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Diversity and status of day butterflies (Lepidoptera: Rhopalocera) in different plant associations of the Edough Forest Massif (Northeastern Algeria)

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Abstract. *Laref N, Rezzag-Beddida R, Boukheroufa M, Sakraoui R, Henada RLI, Hadiby R, Sakraoui F. 2022. Diversity and status of day butterflies (Lepidoptera: Rhopalocera) in different plant associations of the Edough Forest Massif (Northeastern Algeria). Biodiversitas 23: 954-961.* The current study seeks to evaluate the biodiversity and the structure of the Lepidoptera, Rhopalocera stand in the Edough mountain range, Northeastern Algeria. The main objective is to analyse specific and dynamic fluctuations depending on the forest species and assess their functional role. The resulting work was conducted during the 2021 spring season at the Ain Bocal Natural Site, characterized by a succession of four forest species in a sampling corridor approximately 2 km long. The sampling strategy was based on the linear transect method derived from the British BMS Butterflies Monitoring Scheme method, where 390 individuals were counted to calculate and analyse the stand structure parameters. We were also able to carry out the taxonomic identification of 13 species belonging to four families, Pieridae, Nymphalidae, Lycaenidae and Papilionidae. Overall, the results revealed that the Mixed Algerian Oak Forest (Zean Oak Forest) is the richest in species, followed by Cork Oak Forest, Algerian Oak Forest and Maritime Pine Forest. The forest of the Edough, by its composition in habitats and ecological niches, allows the installation of the lepidopterological biodiversity.

Keywords: Forest species, linear transect, Lycaenidae, mountainous massif of the Edough, Nymphalidae, Papilionidae, Pieridae

INTRODUCTION

Forest environments are excellent reservoirs of biodiversity, more biologically diverse than any other terrestrial ecosystem (Dajoz 2007). They provide numerous benefits for wildlife, both in terms of botanical diversity and the spatial-temporal distribution of different plant species, thus providing ecological resources that meet the vital needs of animals (Budiaman et al. 2017; Anon 2020). These plant associations are influenced by many animal species, many of which are bioindicator species of the health status of the environment in which they live (Nageleisen and Bouget 2009; Mensah et al. 2018). Among these indicators, Lepidoptera is an important insect order which constitutes a true grid of ecosystem readings (Manil et al. 2007; Wiranti et al. 2019). These "insect tools" are by far the most precise indicators for conserving the natural heritage (Faure 2007; Tarrier and Delacre 2008; Kelly et al. 2019). While most species of day butterflies are associated with herbaceous habitats such as grasslands and lawns (Börschig et al. 2013), they are also found in forest habitats based on composition, the structure and heterogeneity of plant communities (Dennis 2004). Edges and herbaceous intra-forest environments (clearings, forest roads, open stands) can thus serve as refuges (Dover et al. 2000), offering favourable microclimatic conditions (Van Halder et al. 2011), but also nectar resources and host plants. In Algeria, a good deal of work has focused on the biodiversity of the Rhopalocera, particularly in the North-East Algeria (Tennent 1996; Samraoui 1998; Remini and Moulaï 2015; Saad and Bounaceur 2018; Berkane et al. 2019, 2021). However, it is necessary to enrich these inventories, expand the exploration areas, and exploit the lepidopterological diversity as a qualitative and quantitative appreciation of reforestation efforts, especially in post-fire forest environments. The main objective of this study is to study the spring dynamics of the Rhopalocerous Lepidopteran population in a forest environment characterized by a succession of plant associations, typical of the mosaic of high-altitude Mediterranean habitats case the Edough Forest Massif. We have set ourselves the objective of analysing the structure parameters of the adult Rhopalocera stand according to the use of the different forest habitats.

MATERIALS AND METHODS

Study area

The study was carried out during the spring period 2021 (from the end of January to the end of May) on the northern slope of the Edough Massif, Northeastern Algeria, between 363 m and 510 m of altitude. The overall framework is the forest massif of the track of 8 km called Col du Chacal. The trail starts from the W16 road connecting Annaba to the village of Seraidi and continues at an altitude of about

500 m, a little varied, for 5.5 km (Figure 1). In a sampling "corridor", approximately 200 m wide and 5 km long, taking into account the development of the runway, Rhopalocera were sampled in a 200 m wide and 5 km long corridor comprising four types of forest habitat.

This locality is characterized by four forest habitats (Mechtoub 2020, Figure 2): (i) Cork Oak Forest: *Quercus suber* L., and its associated rich floristic procession. (ii) Mixed Algerian Oak (also called Mixed Zean Oak) whose main essence is the *Quercus canariensis* Willd. mixed with the Cork Oak and the Mesogenic Pine; with sometimes dense undergrowth. (iii) Pure Algerian Oak (Zean Oak) with *Q. canariensis.* (iv) A Maritime Pine Forest with a tree-filled stratum occupied by the *Pinus pinaster* Aiton, the undergrowth is poor.

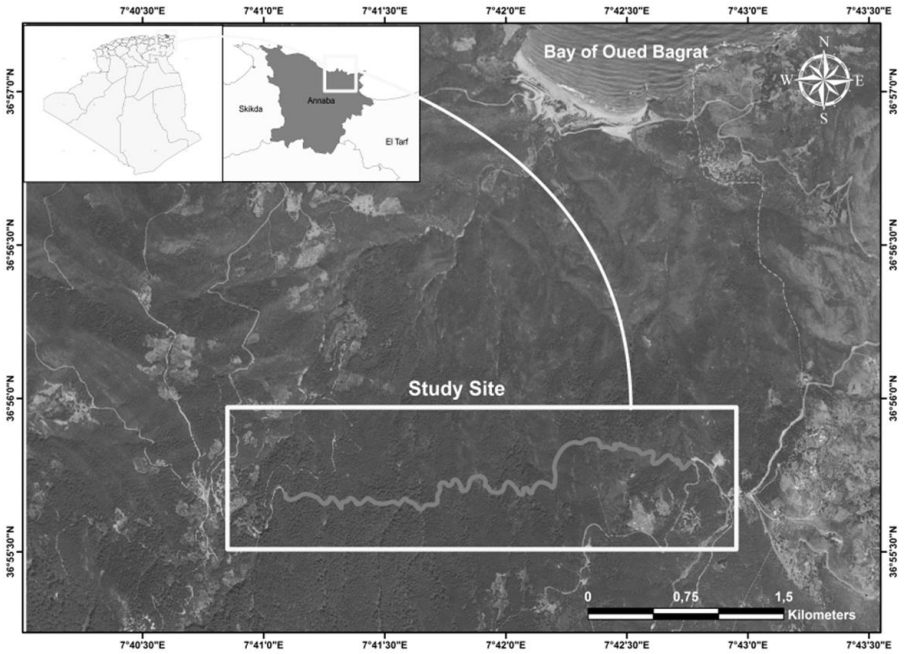

Figure 1. Location of the study area in the Edough Forest Massif, Northeastern Algeria

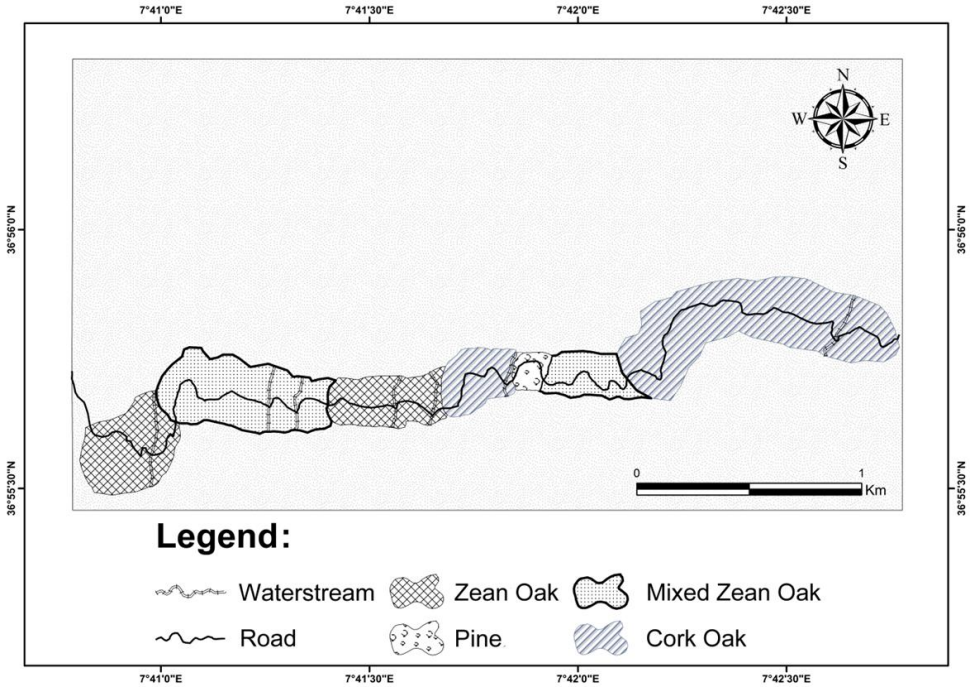

Figure 2. The four forest sampling habitats (Mechtoub 2020, modified by Laref et al. 2022, present work)

Procedures

Two sampling methods were used: the linear transect method derived from the British method (BMS Butterflies Monitoring Scheme) (Pollard 1977; Pollard and Yates1993; Lafranchis 1997; Pellet and Gander 2009; Van Swaay 2015b) (Figure 3) and the Kilometric Abundance Index (KAI) technique, which allows long-distance prospecting. During sampling, the abundance of each species is recorded. A regular count at sight of individuals of all species encountered was made by the same observer at least once a week, while respecting the hours and duration of time spent at each station.

All outings were conducted in the morning from 09 am until 02 pm, with a constant speed of 2 km/h, few pauses were taken to record the species and prepare for the next capture.The fieldwork was conducted in good weather conditions, as mentioned in Robineau's work (2007). Between 13 and 17°C for minimum sunshine of 60% and without the constraint of sunshine beyond 17°C except for the force of the wind never to exceed 40 km/h (Ouin et al. 2000; Carriere 2013). Hard-to-identify specimens were captured (Demerges and Bachelard 2002) for identification based on keys from Tennent (1996) and Tolman and Lewington (1999). The operator visually counts the individuals encountered in a virtual cube (5x5x5 m) located in front of it along a predefined route traveled at a constant speed. Transect is visited regularly during the period of appearance of the species (Nageleisen and Bouget 2009). Only individuals that occur over a distance of 2.5 m on either side of the observer or over a width of 5 m are counted (Manil et al. 2006).

Capture: When the butterfly is in flight, hunting is carried out by a wide horizontal movement (Pesttmal-Saint-Sauveur 1978). The most conventional hunt is conducted on sight with a butterfly net (Leraut 1997). It must have a light and robust steel frame, circular or pyriform in shape from 30 to 40 cm, a solid wire of 3 mm cross-section attached to a wooden handle, bamboo, rattan or light metal from 1,20 to 2 meters. The net, on the other hand, must be made of light and supple fabric such as tulle or muslin, it must have the shape of a rounded cone in the tip (Benkhelil 2001).

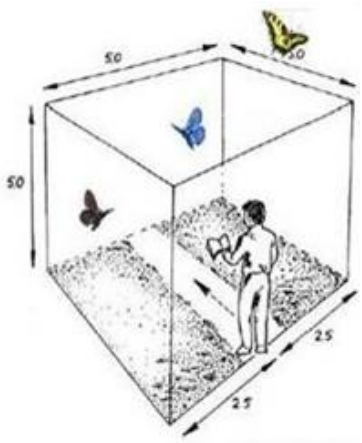

Figure 3. The linear transect method (Van Swaay 2015b)

It is a matter of getting the insect into the net that is enclosed (to prevent the insect from coming out) this net is lighter to be more manageable and not damage insects, but also deeper to not damage butterflies. When butterflies are placed on land or on vegetation, their capture is a bit special; it is a matter of blocking the opening of the net on the ground on the insect, the tip of the net maintained allows the butterfly to rise in the tulle (Benkhelil 2001). The specimens are sacrificed be able to identify them. They are killed in so-called jars of death where 70° or 90° ethanol is put, at the bottom of the cotton-lined bottle, the butterfly dies after inhaling the product (Pesttmal-Saint-Sauveur 1978).

Data analysis

To examine the butterfly's community composition and structure, we used this index entitled Species richness (S), the total number of species present in a station (Ramade 1984). The occurrence frequency (F%) or the presence index (Pi) is expressed by the number of occurrences of a given species to the total number of records N. The following formula calculates it: Fo%= (Pi x 100)/N (Fo%: frequency of occurrence; Pi: number of surveys containing the species under study; N: total number of surveys carried out).

Depending on the frequency of occurrence, the following categories are distinguished (Dajoz 2007), species are: ubiquitous if Fo= 100%, constant if 75% ≤ Fo < 100%, regular if 50% ≤ Fo < 75%, incidental if 25% ≤Fo < 50%, accidental if 5% ≤ Fo < 25%, rare if Fo < 5% (Dajoz 1971; Faurie et al. 2006). Finally, the diversity index of Shannon-Weaver was calculated using the following formula: H´= -Σ (Ni/N) log2 Ni/N (Ni: number of individuals of a given species, ranging from 1 to S (total number of species). N: total number of individuals. The Piélou Fairness Index, Equitability (E), was also calculated. It is the ratio between the maximum diversity (Hmax), it is expressed as follows: E= H´/ H´max (E: Equitability Index; H´: Shannon-Weaver Diversity Index; H´max: Maximum diversity). It is obtained by the following formula H´max= log 2(S) (S: Is the number of species forming the stand). Fairness makes it possible to compare the structures of insect stands (Pielou 1969; Ramade 1984). All results are illustrated in Microsoft Office Excel by histograms and sectors.

RESULTS AND DISCUSSION

Taxonomic identification of individuals

The taxonomic identification of individuals allowed to characterize, all habitats combined, 13 species belonging to four taxonomic families. These families are Pieridae, Lycaenidae, Nymphalidae, and Papilionidae.

Analysis of the composition of the Rhopalocerean stand

At the end of our sampling campaign, we counted at least 390 individuals from all habitats. The highest occurrence frequencies were recorded for species holly blue (*Celastrina argiolus* Linnaeus, 1758); cleopatra

butterfly (*Gonepteryx cleopatra* Linnaeus, 1767); painted lady (*Vanessa cardui* Linnaeus, 1758); red admiral (*Vanessa atalanta* Linnaeus, 1758); large cabbage white (*Pieris brassicae* Linnaeus, 1758) and cabbage white (*Pieris rapae* Linnaeus, 1758) with a percentage of (100%), followed by speckled wood (*Pararge aegeria* Linnaeus, 1758) which presents an F of the order of 75%, clouded yellow (*Colias croceus* Fourcroy, 1785) and southern scarce swallowtail (*Iphiclides feisthamelii* Duponchel, 1832) are those that show a frequency of 50%. However, the lowest F values (25%) are noted in green-underside blue (*Glaucopsyche alexis* Poda, 1761); Moroccan pearly heath (*Coenonympha arcaniodes* Pierret, 1837); two-tailed pasha (*Charaxes jasius* Linnaeus, 1767); and Moroccan orange tip (*Anthocharis belia* Linnaeus, 1767).

Rhopalocera/habitat relationship

The results obtained show that the most important abundances were recorded at the Mixed Algerian Oak and Cork Oak Forest level with 133 and 130 individuals, respectively. Each of these two dwellings contains 34% of all the stand individuals. In comparison, the Algerian Oak Forest (Zean Oak) is home to 79 individuals and the Maritime Pine Forest 48 individuals, representing the least populated environment (only 12% of the whole exists there). Overall, there is a relatively balanced distribution in species richness, with 10 and 9 species respectively for Mixed Zean Oak and Zean Oak, 8 species for Cork Oak and Maritime Pine Forest.

The calculation of the Species Diversity (H') and Equitability (E) parameters allowed us to characterize the Algerian Oak Forest as the most diverse habitat due to its highest Shannon index relative to other habitats (H'= 2.90 bits), and the most equitable as well (E= 0.91) indicating a fairly good distribution of populations among species. Followed by the Mixed Algerian Oak Forest with an H' equal to (2.62 bits). However, Cork Oak Forest and Maritime Pine Forest are marked by low values of H' (2.23; 2.24 bits) same for equitability (0.74 and 0.75, respectively).

Table 1. The number of Rhopalocera inventoried in forest dwellings and frequencies of occurrence of each species

Families	Species identified	Common names	Code	Abundances (numbers)	F (%)
Lycaenidae	*Celastrina argiolus* (Linnaeus,1758)	*Holly blue*	*Car*	115	100
	Glaucopsyche alexis (Poda, 1761)	*Green-underside blue*	*Gal*	1	25
Papilionidae	*Iphiclides feisthamelii* (Duponchel, 1832)	*Southern scarce swallowtail*	*Ife*	10	50
Nymphalidae	*Vanessa cardui* (Linnaeus, 1758)	*Painted lady*	*Vca*	28	100
	Coenonympha arcaniodes (Pierret, 1837)	*Moroccan pearly heath*	*Car*	1	25
	Pararge aegeria (Linnaeus, 1758)	*Speckled wood*	*Pae*	18	75
	Charaxes jasius (Linnaeus, 1767)	*Two-tailed pasha*	*Cja*	2	25
	Vanessa atalanta (Linnaeus, 1758)	*Red admiral*	*Vat*	68	100
Pieridae	*Gonepteryx cleopatra* (Linnaeus, 1767)	*Cleopatra butterfly*	*Gcl*	22	100
	Colias croceus (Fourcroy, 1785)	*Clouded yellow*	*Ccr*	11	50
	Pieris brassicae (Linnaeus, 1758)	*Large cabbage white*	*Pbr*	61	100
	Pieris rapae (Linnaeus, 1758)	*Cabbage white*	*Pra*	53	100
	Anthocharis belia (Linnaeus, 1767)	Moroccan orange tip	*Abe*	1	25

Table 2. Distribution of species encountered on the four habitats

Families	Species identified	Cork Oak	Mixed Algerian Oak	Algerian Oak	Maritime Pine
Lycaenidae	*Celastrina argiolus*	66 individuals	26 individuals	13 individuals	10 individuals
	Glaucopsyche alexis	1 individual	-	-	-
Papilionidae	*Iphiclides feisthamelii*	-	8 individuals	2 individuals	-
Nymphalidae	*Coenonympha arcaniodes*	-	1 individual	-	-
	Pararge aegeria	10 individuals	-	5 individuals	3 individuals
	Charaxes jasius	-	-	-	2 individuals
	Vanessa atalanta	11 individuals	47 individuals	8 individuals	2 individuals
Pieridae	*Gonepteryx cleopatra*	2 individuals	4 individuals	8 individuals	8 individuals
	Colias croceus	-	8 individuals	3 individuals	-
	Pieris brassicae	12 individuals	20 individuals	18 individuals	11 individuals
	Pieris rapae	10 individuals	17 individuals	16 individuals	10 individuals
	Anthocharis belia	-	1 individual	-	-

Table 3. The abundance and richness of Rhopalocera

Ecological indices	Cork Oak	Mixed Algerian Oak	Algerian Oak	Maritime Pine	Total number
N (abundance)	130	133	79	48	390
S (species richness)	8	10	9	8	35

Table 4. The Shannon H' and Blondel E specific diversity index

Ecological indices	Cork Oak Forest	Mixed Algerian Oak Forest	Algerian Oak Forest	Pine Forest
H' (bits)	2.23	2.62	2.90	2.24
E	0.74	0.79	0.91	0.75

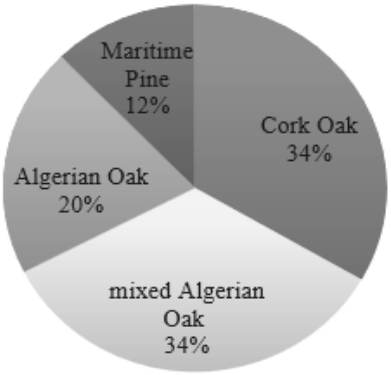

Figure 4. Rhopalocerous abundance composition for each habitat (in percent)

Discussion

The results obtained showed a specific richness particularly characteristic of Mediterranean environments, with a difference in the exploitation of forest species by Rhopalocera. If Rhopalocerean butterflies have a marked preference for open and prairial habitats (Pollard and Yates 1993; Demergues 2002), we have been able to record a more at least rich and diversified stand in the forest, composed of typically forest and less characteristic species, but that frequent the habitats that provide them with the nutrition of their caterpillars (presence of host plants), nectar plants and places of refuge (Saarinen et al. 2005). The difference in size can be explained by the diversity of the floral procession of each plant species, which is the limiting factor for the presence of Rhopalocera (Demergues 2000). Deschamps et al. (1997) emphasize that a nourishing plant is one of the key factors in maintaining insect species in a habitat. For various reasons, characterization of host plants is essential for understanding the presence and dynamics of Rhopalocera, so the presence or absence of a species may provide information on the availability of the host plant (Tolman and Lewington 1999). The results show that the most common species use the four habitat types, which is explained by the fact that they perfectly meet their food needs (Saarinen et al. 2005)**,** Brassicaceae for Pieridae (large cabbage white *P. brassicae* and cabbage white *P. rapae*); common buckthorn (*Rhamnus catharticus* Pall., 1776), common golden thistle (*Scolymus hispanicus* L.) and purple milk thistle (*Galactites tomentosa* Moench) for cleopatra butterfly (*G. cleopatra*) and the painted lady (*V. cardui*); Fabaceae for the clouded yellow (*C. croceus*); European blackberry (*Rubus fruticosus* L.) and scarlet firethorn (*Pyracantha coccinea* M.Roem.) (Rosaceae) for blue *C. argiolus*; large-leaved nettle (*Urtica membranacea* Poir.), roman nettle (*Urtica pilulifera* L.), burning nettle (*Urtica urens* L.), eastern pellitory-of-the-wall (*Parietaria officinalis* L.) for the red admiral (*V. atalanta*). Strawberry tree (*Arbutus unedo* L.) for two-tailed pasha (*C. jasius*); cherry (*Prunus*) for southern scarce swallowtail (*I. feisthamelii*) Tolman and Lewington (1999) with a marked preference for heterogeneous habitats. In this sense, the Mixed Algerian Oak Forest is particularly beneficial for butterflies finding favorable conditions. The heterogeneity and quality of the habitat play a discriminant role in the persistence of the Rhopalocerean populations since the richest sites of Rhopalocera, in terms of diversity of species, are those belonging to a heterogeneous landscape (Gonseth 1994; Kati et al. 2010; Rocchini et al. 2010; Lang 2019). On the other hand, the Maritime Pine Forest is a poor habitat dominated by the Maritime Pine, which opposite the Cork Oak, does not allow the installation of the undergrowth or a floristic procession that directly affects the richness of Rhopalocera. The vegetation cover is indeed dominated by *Retama sphaerocarpa* (L.) Boiss. There are also: spiny broom (*Calycotome spinosa* Link), tree heather (*Erica arborea* L.), Montpelier rock rose (*Cistus monspelliensis* L.), strawberry tree (*A. unedo*), jasmine box (*Phillyrea angustifolia* L.), common myrtle (*Myrtus communis* L.), wild blackberry (*Rubus ulmifolius* Schott) (Boulemtafess 2015). Consequently, the heterogeneity of the composition of the environment increases the diversity of the Rhopalocera communities because it allows the provision of various habitats (ecological niches) and increases the possibilities of complementing trophic resources (Fahrig et al. 2011). Frequency of occurrence analysis allowed us to characterize *C. argiolus*, *V. Cardui*, *G. Cleopatra*, *V. Atalanta*, *P. brassicae*, *P. rapae* as ubiquitous species in all forest species (F= 100%). The latter is a common and

replenished species from the North East of Algeria and which find their preferred habitats in the Edough Forest Massif. *Pararge aegeria* has a frequency of the order of (75%), which according to Dupont et al. (2013), is a forest species that generally prefers edges and sites more or less shady, it is a cosmopolitan and polyphasic species (Manil et al. 2008). On the other hand, *G. alexis* is a rare species that has already been reported in Algeria: Saida, Aflou, Batna, and Khenchla, but not in the humid domain of Annaba (Tolman and Lewington 1999). *Anthocharis belia* (F= 25%) is endemic to Northwest Africa and is considered an incidental species to our stand (Tarrier and Delacre 2008; Van Swaay et al. 2015a). Butterflies are not randomly distributed in time and space. Each species has a specific flight time and habitat (Chinery and Cuisin 1994). Kacha et al. (2020) also show that these differences are likely due to specific biotic and abiotic conditions in each canton, although trapping techniques may also be a factor.

The calculation of the parameters: Species diversity (H') and Equitability (E) allowed to characterize the Algerian Oak Forest as the most diverse habitat because of its Shannon index highest compared to other habitats (H'= 2.90 bits), and the most equitable also (E= 0.91) indicating a fairly good distribution of populations among species. Followed by the Mixed Algerian Oak Forest with an H' equal to (2.62 bits). The species are well distributed in these two environments, a high value of this index corresponds to a species-rich stand with a balanced distribution of abundance. This generally reflects a high degree of complexity and maturity of the stand and, by the same token, the complexity of environmental factors (Benyacoub 1993). However, the Cork Oak Forest and the Maritime Pine Forest are marked by low values of H' (2.23; 2.24 bits) same thing for equitability (0.74 and 0.75). The Cork Oak Forest, despite its high abundance of butterflies (home to 34% of the butterflies of all the stand), is marked by the dominant species, the holly blue (*C. argiolus*), which dominates with (66) individuals (That is almost 50% of all the species found in The Cork Oak Forest) thus reducing diversity. Marcon (2015) said that the presence of dominant species leads mathematically to the rarity of some others: it is therefore fairly intuitive to understand that the maximum diversity will be reached when the species have a very regular distribution. The same goes for the Maritime Pine Forest, which represents a small number of species. However, Berkane (2011) recorded the dominance of speckled wood *P. aegeria* (as opposed to *C. argiolus*) with 15.33% of the whole at the level of Cork Oak Forest of the Taza National Park (Jijel).

According to Kacha (2017), habitat degradation is the key factor in the decrease of lepidopterological diversity, in this case, the pasture that destroys the vegetative cover, also the presence of defoliant species that colonize Oak trees, an example of: gypsy moth (*Lymantria dispar* Linnaeus, 1758), tussock moth (*Orgyia trigotephras* Boisduval, 1829), and the Oak yellow underwing (*Catocala nymphagoga* Esper, 1787) which attack the leaves of the Cork Oak and are capable of destroying all Cork Oak Forest; they are responsible for the majority of the damage observed on the forest trees. This author points out that pine processionary caterpillar (*Thaumetopoea pityocampa* Denis & Schiffermüller, 1775) is one factor in the poverty of Maritime Pine Forests in biodiversity.

In conclusion, Rhopalocera are an essential link for the proper functioning of ecological and functional systems and have specific characteristics that make them an excellent model for understanding the functioning of their communities in different environments, including forest environments. Their high sensitivity to abiotic fluctuations allows them to characterize the state of the environment in which they operate (Blair and Launer 1997; Perović et al. 2015). The study of Rhopalocere in the Edough Forest Massif has made it possible to characterize 13 different species belonging to the forest landscape. The results show a difference in the richness of day butterflies in favour of evergreen forest habitats represented by Cork Oak Forest, compared to deciduous habitats, represented by pure Algerian Oak Forest, Mixed Algerian Oak Forest and Maritime Pine Forest. This difference is probably due to the structural complexity and richness of the floristic procession of each forest habitat. Also, the abundance of Rhopalocera is conditioned not only by the richness of the herbaceous stratum but also by the abundance of host plants specific to each species of Rhopalocera.

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REFERENCES

Anon. 2020. Collectif 2020. Forêts Françaises en Crise: Nature, Climat, Société. Analyse et Propositions des O.N.G. de Conservation de la Nature. Humanité & Biodiversité, WWF, France Nature Environnement, Ligue pour la Protection des Oiseaux, Comité Français de l'UICN, Réserves Naturelles de France, Paris. [French]

Benkhelil ML. 2001. Les Techniques de Récolte et de Piégeages Utilisées en Entomologie Terrestre. Office des Publications Universitaires Ben-Aknoun, Alger. [French]

Benyacoub. 1993. Ecologie de l'Avifaune Forestiere Nicheuse de la Region d'El-Kala (Nord-Est Algerien). Université de Bourgogne, France. [French]

Berkane S, Hafir H, Moulaï R. 2021. Ecological analysis of butterflies and day-flying moth's diversity of the Gouraya National Park (Algeria). Zoodiversity 55 (2): 155-166. DOI: 10.15407/zoo2021.02.155.

Berkane S, Rahmani A, Arifi B, Moulai R. 2019. Diversity and ecology of diurnal Lepidoptera in Belezma National Park (Aures, Algeria). Zool Ecol 29 (2): 143-151. DOI: 10.35513/21658005.2019.2.11.

Berkane. 2011. Contribution à l'Etude de la Diversité et de l'Ecologie des Papillons de Jours (Rhopalocères et Hétérocères Diurnes) au Parc National de Taza (Jijel). Université Abderahmane Mira Béjaïa, Algeria. [French]

Blair RB, Launer AE. 1997. Butterfly diversity and human land use: Species assemblages along an urban gradient. Biol Conserv 80: 113-125. DOI: 10.1016/S0006-3207(96)00056-0.

Börschig C, Klein AM, Von Wehrden H, Krauss J. 2013. Traits of butterfly communities change from specialist to generalist characteristics with increasing land-use intensity. Basic Appl Ecol 14: 547-554. DOI: 10.1016/j.baae.2013.09.002.

Boulemtafess. 2015. Diagnostic de la Diversité Animale et Végétale du Littoral de la Péninsule de l'Edough Nord-Est Algerien. Universite Badji Mokhtar, Annaba. [French]
Budiaman A, Haneda NF, Robaikah ID. 2016. Short Communication: Effects of felling intensity on Hymenoptera biodiversity in a natural production forest in East Kalimantan, Indonesia. Biodiversitas 18: 990-995. DOI: 10.13057/biodiv/d180317.
Carriere M. 2013. Les Papillons par la Photo. Livre Electronique. Ed. Les-Snats, collection Pense-betes, France. www.les-snats.com/download/les-papillons-par-la-photo.pdf
Chincry M, Cuisin L. 1994. Lespapillons d'Europe. Debcbaux et Niestle, Paris. [France]
Dajoz R. 1971. Précis D'écologie. Dunod, Paris. [French]
Dajoz R. 2007. Les Insectes des Forêts. Rôle et Diversité des Insectes dans le Milieu Forestier. Lavoisier, Paris. [French]
Demerges D, Bachelard P. 2002. Proposition de Mise en Place d'Une Méthode de Suivi des Milieux Ouverts par les Rhopalocères et Zygaenidae dans les Réserves Naturelles de France. Réserves Naturelles de France, Paris. [French]
Demergues D. 2000. Première Contribution a l'Etude des Lépidoptères Rhopalocères et Zygaenidae du Projet de Parc Naturel Regional de la Narbonnaise en Mediterranee. Office pour l'Information eco Entomologique du Langue doc- roussillon (O.P.I.E. - L.R.), Paris. [French]
Dennis. 2004. Des pelouses calcicoles d'Évreux et commentaires sur la disparition présumée de certaines espèces. Bulletin Société Linnéenne de Normandie 119: 75-85. [French]
Deschamps-Cottin M, Descimon H, Roux M. 1997. Valeur trophique des plantes nourricières et préférence de ponte chez *Parnassius apollo* L. (Lepidoptera, Papilionidae). Comptes Rendus de l'Académie des Sciences - Series III - Sciences de la Vie 320 (5): 399-406. DOI: 10.1016/s0764-4469(97)85028-7. [French]
Dover J, Sparks T, Clarke S, Gobbett K, Glossop S. 2000. Linear features and butterflies: The importance of green lanes. Agric Ecosyst Environ 80 (3): 227-242. DOI: 10.1016/S0167-8809(00)00149-3.
Dupont P, Demerges D, Drouet E, Luquet G. 2013. Révision Systématique, Taxinomique et Nomenclaturale des Rhopalocera et des Zygaenidae de France métropolitaine. Conséquences sur l'Acquisition et la Gestion des Données d'Inventaire. Rapport MMNHN-SPN. Muséum National d'Histoire Naturelle de Paris, Paris. [French]
Fahrig L, Baudry J, Brotons L, Burel FG, Crist TO, Fuller RJ, Sirami C, Siriwardena GM, Martin JL. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. Ecol Lett 14: 101-112. DOI: 10.1111/j.1461-0248.2010.01559.x.
Faure É. 2007. Suivi de milieux ouverts dans le parc naturel régional du Luberon par des papillons de jour (Rhopalocères) bioindicateurs. Courrier Scientifique du Parc Naturel Régional du Luberon (8): 86-101. [French]
Faurie C, Ferra C, Medori P, Dévaux J, Hemptinne JL. 2006. Écologie, Approche Scientifique et Pratique. Lavoisier, Paris. DOI: 10.1016/S1261-694X(06)78669-2. [French]
Gonseth Y. 1994. La faune des Lepidopteres diurnes (Rhopalocera) des milieux humides du Canton de Neuchatel - Ii - Tourbiers, prés a litière, megaphorbiees. Bulletin de la Société Neuchâteloise des Sciences Naturelles: 33-57. DOI: 10.5169/seals-89414. [French]
Kacha S, Adamou-Djerbaoui M, Marniche F, De Prins W. 2017. The richness and diversity of Lepidoptera species in different habitats of the National Park Theniet El Had (Algeria). J Fundam Appl Sci 9 (2): 746-769. DOI: 10.4314/jfas.v9i2.10.
Kacha S, Djerbaoui M, Marniche F, De Prins W, Ramdani M, Roger F, Moulaï R. 2020. Diversity and abundance of Lepidoptera populations in the Theniet El Had National Park (Algeria). Zootaxa 4743 (1): 035-046. DOI: 10.11646/zootaxa.4743.1.3.
Kati V, Poirazidis K, Dufrêne M, Halley J. M, Korakis G, Schindler S, Dimopoulos P. 2010. Towards the use of ecological heterogeneity to design reserve networks: A case study from Dadia National Park, Greece. Biodivers Conserv 19 (6): 1585-1597. DOI: 10.1007/s10531-010-9788-y.
Kelly EK, Hovis CL, da Silva RFB, Buchholtz EK, Carlson AK, Dou Y, Du Y, Furumo PR, Li Y, Torres A, Yang D, Wan HY, Zaehringer JG, Liu J. 2019. Telecoupling research: The first five years. Sustainability 11 (4): 1033. DOI: 10.3390/su11041033.
Lafranchis T. 1997. L'étude de population: Une méthode simple et ses applications. Insectes 106 (3): 23-26. [French]
Lang. 2019. Caractérisation de l'Hétérogénéité Spatiale de Milieux Naturels à Partir d'Imagerie Optique très Haute Résolution Spatiale: cas d'Application aux Milieux Méditerranéens de Garrigue. Agro Paris Tech, Paris. [France]
Leraut P. 1997. Liste Systématique et Synonymique des Lépidoptères de France. Belgique et Corse, Paris. [French]
Manil L, Henry PY, Merit X, Julliard R. 2006. Suivi Temporel des Rhopalocères de France (STERF). Suivi Temporel des Insectes Communs (STIC). Protocole STERF, Paris. [French]
Manil L, Henry P-Y, Lerch A, Edelist C, Ancrenaz K, Gaboly M, Fontaine B, Lorrilliere R, Julliard R. 2007. Suivi Temporel des Rhopalocères de France Bilan 2006-2007. Département Écologie et Gestion de la Biodiversité du Muséum National d´Histoire Naturelle, Association des Lépidoptéristes de France, Paris. [French]
Manil L, Lerch A, Edelist C. 2008. Suivi Temporel des Rhopalocères de France (STERF). Association des Lépidoptéristes de France (ALF), Paris. [French]
Marcon. 2015. Mesures de la Biodiversité. Université Kourou, Guyana. [French]
Mechtoub R. 2020. Importance des Milieux Forestiers de l'Edough pour l'Avifaune Nicheuse. [Mémoire de Master]. Université Badji Mokhtar Annaba, Algeria. [French]
Mensah BA, Kyerematen R, Annang T, Adu-Acheampong S. 2018. Influence of human activity on diversity and abundance of insects in three wetland environments in Ghana. Bonorowo Wetlands 2: 33-41. DOI: 10.13057/bonorowo/w080104.
Nageleisen LM, Bouget C. 2009. L'étude des Insectes en Forêt: Méthodes et Techniques, Eléments Essentiels pour Une Standardisation. Synthèse des Réflexions Menées par le Groupe de Travail. Inventaires Entomologiques en Forêt. Les Dossiers Forestiers n°19, Office National des Forêts, Paris. [French]
Ouin A, Paillisson JM, Lhonore J. 2000. Methodes de suivi et d'evaluation des populations et peuplements de papillons de jour. Insectes 117 (2): 29-31. [French]
Pellet J, Gander A. 2009. Comparaison de méthodes pour l'estimation de l'abondance des populations de papillons de jour: Etablissement d'un protocole de suivi du Grand Negre des bois (*Minois dryas* (Scopoli, 1763) sur la rive sud du lac de Neuchatel. Entomo Helvetica 2: 201-216.
Perović D, Gámez-Virués S, Börschig C, Klein A-M, Krauss J, Steckel J, Rothenwöhrer C, Erasmi S, Tscharntke T, Westphal C. 2015. Data from: Configurational landscape heterogeneity shapes functional community composition of grassland butterflies. J Appl Ecol 52 (2): 505-513. DOI:10.1111/1365-2664.12394.
Pesttmal-Saint-Sauveur RD. 1978. Comment Faire Une Collection de Papillon et Autres Insectes. Ed. Gauthier, Paris. [French]
Pielou E. 1969. Introduction to Mathematical Ecology. Witley-Interscience, John Wiley and Sons Inc, New York.
Pollard E, Yates TJ. 1993. Monitoring Butterflies for Ecology and Conservation. Chapman & Hall, London.
Pollard E. 1977. A method for assessing change in the abundance of butterflies. Biol Conserv 12 (2): 115-134. DOI: 10.1016/0006-3207(77)90065-9.
Ramade F. 1984. Eléments d'Ecologie: Ecologie Fondamentale. McGraw-Hill, Paris. [French]
Remini L, Moulaï R. 2015. Diversity and structure of butterfly populations in agro-ecosystems of Mitidja (Algeria). Zool Ecol 25 (4): 355-364. DOI: 10.1080/21658005.2015.1090119.
Robineau R. 2007. Guide des Papillons Nocturnes de France, Paris. Ed. Delachaux et Niestlé, Paris. [French]
Rocchini D, Balkenhol N, Carter GA, Foody GM, Gillespie TW, He KS, Kark S, Levin N, Lucas K, Luoto M, Nagendra H, Oldeland J, Ricotta C, Southworth J, Neteler M. 2010. Remotely sensed spectral heterogeneity as a proxy of species diversity: Recent advances and open challenges. Ecol Inform 5 (5): 318-329. DOI: 10.1016/j.ecoinf.2010.06.001.
Saad A, Bounaceur F. 2018. Diversity of Lepidoptera (Rhopalocera) in natural and modified habitats of Bousaâda, Algeria. World J Environ Biosci 7 (1): 79-83.
Saarinen K, Valtonen A, Jantunen J, Saarnio S. 2005. Butterflies and diurnal moths along road verges: Does road type affect diversity and abundance? Biol Conserv 123 (3): 403-412. DOI: 10.1007/s10531-010-9788-y.
Samraoui B.1998. Status and seasonal patterns of adult Rhopalocera in North-eastern Algeria. Nachrichten des Entomologischen Vereins Apollo (NF) 19: 285-298.

Tarrier MR, Delacre J. 2008. Les Papillons de Jour du Maroc. Guide d´Identification et de Bio-indication. Publications Scientifiques du Muséum, Paris. [French]

Tennent WJ. 1996. The Butterflies of Morocco, Algeria and Tunisia. Gem Publishing Co., Timonium, Maryland, USA.

Tolman T, Lewington R. 1999. Guide des Papillons d'Europe et d'Afrique du Nord. Delachaux et Niestlé, Paris. [French]

Van Halder I, Barbaro L, Jactel H. 2011. Conserving butterflies in fragmented plantation forest: Are edge and interior habitats equally important ? J Insect Conserv 15: 591-601. DOI: 10.1007/s10841-010-9360-9.

Van Swaay C, Wynhoff I, Wiemers M, Katbeh-Bader A, Power A, Benyamini D, Tzirkalli E, Balletto E, Monteiro E, Karacetin E, Franeta F, Pe'er G, Welch H, Thompson K, Pamperis L, Dapporto L, Šašić M, Munguira ML, Micevski N, Dupont P, Garcia-Pereira P, Moulai R, Caruana R, Verovnik R, Bonelli S, Beshkov S. 2015a. *Anthocharis belia* (Linnaeus, 1767). The IUCN Red List of Threatened Species 2015. DOI: 10.2305/IUCN.UK.2015-2.RLTS.T62148675A62153378.en.

Van Swaay C, Regan E, Ling M, Bozhinovska E, Fernandez M, Marini-Filho, OJ, Huertas B, Phon CK, K"orösi A, Meerman J, Pe'er G, Uehara-Prado M, Sáfián S, Sam L, Shuey J, Taron D, Terblanche R, Underhill L. 2015b. Guidelines for Standardised Global Butterfly Monitoring. GEO BON Technical Series. Group on Earth Observations Biodiversity Observation Network, Leipzig, Germany. DOI: 10.13140/RG.2.1.1610.8885.

Wiranti D, Nurtjahya E, Dahelmi. 2019. Short Communication: The diversity of butterflies (Superfamily Papilionoidea) as asuccess indicator of tin-mined land revegetation. Biodiversitas 20: 1923-1928. DOI: 10.13057/biodiv/d200719.