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Entomofaunal diversity and similarity indices of different agroecosystems in northwest Algeria

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ABSTRACT. The present study has been carried out in order to determine the entomofauna of four different agroecosystems from the study area, northwestern Algeria. Regular sampling was done using the Barber pitfall trap and the sweep net in addition to visual observations in the field. Nine (09) taxonomic orders of insects was identified from the four studied environments. It varies from one agroecosystem to another. Coleoptera and Orthoptera were the most represented in terms of both species and numbers. Entomofaunal diversity was more important in un-cultivated fields (diversity index = 4.15 bits, equitability = 0.89) than in arable fields (index ranging from 1.68 to 2.87 and a equitability between 0.41 and 0.72). Limited biodiversity in cultivated areas was the consequence of insect communities' interactions disturbances caused by agricultural practices in these environments. Therefore, it is important to reduce these disturbances in order to enhance food resources, habitats and overwintering sites for insects. This will ensures sustainable entomological diversity, thereby increasing the role of biological control in pest management systems.

Key words: Agriculture, Agroecosystem, Diversity, Entomofauna, Insects

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Introduction

Insects represent more than half of the current living species, about one million species are yet identified (Meurgey, 2011). One-third of determined insects belonging to Coleoptera order with about 350,000 species, followed by Diptera with 150 000 species and Lepidoptera with 120,000 species (Zagatti et al., 2001). These include a large number of so-called harmful species, which are responsible for crops damage, but also an equally large number of insects species that are able to regulate phyto-phagous species populations.

Entomological fauna composition varies not only during the year depending on the life cycles of the species (Corbara, 2004), but also from one year to another due to several factors, including human-induced

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disturbances, such as destruction and fragmentation of natural habitats, or the application of pesticides in arable areas. Altieri (1994) noted that a key strategy in sustainable agriculture is to restore biodiversity. This one performs key ecological services and if correctly assembled in time and space can lead to agroecosystems capable of sponsoring their own soil fertility, crop productivity and protection with regulation through restoration of natural control of insect pests, diseases and nematodes (Altieri, 1999).

Identifying the diversity and abundance of entomofauna, especially in agricultural environments, allows us to identify the key pests of our potential crops, their natural enemies and other beneficial species. The outcome of the current study will contribute in developing tools to enhance the effectiveness of auxiliaries in the study area, in order to support organic agriculture and productivity of our agrosystems. In this context, this study was conducted.

Material and methods

The present study was done out in the Chlef area which is located about 200km northwest of Algiers and 36°12′ N, 1°19′ E. It is an agricultural region, located in Chlef valley, one of the most fertile regions of Algeria.

The main aim of the study is identifying the entomofauna of potential crops grown in the region. For this purpose, three crops have been chosen; a cereal field (*Triticum durum* Dest), a potato field (*Solanum tuberosum* L.), a citrus orchard (*Citrus sp.* L.) and an uncultivated field. In each of the studied environments, regular sampling was done using the Barber pitfall trap and the sweep net in addition to visual observations in the field.

In each field, six (06) Barber pitfall traps were deposited in a regular triangle in a perimeter of 180 meter, a black trap was placed at the top, however yellow traps were suspended in the middle of each side. The interval between two consecutive traps was 30 meters. Yellow traps are effective for attracting flying insects and heliophiles (Duelli et al., 1999), while black traps are suitable for walking insects, accustomed to hiding in crevices and litter (Roth, 1972). The Barber trap is one of the best ways to capture the above ground fauna (Biaggini et al., 2007). Captured insects were collected every 15 days and stored in glass jars containing 70% alcohol, before being processed in the laboratory. After each collection, sampling plots were changed in order to avoid over-exhaustion of the surrounding entomofauna. To capture small species of geophilic arthropods, we added sweep net capture, an effective tool to collect flying arthropods inhabiting grasses and shrubs. For the analysis of the results, using the excel software, we calculated:

The centesimal frequency Fc=Ni. 100/N of which Ni is the ratio of the number of individuals of a species found in a given environment and N is the total number of individuals of all species combined (Dajoz, 1985).

The Shannon-Waever diversity index H = -Σi Pi (log Pi) where Pi is the proportion of the total number of individuals that are counted of a species i. It provides both information on species richness and abundance (Barrantes & Sandoval, 2009).

The equitability index represents the ratio of the calculated Shannon index to the theoretical maximum index in the population [$E = H/H_{max}$, where H_{max}= Log2 S (S being the number of species)]. This index varies between 0 and 1 (Blondel, 1979).

The Jaccard index S1-2 = W/A + BW where S1-2 is the Jaccard index between habitats 1 and 2, W is the abundance of species common to both sites, A is the abundance of species in the middle A and

B being the abundance of species in the B medium. It makes it possible to determine the similarities between the fauna of the environments studied, taking into account the abundance of species in each environment (Younes & Sporta, 2004).

Results

Entomological inventory of the four agricultural environments

The entomofauna identified in the four prospected agroecosystems was divided into 9 orders. Insect species varied from one agroecosystem to another. In fact, we identified 95 species in the uncultivated field, and only 72 species in the citrus orchard, 60 in the cereal field and only 27 species in the potato field. The highest number of recorded species belonged to the orders of Coleoptera and Orthoptera, followed by Hymenoptera and Heteroptera. The remaining species were divided over the other orders.

The largest number of insects was reported in the uncultivated field (936 individuals) followed by the citrus tree crop environments (803 individuals), then the cereal crop (715 individuals) and finally the potato crop with 465 individuals.

In cereal and the potato fields, insect species belonged to Orthoptera were the most common with 44.2% and 33.3% respectively, and the order of Coleoptera was second, with 36.4% and 26%. In contrast, in the uncultivated field, we have recorded 32.91% of Orthoptera and 34.19% of Coleoptera. However, in the citrus orchard, insect species belonged to homoptera order were dominant with 26.9%, followed by Coleoptera with only 16.9%.

Heteroptera, Hymenoptera, Lepidoptera and Diptera were also present in all agrosystems but with lower frequencies. Whereas, Dictyoptera and Dermaptera were scarce and completely absent in the potato field.

Table 1. Number and frequency centesimal of different orders in the four agroecosystems.

Orders	Cereal field			Potato field			Citrus orchard			Un-cultivated field		
	No. sp	No. ind	C.fr (%)	No. sp	No. ind	C.fr (%)	No. sp	No. ind	C.fr (%)	No. sp	No. ind	F.c
Dictyoptera	2	5	0.7	0	-	-	2	15	1.87	1	9	0.96
Orthoptera	27	316	44.19	9	155	33.33	14	102	12.7	35	320	34.19
Dermaptera	0	-	-	0	-	-	2	23	2.86	1	18	1.92
Heteroptera	7	80	11.19	1	24	5.16	7	120	14.94	7	69	7.37
Homoptera	1	8	1.12	2	60	12.9	11	216	26.9	0	-	-
Coleoptera	17	260	36.36	7	121	26.02	21	136	16.94	39	308	32.91
Hymenoptera	4	25	3.5	4	44	9.46	9	69	8.59	7	102	10.9
Diptera	1	12	1.68	2	33	7.1	4	58	7.22	4	76	8.12
Lepidoptera	1	9	1.26	2	28	6.02	2	64	7.97	1	34	3.63
Total	60	715	100	27	465	100	72	803	100	95	936	100

No. sp: number of species, **No. ind:** number of individuals, **C.fr:** centesimal frequency

Faunistic diversity of agroecosystems

Shannon-Wiever's Diversity index and equitability values showed that the uncultivated field was the most diversified ecosystem with a diversity index of 4.15 bits and an equitability of 0.89 (Table 2) . In second position, the cereal field, its Shannon-Wiever's Diversity index was 2.87 bits and an equitability index of 0.72. The citrus orchard was third, this perennial agroecosystem showed a diversity index of 2.45 bits and an equitability of 0.51. However the lowest level of diversity and equitability was noted in potato crop field, with only 1.68 and 0.4 respectively.

The highest values of the Shannon-Wiever index and equitability were recorded in spring and summer, lesser in autumn, and significantly low in winter. Moreover, in uncultivated and cereal fields, diversity has reached its highest values in spring, Shannon-Wiever index values showed 4.28 bits and 3.47, whereas equitability values were 0.91 and 0.88 espectively. In citrus orchard and the potato field, the highest diversity values in the perennial agroecosystem were noted in summer with an Shanon-Wiever index of 2.78 bits against 2.75 bits in spring. In potato field Shannon –Wiever index has been evaluated at 1.88 bits in summer against 1.81 bits in spring (Table 3).

Table 2. Values of Shannon-Wiever diversity index and equitability calculated for each agroecosystem.

Agroecosystems Parameters	Cereal field	Potato field	Citrus orchard	Uncultivated field
H (bits)	2.87	1.68	2.45	4.15
H_{max} (bits)	4.02	3.37	4.42	4.85
E	0.72	0.41	0.51	0.89

H: Shannon-Wiever index, **H_{max}:** maximum Shannon-Wiever index, **E:** equitability.

Table 3. Values of Shannon-Wiever index and equitability calculated for each agro-ecosystem in four Seasons.

Agroecosystems	Parameters	Winter	Spring	Summer	Autumn
Cereal field	H (bits)	0.7	3.47	3.23	2.O5
	H_{max} (bits)	2.12	4.17	3.76	2.86
	E	0.28	0.88	0.82	0.58
Potato field	H (bits)	0.72	1.81	1.88	1.24
	H_{max} (bits)	2.65	3.41	3.44	3.12
	E	0.21	0.48	0.55	0.33
Citrus orchard	H (bits)	1.2	2.75	2.78	1.93
	H_{max} (bits)	2.5	4.01	4.09	3.61
	E	0.38	0.72	0.74	0.47
Uncultivated field	H (bits)	1.64	4.28	3.75	2.87
	H_{max} (bits)	2.89	4.29	4.27	3.77
	E	0.47	0.91	0.86	0.71

Entomological similarity of agroecosystems studied

Similarity of the whole recorded entomofauna with that of the uncultivated land was 0.39, in the citrus orchard, 0.29 of similarity was found, 0.25 with the cereal crop and only 0.12 with entomofauna from potato field. Comparison between the four agricultural lands has revealed that the highest similarities were noted between the uncultivated land and that of the cereals and citrus grove with an index of 0.36 and 0.19 respectively. The other values of the similarities varied from 0.11 to 0.17 (Table 4).

Table 4. Values of the quantitative Jaccard community index calculated between the entomofauna of the four agroecosystems.

Entomofauna	E. C	E. P	E. C.O	E. U
A. E	0.25	0.12	0.29	0.39
E.C		0.17	0.11	0.36
E.P			0.16	0.15
E.C.O				0.19

A.E: all entomofauna, **E.C:** entomofauna of the cereal field, **E.P:** entomofauna of the potato field, **E.C.O:** entomofauna of the citrus orchard; **E.U:** entomofauna of the uncultivated field.

Discussion

The composition of entomofauna recorded in the studied agrosystems was dominated by Coleoptera, followed by Orthoptera. Coleoptera represent one-third of the world's known insects (Zagatti et al., 2001). Several studies on entomofauna noted the dominance of the order of Coleoptara as those carried out in the Sous Valley in Morocco by Smirnoff (1991), in the protected park of Babor mountain in Algeria by Benkhelil & Doumandji (1992) and by Brunel (1998) at the Mount Souprat and Corniche de Pail. Orthoptera species are phytophagous and and very harmful on crops. Their abundance has been reported by Boukhemza et al. (2000, 2004), by studying the diet of an insectivorous bird (*Bubulcus ibis* L.) by examining these pellets, in an uncultivated and a cereal field in Kabylie, but they are often less abundant in fruit tree and horticultural crops. These observations were supported by the studies carried out in Benin by Hautier et al. (2003) and by Smirnoff (1991) in Morocco.

Insect populations varied from one agrosystem to another. However, the noticed presence of annual crops and the scarcity of perennial ecosystems lead the landscape to become uniform, and consequently less biodiversity and resilience of the ecosystem (Lacoste & Salanon, 2001).

Chambon (1983) worked on the entomological complex of cereal fields conducted under the usual conditions of agricultural practice, its variations during the year and for over a decade in the Fontainebleau region, allowed the capture of 100 000 individuals per year and by fields. This fauna consists of about 1000 species of which only 3% grow at the expense of cereals. In New Zealand, on wheat and barley crops, Bejakovich et al. (1998) found 106 species on wheat and 95 species on barley. In contrast, Gallo & Pekxr (1999) recorded 64 species on winter wheat in Slovakia. In Algeria, a study of potato entomofauna in the Djelfa region revealed the presence of 92 species trapped in Barber traps and 125 other species attracted with yellow traps (Belatra et al., 2012). As for uncultivated fields, there are few studies on their role as wildlife habitat. However, there are animals, particularly insects requiring open habitats, developed herbaceous or shrub cover or those seeking preys present in this habitat (Cusson, 2006). The variation in the frequency of insect abundance from one crop to another is explained by several conditions, including monocultures that are frequently invaded by pests (Dajoz, 2003).

In this study area, the most diversified ecosystem is the uncultivated one, followed by the cereal field, then the citrus orchard and finally the potato field. This was also the case in the Niort-Brioux plain south of the Deux-Sèvres where Clere & Bretagnolle (2001) found that the entomological diversity was low in a cereal field which is a disturbed environment and high in a fallow witch is less upset. It is known that in natural or poorly disturbed environments, biodiversity is high. On the other hand, the anthropic pressure in agriculture, which is exerted more in intensive agriculture, causes a weakness of faunistic wealth. Woolouse & Harmsen (1987) have shown that the variability of arthropod population abundance is higher in agroecosystems than in natural ecosystems. Altieri (1999) indicates that fallow lands are preferred habitats for species that require open spaces, but the agricultural fields where intensive farming is practiced, are habitats with minimal heterogeneity and are unattractive to most wildlife species except for the pests of these crops. Nevertheless, the evolution of agricultural activity also contributes to the enrichment of diversity. It creates and preserves particular ecosystems and habitats. Thus the mosaic made up of cultivated fields delimited by hedges and ditches provides the resource for certain types of flora and fauna. It is also the wintering ground for many insects (Pinay et al., 1993; Caubel, 2001). The relations between agriculture and biodiversity are interacting. Agricultural practices are at the heart of the mechanism, with action on the diversity of species and landscapes. This diversity may vary according to certain climatic characteristics. The nature and diversity of interactions also have an impact on ecosystem performance, since the density of the various populations that participate in the ecosystem is largely under the control of predation processes for access to resources. Any change in the intensity of these interactions modifies the structure of food webs and thus the functioning of ecosystems (Debras et al., 2007). Therefore, biodiversity conservation involves preserving both the diversity of genes in each species, the diversity of species, and the diversity of ecosystems (Lamy, 1999).

In all studied environments, entomological diversity was high in spring and summer, lesser in autumn and very low in winter. In winter, the lowest diversity was noted in the cereal field and the highest in the uncultivated field. Agricultural practices, particularly, tillage carried out in the cereal field could be at the origin of this imbalance. In addition, the use of insecticides, particularly those with a broad-spectrum action, can reduce the numbers and diversity of insects found in cereal crops (Vickerman & Sunderland, 1977).

The values of the Jaccard community index calculated for the stands of the four studied ecosystems showed that the entomofauna of these environments are by far different from each other. The richness of plant communities can favor that of insects (Hartley et al., 2003). In one hand, Off-crop fields clearly appear to be a favorable element for landscape by the evolution and maintenance of a high biodiversity in an agroecosystems, mainly for banal, rare and neutral species for agriculture than for beneficial species of crops (Thomas et al., 1999). On the other hand, cultivated environments are environments in which the intensity and frequency of disturbances allow only a small number of species to develop. In orchards, which constitute perennial and complex environments, plant diversity is mainly due to the creation of plant developments within the plot (vegetal cover) or border (hedgerows), as well as the presence of several layers exploitable by biological communities (Altieri & Schmidt, 1986; Rigamonti & Lozzia, 2002).

Data indicate that unweeded orchards exhibit a lower incidence of insect pests than weeded orchards, mainly because of an increased abundance and efficiency of predators and parasitoids (Ali Arous, 2008). Certain weeds (mostly Umbelliferae, Leguminosae and Compositae) play an important ecological role by harboring and supporting a complex of beneficial arthropods that aid in suppressing pest populations (Altieri, 1999).

At plot scale, any strong intensification of practices (fertilization, pesticides, grazing and tillage) leads to a negative effect on biodiversity in terms of reducing richness and trivialization of the species present, for a broad range of groups of organisms, as well as a profound change in the functional characteristics of the species. Many studies have demonstrated increased abundance of natural enemies and more effective biological control where crops are bordered by wild vegetation. These habitats may be important as overwintering sites for natural enemies and may provide increased resources such as alternative prey/hosts, pollen and nectar for parasitoids and predators from flowering plants (Altieri & Letourneau, 1982).

The total entomofauna found in the study area had significant similarity with the fauna inventoried in the uncultivated land, and slightly less with those of the cereal field and citrus orchard, but significantly low with the potato field. The presence of several strata exploitable by the biological communities (spatial aspect) and their maintenance (temporal aspect) is a situation potentially favorable to the maintenance of trophic chain and animal diversity. Nevertheless, in the potato field, cultural practices and the heavy crop protection management strategy do not allow, except in exceptional cases, to preserve a natural balance within this environment, hence a reduced faunal population (Debras et al., 2007), which could justify this dissimilarity with the entomofauna inventoried in the study area.

The results of this study are consistent with studies that suggest that the longer the agro-ecosystem diversity is intact, the more internal linkages develop to promote greater insect stability (Altieri, 1999).

Conclusion

The uncultivated field clearly appears as a part of the landscape favorable to the development of an important entomological diversity. Whereas, cultivated environments constitute environments in which a small number of species develop. This faunistic weaknesses is the consequence of the instability of these environments due to agricultural practices on the one hand and the expansion of monocultures at the expense of natural vegetation on the other hand, thus reducing in quantity and quality the necessary habitats and refuges to these species. This low entomological diversity results in an abundance of pests, thus a loss of production, from these results we can say that the enhancement of entomofaunistic richness by ensuring them wild plants in the cultivated areas, which serve as, hosts could be very powerful. Furthermore providing habitats and preys for beneficials by modifying crops and preserving the herbaceous vegetation and natural hedges will effectively contribute to sustainable pest management strategies.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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تنوع زیستی و شاخص‌های مشابهت فون حشرات در اکوسیستم‌های کشاورزی شمال‌غرب الجزایر

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چکیــده: مطالعه حاضر به منظور تعیین فون حشرات چهار اکوسیستم کشاورزی مختلف در منطقه مورد مطالعه در شمال غرب الجزایر انجام شد.. نمونه‌برداری منظم با استفاده از تله گودالی باربِر و تور حشره‌گیری علاوه بر مشاهدات بصری در مزرعه انجام شد. نه (۹) راسته حشرات از چهار منطقه مورد مطالعه شناسایی شد. حشرات شناسایی شده در هر اکوسیستم با اکوسیستم‌های دیگر متفاوت بودند. سخت‌بالپوشان و راست‌بالان فراوانی و تعداد گونه بیشتری داشتند. تنوع زیستی حشرات در مناطق کشت نشده (شاخص تنوع: ۴,۱۵ بیت، معادل ۰,۸۹) مقدار بیشتری نسبت به مزارع قابل کشت (مقدار شاخص بین ۱,۶۸ و ۲,۸۷ بیت، معادل ۰,۴۱ و ۰,۷۲) داشت. تنوع زیستی کم، در مناطق کشت شده در نتیجه ارتباط حشرات با فعالیت‌های کشاورزی در این مناطق است. بنابراین، مهم است که این اختلالات را به منظور افزایش مواد غذایی، زیستگاه و مکان‌های زمستان‌گذارانی برای حشرات کاهش دهیم. این امر تنوع زیستی پایدار را ایجاد می‌کند و در نتیجه نقش کنترل بیولوژیک در سیستم‌های مدیریت آفات را افزایش می‌دهد.

واژگــان کلیدی: کشـاورزی، اکوسیســتم کشـاورزی، تنــوع زیســتی، فــون حشــرات، حشرات