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Analysis of Insect Diversity of Three Islets in the North-East of Algeria

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ABSTRACT

During spring and summer (April to July) of 2009, insects of three islets in the North-East of Algeria were sampled by pitfall traps, sweep net and Japanese umbrella. Analysis of insect diversity shows the existence of 144 species in the three islets. Petit Cavallo island is the most rich with 140 species, followed by Grand Cavallo island and Grand Cavallo islet with 92 and 25 species, respectively. Diversified orders were Coleopters on the two main islet (Petit Cavallo island: 42 species, Grand Cavallo Island: 33 species) and Hymenopters on Grand Cavallo islet (10 species). For abundance, Hymenoptera was the most dominant on the three islands (Petit Cavallo: 428 individuals, Grand Cavallo island: 229 individuals, and Grand Cavallo islet: 118 individuals). The main three richer families in Petit Cavallo island were Formicidae (9 species), Pentatomidae (8 species) and Miridae (7 species). In Grand Cavallo island, two families were prosperous: Formicidae (8 species) and Chrysomelidae (6 species). However, Formicidae seemed to be richer in Grand Cavallo islet with 5 species. In terms of abundance, Formicidae was the most dominate in three islands (Grand Cavallo islet: 69.87%, Petit Cavallo island: 34.95%, Grand Cavallo isalnd: 25.88%). From the point of view of the similarity, the composition of insect fauna seemed to be close between Petit Cavallo island and Grand Cavallo island (77.58%).

Keys words: Insect, diversity, abundance, pitfall traps, sweep net, Japanese umbrella, spring, summer, islets, Algeria.

INTRODUCTION

Island ecosystems are considered natural laboratories of evolution in which patterns and ecosystem processes can be addressed optimally, especially on islands of small size (Whitehead and Jones, 1969; Höner and Greuter, 1988). The study of explanatory patterns of richness and diversity of living organisms within the continental islands connected to continent remains major themes in ecology and populations biogeography (Blondel, 1995). Studies of island insect faunas have been widely reported and described in the northern part of the Mediterranean. Several authors have investigated insect species richness and diversity of many continental Mediterranean islands, for example, on Bagaud island (Port-Cros, France) Orgeas *et al.* (2007) were sampled 148 insect species (Coleoptera, Hymenoptera and Hemiptera). Nearby, at

the eastern Iberian Mediterranean islands 76 Tenebrionid beetles were identified (Cartagena and Galante, 2002) and 61 Butterflies captured on the Greek island (Olivier, 2000; Coutsis, 2001). Such studies can be used to monitor environmental degradation, to select protected areas and to establish a policy of environmental conservation (Gillon, 1990; Cartagena and Galante, 2002). However, this is not the case of the southern shore of the Mediterranean, particularly in Algeria. Studies on insect fauna of Algerian islands are virtually non-existent. Only ants of Habibas islands appeared to be listed (Bernard, 1958). This study is considered as an original approach to establish the first elements of a faunal inventory on these islets ecosystems. The main purpose was to evaluate the diversity of insect population through an index study. Finally, this study is intended as a reference state of the insect population on a given date where the number of pairs of gulls (Bougaham and Moulaï, 2013) and plant species richness (Benhamiche-Hanifi and Moulaï, 2012) are known.

MATERIALS AND METHODS

Site descriptions

The study area is located in west of Jijel (36° 49 'North, 5° 45'East) (Fig. 1). Jijel belonged to wet with a mild winter bioclimatic floor (Q= 137, m = 6) . The coast of this region stretched 120km, and in the west, it contains three small islets: Grand Cavallo island, Petit Cavallo island and Grand Cavallo islet (Fig. 1). The main physiographic characteristics (size, distance from the mainland, altitude, and substrate type and richness) of each island were given Benhamiche-Hanifi and Moulaï (2012).

Methodology

The inventory of the insect fauna of Jijel insular systems took place during the spring and summer, between April and July 2009. We sampled most of the sites occupied by the insect fauna. For insects evolving at ground level (ground dwelling), traps were used on each island, in fact the pots were cans or plastic box 10 cm diameter and 15 cm depth. Each pot should be three-quarters full of water and a preservative fluid to prevent decay of trapped invertebrates. On each islet we placed 10 pots separated by an intervals of 5 m line, the output made, were regulated by the availability of a boat and weather conditions (sea state, rain and wind,). Content of pots was recovered according to the timing of these outputs. For those attending the herbaceous layer (Orthoptera, Coleoptera, Lepidoptera, Hemiptera), they were harvested by mowing using a sweep net, on a plot of 100 m^2, we took 10 plots 4 m^2, 40 hauls were performed on 4 m^2, making 400 shots on the surface already mentioned (100 m^2), this method was repeated for each field companion. Insects frequenting the shrub layer were harvested by mowing and using a Japanese umbrella. A square canvas of light color 120 x 120 cm was stretched on a wooden folding frame. The web washeld with one hand under the foliage of trees and shrubs while we brutally shook plants with the other hand (threshing). Insects dropped into the web where they were easily collected.

Sampling was supplemented by hunting for insects. Major constraints were reported in this work, the accessibility to islands was only possible with a boat that was often unfortunately not available. There is also the use of pots that was made difficult by legged Gull, which in each case overturned.

Once separated, the specimens were determined by books and specialized keys: of Portevin (1924), Perrier (1935, 1961, 1963, and 1964), Chopard (1943), Bernard (1968), Plateaux-Quéner (1972), Delvare and Aberlenc (1989) and Auber (1999). Collections containing specimens of the continental environment were also consulted, including those found in the Laboratory of Applied Zoology and Animal Ecophysiology of the University of Bejaia (Algeria).

The results obtained were operated by using ecological composition indexes, such as species richness (S) and centesimal frequency (Cf %), and structure indexes: maximum diversity index (H_{max}) and equitability index (E). Several mathematical indexes could quantify species diversity. In our case, we chose Shannon and Weaver index (H).

Shannon and Weaver index (H)

It assesses the actual diversity of a population in a habitat and its value ranges from 0 (one species) in logs (when all species have the same abundance) (Ramade 1984). It is calculated from the following formula:

$H= - \Sigma P_i \, Log_2$

H: Diversity index (in bits)

P_i: Probability of encountering species i

From this index, we calculate the maximum diversity (Hmax), in which each species is represented by the same number of individuals (Ponel, 1983) It is calculated by the following formula:

$H_{max} = \log_2 S$

$H_{max:}$ Maximum diversity index (in bits)

S: Total number of species

Equitability index (E)

Is the ratio between Shannon-Weaver index (H) and the maximum theoretical diversity (H_{max})

$E = H / H_{max}$

H: Shannon-Weaver index

This index varies from 0 to 1. When it tends to mean that almost all staff tends to be concentrated on a single species stand, it is unbalanced. It is equal to 1 when all species have the same abundance and populations are equilibrium (Barbault, 1981).

In order to find the degree of association or similarity of the insect fauna between the three islets, the similarity coefficient of Sorensen is used (Maguran, 1988).

The formula is as follows:

Cs= (2J/ a+b). 100

Cs: Sorensen index

a: Number of species present on the site a

b: Number of species present on the site b

J: Number of common species between the two sites

This index ranges from 0 to 100. If it is equal to 0, the two sites are dissimilar and have no species in common. If it is equal to 100, the similarity between the two sites is complete and the species of the two sites are identical.

Statistic analysis

Kruskal-Wallis test was used to compare the richnes and abundance of orders, families and insect species among the three islets of Jijel.

RESULTS

Structure and composition of insects' fauna

Petit Cavallo island seemed to be the richest with 140 species; it is followed by the Grand Cavallo island with 92 species. Grand Cavallo islet was the least rich, with only 25 species (Table 1). The Shannon-Weaver index confirm these results, where the highest value (5.35 bits) is reported at Petit Cavallo island and the lowest value (2.93 bits) is recorded at the Grand Cavallo islet (Table 1). In addition, Grand Cavallo island seems to be more balanced with a value (E=0.8) , followed by Petit Cavallo island and Grand Cavallo islet with 0.75 and 0.63 respectively (Table 1).

Table 1. Different ecological indicators applied to insects of the three islets of Jijel, the Total Richness (S), the Number of individuals (N), Shannon-Weaver Diversity index (H'), Maximum diversity (H_{max}) and Equitability index (E)

Parameters	Petit Cavallo Island	Grand Cavallo Island	Grand Cavallo Islet
S	140	92	25
N	1011	680	156
H' (bits)	5.35	5.26	2.93
H max	7.12	6.52	4.64
E	0.75	0.80	0.63

Insects' diversity

During four months of investigations, 144 species were sampled on the three islets of Jijel. We captured 140 species in Petit Cavallo island with 1011 individuals pertaining to 66 families and 9 orders. In addition, on Grand Cavallo, we inventoried

92 species with 680 individuals spread on 50 families and 9 orders. However, on Grand Cavallo islet, 25 species were sampled with 156 individuals, pertaining to 13 families and 4 orders (Tables 3 and 4).

Diversity and abundance of insect orders

In terms of diversity, Coleopteran order was the most represented on the two large islets: Grand Cavallo and Petit Cavallo, with 42 and 33 species, respectively. While, it occupied the second position on the Grand Cavallo islet with only 8 species behind Hymenoptera (10 species) (Table 4). No significant differences on insect orders diversity were observed between the three islets ($\chi 2$ = 7.97, p = 0.019).

In terms of abundance, things seem to be different. On Petit Cavallo island, Hymenoptera, Coleoptera, Hemiptera and Diptera, are the principal representatives orders with 42.38%, 27.72%, 17.33% and 07.33%, respectively (Table 4). While, in Grand Cavallo island, Hymenoptera, Hemiptera, Coleoptera and Diptera, are the main orders respectively with 33.68%, 21.62%, 20.44% and 10.29% (Table 2). On Grand Cavallo islet, Hymenoptera take the first position (76.28%), followed by Coleoptera with 16.03% and Diptera with 7.05% (Table 4). Kruskal-Wallis test showed that insect orders abundance between the three islets was significantly different ($\chi 2$ = 8.39, p = 0.015).

Table 2. Values of Sorensen similarity coefficient applied to the insect species of the three islands of Jijel

	Petit Cavallo Island	Grand Cavallo Island	Grand Cavallo Islet
Petit Cavallo Island	100%	77.58%	25.74%
Grand Cavallo Island	-	100%	41.10 %
Grand Cavallo Islet	-	-	100%

Diversity and abundance of insect families

For species diversity within families, things appear to be different. Indeed, Petit Cavallo island, four (4) families have a rather marked species diversity Formicidae (9 species) Chrysomelidae (9 species), Pentatomidae (8 species) and Miridae (7 species). Moreover, on Grand Cavallo, there is a diversity of species within two families; it is Formicidae and Chrysomelidae respectively with 8 and 6 species. In terms of species richness, Formicidae take the first position on the Grand Cavallo island with 5 species (Table 4). The comparison of the diversity of insect families, among the three islets, revealed a significant differences ($\chi 2$ = 52.77, p <0.0001).

The most dominant families in Petit Cavallo island were Formicidae (34.95%), Miridae (8.22%) and Alleculidae (7.53%). Moreover, on Grand Cavallo island, Formicidae (25.88%), Issidae (11.32%), Acrididae (9.71%) and Mordellidae (8.82%) were the principal predominant families (Table 4). Grand Cavallo islet seemed to be the poorest in abundance insect families. The main predominate families were: Formicidae (69.87%) and Mylaridae (7.05%) (Table 4). Insect families abundance was significantly different between the three islets ($\chi 2$= 59.4, p = 0.0001).

Table 3 Number (N) and centesimal frequency (Cf) applied to insect species on each island.

	Petit Cavallo Island		Grand Cavallo Islet		Grand Cavallo Islet	
	N	Cf %	N	Cf %	N	Cf %
Orthoptera						
Acrididae						
Eyprepocnemis plorans charpentier 1825	2	0.28	0	0	0	0
Ochrilidia tibialis Fieber 1853	1	0.1	0	0	0	0
Aiolopus strepens Latreille 1804	3	0.3	0	0	0	0
Calliptamus barbarus Costa 1836	14	1.39	66	9.71	0	0
Tettigoniidae						
Phaneroptera nana Fieber 1853	1	0.1	0	0	0	0
Dermaptera						
Carcinophoridae						
Anisolabis mauritanicus	2	0.2	3	0.44	0	0
Forficulidae						
Forficularia auricularia Linnaeus 1758	4	0.4	3	0.44	0	0
Dictyoptera						
Mantidae						
Mantis religiosa Linnaeus 1758	2	0.2	2	0.29	0	0
Sphodromantis viridis Forskal 1775	2	0.2	2	0.29	0	0
Hemiptera						
Lygaeidae						
Heterogaster sp	2	0.2	2	0.29	0	0
Anthocoridae						
Anthocoris nemorum Linnaeus 1761	2	0.2	2	0.29	0	0
Orius niger Wolff 1811	2	0.2	2	0.29	0	0
Tingidae						
Tingis sp	2	0.2	2	0.29	0	0
Miridae						
Calocoris sp1	23	2.28	20	2.94	0	0
Calocoris sp2	12	1.19	15	2.21	0	0
Deraeocoris sp	4	0.4	7	1.03	0	0

Table 3. Continued.

	Petit Cavallo Islet		Grand Cavallo Islet		Grand Cavallo Islet	
	N	Cf %	N	Cf %	N	Cf %
Dictyoptera						
Miridae						
Adelphocoris sp	11	1.09	0	0	0	0
Cantharis sp	1	0.1	0	0	0	0
Psallus ambiguus Fallen 1880	3	0.3	6	0.88	0	0
Plagiotylus sp	29	2.87	0	0	0	0
Issidae						
Issus coleoptrata Fabricius 1781	20	1.98	45	6.62	0	0
Hysteropterum sp	15	1.49	32	4.71	0	0
Issus sp	1	0.1	0	0	0	0
Tropiduchidae						
Tropiduchidae sp ind	2	0.2	0	0	0	0
Pentatomidae						
Graphosoma italicum Linnaeus 1758	2	0.2	0	0	0	0
Nezara viridula Linnaeus 1758	4	0.4	10	1.47	0	0
Piezodorus lituratus Fabricius 1794	8	0.79	0	0	0	0
Pentatoma rufipes Linnaeus 1758	2	0.2	0	0	0	0
Stollia venustissima Schrank 1776	16	1.58	5	0.74	0	0
Dolycoris numidicus Horvath 1908	6	0.85	0	0	0	0
Eurydema sp	2	0.2	0	0	0	0
Dyroderes umbraculatus Fabricius 1775	4	0.4	4	0.59	0	0
Pyrrhocoridae						
Pyrrhocoris apterus Linnaeus 1758	1	0.1	0	0	0	0
Coreidae						
Syromastes rhombeus Linnaeus 1767	1	0.1	0	0	0	0
Coleoptera						
Cetoniidae						
Oxythyrea funesta Poda 1761	19	1.88	4	0.59	0	0
Apionidae						
Apion sp	2	0.2	2	0.29	0	0

Table 3. Continued.

	Petit Cavallo Island		Grand Cavallo Islet		Grand Cavallo Islet	
	N	Cf %	N	Cf %	N	Cf %
Coleoptera						
Chrysomelidae						
Lachnaia tristigma Lacordaire 1848	6	0.59	3	0.44	0	0
Lachnaia pubescens Dufour 1820	7	0.69	2	0.29	0	0
Cryptocephalus rufipes Goeze 1777	1	0.1	1	0.15	0	0
Podagrica fuscicornis Linnaeus 1766	1	0.1	1	0.15	0	0
Tituboea sp	2	0.2	1	0.15	0	0
Aphthona cyparissiae Koch 1803	1	0.1	1	0.15	0	0
Chrysomela sp	1	0.1	1	0.15	0	0
Psylliodes sp	1	0.1	0	0	0	0
Chaetocnema concinna Marsham 1802	1	0.1	0	0	0	0
Coccinellidae						
Scymnus interruptus Goeze 1777	6	0.59	2	0.29	0	0
Scymnus apetzoides Capra & Fursch 1967	3	0.3	1	0.15	0	0
Coccinella algerica Kovar 1977	2	0.2	1	0.15	0	0
Clitostethus arcuatus Rossi 1794	1	0.1	1	0.15	0	0
Mordellidae						
Variimorda villosa Schrank 1781	29	2.87	34	5	2	1.28
Variimorda acculeata Linnaeus 1758	15	1.49	10	1.47	2	1.28
Variimorda sp	9	0.89	16	2.35	0	0
Phalacridae						
Olibrus sp	4	0.4	2	0.29	0	0
Elateridae						
Athous sp	2	0.2	2	0.29	0	0
Tenebrionidae						
Tenebrionidae sp ind	1	0.1	0	0	0	0
Scaurus atratus Fabricius 1775	2	0.2	0	0	0	0
Opatrum sp	0	0	1	0.15	0	0

Table 3. Continued.

	Petit Cavallo Island		Grand Cavallo Islet		Grand Cavallo Islet	
	N	Cf %	N	Cf %	N	Cf %
Coleoptera						
Alleculidae						
Heliotaurus ruficollis Fabricius 1781	75	7.43	10	1.47	0	0
Oedemeridae						
Oedemera femorata Scopoli 1763	20	1.98	10	1.47	2	1.28
Oedemera podagrariae Linnaeus 1767	10	0.99	0	0	0	0
Oedemera tristis W. Schmidt 1846	4	0.4	0	0	0	0
Bruchidae						
Bruchidius villosus Marsham 1802	1	0.1	0	0	0	0
Curculionidae						
Pissodes sp	1	0.1	1	0.15	0	0
Magdalis sp	1	0.1	1	0.15	0	0
Lixus sp	1	0.1	3	0.44	0	0
Cerambycidae						
Agapanthia cardui Linnaeus 1767	9	0.89	5	0.74	0	0
Calamobius filum Rossi 1790	1	0.1	3	0.44	0	0
Cerambycidae sp ind	1	0.1	0	0	0	0
Gyrinidae						
Gyrinus sp	1	0.1	0	0	0	0
Cantharidae						
Cantharis sp	2	0.2	0	0	0	0
Melyridae						
Psilothrix sp	9	0.89	4	0.59	4	2.56
Dasytes sp	23	2.28	10	1.47	7	4.49
Buprestidae						
Anthaxia sp	2	0.2	1	0.15	0	0
Cassidinae						
Cassida viridis Linnaeus 1758	1	0.1	1	0.15	0	0
Cassida sanguinosa Suffrian 1844	1	0.1	0	0	0	0

Table 3. Continued.

	Petit Cavallo Island		Grand Cavallo Islet		Grand Cavallo Islet	
	N	Cf %	N	Cf %	N	Cf %
Coleoptera						
Melolonthidae						
Melolonthidae sp ind	1	0.1	0	0	0	0
Neuroptera						
Myrmeleontidae						
Myrmeleontidae sp ind	2	0.2	0	0	0	0
Hymenoptera						
Eulophidae						
Aulogymnus sp1	2	0.2	2	0.29	0	0
Aulogymnus sp2	1	0.1	0	0	0	0
Ormyridae						
Ormyrus sp	1	0.1	1	0.15	0	0
Ichneumonidae						
Icheumonidae sp ind	1	0.1	0	0	0	0
Braconidae						
Braconidae sp ind	1	0.1	0	0	0	0
Formicidae						
Camponotus vagus Scopoli 1763	3	0.3	4	0.59	2	1.28
Camponotus sp	0	0	0	0	1	0.64
Cataglyphis bicolor Fabricius 1793	240	23.8	110	16.18	80	51.28
Aphaenogaster testceopilsa Lucas 1849	6	0.59	3	0.44	0	0
Messor barbarus Linnaeus 1767	60	5.94	30	4.41	20	12.82
Crematogaster scutellaris Olivier 1792	20	1.98	12	1.76	5	3.21
Crematogaster auberti Emery 1869	18	1.78	10	1.47	0	0
Tapinoma simrothi Krausse 1911	2	0.2	1	0.15	0	0
Pheidole pallidula Nylander 1849	1	0.1	3	0.44	0	0
Tetramorium biskrensis Forel 1904	4	0.4	4	0.59	0	0

Table 3. Continued.

	Petit Cavallo Island		Grand Cavallo Islet		Grand Cavallo Islet	
	N	Cf %	N	Cf %	N	Cf %
Hymenoptera						
Pompilidae						
Pompilus sp1	4	0.4	6	0.88	0	0
Pompilus sp2	2	0.2	3	0.44	0	0
Pompilidae sp	2	0.2	0	0	0	0
Anoplius sp	0	0	2	0.29	0	0
Halictidae						
Halictus intumescens Pérez 1895	4	0.4	3	0.44	2	1.28
Halictus quadricinctus Fabricius 1777	3	0.3	2	0.29	1	0.64
Halictus sp	0	0	0	0	2	1.28
Colletidae						
Hylaeus sp	6	0.59	14	2.06	1	0.64
Anthophoridae						
Ceratina cyanea Kirby 1802	10	0.99	13	1.91	1	0.64
Andrenidae						
Andrena sp	4	0.4	1	0.15	1	0.64
Sphecidae						
Trypoxylon figulus Linnaeus 1758	1	0.1	0	0	0	0
Apidae						
Apis mellifera Linnaeus 1758	31	3.07	5	0,74	4	2.56
Lepidoptera						
Papilionidae						
Zerynthia rumina Linnaeus 1758	2	0.2	0	0	0	0
Pieridae						
Pieris rapae Linnaeus 1758	4	0.4	3	0.44	0	0
Colias croceus Fourcroy 1785	1	0.1	1	0.15	0	0
Gonepteryx cleopatra Linnaeus 1767	1	0.1	0	0	0	0

Table 3. Continued.

	Petit Cavallo Island		Grand Cavallo Islet		Grand Cavallo Islet	
	N	Cf %	N	Cf %	N	Cf %
Hymenoptera						
Lycaenidae						
Lampides boeticus Linnaeus 1767	2	0.2	0	0	0	0
Polyommatus icarus Rottemburg 1775	2	0.2	0	0	0	0
Lycaena phlaeas Linnaeus 1761	1	0.1	3	0.44	0	0
Nymphalidae						
Vanessa atalanta Linnaeus 1758	1	0.1	2	0.29	2	1.28
Cynthia cardui Linnaeus 1758	1	0.1	3	0.44	0	0
Geometridae						
Rhodometra sacraria Linnaeus 1767	1	0.1	1	0.15	0	0
Arctiidae						
Utetheisa pulchella Linnaeus 1758	1	0.1	2	0.29	0	0
Noctuidae						
Autographa gamma Linnaeus 1758	1	0.1	5	0.74	0	0
Heliothis peltigera Denis & Schiffermüller 1775	1	0.1	0	0	0	0
Acontia lucida	1	0.1	1	0.15	0	0
Diptera						
Calliphoridae						
Calliphora sp1	8	0.79	6	0.88	0	0
Calliphora sp2	2	0.2	0	0	0	0
Lucilia sp1	6	0.59	10	1.47	4	2.56
Lucilia sp2	6	0.59	6	0.88	0	0
Otitidae						
Otites sp	7	0.69	2	0.29	0	0
Anthomyiidae						
Pegomyia silacea	4	0.4	0	0	0	0
Delia sp	3	0.3	2	0.29	0	0
Anthomophora sp	3	0.3	2	0.29	0	0

Table 3. Continued.

	Petit Cavallo Island		Grand Cavallo Islet		Grand Cavallo Islet	
	N	Cf %	N	Cf %	N	Cf %
Diptera						
Muscidae						
Musca domestica Linnaeus 1758	7	0.69	2	0.29	2	1.28
Musca sp	1	0.1	0	0	0	0
Mucidae sp ind	1	0.1	0	0	0	0
Therevidae						
Thereva sp	4	0.4	0	0	0	0
Bombyliidae						
Villa modesta Meigen 1820	2	0.2	2	0.29	0	0
Exoprosopa jacchus Fabricius 1805	4	0.4	3	0.44	0	0
Asilidae						
Philonicus albiceps Meigen 1820	1	0.1	0	0	0	0
Sarcophagidae						
Sarcophaga sp	3	0.3	6	0.88	1	0.64
Miltogramma sp	2	0.2	1	0.15	0	0
Tachinidae						
Nowickia sp	1	0.1	0	0	0	0
Cylindromya auriceps Meigen 1838	2	0.2	4	0.59	0	0
Tophomyia sp	1	0.1	2	0.29	1	0.64
Exorista sp	1	0.1	2	0.29	0	0
Fanniidae						
Fannia sp	2	0.2	1	0.15	0	0
Tipulidae						
Tipula sp1	1	0.1	1	0.15	0	0
Tipula sp2	1	0.1	0	0	0	0
Stratiomyidae						
Chloromyia Formosa Scopoli 1763	2	0.2	15	2.21	0	0
Syrphidae						
Episyrphus balteatus De Geer 1776	2	0.2	0	0.00	0	0.00
Total species 144	1011	100%	680	100%	156	100%

Table 4 Centesimal frequency (Cf %) by insect orders and families on the three islets of Jijel: Number of species per order and family (n), Number of individuals per order and family (N).

Orders/Families	Petit Cavallo island				Grand Cavallo Islet				Grand Cavallo Islet			
	n	Cf %	N	Cf %	n	Cf%	N	Cf %	n	Cf %	N	Cf %
Orthoptera	5	3.57	21	2.08	1	1.09	66	9.71	0	0	0	0
Tettigoniidae	1	0.71	1	0.1	0	0	0	0	0	0	0	0
Acrididae	4	2.86	20	1.98	1	1.09	66	9.71	0	0	0	0
Dermaptera	2	1.43	6	0.89	2	2.71	6	0.88	0	0	0	0
Carcinophoridae	1	0.71	2	0.2	1	1.09	3	0.44	0	0	0	0
Forficulidae	1	0.71	4	0.4	1	1.09	3	0.44	0	0	0	0
Dicoptera	2	1.43	4	0.4	1	1.9	1	0.15	0	0	0	0
Mantidae	2	1.43	4	0.4	1	1.09	1	0.15	0	0	0	0
Hemipetra	25	17.56	175	17.33	10	10.87	147	21,62	0	0	0	0
Miridae	7	5.00	83	8.22	4	4.35	48	7.06	0	0	0	0
Lygaeidae	1	0.71	2	0.2	1	1.09	1	0.15	0	0	0	0
Anthocoridae	2	1.43	4	0.4	0	0	0	0.00	0	0	0	0
Tingidae	1	0.71	2	0.2	1	1.09	2	0.29	0	0	0	0
Issidae	3	2.14	36	0.56	2	2.17	77	11.32	0	0	0	0
Tropiduchidae	1	0.71	2	0.2	0	0	0	0.00	0	0	0	0
Pentatomidae	8	5.71	44	4.36	3	3.26	19	2.79	0	0	0	0
Pyrrhocoridae	1	0.71	1	0.1	0	0	0	0.00	0	0	0	0
Coreidae	1	0.71	1	0.1	0	0	0	0.00	0	0	0	0
Coleoptera	42	30	280	27.72	33	38.68	139	20.44	8	32	25	16.03
Cetoniidae	1	0.71	19	1.88	1	1.09	4	0.59	1	4	4	2.56
Apionidae	1	0.71	2	0.2	1	1.09	2	0.29	0	0	0	0
Chrysomelidae	9	6.43	20	1.98	6	6.52	9	1.32	3	12	6	3.85
Coccinellidae	4	2.86	12	1.19	4	4.35	5	0.74	0	0	0	0
Mordellidae	3	2.14	51	5.05	4	4.35	60	8.82	0	0	0	0
Phalacridae	1	0.71	4	0.4	1	1.09	2	0.29	0	0	0	0
Elateridae	1	0.71	2	0.2	1	1.09	2	0.29	0	0	0	0
Tenebrionidae	3	2.14	6	0.59	2	2.17	2	0.29	0	0	0	0
Alleculidae	1	0.71	75	7.43	1	1.09	10	1.47	0	0	0	0
Oedemeridae	3	2.14	34	3.37	2	2.17	12	1.76	2	8	4	2.56
Bruchidae	1	0.71	1	0.1	0	0	0	0.00	0	0	0	0

Table 4. Continued.

Orders/Families	Petit Cavallo Island				Grand Cavallo Island				Grand Cavallo Islet			
	n	Cf %	N	Cf %	n	Cf%	N	Cf %	n	Cf %	N	Cf %
Coleoptera	42	30	280	27.72	33	38.68	139	20.44	8	32	25	16.03
Curculionidae	3	2.14	3	0.3	2	2.17	4	0.59	0	0	0	0
Cerambycidae	3	2.14	11	1.09	3	3.26	8	1.18	0	0	0	0
Gyrinidae	1	0.71	1	0.1	1	1.09	1	0.15	0	0	0	0
Cantharidae	1	0.71	2	0.2	0	0	0	0.00	0	0	0	0
Melyridae	2	1.43	32	3.17	0	0	14	2.06	2	8	11	7.05
Buprestidae	1	0.71	2	0.2	1	1.09	1	0.15	0	0	0	0
Cassidinae	2	1.43	2	0.2	2	2.17	2	0.29	0	0	0	0
Melolonthidae	1	0.71	1	0.1	0	0	0	0.00	0	0	0	0
Nevroptera	1	0.7	2	0.2	1	1.09	1	0.15	0	0	0	0
Myrmeleontidae	1	0.71	2	0.2	1	0	2	0.29	0	0	0	0
Hymenoptera	26	18.57	428	42.42	20	21.74	229	33.68	10	10	118	76.28
Formicidae	9	6.43	222	34.95	8	8.7	177	25.88	5	20	103	69.87
Halictidae	3	2.14	9	0.89	2	2.17	5	0.74	2	8	3	1.92
Colletidae	1	0.71	6	0.59	1	1.09	14	2.06	1	4	1	0.64
Anthophoridae	1	0.71	10	0.99	1	1.09	13	1.91	1	4	1	0.64
Andrenidae	1	0.71	4	0.4	1	1.09	1	0.15	1	4	1	0.64
Apidae	1	0.71	31	3.07	1	1.09	5	0.74	1	4	4	2.56
Ichneumonidae	1	0.71	1	0.1	0		0	0.00	0	0	0	0
Eulophidae	2	1.43	3	0.3	1	1.09	2	0.29	0	0	0	0
Ormyridae	1	0.71	1	0.1	1	1.09	1	0.15	0	0	0	0
Braconidae	1	0.71	1	0.1	1	1.09	1	0.15	0	0	0	0
Pompilidae	4	2.86	8	0.79	3	3.26	11	1.62	0	0	0	0
Sphecidae	1	0.71	1	0.1	0	0	0	0.00	0	0	0	0
Lepidoptera	13	9.29	20	1.98	7	7.61	21	3.09	1	4	1	0.64
Lycaenidae	3	2.14	5	0.5	1	1.09	3	0.44	0	0	0	0
Pieridae	3	2.14	6	0.59	1	1.09	4	0.59	0	0	0	0
Noctuidae	2	1.43	2	0.2	1	1.09	6	0.88	0	0	0	0
Nymphalidae	2	1.43	3	0.3	2	2.17	5	0.74	0	0	0	0
Papilionidae	1	0.71	2	0.2	0	0	0	0.00	0	0	0	0
Arctiidae	1	0.71	1	0.1	1	1.09	2	0.29	0	0	0	0
Geometridae	1	0.71	1	0.1	1	1.09	1	0.15	0	0	0	0

Table 4. Continued.

Orders/Families	Petit Cavallo Island				Grand Cavallo Island				Grand Cavallo Islet			
	n	Cf %	N	Cf %	n	Cf%	N	Cf %	n	Cf %	N	Cf %
Diptera	24	47.14	74	7.33	17	18.48	70	10.29	6	24	11	7.05
Calliphoridae	3	2.14	20	198	3	3.26	24	3.53	2	8	4	2.56
Otitidae	1	0.71	7	0.69	1	1.09	2	0.29	0	0	0	0
Anthomyiidae	3	2.14	10	0.99	2	2.17	4	0.59	1	4	2	1.28
Muscidae	2	1.43	8	0.79	1	1.09	2	0.29	1	4	2	1.28
Therevidae	1	0.71	4	0.4	0	0	0	0.00	0	0	0	0
Bombyliidae	2	1.43	6	0.59	2	2.17	5	0.74	0	0	0	0
Asilidae	1	0.71	1	0.1	0	0	0	0.00	0	0	0	0
Sarcophagidae	2	1.43	5	0.5	2	2.17	8	1.18	2	8	4	2.56
Tachinidae	4	2.86	5	0.5	3	3.26	8	1.18	0	0	0	0
Fanniidae	1	0.71	2	0.2	1	1.09	1	0.15	0	0	0	0
Tipulidae	2	1.43	2	0.2	1	1.09	1	0.15	0	0	0	0
Stratiomyidae	1	0.71	2	0.2	1	1.09	15	2.21	0	0	0	0
Syrphidae	1	0.71	2	0.2	0	0	0	0.00	0	0	0	0

Diversity and abundance of insect species

Average species richness

High average species richness is recorded at Petit Cavallo island (34.45 ± 6.71), while the low average is noted at the Grand Cavallo islets (10.50 ± 1.04) (Fig. 2).

Average species abundance

If Petit Cavallo island hosts high average species abundance (88.25 ± 12.26), Grand Cavallo island has an average species abundance of (68.00 ± 12.43), while Grand Cavallo islet (16.75 ± 3.94) (Fig. 2).

Data analysis

Insect similarity between three islets

The highest similarity was noted between Petit Cavallo island and Grand Cavallo islet (77.58%). It is followed by Grand Cavallo island and Grand Cavallo islet with a 41.10%. Moreover, the similarity coefficient between the Grand Cavallo islet and Petit Grand Cavallo island seemed to be the lowest with 28.74% (Table 2).

DISCUSSION

The differences between the three islets are related to several parameters including, in order of importance, nature and the richness of plant cover, patch size, distance

from the mainland and finally the intensity of exogenous shocks, whether human or relating to the presence of seabird colonies origins (MacArthur and Wilson, 1967; Vidal, 1998; Ponel and Andrieu-Ponel, 1998). In our case, the diversity of vegetation seemed to be crucial in structuring insect populations. In this context, floristic surveys conducted at the same islets indicated that Petit Cavallo island is the richest with 103 species, then comes Grand Cavallo islets with 83 species and Grand Cavallo islet with 24 species (Benhamiche-Hanifi and Moulai, 2012). Despite the balanced structure of the insects fauna in the three islands, which can be explained by a balance between the colonization and extinction rates (MacArthur and Wilson, 1967), which is also favoured by the near shore (≤ 950m). The presence of Yellow-legged Gulls colonies on these sites is not without impact on plant diversity and thus on the entomological stand. The fast growth rate of breeding pairs on these islands is to be feared in the future, especially when we know that the numbers of this bird have been multiplied by 17 on Petit Cavallo island over the past 30 years (Bougaham and Moulaï, 2013). Already, based on data from a study on the same sites (Benhamiche-Hanifi and Moulaï, 2012), the impact of Yellow-legged Gull is very pronounced, in other words, its presence in abundance, strongly contributes to the soil acidification, which favours the establishment of ruderal invasive plant species (67.9% of ruderal). As stipulated by Orgeas *et al.* (2007), invasive plant species, did not contribute in terms of entomological diversity and their expansion would be a catastrophic scenario for biodiversity, organization and functioning of the entomological community.

The distribution of taxonomic affiliation is not uniform, both in diversity and in abundance of insects. However, in Petit Cavallo island, some Coleoptera species predominate such as *Heliotaurus ruficollis* Fabricius (Coleoptera: Alleculidae) (75 individuals), *Dasytes sp* Paykull (Coleoptera: Cantharidae) (23 individuals) and *Oxythyrea funesta* Poda (Coleoptera: Cetoniidae) (19 individuals) (Table 4). While, on Grand Cavallo isalnd, Coleoptera still dominant but with a different species assemblages: *Variimorda villosa* Schrank (Coleoptera: Mordellidae) (34 individuals, *Variimorda* Mequignon (Coleoptera: Mordellidae) (16 individuals). We note that most abundant species in the last two sites are floricolous or anthophagous such as: *Oxythyrea funesta*. The period of capture of these specimens is the full flowering of a number of herbaceous plants (*Sonchus tenerrimus* L. (Asteraceae)*, Hyoseris radiata* L. (Asteraceae)*, Lotus creticus* L. (Fabaceae)*, Chysanthemum corymbosum* L. (Asteraceae)*, Anthemis maritima* L. (Asteraceae) ...). Moreover, we note that the majority of beetles captured (about 30 species) at Grand Cavallo and Petit Cavallo islands are present with a small number not exceeding ten (10) individuals. Orgeas *et al.* (2007) explained the phenomenon by (i) the effective rarity in the ecosystem, (ii) the sampling methods used, which are not adequate to their capture. Other observations, according to Ponel and Andrieu-Ponel (1998), and Orgeas *et al.* (2003), Coleoptera Tenebrionidae are the first to benefit from the presence of gulls colony. Because, as explained by the same authors, gulls intense attendance and bringing new nutrients promotes the development of some groups of Tenebrionidae. Paradoxically, in our islands, despite the presence of large colonies of Yellow-legged Gulls (Bougaham and

Moulaï, 2013) Tenebrionidae, are poorly represented with only three species including *Scaurus atratus* Fabricius (Coleoptera: Tenebrionidae). This scarcity may be related to rats' predation (Soldati, 2009). Increased densities of rats are due likely to inorganic waste and dead chicks Gulls (Vidal *et al.*, 1997). Hymenoptera also seems to be well represented on the two main islets. Obviously, Formicidae, Andrenidae, Anthophoridae and Apidae are the main families that contribute to the diversity and abundance of this order. Much of the insects of these families are attracted by many flowering plants. According to Louadi and Doumandji (1998) and Bendifallah *et al.* (2010), climatic factors and the availability of preferred plants promote diversity and abundance of Apoidea. In terms of abundance, ants provide the bulk of the insects captured on the three islets (50.78% of total abundance). Hölldobler and Wilson (1990) explained this dominance by the efficiency of their social structures in the exploitation of nutrient resources and their demographic growth. In addition, according to Bernard (1958), islands of northern Africa are poor of ants compared to the northern Mediterranean shore. The same author explained, that heat summer more pronounced in Africa then in Europe, has selected Barbary's species, which are best climate resilient. Only 10 species of ants are identified on all three islets, against 28 species on the islands of Port- Cros (Berville *et al.*, 2012) and 27 species on the island of Reunion, the majority (≈33% 9 species) from Africa (Blard *et al.,* 2003). Herbaceous plants richness on Petit Cavallo island, apparently allowed the presence of a significant number of species belonging to Hemiptera order (25 species) such as, *Calocoris* Fieber (Hemiptera: Miridae)*, Plagiotylus* Scott (Hemiptera: Miridae) and *Issus coleoptra* Fabricius (Hemiptera: Issidae). The vast majority of these species has a phytophagous diet and sampled mainly on *Asteriscus maritimus* Less (Asteraceae)*, Chenopodium album* L. (Chenopodiaceae) and *Pistacia lentiscus* L. (Anacardiaceae). The presence of large colonies of Yellow-legged Gulls on the three islets of Jijel (Bougaham and Moulaï, 2013) has certainly favoured the development of several species of Diptera like Saprophagous and Scavengers that thrive on debris and decomposing dead animals (Yellow-legged Gulls and Black Rats). The same phenomenon is observed on Marseille islands (Vidal, 1998). Few families are well represented on Jijel's islets, for example: Calliphoridae, Muscidae and Sarcophagidae. These families, as noted by Wyss (2005), arrive on the substrate immediately after the death of an animal. We reported 26 species of flies on our islets which belonging to 13 families. While in China (Zhou Shan's island) with the same number of families, Hai-wei *et al.* (2008) have identified 13 Diptera species. Orthoptera are very sensitive to changes made on island (Ragge, 1963). Drought and lack of supportive environments on these islets are probably limiting factors. This partly explains the scarcity of representatives of this order on our islets. Five (5) species are observed; *Calliptamus Barbarus* Costa (Orthoptera: Acrididae)*, Phaneroptera nana* Fieber (Orthoptera: Tettigoniidae)*, Eyprepocnemis plorans* charpentier (Orthoptera: Acrididae)*, Ochrilidia tibialis* Fieber (Orthoptera: Acrididae) *and Aiolopus strepens* Latreille (Orthoptera: Acrididae) (Table 3). For comparison, 23 species of grasshoppers are counted on Yeu island (French Atlantic coast) (Dusoulier and Perrotin, 2001). It is also true that favourable environments for Orthoptera are rare on the Jijel islands like heaths and grasslands,

which is not the case of Yeu island. The same observation can be made for diurnal Lepidoptera activities on Jijel's islets where only 14 species are recorded against 48 on the nearest continent (Berkane, 2011). On the Greek islands, Olivier (2000) lists 28 species of Lepidoptera on Nissoros while Coutsis (2001) lists 33 species on Lomnos. In addition to the preferred habitats, that explains these differences. The size and physiognomy of the islets also appear to be involved in species richness. This observation may be valid in most insect orders.

The use of Sorensen similarity coefficient between the three stations, shows that the two islets, Petit and Grand Cavallo, are closest in terms of insect fauna composition (77.58%) (Table 3). Apparently, similarity between insect fauna of three islets of Jijel was closely linked with that of flora. In this sense, Benhamiche - Hanifi and Moulaï (2012) noted a plant similarity of 61.62 % between Petit Cavallo and Grand Cavallo island, 41.12% between Grand Cavallo islet and Grand Cavallo island and 30.16% between Petit Cavallo island and Grand Cavallo island.

This work does not pretend to make discoveries in the field of taxonomy nor of biogeography or even in that of conservation biology, because many insects found in Jijel islets were not identified to species, and many data are then missing. The primary purpose is to assess the diversity of insect population on nearly different islands. The data obtained could be a milestone in the long-term monitoring of insect population on these small islets according to the evolution of certain disturbing factors like breeding pairs of Yellow-legged Gulls or human population attendance.

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