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Research Article

BUTTERFLY SPECIES RICHNESS AND DIVERSITY IN DIFFERENT HABITATS OF M'SILA REGION, ALGERIA

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ABSTRACT

Investigations of the Rhopalocera fauna in M'sila region were carried out in four different type of habitats (agricultural, steppe , forest, and ruderal areas) . Surveys were allowed to collect a total of 1139 mature butterflies rounded up in nineteen species. These species were belonging to five families from which the most represented was those of Pieridae 714 (62.7%) .While the Nymphalidae family was the most diversified family 28.6 % of the observed species .The forest habitat was the richest biotope in butterflies species (S = 16). Agricultural and forest habitats showed the highest degree of similarity in species 0.72 between habitats.Butterfly species richness was correlated with habitat selection.

A first list of the butterflies of M'sila is given based on this study.

Keywords: Forest; Rhopalocera; M'sila; Pieridae; Diversity; Species.

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1. INTRODUCTION

Butterflies are frequently used as bioindicators in ecological studies in a variety of ecosystems, and have also proved to be a suitable target group when studying changes in species richness and composition along ecological gradients [1]. Furthermore, butterflies have relatively short life cycles and are at a low trophic level; consequently, they respond rapidly to subtle habitat and climatic changes in their environment [2].

They are greatly affected by vegetation change because most butterfly larvae have strong associations with host-plants, and adults also need a specific range of nectar plants [3, 4].

they are more sensitive to land-use changes than long-lived animals such as birds and mammals , due to their short cycle, narrow niches and relatively low mobility [5].

Biosystematics and conservation biology provide an understanding of our natural heritage and provide the scientific information needed by government agencies and non-government organisations for setting conservation priorities and implementing practical biodiversity conservation [6, 7] Conservation and land management policies are designed after diversity and ecological patterns provided by biological surveys

for more two centuries the butterfly fauna of Algeria has held the interest of scientists and naturalists[8] at the same time the recent studies are limited in the place as [8] in northern east of Algeria , [9] in Metidja (north Algeria) and [10] in west of Algeria .However no data are available on the Rhopalocera fauna of many large areas: for example, there is no information on M’sila butterflies.

2. MATERIALS AND METHODS

2.1 THE STUDY REGION

M’sila province, occupies a privileged position in the central part of northern Algeria; between the Tell and the Sahara. Its climate is continental, semi-arid with an average temperature of 35°C in summer and of 07°C in winter and irregular rainfall of the order 100 to 300 mm/year. It covers an area of 18,718 km^2 situated at an altitude of 500 meters between 35° 42' 07" N 4° 32' 49"E [11, 12].by its position in Algeria, offers a great ecological diversity [13].

The M'sila region is made up of a mosaic of different terrestrial habitats represented by two principal ecosystems: steppe (represented by Chott el Hodna, a wetland of international importance as defined by the Ramsar Convention, and reserve of El Mergueb) and forest (represented in the north by the forest of Maadid and Ouanougha and in the south by the forest of Djebel Messaad). The steppe, with over 1.2 million ha, covers the largest amount of the region (63% total area) [11,14,15] .

we examined the distribution and abundance of butterfly species across different type of habitats and concomitant changes in community structure by censuring the butterfly populations across 10 localities (Figure 1).

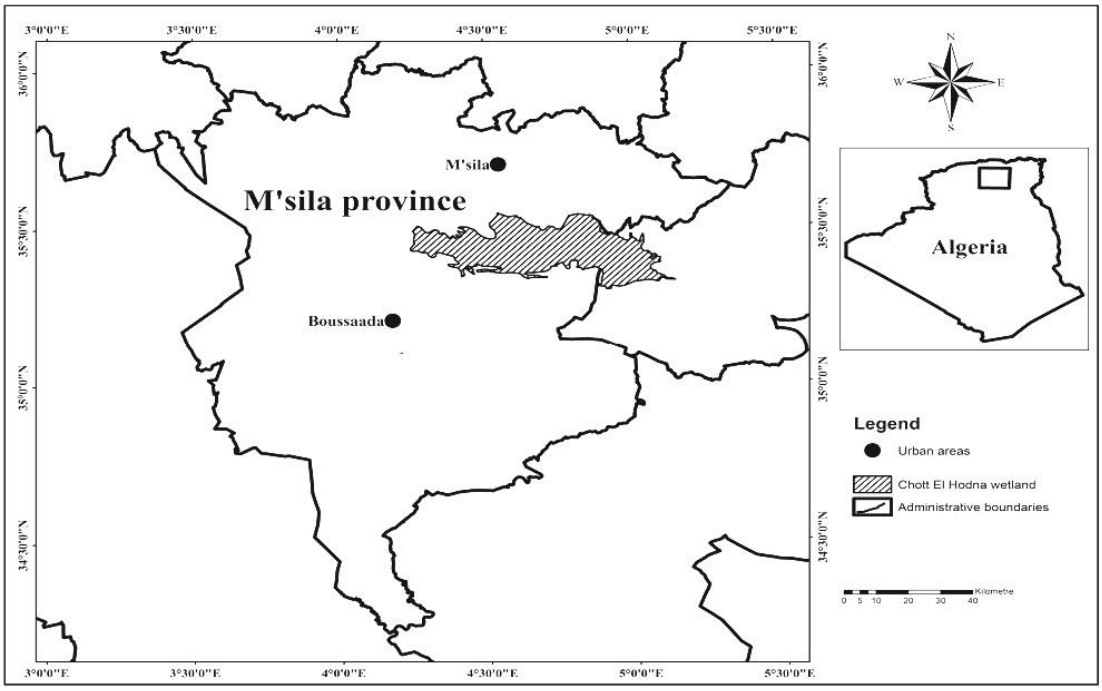

Fig.1. Geographical location of the study region M'sila province, Algeria

2.2 EXPERIMENTAL

Butterflies were surveyed at four habitats:

AGRICULTURE HABITAT

Contains different crops of fruit farming, olive trees, apricot trees, and pomegranate trees with two Layers of vegetation (trees, and herbs), it represent a semi open environment.

Market gardening crops (lettuce, carrots and onion parcels) also cereal crops with a single vegetation layer (herbaceous) these orchards are carried out in irrigated and chemically

treated. It represents an open environment.

FOREST HABITAT

Dominated by Aleppo pine trees and eucalyptus trees with a two vegetation layer (with various herbs and steppe shrubs), and represents an open environment.

STEPPE HABITAT

Two dominating formations Alfa grass and wormwood trees with one Layer of vegetation (herbaceous), and it represents an open environment.

RUDERAL HABITAT

Present a waste places, roadsides or rubbish sometimes it contains some herbs like *Cleome Arabica*, it represents an open environment.

Surveys were done in forty sites spanning elevations ranging from 399 m (chott hodna wetland) to 1172 m (Aleppo pine natural forest of Djebel Messaad) , during 21 months (from March 2015 to December 2016).The surveys were conducted during the adult flight season, In total, 21 surveys were carried out at each survey site. The butterfly census was carried out following the Modified Pollard Walk Method [16] from 08:00 a.m. to 16:30 p.m. in clear weather without clouds. When identifying species by sight was difficult, the butterflies were caught using a net, identified, and released.

Butterfly identification was done using the determination guidelines and benchmarking images from [17] and [18].

Changes in the distribution of species and the structure and composition of species assemblages were compared between the four habitats. The results were interpreted in the context of land use and climate change in the region.

2.3 DATA ANALYSIS

To evaluate the species abundance and species diversity at each site and the differences in community composition, data of butterflies was analyzed using PAST software (Paleontological Statistics) Version 2.17.

The indexes used to examine butterfly community composition and structure at the four sites in M'sila region , were species richness (S), relative abundance (RA), occurrence frequency (O), dominance(D), Shannon's diversity index (H), and evenness (E).

To assess the species composition similarity we used, non-metric multidimensional scaling

that was performed using PC-ORD version 5.

Species richness counts from each trail were pooled to obtain rarefaction curves for comparison of estimated species richness between the habitats.

Sampling completeness was calculated as a ratio of the observed species richness to the richness estimate [19].

4. RESULTS

4.1 BUTTERFLY FAUNA

The present research was conducted at forty sample sites in M'sila region and collected a total of 1139 butterflies representing 19 species, which are belonging to 05 families.

The number of butterfly individuals per station varies between 45 (steppe habitat) and 684 individuals (Agricultural habitat) (Table 1 &2). The most abundant butterfly species in the latter are *Pieris rapae* (252 individuals) followed by *Pontia dapilidice* (111 individuals). The forest habitat ranks second in butterfly abundance with 345 individuals recorded therein. A slight difference in butterfly abundance was found between Steppe habitat (45 individuals) and ruderal habitat (65 individuals).

Table1. The butterfly species found on the four research sites in M'sila province. Abbreviations: A= Agricultural habitat, F = forest habitat, S= steppe habitat and R = ruderal habitat

Family	Genera	Species	Descriptor	Sites	Total (no. individuals)
Nymphalidae	*Vanessa*	*V.cardui*	(Linnaeus, 1758)	A F S R	238
		V.atalanta	(Linnaeus, 1758)	A	2
	Melanargia	*M.galathea*	(Fabricius, 1793)	A F	28
	Danaus	*D. Chrysippus(L.)*	(Linnaeus, 1758)	A F S R	45
	Pararge	*P. aegeria*	(Linnaeus, 1758)	R	2
	Pyronia	*P. bathseba*	(Linnaeus, 1758)	A F	3
	Hipparchia	*H. aristaeus*	(Bonelli, 1826)	F S	8
Pieridae	*Pieris*	*P.rapae*	(Linnaeus, 1758)	A F S R	359
		P. brassicae	(Boisduval, 1832)	A F	6
	Colias	*Colias crocea*	(Linnaeus, 1758)	A F S R	125
	Euchloe	*E. charlonia*	(Fourcroy, 1785)	A F S R	59
		E.belemia	(Donzel, 1842)	A F S	11
	Pontia	*P. daplidice*	(Linnaeus, 1758)	A F S R	154
Papilionidae	*Papilio*	*P. machaon*	(Linnaeus, 1758)	F	1
	Iphiclides	*I. feisthamelii*	(Duponchel, 1832)	A F R	53
Hesperiidae	*Carcharodus*	*C. baeticus*	(Linnaeus, 1761)	A	5
	Gegenes	*G. pumilio*	(Oberthür, 1876)	F	2
Lycaenidae	*Lycaena*	*L. phlaeas (L.)*	(Rambur, 1839)	A F	17
	Polyommatus	*P. icarus*	(Rottemburg, 1775)	A F R	21

A maximum of 16 species of butterflies was recorded in the forest habitats with a minimum of 08 species recorded in the steppe habitats.

Of the 19 species observed, 05 species (26.31%) were recorded only at one of the four habitats and were considered 'unique' species. One of those was labeled as 'singleton' species, that is, only one individual per species was observed.

All of those discovered butterfly species are listed as "Least Concern" status, following the IUCN Red List [20]. Six of them are protected by the Algerian law [21].

Table 2. Abundance and centesimal frequencies of butterflies in M'sila

	Agricultural		**Forest**		**Steppe**		**Ruderal**	
Station species	ni	F(%)	ni	F(%)	ni	F(%)	ni	F(%)
Vanessa cardui	108	16	101	29	14	31	15	23
Melanargia galathea	1	0	27	8	0	0	0	0
Danaus chrysippus L.	7	1	18	5	15	33	5	8
Vanessa atalanta	2	0	0	0	0	0	0	0
Pararge aegeria	0	0	0	0	0	0	2	3
Pyronia bathseba	1	0	2	1	0	0	0	0
Hipparchia aristaeus	0	0	7	2	1	2	0	0
Pieris rapae	252	37	88	26	5	11	14	22
Pontia daplidice	111	16	34	10	3	7	6	9
Colias crocea	88	13	32	9	1	2	4	6
Euchloe charlonia	23	3	15	4	5	11	16	25
Euchloe belemia	7	1	3	1	1	2	0	0
Pieris brassicae	4	1	2	1	0	0	0	0
Papilio machaon	0	0	1	0	0	0	0	0
Iphiclides feisthamelii	49	7	3	1	0	0	1	2
Carcharodus baeticus	5	1	0	0	0	0	0	0
Gegenes pumilio	0	0	2	1	0	0	0	0
Lycaena phlaeas L.	12	2	5	1	0	0	0	0
Polyommatus icarus	14	2	5	1	0	0	2	3
Total	684	100	345	100	45	100	65	100

4.2 BUTTERFLY DIVERSITY

Family-wise distribution of butterflies showed that , the most abundant families are Pieridae 714 (62.7 %), Nymphalidae 326 (28.6%).However, Hesperiidae is the least diversified families with the least number of individuals 7 (0.6%).furthermore, Pieridae and Nymphalidae were the most commonly found and Table 2 shows that both of those families were discovered in all research locations, opposite with family Hesperidae which was found only in two research habitat (agricultural and forest habitats).

Table 3. Families proportion in percentage per each habitat and in the pooled data

	Agricultural	forest	Steppe	Ruderal	TOT (%)
Nymphalidae	17,4	44,9	66,7	33,8	28,6
Pieridae	70,9	50,4	33,3	61,5	62,7
Papilionidae	7,2	1,2	0,0	1,5	4,7
Hesperiidae	0,7	0,6	0,0	0,0	0,6
Lycaenidae	3,8	2,9	0,0	3,1	3,3

At the genus level, The higher number of individuals of genera belonging to genus Pieris (with 365 individuals).

Agricultural habitat ranks first in terms of species richness average (3,26 species per survey) followed by the forest habitat (1.64) . However, Close values were also recorded between the steppe habitat (0.21) and the ruderal habitat (0.31).

4.3 Richness estimates

Species richness estimate, using Chao 1, was found to give the best estimate for the samples of this study. Estimation of species richness in the four habitats showed expected richness values that were very close to equal to the observed values with exception to steppe habitat (Chao1=11, S =08) (Table 04).This was also evident from the high values of the sampling completeness of this study, which varied between 72.72 % and 100% between four habitats.

Table 4. Diversity parameters and species richness estimates of butterfly communities in the four habitats of M'sila

Habitat type	Taxa S	Individuals n	Dominance (D)	Simpson (1-D)	Shannon (H)	Evenness e^H/S	Menhinick	Equitability J	Chao 1	Sampling Completenes s (%)
Agriculture	15	684	0,2109	0,7891	1,868	0,4315	0,5735	0,6897	15,5	96.77
Forest	16	345	0,1809	0,8191	2,038	0,4795	0,8614	0,7349	16	100
Steppe	8	45	0,2385	0,7615	1,652	0,6522	1,193	0,7945	11	72.72
Redurale	9	65	0,1806	0,8194	1,881	0,7292	1,116	0,8563	9	100
overall	19	1139	0,1811	0,8189	2,042	0,4054	0,563	0,6934	19	100

Rarefaction curves from the four habitats showed quick rises at first and then either leveled off (steppe and habitats) or moved toward an asymptote (forest and agricultural habitats) (Figure 2).

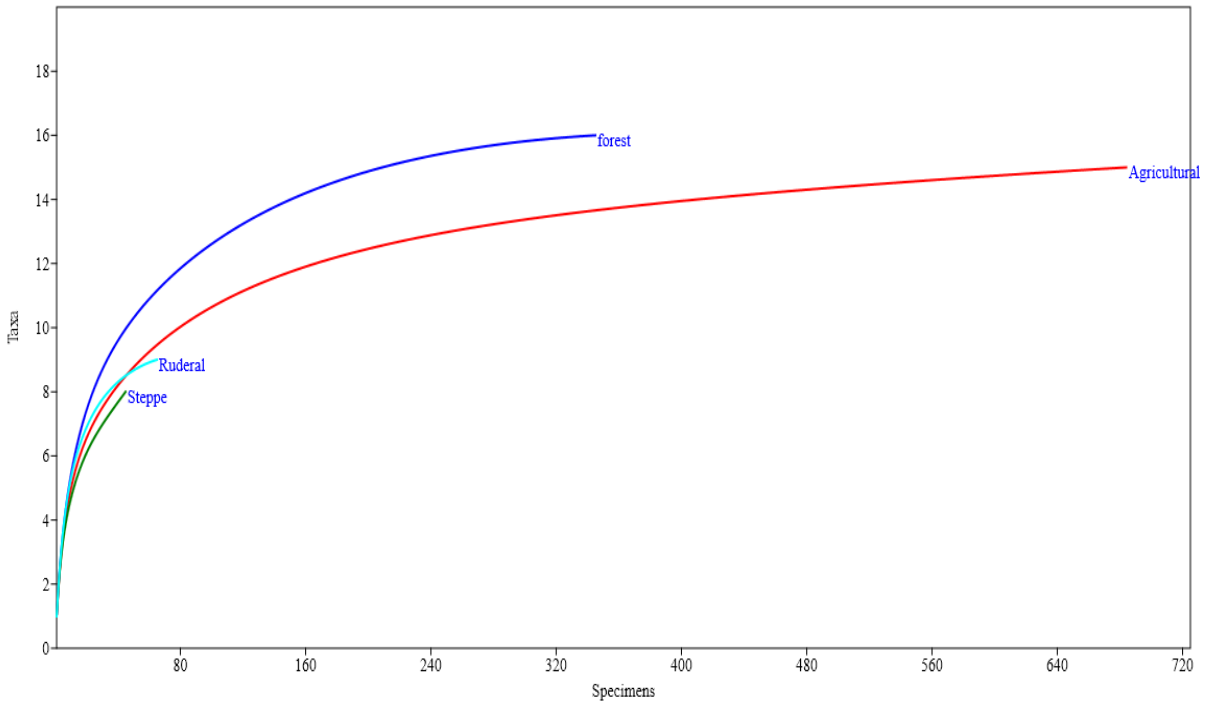

Fig.2. Sample-based rarefaction curves of estimated species richness at four habitat types of M'sila

4.4 BUTTERFLY SPECIES COMPOSITION

The cluster analysis based on Jaccard distance indicated that agricultural and forest habitats showed the highest degree of similarity in species 0.72 between habitats. (Figure 3) and (Figure 4).

The steppe and ruderal habitats were separated from the other plots by an average linkage of similarity distance of 0.55, representing the lowest similarity.

The results of the NMDS (Figure 4) show that agricultural and forest habitats had more species similarity with a less degree the steppe habitats while ruderal habitats had some species associated exclusively to it than was shared with the other habitats for example (Pararge aegeria) was found only in one site (s39) in a ruderal habitat of Maadhid.

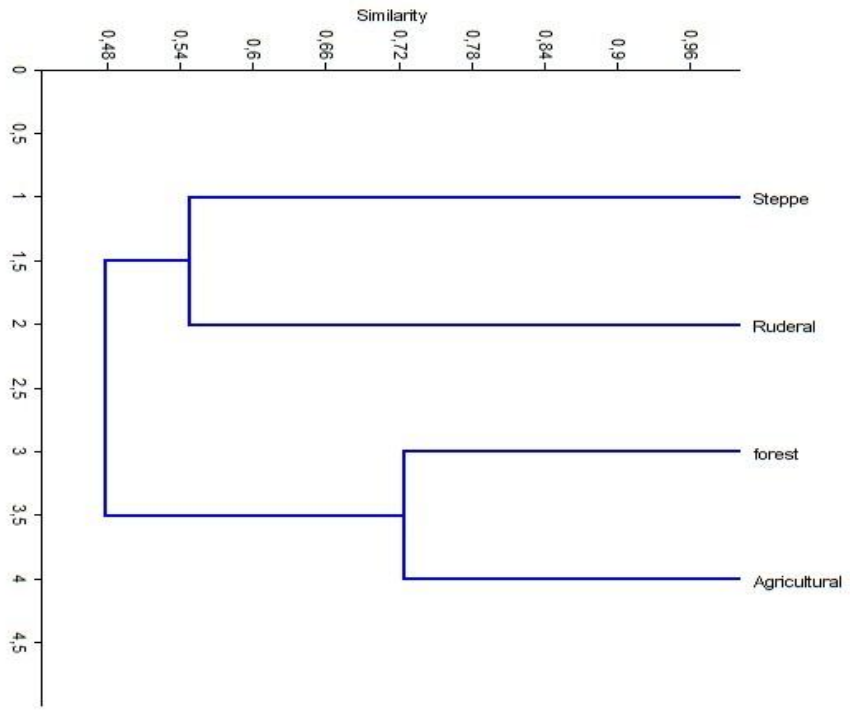

Fig. 3. Hierarchical cluster analysis between habitats using Jaccard distance similarity as aggregation method

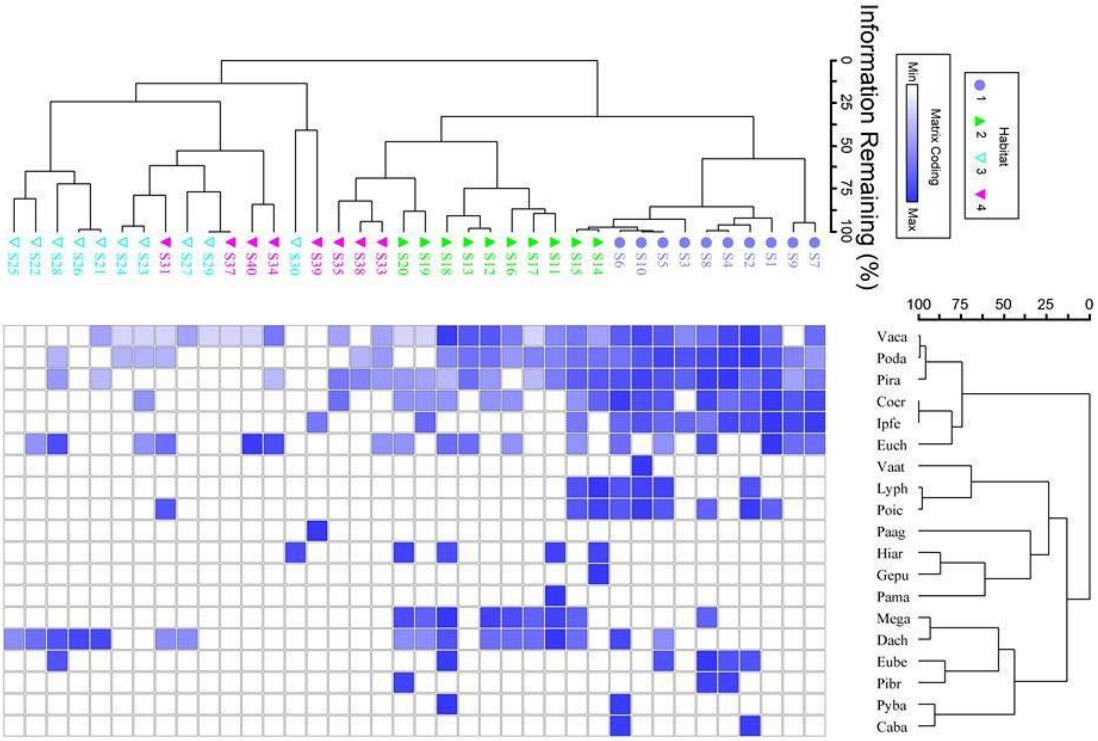

Fig.4. The sites and taxa two way cluster analysis based on a Sorenson distance with flexible beta linkage method

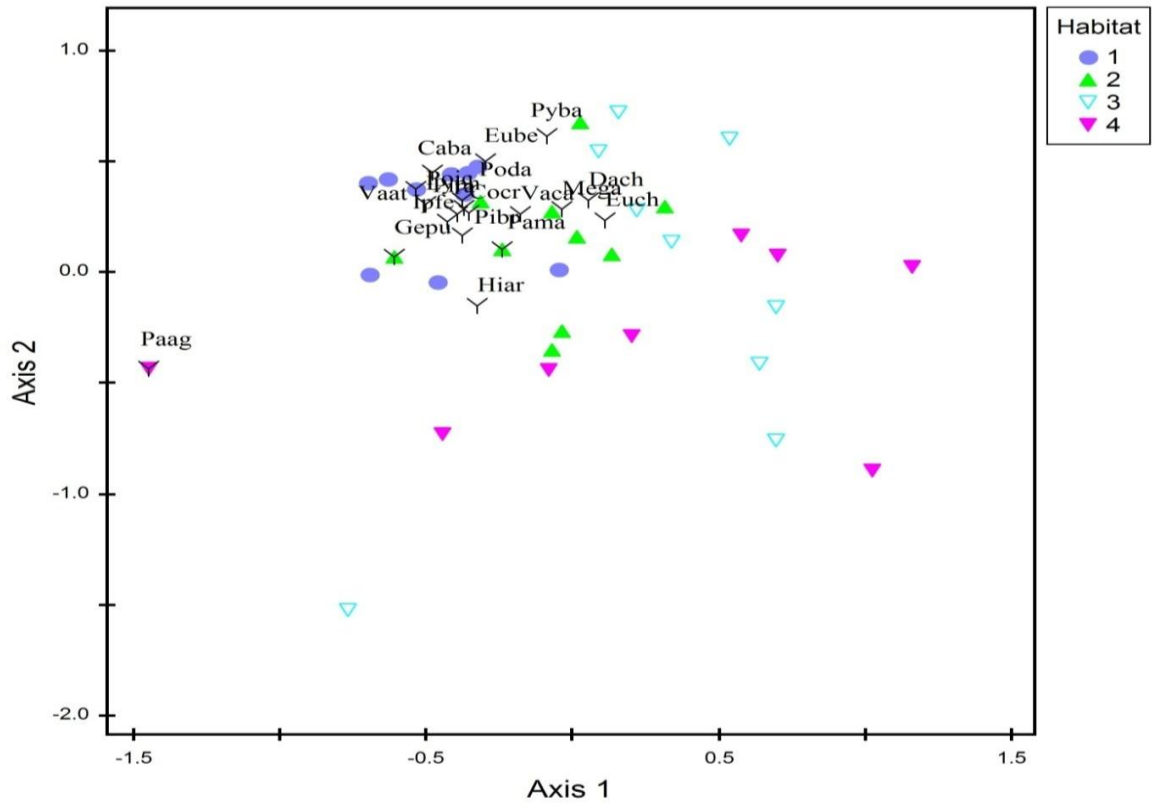

Fig.5. Species composition similarity between different four habitats in M'sila,

Notes : 1= agricultural ; 2= forest ; 3 = steppe ; and 4= ruderal habitats

The families proportion in percentage from the pooled data Nymphalidae and pieridae expresses significantly different proportion among the habitats (Table 3).

A higher proportion of Nymphalidae was found in the steppe habitats, the proportion of the pieridae species was significantly higher in the agricultural and ruderal habitats.

5. DISCUSSION AND CONCLUSION

Our study is the first to assess the butterfly species diversity in M'sila region in the East of semi arid of the country which underlies strong land use pressures due to population growth and intensified agriculture [22].

A total of 1139 individuals belonging to nineteen species have been recorded during this study which represent around **15.9 %** of the total Rhopalocera of Algeria [8].

For several years great effort has been devoted to the study of the butterly fauna across the world.

Unlike in Algeria , some previous studies were done to assess the biodiversity of butterfly fauna, [8] recorded forty six species in the north-eastern Algeria includes (wetlands, mountain and lake) [9]. captured 1507 butterflies during their study performed in five agricultural landscapes of northern Algeria. [10] also noted thirty one butterfly species during their surveys in a several habitats of the National Park Theniet El Had.

In the western part of France [23] captured a total of 2276 individuals representing 22 species during their study in five different landscapes .

[24] noted 1112 butterflies during their study conducted in different habitats (which includes a plot of cultivated crops, meadows and high density of hedgerows and grassy field margins) in the western France.

[25] captured 522 individuals representing 45 species along five tourist trails in the northeast region of Portugal.

In India [26] carried out a detailed inventory of butterflies in mixed moist deciduous and evergreen forests with patches of long grasses , a total of 1005 butterflies representing 59 species were recorded in their study .

In this study, Nymphalidae account 28.6 % of the observed species was the most diverse

family, but, Pieridae was the most abundant family representing 62.7 % of the recorded species Papilionidae, Hesperiidae and Lycaenidae represent the lowest number of individuals and species.

Not all butterfly groups were easy to inventory. The Lycaenidae and Hesperiidae were especially erratic and difficult to sample [27]. In fact the lower number of individuals belonging to small body size species.

Habitat preferences of butterfly species were also studied .It was observed that forest habitat were preferred sites (representing 16 species) followed by the agricultural landscapes (15 species). The poor species richness and low diversity of butterflies recorded in the ruderal (09 species) and steppe habitats (with 08 species only) due to the lower vegetation layers.

According to [9] findings , in agricultural landscapes, butterfly species richness varies between 8 and 18. Forest habitats provided higher butterfly diversity compared to the agricultural habitats that is due to the human practices and pressure [28].

Recorded differences in species diversity can be explained by habitat selection which is directly related to the availability of nourishing plants for larvae and adults [29,30].

As mentioned earlier [31], Mediterranean Africa is inhabited by palaearctic fauna .The majority of recorded butterflies are of Palaearctic origin with few holarctic species

The diversity and abundance of butterflies were different among the habitats explained by the diversity index.

Shannon-Weaver values vary from 1.652 (steppe habitats) to 2.038 (forest habitats) that seems to be the most diversified habitats.

[25] pointed out that the value of diversity index in the mixed landscapes of agriculture, pasture areas, marshes, grassland and natural forests diversifies from H = 2.25 and H = 2.55.

In our study ,the value of diversity index in the agricultural landscapes equaling H = 1.868 (Table 4) , [9] have also found that the valueof this index fluctuate between H = 0.94 and H = 2.44 in the in the agrosystemes of Mitidja, however [23] reported that the value of this index in five studied landscapes vary from H = 1.85 and H = 2.5.

These changes observed between sites is due to some critical factors for butterflies, such as larval food plants and adult nectaring sources [32].

The differences in butterfly species composition are determined largely by plant communities [25,33,34].

Equitability values vary from E = 0.6897 (Agricultural habitats) to E = 0.8563 (Ruderal habitats) these latter represent the most balanced study habitats . Unlike Equitability values of these four types of habitat seems to be too close and shows the presence of certain balance between numbers of butterfly individuals.

Sorensen's index C_s , is used to express the degree of similarity between two samples , the highest value of butterfly similarity index (84 %) was found between the agricultural and forest habitats, the results show 13 common species between the two sites such as *Pieris rapae Vanessa cardui , Pontia daplidice and Colias crocea* this group of species represent the most common butterfly species with a great value of relative abundance (82 % and 74 % respectively). A significant similarity was also noted between steppe and ruderal habitats, with similarity coefficient of (71 %).The lowest value (61 %) was found between Agricultural and steppe habitats (Table 5).

Table 5. Values of Sorensen's similarity coefficient used in the study of day butterfly species in the four habitats

	Agricultural	forest	Steppe
forest	**84**		
Steppe	**61**	**67**	
Ruderal	**67**	**64**	**71**

The results show that more than 30 % of the butterfly species recorded in the all the habitat types was the same. Forest habitats provided higher butterfly diversity compared to the agricultural habitats that is due to the human practices and pressure [28] found that a significant decrease in species numbers associated with an increase in human pressure.also agrees with the observation of [35].

Agricultural habitats are managed by farmers; they may be influenced by intensive, the variability of the species diversity in Agricultural habitats may be due to the diversity of crops and the fields adjacent.Agricultural landscapes mainly cereals fields, olive groves, and

orchards predominate presenting different quantities and qualities of herbaceous elements that support the Butterfly diversity, but some farming practices (as : conversion of unimproved grasslands to arable crops, fertilization of pastureland and increasing use of herbicides and pesticides) may lead to the loss of breeding habitats and the fragmentation and isolation of remaining habitats.

Climate change is another important threat to butterflies in the Mediterranean region [20].

Thus, it can be seen that the six species present at virtually all sites (V.cardui, D. Chrysippus, P.rapae, Colias crocea, E. charlonia and P. daplidice) and present 86.04 % of all individuals As reported by (Thomas, Jordano et al. 1998) these wide-ranging species tend to average the environment' over larger scales than more sedentary species.

This could be one of the possible explanations for the fewer number of individual butterflies collected in steppe habitats as compared to the ruderal plot.

our study represents the first comprehensive and long term butterfly survey in the M'sila province.We thus believe that further analysis taking into account the phylogenetic relationships among butterflies would reveal more complex patterns of species richness.

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