the arid regions of Biskra. At the El-Mleh site (Sidi Okba, Biskra), Barkat (2019) reported 37 insect species distributed over 28 families and seven orders. In this context, the present study aims to elucidate the previously understudied entomofaunal diversity supported by lucerne crop in the locality of El-Outaya. Specifically, it evaluates insect diversity and richness under local bio-conditions through general monitoring and assesses the functional roles of the surveyed groups, including pollinators, natural enemies, and organisms involved in decomposition and nutrient recycling within the lucerne agro-ecosystem.

Materials and Methods

In the Biskra region, lucerne is the sole cultivated forage species within the Fabaceae family. Most farmers in the region adopt flood irrigation while a minority use aspersion irrigation, twice per week in summer and once per week for the rest of the seasons. Organic manure, compost or basal fertilisation is generally applied before ploughing or during seedbed preparation. The majority of farmers maintain lucerne for periods exceeding seven years and harvest it at the early flowering stage, using mowing intervals of 16–20 days during spring and summer and longer intervals of more than 40 days in autumn and winter (Benounas and Chaïb 2007).

In the El-Outaya plain, agricultural activity was intensified following the adoption of policies supporting land development in the region, and lucerne has been widely adopted by growers as the main forage crop. Nevertheless, important data about its entomofauna remains limited. According to Serraoui (2022), most farmers in the region use phytosanitary products on lucerne, thus insecticides are commonly used to control pests.

In this context, the present study was conducted on a lucerne crop of the Timacine population grown at the CRSTRA Bio-Resources Station in the El-Outaya plain, north-east of Biskra (34°55′41.73″ N, 5°38′ 59.86″ E; 263 m a.s.l.). Sampling was carried out on a flood-irrigated, insecticide-free plot of 218.75 m², with loamy-clayey soil, cultivated since 2007 under bio-conditions. Irrigation is performed by flooding since, as mentioned by Smith et al. (1999), lucerne prefers deep, well-drained loam soils.

During 2018, general entomofauna monitoring was conducted using conventional circular yellow water traps of 30 cm diameter. Water traps are simple, easy-to-use, effective, and inexpensive general sampling tools for phytophagous insects as aphids, also suitable for assessing the abundance of Diptera auxiliaries such as Tachinidae and Syrphidae, and Hymenoptera parasitoids. Yellow is the most commonly used color as attractant and has been shown to capture significantly higher numbers of species than other trap colors. This method performs equally well or even better than Malaise traps for pollinator sampling (Acharya 2021, Campbell and Hanula 2007, Franck 2013, Jaques et al. 2023, Kirk 1984).

Insect sampling was carried out using two variants: one trap placed within the lucerne crop (WT1) and one trap placed on bare ground, in approximately 30 m distance from the crop (WT2). Each trap was filled to two-thirds of its volume with an immersion medium consisting of clear water mixed with a few drops of detergent. Sampling was conducted weekly over a three-month period (Aljoboory and Saber 2022), from mid-winter (18 January 2018) to mid-spring (15 April 2018). This period coincided with crop re-growth and peak insect activity till the next crop mowing (Seghir et al. 2022).

Collected insects were preserved in tubes containing 70% ethanol and transported to the laboratory for identification and counting. The number of individuals was reported at species level only for the most abundant harmful taxa, whereas for the remaining groups, individuals were counted at family level.

Insect identification was carried out using available taxonomic keys and guides. The Mikes Insect Keys were mainly used for the identification of families across different orders, as well as for certain Coleoptera species (Cryptophagidae: *Atomaria* and *Cryptophagus* species). Wolfgang and Werner (2009) were consulted for families from multiple orders, Bílý et al. (2011) for the Buprestidae family, SPHDS (2017) for Hemiptera, and babel.csfoy.ca for Hymenoptera. Tolman and Lewington (1999) were utilised for Lepidoptera, San Martin (2004) for Neuroptera, and Moritz (1994) for Thysanoptera.

In addition, some online resources were consulted for species identification and confirmation, mainly boldsystems.org, encyclopedie-pucerons, and waspweb.org. Consequently, some insect taxa could only be identified to genus level.

The climatic conditions of the study region are typically Mediterranean, character-

Table 1: Main values of climatic conditions in 2018, with Maximal Wind Records.

Month	Tm (°c)	H (%)	P (mm)	Wm (Km/h)	Wmax (Km/h)	WmaxR
January	13.7	52.3	0.25	18.1	29.4	42.8 (on 21st, 22ndand 27th)
February	12.2	55.6	8.39	16.8	27.7	50 (on the 3rd)
March	17.5	44.5	11.67	22.3	36	68 (on 16th) and 64 on 17th
April	22.4	40.7	0.5	19.4	33.9	53.5 on 8th and 14th)

Tm: mean temperature, H: humidity, P: precipitation, Wm: mean speed value of wind, Wmax:mean of the maximum wind speed values, WmaxR maximum record of wind ized by mild winters and hot, dry summers. Monthly climatic data corresponding to the study period, including records of maximum wind intensity in the Biskra region, were obtained from https://fr.tutiempo.net/ and are summarized in Table 1.

Family diversity, for both the lucerne crop and the bare ground, was assessed using the Shannon diversity index (**H'**), which permits the evaluation of taxa diversity within family level (Magurran 2004). The Shannon index is expressed as follows:

$$H' = -\Sigma pi \ln pi$$

where: **i**: a taxon from the study environment; **Pi**: relative frequency of the taxon.

Statistical analyses were carried out using SPSS 10. software. The Chi-square was used to compare between numbers of individuals per order per date of capture between the two variants (lucerne crop and bare land). A probability level of 0.05 was used to determine statistical significance.

Results

Individuals' abundance. In the El-Outaya plain, the 2018 survey for lucerne revealed 80 insect species, distributed across seven orders and 47 families. Hymenoptera was the most diverse, with 21 species, followed by Diptera (18 species), Hemiptera (14 species), Coleoptera (12 species), Lepidoptera (8 species), Thysanoptera (5 species), and Neuroptera (2 species).

Hymenoptera was the richest order qualitatively. In contrast, Diptera was the richest order quantitatively on the lucerne site, whereas Hemiptera was the richest order quantitatively on bare ground. Thus, the trap on bare ground WT2 captured fewer individuals (1618) dominated by Hemiptera, compared to the trap on the lucerne site (WT1), which captured (3037) with the dominance of Diptera. The Shannon diversity Index was higher on the lucerne site than on bare ground (Table 2).

Statistical tests comparing the abundance of different orders between the lucerne site and bare ground revealed significant differences for five orders ($p < 0.05$): Coleoptera, Diptera, Lepidoptera, Neuroptera, and Thysanoptera. In contrast, Hemiptera and Hymenoptera showed no significant differences (Table 2).

Pests and beneficial species. Hemiptera represented the highest number amongst agricultural pest species (14), followed by Lepidoptera and Coleoptera with 8 species each. Thysanoptera, Diptera, Hymenoptera and Neuroptera accounted for 4, 3, 2 and 0 species, respectively. Meanwhile, Hymenoptera had the highest number of beneficial species (19) followed by Diptera, Coleoptera, Neuroptera, Thysanoptera, and He-

Table 2: Number of families, species and individuals per order, Chi-square results and Shannon Weaver Index.

Order	NbrF	NbrS	IndWT1*	IndWT 2*	Total	Chi-square	P-value
Coleoptera	9	*12*	198	71	269	23.667	0.023
Diptera	13	*18*	1326	148	1474	30.667	0.010
Hemiptera	5	14	796	1000	1796	0.000	1.00
Hymenoptera	16	21	177	80	257	8.5000	0.862
Lepidoptera	5	8	10	2	12	43.667	0.000
Neuroptera	2	2	27	2	29	46.000	0.000
Thysanoptera	4	5	503	315	818	27.522	0.011
Total	**54**	**80**	**3037**	**1618**	**4655**	/	/
Shannon index			***1.415***	***1.137***	***1.408***	/	/

NbrF: Number of Families, **NbrS:** Number of species, **IndWT 1*:** Number of individuals in trap 1 (Lucerne site), **IndWT 2*:** Number of individuals in trap 2 (bare ground).

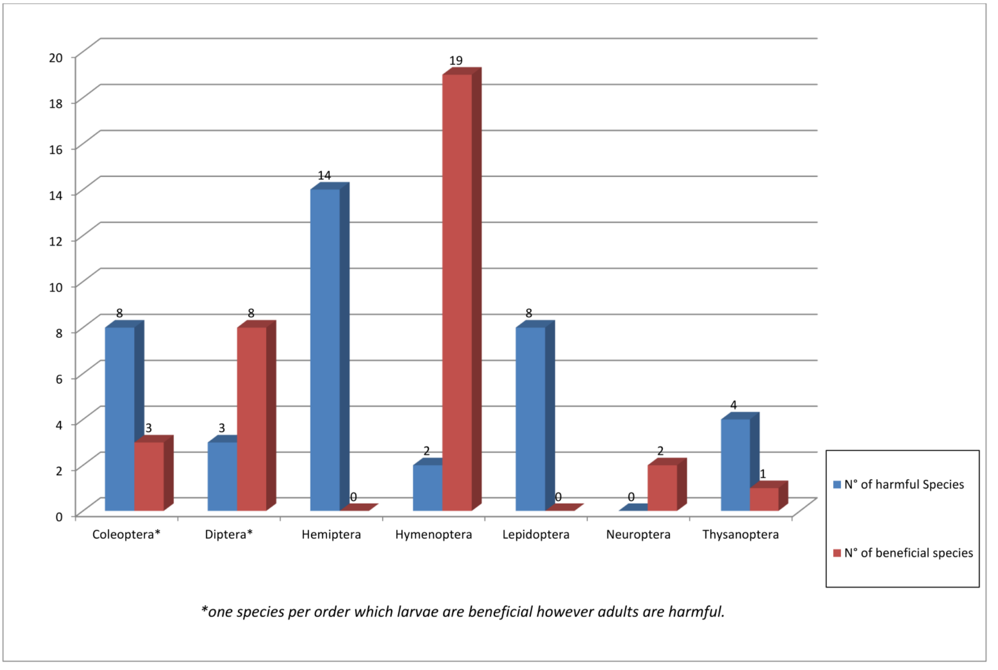

FIG. 1: Number of pests and beneficial species per order.

miptera with 8, 3, 2,1 and 0 species, respectively (Fig 1.).

Species diversity. Our study revealed the presence of 80 species, which are listed alphabetically by order, family, genus, and species. Categories of insects' according to their feeding preferences are also provided in Table 3.

With respect to the insects' feeding preferences, 38 species (47.5%) were phytophagous: specifically, Hemiptera 14 species, Lepidoptera 8 species, Coleoptera 8 species, Thysanoptera 4 species, and Diptera 3 species. Twenty-two species (27.5%) were entomophagous (predators or parasitoids), of which three also functioned as pollinators and one was simultaneously detritivorous. Additionally, the larvae of two species were predatory or parasitoid, while adults were phytophagous or floricolous. These entomophagous species included 9 hymenopterans, 7 dipterans, 3 coleopterans, 2 neuropterans and 1 thysanopterus. Eleven species (13.75%) were mainly pollinators, and 9 (11.25%) belonged to other feeding groups, including hematophagous, detritivorous, saprophagous or species with predatory larvae and phytophagous, floricolous or pollinator adults.

Dominant pest species. Most agricultural pest insects belong to the Hemiptera order, mainly Triozidae in WT1 and Aphididae in WT2. The most abundant and dominant pests pecies on the lucerne site was *Bactericera* sp. with 299 individuals, followed by *Empoasca* sp. (Cicadellidae) with 230 individuals. In contrast, *Therioaphis trifolii* (Aphididae) was represented by only 35 individuals (Table 4).

Benificial insects' families. Beneficial detected insects belonged to Syrphidae (5 species), Apidae (4 species), Ichneumonidae (4 species), Braconidae (3 species), Halictidae (3 species), and Vespidae (2 species), while all other families were represented by one species (Table 5).

Discussion

Studying the entomofauna of lucerne is essential for developing integrated pest management programs in the Biskra region

Table 3: Biodiversity and categories of insect species captured on lucerne site at Bio-Resources Station El-Outaya (Biskra, Algeria) during 2018.

Order	Family	Species	Categories (Diets)
Coleoptera	Buprestidae	*Acmaeodera* sp.	Phytophagous
		Acmaeoderella discoida	Phytophagous
	Chrysomelidae	*Cryptocephalus rugicollis*	Phytophagous
		Phyllotreta sp.	Phytophagous
	Coccinellidae	*Coccinella septempunctata*	Aphidiphagous
	Cryptophagidae	*Cryptophagus acutangulus*	Detritivorous (Fungivorous)
		Atomaria fuscata	Phytophagous
	Curculionidae	*Ceutorhynchus* sp.	Phytophagous
	Meloidae	*Lytta vesicatoria*	Larva Predatory/ Adults Phytophagous
	Scarabaeidae	*Oxythyrea cinctella*	Phytophagous
		Pleurophorus caesus	Saprophagous
	Staphylinidae	*Anotylus tetracarinatus*	Predatory and Detritus
Diptera	Agromyzidae	*Agromyza* sp.	Phytophagous
		Liriomyza sp.	Phytophagous
	Bombyliidae	*Exoprosopa* sp.	Pollinator
	Calliphoridae	*Lucilia sericata*	Necrophagous
	Ceratopogonidae	*Forcipomyia glauca*	Hematophagous
	Chironomidae	*Chironomus* sp.	Detritivorous
	Culicidae	*Culex* sp.	Females Hematophagous/ males feed on pollen and nectar/ larva decay organic matter
	Hybotidae	*Platypalpus* sp.	Predators of small Diptera/ rarely flower-dwelling
	Muscidae	*Musca domestica*	Detritivorous Larva/ adults are mainly carnivorous
	Sciaridae	*Sciara* sp.	Detritivorous (Decaying plant matter)
	Simuliidae	*Simulium* sp.	Hematophagous
	Syrphidae	*Episyrphus* sp.	Predator
		Eristalinus aeneus	Predator
		Helophilus trivittatus	Predator/pollinator
		Lapposyrphus lapponicus	Predators
		Sphaerophoria philanthus	Predators

Table 3: continued.

	Tachinidae	*Stiremania* sp.	Larva Parasitoid / Adult Floricolous
	Tephritidae	*Tephritis* sp.	Phytophagous
Hemiptera	Aphididae	*Acyrthosiphon pisum*	Phytophagous
		Aphis sp.	Phytophagous
		Brachycaudus helichrysi	Phytophagous
		Hyperomyzus lactucae	Phytophagous
		Macrosiphum euphorbiae	Phytophagous
		Myzus persicae	Phytophagous
		Rhopalosiphum maidis	Phytophagous
		Therioaphistrifolii	Phytophagous
		Uroleucon inulae	Phytophagous
	Cicadellidae	*Deltocephalus* sp.	Phytophagous
		Empoasca sp.	Phytophagous
	Delphacidae	*Laodelphax* sp.	Phytophagous
	Pentatomidae	*Nezara viridula*	Phytophagous
	Triozidae	*Bactericera* sp.	Phytophagous
Hymenoptera	Andrenidae	*Andrena* sp.	Pollinator
	Apidae	*Amegilla* sp.	Pollinator
		Anthophora sp.	Pollinator
		Apis mellifera	Pollinator
		Eucera sp.	Pollinator
	Argidae	*Arge* sp.	Phytophagous larva/ pollinator
	Braconidae	*Cotesia glomerata*	Parasitoid
		Dacnusa sp.	Predator of *liriomyza*sp.
		Opius sp.	Parasitoid
	Cynipidae	*Diplolepis* sp.	phytophagous
	Halictidae	*Halictus* sp.	Pollinator
		Lasioglossum sp.	Pollinator
		Sphecodes ruficrus	Cleptoparasitesolylectic
	Ichneumonidae	*Dichrogaster aestivalis*	Endoparasitoid (hoverflies
		Diplazon laetatorius	hover fly parasitoid
		Exetastes syriacus	Endoparastoid (Arctiinae)
		Ophion luteus	Parasitoid of noctoids
	Megachilidae	*Chalicodoma sicula*	Pollinator
	Pemphredonidae	*Diodontus* sp.	Pollinator
	Vespidae	*Eumenes mediterraneus*	Pollinator
		Polistes sp.	Predators/pollinators

Table 3: continued.

Lepidoptera	Gelechiidae	*Tuta absoluta*	Phytophagous
	Pieridae	*Colias croceus*	Phytophagous
		Pieris rapae	Phytophagous
		Pontia daplidice	Phytophagous
	Lycaenidae	*Leptotes pirithous*	Phytophagous
	Noctuidae	*Autographa gamma*	Phytophagous
	Nymphalidae	*Cynthia cardui*	Phytophagous
		Danaus chrysippus	Phytophagous
Neuroptera	Chrysopidae	*Chrysoperla carnea*	Predator
	Hemerobiidae	*Hemerobius* sp.	Predator
Thysanoptera	Aeolothripidae	*Aeolothrips intermedius*	Predator
	Melanthripidae	*Melanthrips fuscus*	Phytophagous
	Phlaeothripidae	*Haplothrips setiger*	Phytophagous
	Thripidae	*Frankliniella occidentalis*	Phytophagous
		Odontothrips confusus	Phytophagous

(Algeria). From a quantitative point of view, the most representative orders in this study were Diptera, Hemiptera, Thysanoptera, Coleoptera, Hymenoptera, Neuroptera, and Lepidoptera. The total recorded number of individuals greatly exceeded those reported by Bendoumia et al. (2016) in Mitidja (528 individuals), and by Barkat (2019) in Biskra (346 individuals). This difference may be attributed to the irrigation method: in the present study, lucerne was irrigated by submersion, whereas previous studies used sprinkler irrigation. Cultivation age may also play a role; Kherbouche et al. (2015) reported that the number of individuals increased with the age of lucerne, with a count slightly higher than ours (4997 individuals) in a three-year-old lucerne crop. Similarly, Valverde-Rodríguez et al. (2024) recorded 4375 specimens across five lucerne varieties using sweep-netting and beating plants over a plastic tray (for sedentary insects).

Table 4: Agricultural pest families and main species on lucerne in Bio-Resources Station, El-Outaya (Biskra, Algeria).

Harmful families	**Main species**	**Individuals (WT1) ***	**Individuals (WT2) ****
Aphididae		**240**	**506**
	Therioaphis trifolii	35	–
Cicadellidae		**251**	**112**
	Empoasca sp.	230	95
Triozidae		**299**	**382**
	Bactericera sp.	299	382
Total per family		**790**	**1000**

"-" not observed; * number of individuals in trap 1 (Lucerne site); ** number of individuals in trap 2 (bare ground).

Qualitatively, the number of 80 species recorded in the present study was similar to that reported by Bendoumia et al. (2016) with 72 species, but exceeded what Barkat (2019) reported for Biskra (Algeria), with 37 species. Meanwhile, Genzhemuratovna and Sherniyazovich (2021) identified 125 species from 29 families and 9 orders of insects in the Republic of Karakalpakistan.

Quantitative differences between the two variants WT1 and WT2 could be attributed to the trophic factor. Thus, according to Wenda-Piesik and Piesik (2021), the trophic interactions between plants and herbivorous insects are considered to be one of the primary relationships that occur in agroecosystems. The cultivation of a single plant species, especially in monocultures, promotes the development of specialized phytophagous, as monocultures, which are typical for intensive agriculture, offer ideal conditions to specialized herbivores (Balmer et al., 2014). Additionally, the management of lucerne under bio-conditions (absence of chemical treatments, especially insecticides) in El-Outaya region is indeed another factor for higher diversity. Thus, Abdel Farag El-Shafie (2022) reported that organic farming strongly enhances insects' abundance and biodiversity.

The higher abundance of Hemiptera in WT2 (bare ground) could be justified by climatic factors, particularly wind speed and direction, which reached elevated values during the experimental period (Table 1) and could have caused involuntary dispersal. Similar reports were made by Hall (2009) and Antolínez et al. (2021) on psyllids, by Alyokhin et al. (2011) and Devegili et al. (2019) on aphids, and by Santos et al. (2025), who noted that wind patterns and host plant availability influence early-season population dynamics of *Empoasca fabae*. The low abundance of aphids in this study may be related to lower temperatures, consistent with Lykouressis and Polatsidis (1990), who reported higher population densities of *Acyrthosiphon pisum* and *Therioaphis trifolii* during warmer months.

The identified species in El-Outaya site were not all directly related to lucerne. Several species may accidentally enter the lucerne site or are associated with weeds, within or close to the site. Nevertheless, recording their occurrence is important as it contributes to a more comprehensive understanding of lucerne-associated entomofauna in Biskra region (Algeria). In this context, Genzhemuratovna and Sherniyazovich (2021) reported that the formation of entomofauna on lucerne, as on any other crop, is determined primarily by the crop itself, its preceding crop, and the surrounding microenvironment. This largely explains the occurrence of both randomly encountered insect species and specialized mono- or oligophagous species within lucerne agroecosystems.

The dominance of phytophagous species can be attributed to trophic factors, as lucerne represents a suitable host plant that provides both a favorable microclimate, as well as abundant, nutritious resources. According to Satti and Bilal (2012), lucerne crops offer a suitable microclimate for aphids and other soft-bodied insects, which in turn sustain predator populations. Similarly, Premalatha et al. (2024) reported that nutritional composition, plant architecture, and the availability of resources such as moisture and sunlight contribute to the preference of insects for lucerne.

More than 45% of the collected specimens were agricultural pests; this could be attributed to the age of the cultivation (more than 10 years). Thus, Nikolova (2021) stated that a clear trend was observed of increasing the share of agricultural pest species and reducing the beneficial ones with the lucerne development over the years. In their study, Tamer et al. (1997) identified 60 pest insect species and 36 beneficial insect species associated with lucerne and sainfoin.

Most agricultural pest insects, with potential to cause economic damage belonged to the order Hemiptera however, only five species seem to be pestilent to lucerne and have been reported as pests in different regions worldwide. These include *Bactericera* sp. in the USA (Crawford, 1914), *Odontothrips confusus* in France and the Czech Republic (Pitkin, 1972), *E. fabae* in Canada (Faris et al. 1981), *T. trifolii* in Australia

(Hughes 1987), and *A. pisum* in Isfahan, Iran (Rakhshani et al. 2010). Among these economically important species, *Bactericera* sp. and *Empoasca* sp. were recorded in high numbers in the present study, indicating the need for further investigation, particularly regarding economic thresholds and management strategies.

However, identified predator species such as *Aeolothrips intermedius*, *Chrysoperla carnea*, *Coccinella septempunctata*, *Episyrphus* sp., and *Sphaerophoria philanthus* could be exploited for biological control of these pests and may play a significant role in regulating lucerne agro-ecosystems. (Cotte and Cruz1988, Cunha et al. 2016, Nikolova 2024, Sarkar et al. 2023, Weiser Erlandson and Obrycki 2010, Zhang et al. 2023).

The identified pollinators belonged predominantly to the order Hymenoptera, with two species belonging to Diptera (Bombyliidae and Syrphidae). Similarly, Taha et al. (2016) reported the dominance of Hymenoptera among lucerne pollinators in Saudi Arabia. Kirilov et al. (2016) also noted that lucerne is a preferred crop after sainfoin, with seven identified hymenopteran species. In contrast, Cole et al. (2022) observed relatively few pollinators on *M. sativa*, although the crop was frequently visited by hoverflies. Likewise, Kumar et al. (2024) reported the dominance of Hymenoptera in India and emphasized pollination as a paramount ecosystem service provided by insect pollinators. According to Łowicki and Fagiewicz (2021) pollinators contribute directly to crop yield, while lucerne offers nesting and floral resources. Furthermore, insect pollinators of lucerne play a vital role in ensuring successful fertilization and seed development (Kumar and Doddamani 2024) and may also serve as bio-indicators of ecosystem health (Kevan 1999).

In addition to phytophagous, predator, and pollinator species, detritivorous species also contribute to the diversity of the lucerne ecosystem in the Biskra region. These insects play an important role in maintaining ecosystem balance through their functions in decomposition and nutrient recycling. According to Rupali et al. (2024), detritivorous insects are vital to decay processes and nutrient cycling, thereby sustaining ecosystem health and soil fertility.

Continuous monitoring is essential for assessing the role of pests in qualitative and quantitative yield losses and for identifying natural enemies that can support eco-friendly pest management strategies (Premalatha et al. 2024). Establishing region-specific intervention thresholds is therefore a priority. Summers et al. (2007) emphasized that examining insect populations in each field is the only reliable method for accurately assessing population levels. They further recommended maintaining records of pest and natural enemy abundances, along with weather conditions and crop management practices. Lucerne fields should be monitored weekly during periods of pest activity, with increased monitoring frequency as pest populations approach economic threshold levels.

Lucerne represents a model forage crop for arid regions, such as Biskra, and is highly suitable for integrated pest management (IPM) programs. This perennial crop, characterized by a deep root system, can withstand pest pressure and harsh environmental conditions such as drought, even when cultivated over long periods (exceeding 10 years in the present study) under bio-conditions. Lucerne provides a balanced environment that supports the establishment of diverse insect communities belonging to different functional groups, including predators and parasitoids that persist and feed on insect pests. Nevertheless, the most valuable management proposal remains the implementation of a regular inspection program targeting susceptible pests in lucerne fields of this region, using precise scouting methods focused primarily on plant stems and leaves.

When monitoring indicates that a pest population has reached its economic threshold, farmers are advised to implement an integrated pest management (IPM) program in lucerne fields of this region. Naser and Akordouch (2022) reported that the use of selective insecticides with low mammalian toxicity, while preserving beneficial insects, can reduce production costs and contribute to the production of safer and healthier food.

The adoption of integrated pest management, combined with the synergy of multiple control techniques, has the potential to reduce the impact of insect pests on crop nutritional quality while conserving beneficial organisms by minimizing pesticide applications (Ouaarous et al. 2025).

Conclusion

Lucerne cultivation in arid regions, mainly in El-Outaya (Biskra, Algeria), is of great importance as a fodder crop. The present study examined the entomofauna associated with lucerne to provide new insights into this previously undocumented component of the local ecosystem. Based on species' feeding preferences, approximately half of the identified species were phytophagous, with Hemiptera being the dominant order. Amongst Hemiptera, Aphididae was the most highly represented family qualitatively, while Cicadellidae and Psyllidae ranked highest in terms of individual abundance. Simultaneously, beneficial species made up more than one third of total identified species mainly from the Hymenoptera order with eight families of which Apidae, Ichneumonidae, and Braconidae were the most represented. By means of our results, more attention must be given to studies on the impact of both harmful and beneficial insect species on lucerne crops to support sustainable management practices.

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