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Comparative Study of Insect Biodiversity in Cultivated and Natural Steppes in the Region of Sidi Kacem of Northwest Morocco

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ABSTRACT

Insects represent the most species-rich taxa of the animal kingdom. They are extremely important ecosystem components and help to perform various activities which are necessary for an ecological balance. They play a major role in maintaining the structure and function of the ecosystems. In Morocco, no scientific exploitation of resources regarding insect fauna has taken place in the agroecosystems. This study was aimed at creating the first inventory of insects collected from both cultivated and natural steppes in the region of Sidi Kacem of Northwest Morocco. An entomological investigation was carried out in 5 stations situated on 3 different soil types in the region of Sidi Kacem. Three stations were cultivated fields, and two were natural steppes. Sampling was done during spring and summer in 2020, using sweep net, sight hunting, and pitfall traps methods. Shannon-Weaver, Simpson, and equitability indexes along with Hill indexes were calculated. Seventy-eight species were identified which were distributed into 7 orders, belonging to 29 families. The results obtained showed a richness of Coleoptera by 44 species, Hemiptera by 9 species, Diptera by 6 species, Lepidoptera, Orthoptera, and Odonata by 5 species each, while Hymenoptera aggregating in the final place with 4 species. Furthermore, the diversity and abundance of insects were highest in Station 3 and lowest in Station 5. Soil texture and abundance of vegetation seemed to be the major drivers influencing species abundance and richness.

Keywords: Agroecosystems, Distribution, Ecological indices, Ground beetles, Trapping methods.

Introduction

Insects are important components in ecosystems. They play crucial functional roles that ensure the delivery of various ecosystem services which are important and necessary for an ecological balance. Also, they contribute to some aspects of human livelihood such as agriculture, tourism, and natural resource use.[1,2] Insects are ideal candidates for biodiversity monitoring to measure ecosystem health because of their short life cycles, high diversity, and large population sizes. Their survival is closely tied to the viability of the environment they live in.[3] This makes them very responsive to ecosystem changes and a good early warning indicator of perturbation or stability of the ecosystems.[4] However, despite their importance, the study of this group suffers from a lack of professional resources (professional entomologists, formation) and knowledge that is still fragmentary and incomplete. In Morocco, studies on invertebrate populations in continental ecosystems have focused on freshwater environments. Thus, several studies have focused on the faunistic composition of biocenoses, the structure of the population, their typology, variations in space, and time according to environmental factors. The investigations on these invertebrates were conducted in several studies.[5-10] On the other hand, relatively few studies were focused on terrestrial invertebrate populations. In the forestry sector, major work has been performed on the cork oak,[11,12] or holm oak.[13] The littoral and coastal environments have also been the subject of several researches.[14-17] Various studies were focused on the analysis of fecal biocenosis, mainly on cattle.[18-21] No ecological study on the arthropod biocenoses in highly anthropized agroecosystems has been carried out in Morocco so far. This research was therefore conducted to study the faunistic diversity of terrestrial insects in both the cultivated and natural fields in the region of Sidi Kacem of Northwest Morocco.

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Materials and Methods

Study area

The study was carried out in 5 different stations at the region of Sidi Kacem (34°13′00″N, 5°42′00″E) in northwest Morocco (Figure 1). The region has a semi-arid climate (rainy with moderate winters and hot and dry summers). The region's minimum temperature lowers to 6°C in the autumn, while the highest temperature in the summer exceeds 40°C. Precipitation occurs mainly from the end of September to the last day of May. The soil in the region is divided into three types: A loamy clay soil which is predominant and covers almost the entire study area with more than 75% of the surface area; A sandy clay loam soil; and finally, a clay soil.[22]

Collection of insects by trapping methods

Insects were collected from five localities in the Sidi Kacem region (Table 1).

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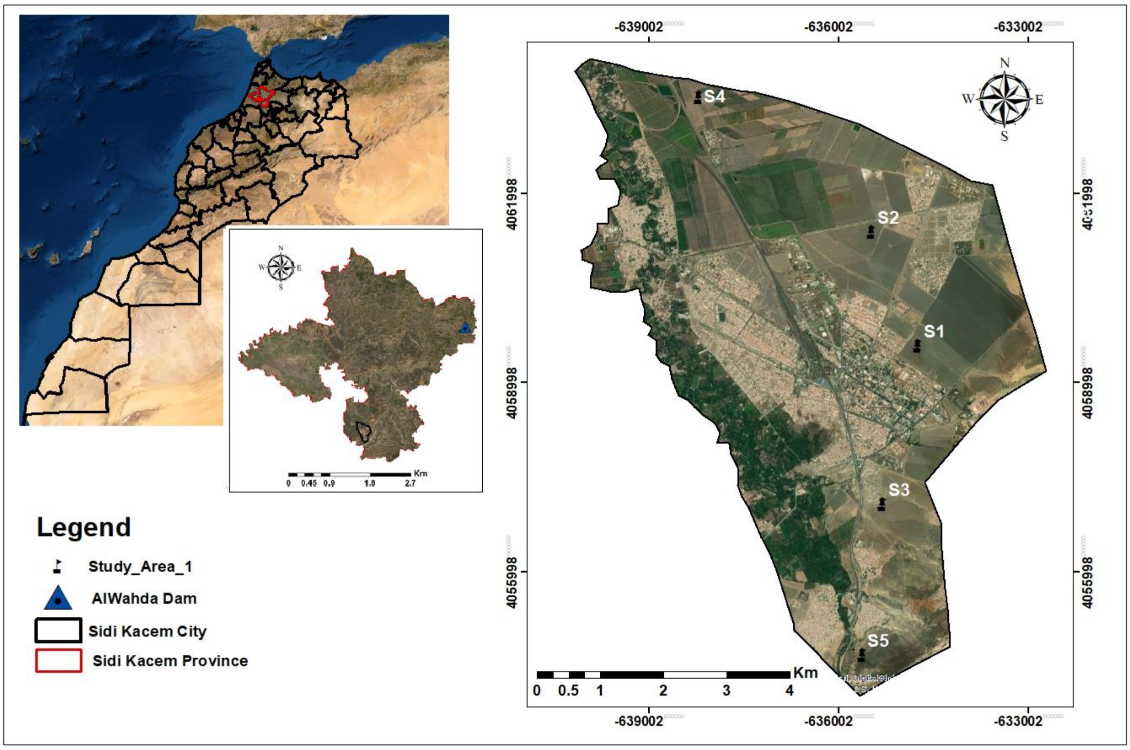

Figure 1: Geographical location of the Sidi Kacem region and study site

Sampling was conducted during the spring through late summer of 2020, with 2 sampling/ month. Three sampling techniques were adopted: pitfall traps, sweep nets,[23] and sight hunting. Ten pots were installed on the ground in each station during both seasons. Then, trapped species were recovered in plastic or glass bottles containing 70-80% alcohol. The sweep nets allowed the collection of insects present in the vegetation and more specifically those available at the top of the herbs with little mobility,[24] while sight hunting involved looking for all the wildlife that was observable by the eyes. After each sampling, the collected insects were brought back to the laboratory, counted, identified down to the family level using a binocular magnifier with a maximum magnification of x35. Various determination keys for species identification for beetles,[25-29] and hemipterans,[30,31] were referred to.

Data analysis

To exploit the data obtained, various ecological indices and statistical analyses were performed. Some of the analyses include the ecological composition indices (specific richness and relative abundance), as well as the ecological structure indices (Shannon, Hill, Simpson, and equitability indices). The data were analyzed using Microsoft Excel Worksheet (version 16.0 for Windows) and presented as frequency and percentage for comparison between the different stations.

Specific richness as a measure of ecological composition indices

Species richness represents a measure of the variety of species based simply on a count of the number of species in a particular sample.[32]

Relative abundance as a measure of ecological composition indices

Relative abundance (RA) is the percentage of individuals of one species (ni) divided by the total number of individuals (N).[33]

RA% = ni / N x 100 ----------------- (1)

Shannon-Weaver Diversity (H') as a measure of ecological structure indices

This index is considered to be the best way to reflect diversity. According to Dajoz,[34] the index is calculated by the formula:

$$H' = -\sum qi \log 2\, qi \quad \text{----------------- (2)}$$

Where H': Diversity index expressed in bit units; qi: Relative frequency of species i relative to individuals in the stand as a whole; Log_2: Logarithm based on 2.

Equitability index (E) as a measure of ecological structure indices

Equitability or evenness index (E) is the relationship between diversity H' and maximum diversity H' max.[35]

$$E = H' / H_{max} \quad \text{-------------------------- (3)}$$

Where E: Regularity index; H': Shannon diversity index expressed in bits; H'_{max}: Index of the maximum diversity expressed in bits.

Coefficient of concentration and Simpson's diversity index as measures of ecological structure indices

The concentration coefficient is based on the probability that 2 interacting individuals in a population are of the same species. The higher the probability, the lower the diversity.[35]

It was calculated by the formula: $C = \sum_{i=1}^{S} \left(\frac{ni}{N}\right)^2$ ------------- (4)

Where C: Concentration coefficient; S: Total number of species present in the population; ni: Number of individuals of the species of rank I; N: Total number of individuals.

Simpson's index as a measure of ecological structure indices

Simpson's index measures the probability that two individuals selected at random belong to the same species.[36]

It is calculated using the formula: D = 1- C ---------------- (5)

Where D: Simpson's Diversity Index; C: Concentration coefficient; It is between [0.1]. If D is closer to 1, the diversity is maximal, and for a value of D equal to 0, the diversity is minimal.

Hill index as a measure of ecological structure indices

It combines two indices, the Shannon-Weaver Index and the Simpson Index. When the Hill index is closer to 1, the diversity is lower. According to Legender and Legender,[35] it is given by the formula:

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$H = D/e^{H'}$ ----------------- (6)

Where D: Simpson's Diversity Index; $e^{H'}$: Exponential of the Shannon-Weaver index

Results and Discussion

Analysis of the faunal composition at the five study stations

Table 2 represents the list of the numbers and relative abundance of the different taxonomy of insects captured by the three sampling methods during the two seasons. In the present study, 78 species were collected and they were distributed among 7 orders belonging to 29 families. Among the 78 taxa captured, there were 31 (Station 1), 55 (Station 2), 64 (Station 3), 28 (Station 4), and 16 (Station 5) taxa, distributed among 7 orders: Hemiptera, Coleoptera, Orthoptera, Lepidoptera, Odonata, Hymenoptera, and Diptera. In terms of species richness, Beetles dominated with 44 species, followed by Hemiptera (9 species), Diptera (6 species), Lepidoptera, Orthoptera, and Odonata (5 species each), and finally Hymenoptera (4 species) as presented in Table 2. Similarly, the results of the relative abundance showed that Coleoptera (76.54%) was the most dominant insect in the five stations, followed by Hymenoptera (11.53%), and Hemiptera (3.47%). The rarest insect orders were Orthoptera, Diptera, Odonata, and Lepidoptera which were lower than 2% (Table 2).

The results of the entomofauna inventory carried out using the barber traps, sight hunting, and a mowing net in the 5 stations in the region of Sidi Kacem, Northwest of Morocco during the spring and summer in 2020 revealed that beetles were extremely dominant with a total of 44 species. The dominant species were *Pterostichus ebenus*, *Pachychila salzmanni*, *Thanatophilus ruficornis,* and *Silpha tristis*. The presence of Coleoptera in large numbers in the five stations is due to their wide presence in the world with more than 350,000 to 400,000 species, more species than any other order,[37] as well as their adaptive capacities to all climatic conditions. It can be found in all major habitats and can adapt to even the most difficult situations.[38] The number of species caught also depends on the method and the intensity of sampling.

Table 1: Location and principal characteristics of the prospected sites

Stations	Coordinates	Description
1	34°12'35.5"N - 5°42'31.8"W	field of beans *Vicia faba L.* (Fabaceae), characterized by a silty clay soil
2	34°14'41.5"N - 5°42'14.9"W	field of cereal crops: soft wheat: *Triticum aestivum L.* (Poaceae), characterized by a silty clay soil
3	34°13'50.5"N - 5°42'14.7"W	natural steppe. The plant species that dominate the area are: *Nicotiana glauca* (Solanaceae), *Ferula communis* (Apiaceae), *Cynara humilis L* (Asteraceae), and *Ammi visnaga* (Apiaceae). It is characterized by silty clayey soil.
4	34°15'19.1"N - 5°44'01.3"W	alfalfa field *Medicago sativa L.* (Fabaceae) and a wasteland dominated mainly by *Dittrichia viscosa L* (Asteraceae). The station is characterized by sandy clay loamy soil.
5	34°11'12.5"N - 5°42'32.8"W	matorral, characterized by clay soil. The plant species that dominate the area are: *Chamaerops humilis L.* (Arecaceae), *Eucalyptus sp* (Myrtaceae), *Olea europaea* L (Oleaceae), and *Opuntia ficus-indica L. Mill* (Cactaceae).

Measuring biodiversity using ecological composition indices

The ecological composition indices used were total and average richness along with the sampling quality values (Table 3), and the relative abundance (Table 2). The sampling quality (S.Q) value was between 0.10 (Stations 1,2), 0.23 (Station 2) as depicted in Table 3. The number of species collected at a single time varies from 14 (Station 2) to 6 (Stations 1,2). This is related to richness (S). The a/N ratio was close to 0 in all 5 biotopes, indicating that the value of the sampling quality was good. The total richness varies per station, ranging from 64 species in Station 3 to 16 species in Station 5 (Table 3). The average richness was also highest in Station 3 (8.03) and lowest in Station 5 (1.33) as reflected by Table 3 and Figure 2. In terms of abundance station, 3 had the highest value (482 individuals) and Station 5 had the lowest (80 individuals), while the rest of the stations range between 189- 345.

The present observations suggest that abundance, species richness, and diversity of insects were highest in Station 3. These results highlight that this area can be considered as the best habitat type. This can be explained by the fact that this ecosystem offers the best combination of conditions (soil humidity and texture, heterogeneity of vegetation, availability of food). The result of the present work suggests that insects, and in particular beetles, prefer silty-clayed soils. Lemic *et al.*[39] also showed that beetles prefer soils with a high amount of silt and a low proportion of clay, which is consistent with the results of this study. The absence of anthropological activities may also play a major role in these results. The significant reduction of the insects' population recorded in the stations (1, 2, and 4) illustrates the threat of the entomofauna in their biotope. This result can be related to the anthropological activity that has probably led to a disturbance of the environment leading to a decrease in plant density.[40] Concerning the species observed only once, their scarcity is probably related to the absence of host plants or prey. However, this may also be explained by the sampling techniques used and the location of the traps that do not allow the capturing of all the species present.

Measuring biodiversity using ecological structure indices

Table 4 illustrates values of the Shannon-Weaver index (H'), maximum diversity (H max), and equitability for each station during the study period. The values of the Shannon-Weaver diversity index vary from one station to another. The data range from 4.80 bits (Station 3) to 3.09 bits (Station 5). These findings indicated that all the five stations contained a well-diversified entomofauna. The equitability index also showed high values between 0.82 (Station 4) and 0.77 (Station 5) as illustrated in Figure 3.

The values of the concentration coefficient, Simpson's diversity index, and Hill's index for each station during the study period are presented in Table 5 and Figure 4. The value of the concentration coefficient varies from 0.12 (Station 5) to 0.06 (Station 1). This indicated that the species were numerous, and the 5 environments were rich in species population. The Simpson's diversity index (D) ranges from 0.93 (Station 3) to 0.85 (Station 5). Similarly, the Simpson diversity index showed as the Shannon-Weaver index revealed that the insect population at the 5 stations was well diversified. Hill's index tends to be 0 in all five stations (Table 5 and Figure 4). This reveals that diversity is high and species were well distributed in all 5 stations, with some variations from one station to the other.

According to Legender and Legender (1984),[35] the Shannon-Weaver diversity index allows for the determination of the diversity of species in each environment, which is directly related to the number of species. The Shannon-Weaver diversity index values range from 3.09-4.8 and the equitability index values range from 0.77-0.89, suggesting good entomological diversity at almost all stations. These results were confirmed by the concentration coefficient. According to Legender and Legender (1984),[35] when the coefficient is low, the diversity is automatically high. The values of the Simpson diversity index and the Hill index, eventually point in a similar direction (Table 5 and Figure. 4). The data obtained for the indices used in this study indicate that Station 3 (the natural steppe) is the most favorable for the presence and propagation of insects.

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Table 2: List of insect species harvested at the five stations

Order and Family	Station 1		Station 2		Station 3		Station 4		Station 5	
	ni	**RA%**	**ni**	**RA%**	**ni**	**RA%**	**ni**	**RA%**	**ni**	**RA %**
Coleoptera										
Carabidae										
Brachinus crepitans Linnaeus, 1758	0	0	18	5.22	16	3.32	0	0	0	0
Brachinus efflans Dejean, 1830	0	0	1	0.29	4	0.83	0	0	0	0
Brachinus immaculicornis Dejean, 1826	0	0	1	0.29	7	1.45	0	0	0	0
Chlaenius decipien L. Dufour, 1820	0	0	3	0.87	6	1.24		0	0	0
Pterostichus ebenus Quensel, 1806	40	22.6	60	17.3	86	17.8	11	4.15	19	23.7
Chlaenius chrysocephalus P. Rossi, 1790	2	1	2	0.58	3	0.62	0	0	0	0
Carabus rugorus rugorus Fabricius, 1775	5	2.82	3	0.87	2	0.41	0	0	0	0
Licinus punctatulus Fabricius, 1792	8	5	5	1.45	8	1.66	1	0.38	0	0
Graniger cordicollis Audinet-Serville, 1821	6	3.39	3	0.87	5	1.04	0	0	0	0
Calathus circumseptus Germar, 1823	3	1.69	5	1.45	7	1.45	0	0	0	0
Scybalicus oblongiusculus Dejean, 1829	6	3.39	7	2.03	15	3.11	0	0	0	0
Odontocarus cephalotes Dejean, 1826	0	0	2	0.58	3	0.62	0	0	0	0
Ditomus tricuspidatus Fabricius, 1792	0	0	1	0.29	1	0.21	0	0	0	0
Carterus interceptus Dejean and Boisduval,1829	0	0	1	0.29	0	0	0	0	0	0
Carterus dama P. Rossi, 1792	0	0	2	0.58	1	0.21	0	0	0	0
Siagona rufipes Fabricius, 1792	0	0	2	0.58	2	0.41	0	0	0	0
Siagona dejeani Rambur, 1838	0	0	2	0.58	1	0.21	0	0	0	0
Parophonus hispanus Rambur, 1838	0	0	0	0	2	0.41	0	0	0	0
Poecilus decipiens Waltl, 1835	0	0	3	0.87	1	0.21	0	0	0	0
Scarites terricola Bonelli, 1813	5	2.82	1	0.29	4	0.83	0	0	0	0
Dixus clypeatus P. Rossi, 1790	0	0	1	0.29	0	0	0	0	0	0
Dixus sphaerocephalus Olivier, 1795	0	0	1	0.29	0	0	0	0	1	1.25
Acinopus sabulosus Fabricius, 1792	0	0	6	1.74	9	1.87	14	5.28	10	12.5
Poecilus purpurascens Dejean, 1828	2	1.13	2	0.58	4	0.83	0	0	0	0
Distichus planus Bonelli, 1813	3	1.69	0	0	0	0	0	0	0	0
Tenebrionidae										
Pachychila salzmanni Solier, 1835	40	22.6	39	11.3	78	16.1	25	9.43	22	27.5
Dendarus pectoralis Mulsant and Rey, 1854	0	0	2	0.58	3	0.62	1	0.38	0	0
Gastrhaema rufiventris Waltl, 1835	0	0	1	0.29	2	0.41	1	0.38	0	0
Scarabaeidae										
Oxythyrea funesta Poda, 1761	1	0.56	2	0.58	3	0.62	7	2.64	0	0
Gymnopleurus flagellatus Fabricius, 1787	1	0.56	0	0	5	1.04	3	1.13	2	2.5
Gymnopleurus sturmi MacLeay, 1821	3	1.69	0	0	8	1.66	3	1.13	0	0
Coccinellidae										
Coccinella septempunctata Linnaeus, 1758	0	0	10	2.90	6	1.24	5	1.89	0	0
Hippodamia variegata Goeze, 1777	0	0	4	1.16	5	1.04	0	0	0	0
Staphylinidae										
Ocypus aethiops Waltl, 1835	0	0	1	0.29	2	0.41	0	0	0	0
Ocypus olens O. F. Müller, 1764	0	0	1	0.29	1	0.21	0	0	0	0

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Cantharidae										
Cantharis coronata Gyllenhal, 1808	0	0	8	2.32	5	1.04	0	0	0	0
Rhagonycha fulva Scopoli, 1763	7	3.95	0	0	0	0	0	0	0	0
Chrysomelidae										
Chrysolina bankii Fabricius, 1775	2	1.13	3	0.87	1	0.21	0	0	0	0
Silphidae										
Thanatophilus ruficornis Küster, 1851	10	5.65	16	4.64	18	3.73	16	6.04	0	0
Thanatophilus sinuatus Fabricius, 1775	10	5.65	10	2.90	5	1.04	0	0	0	0
Silpha tristis Illiger, 1798	6	3.39	40	11.5	50	10.3	18	6.79	0	0
Silpha olivieri Bedel, 1887	3	1.69	15	4.35	16	3.32	0	0	0	0
Silpha puncticollis Lucas, 1846	5	2.82	13	3.77	10	2.07	0	0	0	0
Oedemeridae										
Oedemera simplex Linnaeus, 1767	12	6.78	0	0	0	0	0	0	0	0
Hemiptera										
Reduviidae										
Peirates stridulus Fabricius, 1787	0	0.00	1	0.29	0	0	0	0	0	0
Rhynocoris erythropus Linnaeus, 1767	0	0	0	0	3	0.62	14	5.28	1	1.2
Pentatomidae										
Graphosoma lineatum Linnaeus, 1758	0	0	0	0	2	0.41	0	0	0	0
Carpocoris mediterraneus Tamanini, 1958	0	0	0	0	1	0.21	0	0	0	0
Carpocoris fuscispinus Boheman,, 1850	0	0	0	0	2	0.41	1	0.38	0	0
Cercopidae										
Cercopis intermedia Kirschbaum, 1868	1	0.56	2	0.58	0	0	0	0	0	0
Scutelleridae										
Eurygaster austriaca Schrank, 1776	0	0	2	0.58	3	0.62	0	0	0	0
Alydidae										
Camptopus laterali Germar, 1817	0	0	2	0.58	0	0	0	0	0	0
Lygaeidae										
Lygaeus equestris Linnaeus, 1758	5	2.82	3	0.87	3	0.62	0	0	0	0
Orthoptera										
Acrididae										
Heteracris annulosa Walker, 1870	1	0.56	2	0.58	1	0.21	1	0.38	2	2.5
Dociostaurus maroccanus Thunberg, 1815	0	0	0	0	2	0.41		0	1	1.25
Aiolopus strepens Latreille, 1804	2	1.13	0	0	1	0.21	1	0.38	0	0
Gryllidae										
Gryllus bimaculatus De Geer, 1773	0	0	0	0	2	0.41	0	0	0	0
Gryllus campestris Linnaeus, 1758	0	0	0	0	1	0.21	0	0	0	0
Lepidoptera										
Pieridae										
Pieris brassicae Linnaeus, 1758	0	0	2	0.58	2	0.41	*5*	1.89	0	0
Pieris rapae Linnaeus, 1758	1	0.56	0	0	1	0.21	0	0	0	0
Anthocharis belia Linnaeus, 1767	0	0	2	0.58	3	0.62	0	0	1	1.25
Nymphalidae										
Danaus chrysippus Linnaeus, 1758	0	0	0	0	2	0.41	6	2.26	0	0

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Vanessa cardui Linnaeus, 1758	0	0	0	0	2	0.41	0	0	1	1.25
Hymenoptera										
Apidae										
Apis mellifera Linnaeus. 1758	3	1.69	7	2.03	6	1.24	8	3.02	5	6.25
Xylocopa pubescens Spinola. 1838	0	0	6	1.74	14	2.90	5	1.89	6	7.5
Vespidae										
Polistes dominula Latreille. 1802	2	1	2	0.58	3	0.62	8	3.02	0	0
Andrenidae										
Andrena sp	5	2.82	10	2.90	12	2.49	12	4.53	6	7.5
Odonata										
Coenagrionidae										
Ischnura graellsii Rambur, 1842	0	0	0	0	4	0.83	0	0	0	0
Libellulidae										
Sympetrum fonscolombii Selys, 1840	0	0	2	0.58	2	0.41	0	0	1	1.25
Trithemis annulate Palisot de Beauvois, 1807	1	0.56	1	0.29	2	0.41	2	0.75	1	1.25
Trithemis kirbyi Selys, 1891	0	0	2	0.58	1	0.21	0	0	1	1.25
Crocothemis erythraea Brullé, 1832	0	0	0	0	2	0.41	3	1.13	0	0
Diptera										
Muscidae										
Neomyia cornicina Fabricius, 1781	0	0	0	0	0	0	5	1.89	0	0
Stratiomyinae										
Stratiomys cenisia Meigen, 1822	0	0	0	0	0	0	6	2.26	0	0
Nemotelus pantherinus Linnaeus. 1758	0	0	1	0.29	0	0	0	0	0	0
Tabanidae										
Tabanus eggeri Schiner, 1868	0	0	0	0	0	0	2	0.75	0	0
Syrphidae										
Eristalis arbustorum Linnaeus. 1758	0	0	0	0	0	0	5	1.89	0	0
Asilidae										
Choerades sp.	0	0	1	0.29	0	0	0	0	0	0
78	**201**	**100**	**345**	**100**	**482**	**100**	**189**	**100**	**80**	**100**

ni: number of individuals and RA%: relative abundance

Table 3: Total richness (S), Average richness (Rm) and Sampling Quality (SQ) at the five study stations

Index / Stations	S1	S2	S3	S4	S5
species seen once (a)	6	14	11	6	8
Number of samples (N)	60	60	60	60	60
Sampling Quality (S.Q)	0.10	0.23	0.18	0.10	0.13
Total richness (S)	31	55	64	28	16
Number of individuals	201	345	482	189	80
Average richness (Rm)	3.35	5.19	8.03	3.15	1.33

Table 4: Diversity (H' and H max) and equitability (E) values for the five study stations

Index / Stations	S1	S2	S3	S4	S5
Shannon-Weaver H'	4,2	4,4	4,8	4,08	3,09
Diversity H max	5	5,78	6	4,81	4
Equitability index E	0,89	0,90	0,92	0,82	0,77

Table 5: Values of (C), (D) and (H) index for the five stations

Index / Stations	S1	S2	S3	S4	S5
Coefficient (C)	0.06	0.07	0.08	0.1	0.12
Simpson Index (D)	0.90	0.92	0.93	0.89	0.85
Hill Index (H)	0.01	0.01	0.01	0.02	0.04

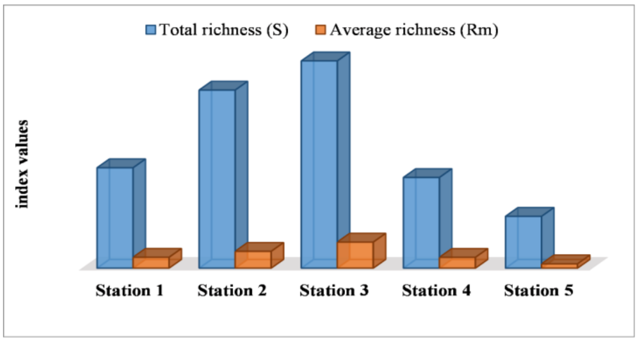

Figure 2: Total and average richness in the five study stations.

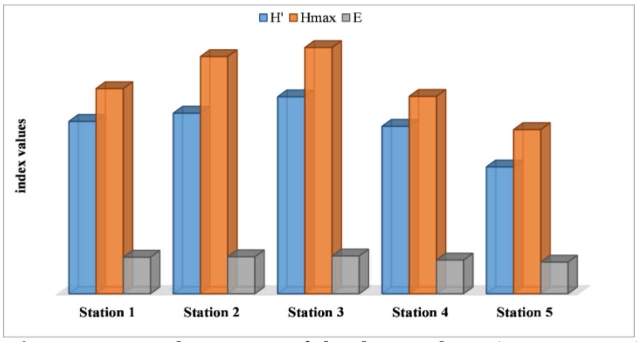

Figure 3: Spatial variation of the three indices (H'. H max. E) in the five study stations.

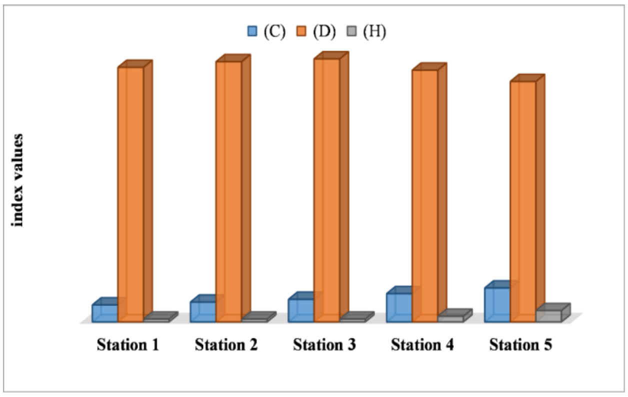

Figure 4: Spatial variation of the three indices (H. C. D) in the 5 study stations

This is therefore the station with the most favorable biotope to host a rich and balanced biocenosis, thus presenting an excellent environment for the activities of the species.
The results of the present study agree with the work of Magagula,[41] which revealed similar observations on carabids fauna in Tambuti Citrus Estate in Swaziland. The results obtained showed that the diversity was higher in natural habitats than in the agricultural landscape. This is due to various reasons, such as the good vegetation cover, the type of soil (silty clayed), soil humidity, vegetation diversity, and the presence of shelters (cracks, rocks.) that offer refuge to insects. According to Boivin and Hance (2003),[42] differences in soil texture may influence the ground beetle assemblage. The results presented in this work are compatible with this observation. Thus, the specific richness and abundance were higher in Station 3, followed by Stations 1 and 2 which was characterized by silty clayed soil. Previous studies have also reported a positive relationship between the abundance of insects (especially ground beetles) and plant species richness,[43] as high plant diversity can potentially provide more food resources for herbivore species.[44] Habitats with dense vegetation cover are characterized by a higher species richness of insects, therefore, vegetation is considered a key factor in the distribution of this community.[45] Conversely, Station 5 showed the lowest values for the various parameters. Thus, this station had the most unfavorable biotope for the development of a rich and diversified biocenosis, due to the type of soil (clay soil) which is compact, making the circulation of air and water difficult, as well as to the propagation of roots, leading to the installation of a low plant and animal density. According to Soliveres *et al.*,[46] the presence of insects is generally positively correlated with the abundance and diversity of vegetation. There is evidence that increasing plant diversity can increase the diversity of phytophagous and consequently of their predators and parasites.[47,48]
The other 3 stations (1, 2, and 4) showed intermediate results which could be linked to anthropogenic factors during the summer season which led to the loss of vegetation such as the diverse farming practices of plowing, use of fertilizers, etc. This loss led to the modification of hygrothermal conditions in the soil causing the extinction of many species that prefer humidity.[49] The results of the present study are in line with the work of Eyre and Luff,[50] on the fauna of European grasslands. These authors postulated that the amount of water in the soil is an important factor in the distribution of insects and more specifically beetles.
Generally, species distribution and abundance are related to biotic and abiotic factors,[51] such as vegetation structure, humidity, and soil texture. Biotic factors like vegetation characteristics influence insects' community structure in general, and ground beetles in particular.[52] The number of species captured also depends on the method and intensity of the sampling.

Conclusion

To the best of our knowledge, this study is considered to be the first in Morocco. The inventory of the terrestrial entomofauna of 5 stations in the Sidi Kacem region revealed the existence of 78 species. Beetles dominated both in the number of species and number of individuals, followed by the order Hymenoptera. The structure of the populations in each station was under the influence of several natural factors such as the nature of the soil, temperature, humidity, and vegetation, which played a major role in determining the quality of the ecosystems and their biodiversity. The results obtained showed the abundance of insects in these crops. To improve the results, it is recommended that this study be completed using alternative sampling techniques over multiple years on a variety of other crops.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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