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DIVERSITY AND ECOLOGY OF DIURNAL LEPIDOPTERA IN BELEZMA NATIONAL PARK (AURÈS, ALGERIA)

Sonia Berkane[a]*, Abdelhak Rahmani[b], Bachir Arifi[b] and Riadh Moulaï[a]

Laboratoire de zoologie appliquée et d'écophysiologie animale, Faculté des sciences de la nature et de la vie, Université de Bejaia-06000 Bejaia, Algérie B. P.: 359 Amizour, Bejaia, Algeria
*Corresponding author. Email: soniaberkane2000@hotmail.com

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Abstract. To establish a list of existing diurnal Lepidoptera in the Belezma National Park (Aurès, Algeria) and produce a first report on the health of its forest environments using these species as bio-indicators, 192 surveys were carried out between March 2010 and February 2011. This sampling comprised four stations among different habitats; three forests (cedar, oak, pine) and a wasteland. This allowed us to identify 896 individuals, representing 30 species: 29 Rhopalocera (Nymphalidae, Pieridae, Lycaenidae and Hesperiidae) and only 1 species of diurnal Heterocera belonging to the family Arctiidae. The wasteland proved to be the richest station with 18 species and also the most diversified and balanced station (H′ = 3.49 bits; E = 0.84). It is followed by cedar forest (17 species; H′ = 3.16 bits; E = 0.77) and oak forest (12 species; H′ = 2.58 bits; E = 0.72). Finally, the pine forest (9 species; H′ = 2.56 bits; E = 0.81) was the least diversified station. Correspondence Analysis of the most characteristic butterflies at each station revealed that despite continual efforts of park services to safeguard forest formations, especially cedar forests, butterflies still suffer from population depletion.

INTRODUCTION

Butterflies are among the most popular and familiar of insects encountered (Chinery and Cuisin 1994). Because of their specific link with their host plants and habitats, they are recognized as excellent bio-indicators of the health status of natural environments (Tarrier and Delacre 2008; Faure 2007; Manil et al. 2007).

A recent systematic and ecological catalogue of butterflies has been established for Algeria (Tennent 1996). It was followed by an inventory on butterflies living in the most interesting habitats in the north-eastern region, particularly wetlands (Samraoui 1998). More recently, work on the diversity and abundance of butterfly species has been carried out in agricultural plots in the north-central part of the country (Remini and Moulaï 2015).

However, there is a need to enrich these inventories by expanding the prospecting areas to other regions of the country in order to cover as much territory as possible in the long. Butterflies can be considered to be a means of monitoring the quality of protected area management in Algeria. As such, they can be a good way to monitor the efforts of reforestation in Algeria's forests.

The Aurès region, and particularly the Belezma National Park (BNP), is a remarkable and promising area to explore. The BNP represents a biogeographical region at the crossroads of sub-humid and arid northern Mediterranean influences. It is also the site of the last remains of *Cedrus atlantica* forests facing the great Sahara Desert. This park acts as a biological reservoir for species dispersal and migration, regulates natural balances and produces economic and social resources (Sahli 2004).

The objective of this study was to compile the first inventory on diurnal Lepidoptera in this area and to increase knowledge about their diversity and ecology. Bio-indicator butterflies can provide us with information on the current state of general species richness in forest environments. This study lasted 12 months, from March 2010 to February 2011. It involved four stations, one each in mixed cedar forest, oak forest, wasteland and pine forest.

MATERIALS AND METHODS

Study sites

Geographical location

The Belezma National Park is in the eastern part of northern Algeria (latitude 35° North and on either side at longitude 6° East). It is in the mountainous massif of Belezma, which is at the western end of the Aurès Mountains, about 7 km northwest of the town of Batna. It covers an area of 26,250 ha. It is a series of small massifs trapped between the Hodna Mountains in the west and the Aurès Mountains in the south-east, while in the north-west and south-west it overlooks the Merouana plains and the Batna valley. Administratively, this territory overlaps eight municipalities belonging

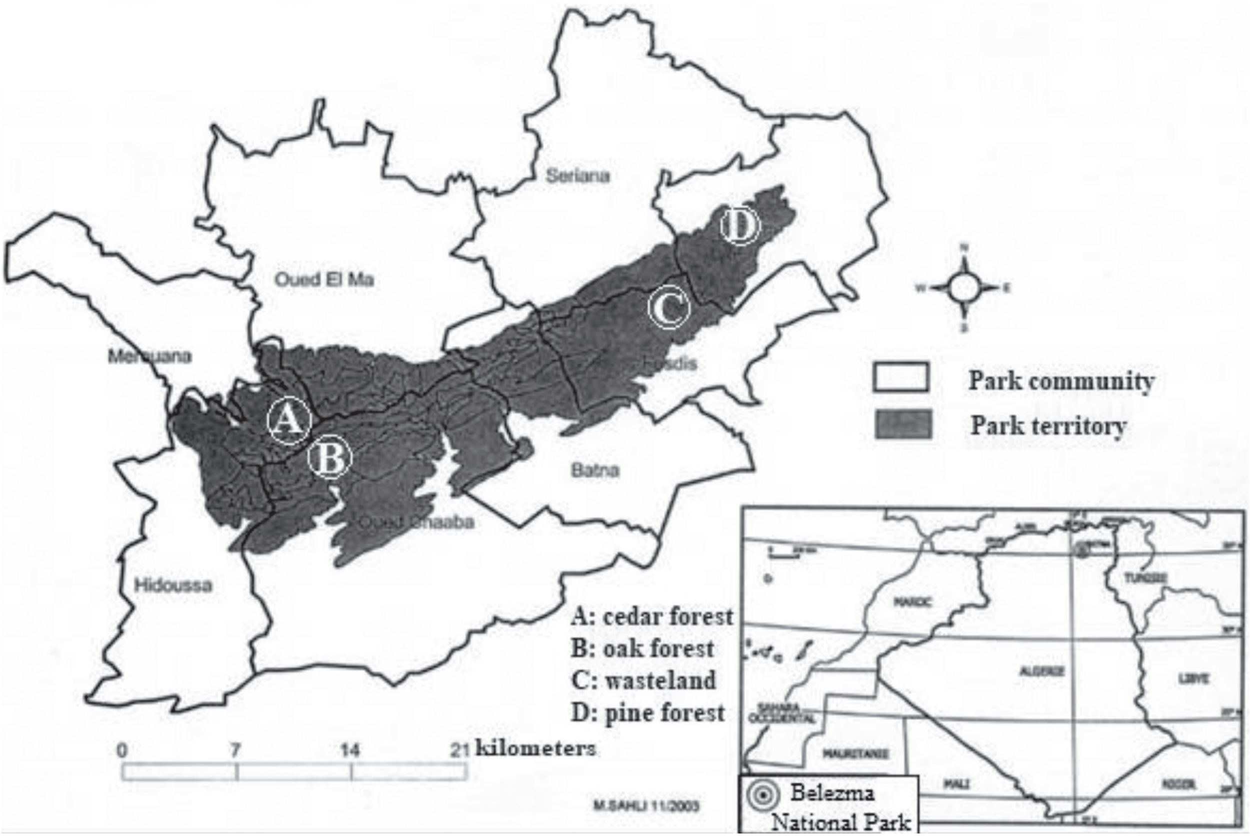

Figure 1. Geographical location of the Belezma National Park and the study stations (Sahli 2004, modified).

to the wilaya of Batna: Merouana, Seriana, Oued El Ma, Hidoussa, Djerma, Fesdis, Oued Chaaba and Batna (Sahli 2004). The BNP was classified as a Biosphere Reserve by the MAB “Programme on Man and the Biosphere” in 2015 (MAB-Algérie 2016) (Figure 1).

Climate and bioclimate

Bioclimatic analysis was carried out using meteorological data from the Ain Skhouna reference station (35°44′20″N 06°21′95″E). It shows that the park area belongs to the lower semi-arid bioclimatic level, characterized by very severe climatic conditions, especially during the summer season. This is due to the increase in temperature values and drought caused by the wind blowing from the south (Sirocco). This area is characterized by a cool and rainy winter and a hot and dry summer. The average annual temperature is 14 °C with a maximum of 25.5 °C and a minimum of 5.1 °C. The average annual rainfall is 300 mm (Arbouche et al. 2012; Houamel 2012; Litim 2012).

Geographic distribution of the sites

The cedar forest (Figure 1 – Station A) (35° 34′ 39.62″N 6°02′ 46.33″E): The cedar forests in the park are essentially made up of *Cedrus atlantica*. It is in Belezma that the largest areas of cedar forest in the country are found (1589.9 ha in 2014). Station A is part of cedar forest that covers an area of about 300 ha. It is mainly located in Jebels Tuggurt and Boumerzoug. The most dominant plant species in this station are: *C. atlantica*, *Juniperus oxycedrus*, *Quercus ilex*, *Fraxinus xanthoxyloides*, *Asphodelus microcarpus* and *Calycotome spinosa*. The oak forest (Figure 1 – Station B) (35°34′43.16″N 6°04′29.93″E): Belezma oak forests are matorrals with *Quercus ilex* associated either with *J. oxycedrus*, *J. phoenicea* or *Olea europaea*. Station B is a matorral oak forest that covers almost the entire mountainous area. The most dominant plant species in this station are: *Quercus ilex*, *J. oxycedrus*, *C. spinosa*, *Stipa tenacissima* and *Ampelodesma mauritanica*. The wasteland (Figure 1 – Station C) (35°37′21.03″N 6°14′17.64″E): The wastelands are in different parts of the park. Station C consists mainly of perennial herbaceous plants. The most dominant plant species in this station are: *Retama raetam*, *Sinapis arvensis*, *Lavandula stoechas* and *Thymus vulgaris*.

The pine forest (Figure 1 – Station D) (35°40′45.14″N 6°15′45.96″E): The pine forests of the park include the Aleppo pine in its natural and wooded state. Station D is the result of reforestation during the 1960s. It is composed of young trees, is improving, and does not show any major deterioration. The most dominant plant species in this station are: *Pinus halepensis*, *J. phoenicea*, *Rosmarinus officinalis*, *C. spinosa* and *L. stoechas* (Smaihi and Kalla 2017; P. N. B. 2010 by P. N. B. 2006; Sahli 2004).

Methodology

The census of diurnal Lepidoptera at BNP stations was carried out by regular counting of images from transect surveys conducted between March 2010 and February 2011. This method was implemented by the English with their "Butterfly Monitoring Scheme" (Moore 1975; Pollard and Yates 1993). The surveys were carried out by 2 observers throughout the series. They observed the images at the rear limit of a virtual box of 5 m on each side, advancing for 1.5 km/1 h at least once a week. Certain weather conditions were constraining: never below 13°C, minimum sunshine period of 60% for temperature between 13°C and 17°C, without any sunshine constraint of sunshine above 17°C, and wind strength having to be less than 40 km/h (Carriere 2013; Demerges and Bachelard 2002; Ouin et al. 2000). All butterflies were identified and counted, either by direct observation of the species where feasible or by capturing individuals, so that they could be released on site. Identification guides were used when necessary: Guide des papillons d'Europe et d'Afrique du Nord (Tolman and Lewington 1999), The Butterflies of Morocco, Algeria and Tunisia (Tennent 1996) and Guide des papillons nocturnes de France (Robineau 2007). For the purposes of identification in the park, collection of a single voucher specimen of each species was required.

Data analysis

The data collected were processed using the following indicators: species richness (S), which is the total number of all species encountered in the course of N observations; average richness (Sm), which is the average number of species encountered during every counting event: $Sm = \Sigma Ni/R$ (Ni: number of species in survey i, R: total number of surveys) (Ramade 1984); relative abundance as a percentage of individuals of a given species in relation to the total number of individuals, which is expressed by the following formula: $F (\%) = (ni/N)*100$ (ni: number of individuals of a species I, N: total individuals of all species combined); frequency of occurrence: $Fo (\%) = P/R * 100$ (P: number of records containing the species studied); species are: ubiquitous if Fo = 100%, constant if $75\% \leq Fo < 100\%$, regular if $50\% \leq Fo < 75\%$, accessory if $25\% \leq Fo < 50\%$, accidental if $5\% \leq Fo < 25\%$, rare if $Fo < 5\%$ (Dajoz 1971; Faurie et al. 2003); Shannon-Weaver Diversity Index: H' (bits) = $-\sum qi \log2 qi$, where $qi = ni/ N$; Equitability Index: $E = H'/ H'max$, where H′: observed diversity, H′max: maximum diversity; $H'max = \log2S$, where S is species richness (Ramade 1984; Dajoz 1985; Pielou 1969); and finally, the Sörensen Index: $Cs = (2J/a + b)*100$ (a: number of species present at site A, b: number of species present at site B, and J: number of species common to the two sites A and B (Maguran 1988). To explore differences in butterfly species diversity in different stations, based on specific abundances, a Correspondence Analysis (CA) was carried out using the Past software, version 3.20 (Hammer et al. 2001). For greater readability, only the abbreviations of the species names appear.

RESULTS

During the study period, 30 species were recorded at BNP level, including 29 Rhopalocera and 1 diurnal Heterocera. Rhopalocera were represented by four families: Nymphalidae, Pieridae, Lycaenidae and Hesperiidae. There were 13, 9, 6 species from the first three families and only 1 species from the last one. However, we only encountered one species of diurnal Heterocera belonging to the family Arctiidae. 3 species were recorded at all the stations studied: *Colias croceus*, *Glaucopsyche melanops* and *Pieris rapae*. However, 17 species were found at only one of the stations: *Melitaea aetherie*, *Nymphalis polychloros*, *Pararge aegeria*, *Polyommatus icarus*, *Pyrgus armoricanus* and *Vanessa cardui* in the cedar forest; *Callophrys avis* and *Melanargia occitanica* in the oak forest; *Coenonympha pamphilus* and *Melanargia ines* in the pine forest; and *Anthocharis belia*, *Chelis maculosa*, *Euchloe ausonia*, *Euchloe belemia*, *Euchloe charlonia*, *Maniola jurtina* and *Pontia daplidice* in the wasteland. The number of individuals recorded per station varied between 100 and 379. *Argynnis pondora* recorded the highest number at cedar forest and oak forest, with 80 and 60 individuals, respectively. *Colias croceus* recorded its highest numbers at the wasteland and pine forest, with 52 and 33 individuals, respectively. Among the species listed, we noted the presence of 3 species protected by Algerian law, namely: *C. croceus*, *Polyommatus icarus* and *Melanargia galathea* (Table1).

Pieris rapae recorded its highest frequencies of occurrence (100%) as a ubiquitous species in the cedar and oak forests. *Pontia daplidice* recorded its highest frequency of occurrence in the pine forest as a ubiquitous species with 100%. Then, *Pieris rapae* was constant at the level of wasteland with 75%. On the other hand, it was absent in the pine forest. *C. croceus* was constant at three stations (oak forest, wasteland and pine forest) with 75% and regular with 50% in the cedar forest. *G. melanops* and *Pieris brassicae* were regular in the wasteland as *Lycaena phlaeas* in the oak forest, with 50% of frequency of occurrence for each one of them (Figure 2).

Pontia daplidice recorded its highest relative abundance in the pine forest with 48.75%. *Pieris rapae* recorded its most important relative abundance in three stations: cedar forest, oak forest and wasteland with, respectively: 46.38%, 47.68% and 35.05%. *C. croceus* also recorded high relative abundance in the pine forest and wasteland with, respectively: 30.2% and 25.63% (Figure 3).

After one year of prospecting, the total species richness varied between 9 and 18 species. The wasteland proved to be the richest station with 18 species. It was followed by cedar forest (17 species) and oak forest (12 species). The pine forest was the least rich station with only 9 species.

The average richness expressed in the average number of species per survey followed the same order. The highest

Table 1. Inventory and numbers of diurnal Lepidoptera species recorded in the four stations of the Belezma National Park (March 2010 – February 2011) (name in bold: protected species in Algeria).

Species	Code	Cedar forest	Oak forest	Wasteland	Pine forest
Anthocharis belia (Linnaeus, 1767)	A.be	0	0	3	0
Argynnis pandora (Denis et Schiffermüller, 1775)	A.pa	80	60	0	15
Callophrys avis (Chapman, 1909)	C.av	0	1	0	0
Chelis maculosa (Gerning, 1780)	C.ma	0	0	2	0
Coenonympha pamphilus (Linnaeus, 1758)	C.pa	0	0	0	5
Colias croceus (Geoffroy in Fourcroy, 1785)	C.cr	40	20	52	33
Euchloe ausonia (Hübner, 1803)	E.au	0	0	14	0
Euchloe belemia (Esper, 1800)	E.be	0	0	12	0
Euchloe charlonia (Donzel, 1842)	E.ch	0	0	2	0
Glaucopsyche melanops (Boisduval, 1828)	G.me	24	1	12	2
Gonepteryx cleopatra (Linnaeus, 1767)	G.cl	9	5	4	0
Hipparchia algiricus (Oberthür, 1876)	H.al	65	57	7	0
Hipparchia ellena (Oberthür, 1893)	H.el	77	44	2	0
Lampides boeticus (Linnaeus, 1767)	L.bo	3	0	2	0
Lasiommata megera (Linnaeus, 1767)	L.me	4	0	0	3
Lycaena phlaeas (Linnaeus, 1761)	L.ph	0	2	8	5
Maniola jurtina (Linnaeus, 1758)	M.ju	0	0	4	0
Melanargia galathea (Linnaeus, 1758)	M.ga	6	0	4	0
Melanargia ines (Hoffmannsegg, 1804)	M.in	0	0	0	3
Melanargia occitanica (Esper, 1789)	M.oc	0	5	0	0
Melitaea aetherie (Hübner, 1826)	M.ae	1	0	0	0
Nymphalis polychloros (Linnaeus, 1758)	N.po	3	0	0	0
Pararge aegeria (Linnaeus, 1758)	P.ae	14	1	0	0
Pieris brassicae (Linnaeus, 1758)	P.br	3	1	16	0
Pieris rapae (Linnaeus, 1758)	P.ra	43	29	34	29
Polyommatus icarus (Rottemburg, 1775)	P.ic	2	0	0	0
Pontia daplidice (Linnaeus, 1908)	P.da	0	0	7	0
Pyrgus armoricanus (Oberthür, 1910)	P.ar	4	0	0	0
Tomares ballus (Fabricius, 1787)	T.ba	0	1	6	5
Vanessa cardui (Linnaeus, 1758)	V.ca	1	0	0	0

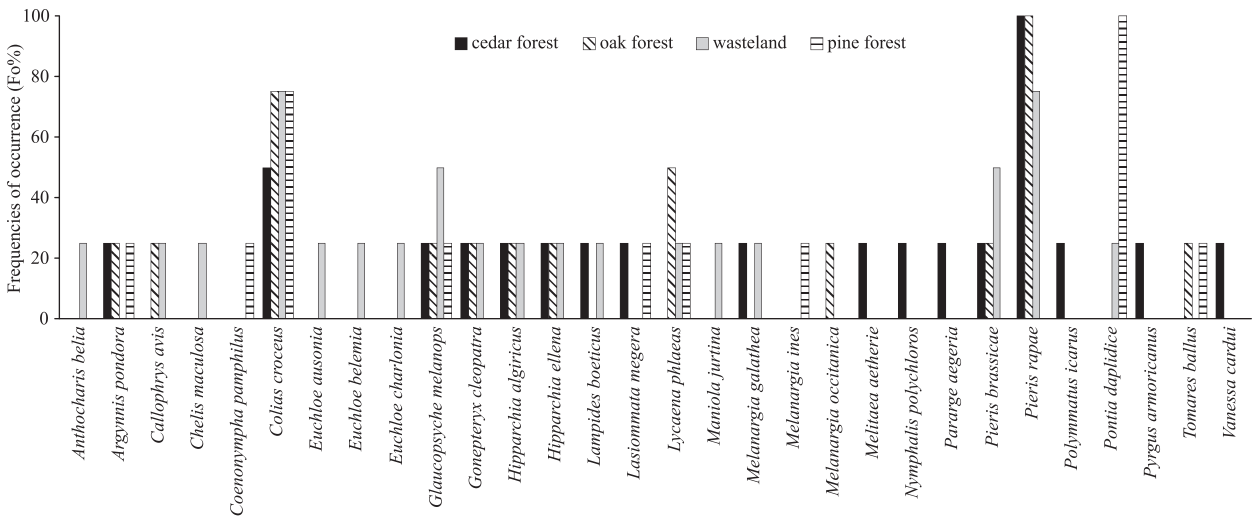

Figure 2. Diagram of frequencies of occurrence of diurnal Lepidoptera species observed by stations in the Belezma National Park.

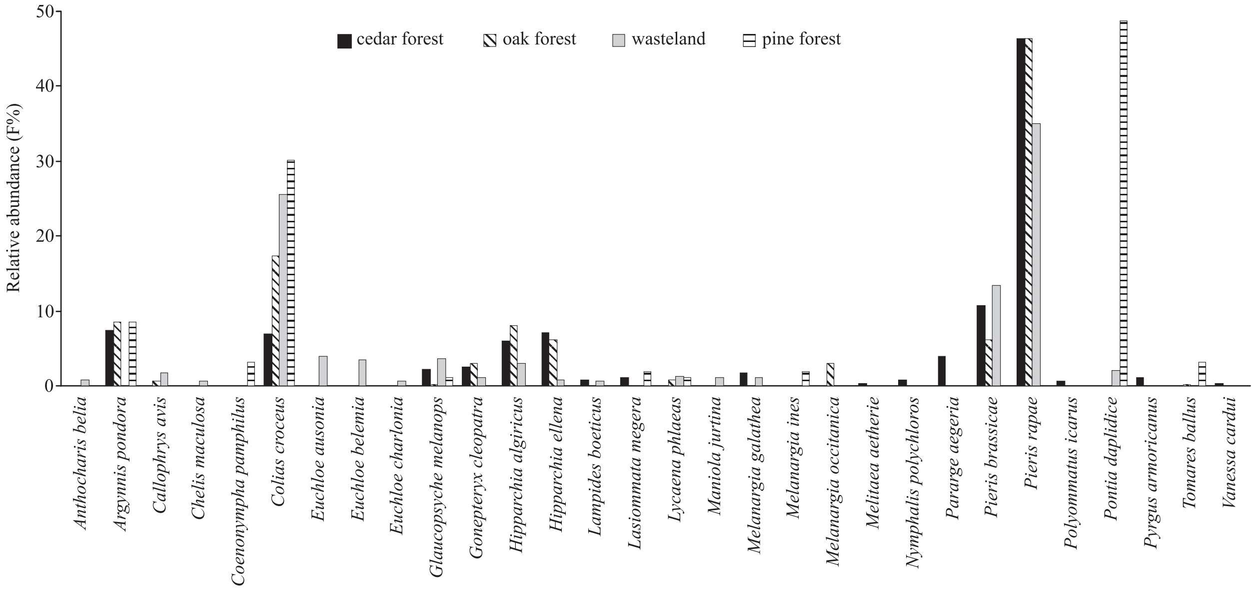

Figure 3. Diagram of relative abundance of diurnal Lepidoptera species observed by stations in the Belezma National Park.

Table 2. Species richness (S), average richness (Sm), Shannon-Weaver Diversity Index (H′), Maximum Diversity Index (H′max), Equitability Index (E), of Rhopaloceran and diurnal Heteroceran species observed at the stations in the Belezma National Park during the study period (March 2010 – February 2011).

Types of habitats	S	Sm	H′ (bits)	H′max (bits)	E
Cedar forest	17	3.5	3.2	4.1	0.8
Oak forest	12	2.5	2.6	3.6	0.7
Wasteland	18	4.2	3.5	4.2	0.8
Pine forest	9	2.1	2. 6	3.2	0.8

values were recorded at the wasteland and cedar forest with, respectively, 4.23 and 3.5 species per survey. They were followed by oak forest and pine forest with, respectively, 2.5 and 2.06 species per survey.

When calculating the Shannon-Weaver Diversity Index and Equitability Index applied to the four stations, the most diversified station was the wasteland with a value of 3.49 bits. It was followed by cedar forest (3.16 bits) and oak forest (2.58 bits). Finally, the pine forest proved to be the least diversified station with a value of 2.56 bits. The wasteland was also the most balanced station with a fairness value of 0.84. Then came the pine forest with 0.81 and the cedar forest with 0.77. The least balanced station was the oak forest, with 0.72 (Table 2).

According to the Sörensen similarity coefficient, the cedar and oak forest stations were the most similar with 62% in common. Then came the oak forest, which had a similarity of 60% with the wasteland and 57% with the pine forest. Next were the cedar forest and wasteland stations, which were 55% similar. Finally, with similar percentages, the pine forest had a similarity of 38% with the cedar forest and 37% with the wasteland.

Statistical study

Figure 4 shows that axis 1 represents 64% of the graph's inertia and axis 2 represents 26%. Between them, they have 90% inertia. Some amenities between the environments and species present are observable. The graph shows the existence of three groups, distributed on either side of the two axes.

The group G1 is represented by the wasteland. It is on the positive side of both axes. It includes the following species: *Euchloe ausonia*, *E. belemia*, *E. charlonia*, *Pontia daplidice*, *Anthocharis belia*, *Chelis maculosa*, *Maniola jurtina* and *Pieris brassicae*.

The group G2 represented by the pine forest is on the positive side of axis 1 and on the negative side of axis 2. It is characterized by the presence of two species: *Coenonympha pamphilus* and *Melanargia ines*.

The group G3 consists of two stations: the cedar forest and the oak forest. It is on the positive side of axis 2 and on the negative side of axis 1. It includes the following species: *Argynnis pandora*, *Callophrys avis*, *Hipparchia algiricus*, *H. ellena*, *M. occitanica*, *Melitaea aetherie*, *Nymphalis polychloros*, *Pararge aegeria*, *Polyommatus icarus*, *Pyrgus armoricanus* and *Vanessa cardui*.

Finally, some species are found in the middle of the graphical representation. The cedar forest and wasteland share the following species: *Gonepteryx cleopatra*, *Glaucopsyche melanops*, *Lampides boeticus* and *Melanargia galathea*. Between the pine forest and the wasteland, there are: *Lycaena phlaeas* and *Tomares ballus*. Between the oak forest and the pine forest, there is *Lasiommata megera*. Finally, between all the stations, *Pieris rapae* and *Colias croceus* are located.

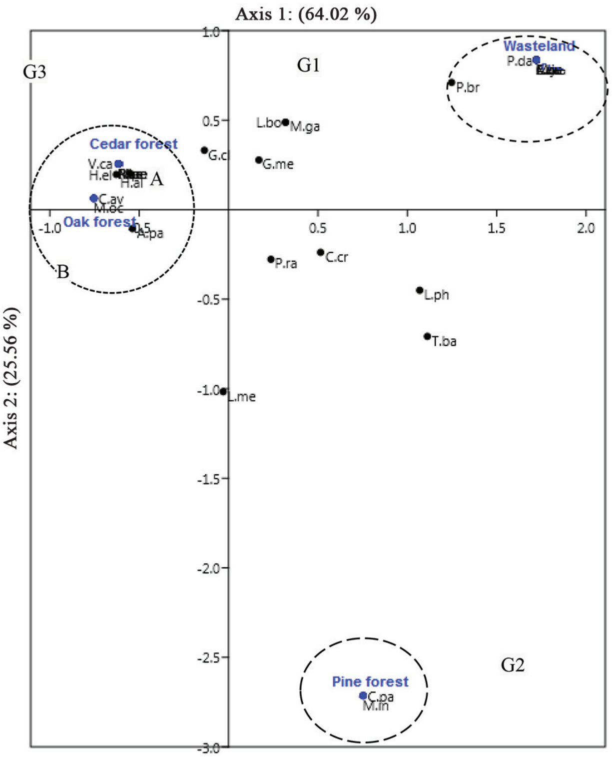

Figure 4. Distribution of diurnal Lepidoptera species among the study stations at the Belezma National Park, as determined by Correspondence Analysis (CA).

DISCUSSION

The monitoring of Belezma National Park's diurnal Lepidoptera enabled us to identify 30 species, among which 29 represented Rhopalocera (Nymphalidae, Pieridae, Lycaenidae, Hesperiidae) and only 1 species of diurnal Heterocera, belonging to the family Arctiidae. Rhopalocera represent 24.17% of the total number of species recorded in Algeria, which counts 120 according to Tennent (1996). Lepidoptera groups that are less specific to their host plants are richer in species (Weincatner et al. 2006). For this study, the Nymphalidae (13 species) were at the top of the ranking. They were followed by Pieridae (9 species), then Lycaenidae (6 species). Finally, there were the Hesperiidae and Arctiidae, which each had 1 species.

Some species were omnipresent and in large numbers, as was the case for ubiquitous species such as *Pieris rapae* in the cedar and oak forests and *Pontia daplidice* in the pine forest. On the other hand, other species were omnipresent (high occurrence frequencies) but generally not very abundant (low relative frequencies). This was the case for *Glaucopsyche melanops* and *Pieris brassicae* in the wasteland and *Lycaena phlaeas* in the oak forest.

The specific richness of the four stations varied between 9 and 18 species. The wasteland was the most diversified (18 species) and most balanced (E = 0.8), as this station has many nectariferous plants: *Retama raetam, Sinapis arvensis, Lavandula stoechas* and *Thymus vulgaris* (Smaihi and Kalla 2017; P. N. B. 2010; Sahli 2004). This type of open environment is most valued by butterflies and particularly bio-indicators of open environments (Faure 2007; Demerges and Bachelard 2002). In some cases, the rarity or location of a species may correspond to that of its host plant (Tolman and Lewington 1999). For example, the presence of *Euchloe ausonia* in wasteland can be explained by the presence of *Sinapis arvensis* (Tennent 1996). Altitude is also a determining factor for the presence of certain species. This may explain the presence of *Melitaea aetherie* only in the cedar forest (1300 m). This species has been recorded in the Aurès region between 1200 and 1800 m altitude (Tolman and Lewington 1999). However, when tree cover is important, it affects species that depend on open environments and warm micro-climates. As trees create a cool microclimate, forests do not generally represent preferential environments for daytime species (Chinery and Cuisin 1994). This may explain a lower number of species observed in forest stations such as: oak forest (12 species) and pine forest (9 species). However, the cedar forest (17 species) was rather rich in butterfly species. This may mean that this station represents a more degraded environment than the two previous ones. Degradation is due mainly to anthropogenic action through illegal logging and overgrazing and a multitude of other factors such as diseases linked to defoliating insects (lepidoptera) or certain parasites, one of which is a wood-eating fungus of the genus Armillaria and another is a wood-boring insect (Boukerker 2016; P. N. B. 2010 by P. N. B. 2006; Sahli 2004). This results in a decline in cedar to the benefit of other species and the presence of open spaces within the station itself.

According to the Sörensen similarity coefficient, the cedar forest and oak forest were the most similar with 62%, noting that these two stations are located in the geographically close western sector of the park (Figure 1). Both also suffer from the state of degradation that affects most Mediterranean woodlands (Sahli 2002; Quezel et al. 1999). The cedar forest sampled for this work was accompanied by a floral procession resulting from extensive degradation (overgrazing, illegal and abusive cutting). Because of this opening of the population, the floral procession is no longer strictly sylvatic, but strongly infiltrated by a lot of species from open environments. Particularly noteworthy in this cedar forest was the abundance of the genus *Asphodelus*, which is characteristic of livestock resting areas, where the soil is highly enriched in nitrate by cattle droppings (Boukerker 2016). It is also important to note that forest fires, amplified by human action on these natural Belezma entities (clearing, cutting and pastoral pressure), considerably transform the oak landscape into less closed formations (Smaihi and Kalla 2017).

The Correspondence Analysis showed aggregations between the environments and species present. Two types of environments: wasteland and pine forest, stood out and the other two environments: cedar forest and oak forest, grouped together in a single cluster. The distribution of species along axis 1 followed a gradient of habitat openness and along axis 2 in relation to butterfly species richness.

For all species aggregated at the wasteland level, these were species linked to an open and flowering environment. This is the case for the Pieridae, which frequent both open environments and forest borders (Chinery and Cuisin 1994). One of these, for example, was *Pontia daplidice*, which is an indigenous migratory butterfly in North Africa. This also applied to *Pieris brassicae*, a migratory species that frequents all kinds of environments. In the wasteland there was the high-altitude butterfly *Chelis maculosa*. Two specimens were recorded at this station, at an altitude of nearly 1000 m. Very distinct, the pine forest has only two species: *Coenonympha pamphilus* and *Melanargia ines*. During this study, these two species were found to be exclusive to this environment. These are species that frequent herbaceous environments, meadows and wastelands, where their caterpillars find the hosts they need, especially grasses (Tolman and Lewington 1999). Their presence at this station was perhaps due to the the present forest being a young Aleppo pine forest, with low trees and undergrowth rich in herbaceous plants (Garah et al. 2016; Litim 2012). For the other two environments, all species were located among them; however, with specific aggregations at each station. These two environments are characterized, first, by their locations – they happen to be located in the same sector of the park (western sector) (Figure 1) and, secondly, by their degraded condition, which has caused them to become open environments (Smaihi and Kalla 2017). The cedar forest shelters: *Melitaea aetherie, Nymphalis polychloros, Pararge aegeria* and *Hipparchia ellena.* All these species are fond of light woods. Then, *Pyrgus armoricanus* and *H. algiricus* follow. They both frequent rocky escarpments and flowery grasslands. This observation shows the alarming situation of this station, which is suffering from decline (Bentouati 2008). The decline in the park's cedar forests is said to be due as much to the attacks of a wood-boring insect discovered in 1982 (*Thaumetopoea bonjeani*) and its weakening by a succession of dry years spread over the decade 1992–2002, as to man and his herds (Kherchouche et al. 2013; Sahli 2004). Finally, there is also the presence of *Vanessa cardui* and *Polyommatus icarus*. These two butterflies inhabit a wide variety of habitats (Tolman and Lewington 1999). The oak forest sampled for this work (1320 m above sea level) appears with a procession associated with high altitude environments, but with two more characteristic species: *Melanargia occitanica*, which resides in the scrubland and along the edge of the forests, and *Argynnis pandora*, which frequents all types of wooded areas. Finally, the oak forest houses *Callophrys avis,* which is adapted to many ecological and climatic environments. This species is common within brush, in clearings and in shaded rocky areas (Tolman and Lewington 1999). Our observations revealed that the degradation of sulphur in this station was of a smaller scale than that of the cedar forest, because the oak forest of the BNP was experiencing renewal and regeneration and, above all, reforestation successes (Smaihi and Kalla 2017). Finally, some species were indifferent to a particular environment, which means that they were in the middle of the graphical representation. Cedar forest and wastelands share species that prefer open spaces or low-density woods. This was the case for the following butterflies: *Gonepteryx cleopatra*, which flies in open scrubland, often rocky and near light woods; *Glaucopsyche melanops*, which frequents scrubland and light woods; *Lampides boeticus*, whose habitat is varied: wastelands, crops, pleasure gardens; and finally, *M. galathea*, which resides in all types of shrubland (Tolman and Lewington 1999). Between the pine forest and the wasteland, there were: *Lycaena phlaeas*, a lepidopteran that likes wasteland, and *Tomares ballus*, which likes dry open meadows and rocky places (Tolman and Lewington 1999). In addition, between the oak grove and the pine forest, there is *Lasiommata megera*, which frequents scrubland and rocky areas (Tolman and Lewington 1999). Finally, for all the habitats there is *Pieris rapae*, which flies to almost everywhere its host plants grow. This species prefers temporary meadows and wastelands. Finally, there is *Colias croceus*, a native of the temperate regions around the Mediterranean, which prefers flowering fallow lands (Tolman and Lewington 1999).

CONCLUSION

The monitoring of diurnal Lepidoptera in the Belezma National Park enabled us to count 896 individuals, representing 30 species: 29 Rhopalocera (Nymphalidae, Pieridae, Lycaenidae, Hesperiidae) and 1 diurnal Heterocera (Arctiidae). The Rhopalfauna of the BNP is interesting from a diversity point of view. It represents 24.17% of the Algerian rhopalfauna, which has 120 species according to Tennent (1996).

The species encountered during this study were for the most part those that are frequent and widespread in Algeria (Tolman and Lewington 1999). Three species were identified at all the stations studied: *Colias croceus*, *Glaucopsyche melanops,* and *Pieris rapae*. Others, on the contrary, were found only on one of the 4 sites: *Melitaea aetherie*, *Nymphalis polychloros*, *Pararge aegeria*, *Polyommatus icarus*, *Pyrgus armoricanus,* and *Vanessa cardui* were observed only in the cedar forest; *Callophrys opinion* and *Melanargia occitanica* were only found in the oak forest; *Coenonympha pamphilus* and *Melanargia* *ines* only in the pine forest; and finally *Anthocharis belia*, *Chelis maculosa*, *Euchloe ausonia*, *E. belemia*, *E. charlonia*, *Maniola jurtina* and *Pontia daplidice* only in the wasteland. Among the 30 species listed, we noted the presence of 3 species protected by Algerian law, namely: *Colias croceus*, *Polyommatus icarus* and *Melanargia galathea*. These species deserve attention, particularly for the preservation of useful species and the orientation of research on species considered rare or threatened.

The primary objective of this work, namely, to establish a first list of the diurnal Lepidoptera fauna of the park, has been achieved – even if this list remains open and the number of Lepidoptera is likely to change significantly in unsurveyed environments.

Secondly, the observation revealed by this inventory is that despite the efforts of the park services to safeguard existing forest formations (P. N. B. 2005; Laabed 2001), these remain insufficient. Indeed, the Correspondence Analysis carried out on the diurnal Lepidoptera and their presence in the four sampled stations made it possible to identify certain groups according to a gradient of openness of the environments. It appears that the forest stations of this inventory were populated with butterflies which are bio-indicators of open environments. These stations therefore will always suffer from a depletion of tree populations.

We therefore recommend monitoring forest stands that are conserved using bio-indicator butterflies in order to have more data on their evolution over time, in order to validate or refute the methods used to restore and maintain them. We propose this monitoring method because diurnal Lepidoptera monitoring can give much faster results than those provided by vegetation monitoring (Faure 2007).

Finally, in order to better protect butterflies in the park, particularly the most vulnerable species, knowledge of their environments and specific needs must be improved by park services. They will have to consider the primary importance of studying and safeguarding these emblematic and beneficial insects in their future development projects.

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References

Arbouche, Y., H. S. Arbouche, F. Arbouche, and R. Arbouche. 2012. Valeur fourragère des espèces prélevées par *Gazella cuvieri* Ogilby, 1841 au niveau du djebel metlili (Algérie). [Feed value of species levied by *Gazella cuvieri* Ogilby, 1841 at the djebel metlili (Algeria)]. *Arch. Zootec*. 233: 145–148.

Bentouati, A. 2008. La situation du cèdre de l'Atlas dans les Aurès (Algérie). [The situation of Atlas cedar in the Aurès (Algeria)]. *Forêt méditerranéenne* 2: 203–208.

Boukerker, H. 2016. *Autoécologie et évaluation de la biodiversité dans les Cédraies de Cedrus atlantica Manetti dans le parc national de Belezma (Batna, Algérie).* [Autoecology and evaluation of the biodiversity in the Cedar forests of *Cedrus atlantica* Manetti in the National park of Belezna (Batna, Algeria)]. Thèse de Doctorat d'Etat., Université de Biskra (Algérie).

Carriere, M. 2013. *Les papillons par la photo*. [*Butterflies by the photo*]. France: Les-Snats.

Chinery, M., and M. Cuisin. 1994. *Les papillons d'Europe (Rhopalocères et Hétérocères diurnes).* [*The European butterflies (Rhopalocera and diurnal Heterocera)*]. Paris: Delachaux et Niestlé.

Dajoz, R. 1971. *Précis d'écologie*. [*Ecology precise*]. Paris: Dunod.

Dajoz, R. 1985. *Précis d'écologie*. [*Ecology precise*]. Paris: Bordas.

Demerges, D., and P. Bachelard. 2002. *Proposition de mise en place d'une méthode de suivi des milieux ouverts par les Rhopalocères et Zygaenidae dans les réserves naturelles*. [*Proposal to set up a method for monitoring open environments with Rhopaloceres and Zygaenidae in the French natural reserves*]. http://www.reserves-naturelles.org/actualites/sUIVIRHOPALO.pdf.

Faure, E. 2007. Suivie de milieux ouverts dans le parc naturel régional du luberon par des papillons de jour (rhopalocères) bioindicateurs. [Monitoring of open areas in the Regional natural park of Luberon by using butterflies (Rhopalocera) like bioindicators]. *Soc. His. Nat. Alcide-d'Orbigny* 8: 86–101.

Faurie, C., C. Ferra, P. Medori, and J. Devaux. 2003. *Écologie – approche scientifique et pratique*. [*Ecology – scientific and practical approach*]. Paris: TEC&DOC.

Garah, K., C. Chafai, and A. Bentouati. 2016. Evolution spatio-temporelle Des écosystèmes forestiers à Pin d'Alep de l'Aurès Oriental en Algérie. [Spatiotemporal evolution of ecosystems Aleppo Pine forest in the Aurès Oriental in Algeria]. *Lebanese Science Journal* 17: 104–116.

Hammer, O., D. A. T. Harper, and P. D. Ryan. 2001. Past: Paleontological Statistics Soft Ware Package for Education and Data Analysis. *Palaeontologia Electronica* 4 (1): 9.

Houamel, A. C. 2012. *Contribution à l'étude du dépérissement de la cédraie dans la région de Batna (cas du* *parc national du Belezma). Diplôme de Magister*., Université de Tlemcen (Algérie). [*Contribution to the study of cedar decline in the Batna region (case of Belezma National Park).* Magister of Tlemcen University (Algeria)].

Kherchouche, D., M. Kalla, A. Briki, and A. Hamchi. 2013. La sécheresse et le dépérissement du cèdre de l'Atlas (*Cedrus atlantica* Manetti.) dans le massif du Belezma (Algérie). [Drought and die back of Atlas cedar (*Cedrus atlantica* Manetti) in the Belezma mountains (Algeria)]. *Sécheresse* 24: 129–137.

Laabed, A. 2001. *Plan de gestion du Parc National du Belezma*. Rapport multigraphié., Batna (Algérie). [*Management plan for the Belezma National Park. Multigraphic report*]. Batna (Algeria).

Litim, A. 2012. *Biodiversité et Étude Ethnobotanique dans le Parc National de Belezma (Batna)*. *Diplôme de* Master., Université de Sétif (Algérie). [*Biodiversity and Ethnobotanical Study in Belezma National Park (Batna)*. Master of Sétif University (Algeria)].

MAB-Algérie. 2016. *Rapport du comité national MAB – Algérie*. [*Report of the National Committee MAB – Algeria*].

Magurran, A. E. 1988. *Ecological Diversity and its Measurement*. New Jersey: Princeton University Press.

Manil, L., P.-Y. Henry, A. Lerch, C. Edelist, K. Ancrenaz, M. Gaboly, B. Fontaine, R. Lorrilliere, and R. Julliard. 2007. *Suivi Temporel des Rhopalocères de France Bilan 2006–2007*. [*Temporal Monitoring of Rhopalocerans in France 2006–2007 Assessment*]. Paris: MNHN et ALF.

Moore, N. W. 1975. Butterfly transects in a linear habitat, 1964–73. *Entomologist's Gazette* 26: 71–78.

Ouin, A., J-M. Paillisson, and J. Lhonore. 2000. Méthodes de suivi et d'évaluation des populations et peuplements de papillons de jour. [Methods for monitoring and evaluating butterfly populations and stands]. *Insectes* 117: 29–31.

Pielou, E. C. 1969. *An introduction to Mathematical Ecology*. New York: Witley-Interscience.

P. N. B. – CF1 2005. *Rapport sur le plan de sauvegarde de la cédraie de la Wilaya de Batna* (Algérie). [*Report on the safeguarding plan for the cedar grove of the Wilaya Batna* (Algeria)].

P. N. B. 2010. *Plan de gestion du parc national de Belezma 2006–2010*. [*Belezma National Park Management Plan 2006–2010*]. Jijel (Algeria), as follows (P. N. B. 2006. Plan de gestion du parc national de Belezma 2006–2010. [Belezma National Park Management Plan 2006–2010]. Batna (Algeria).

Pollard, E., and T. J. Yates. 1993. *Monitoring Butterflies for Ecology and Conservation*. London: Chapman & Hall.

Quézel, P., F. Médail, R. Loisel, and M. Barbero. 1999. Biodiversité et conservation des essences forestières du bassin méditerranéen. *La Forêt Méditerranéenne*. [Biodiversity and conservation of forest essences in the Mediterranean basin]. *Unasylva* 197: 21–28.

Ramade, F. 1984. *Elément d'écologie: écologie fondamentale*. [*Ecological element: fundamental ecology*]. Paris: McGraw-Hill.

Remini, L., and R. Moulaï. 2015. Diversity and structure of butterfly populations in agro-ecosystems of Mitidja (Algeria). *Zoology and Ecology* 25 (4): 355–364.

Robineau, R. 2007. *Guide des papillons nocturnes de France*. [*Guide to the moths of France*]. Paris: Delachaux et Niestlé.

Sahli, M. 2002. *Le recul des forêts en Méditerranée: le cas des monts du Belezma (Algérie)*. Annales volume V: 65–79. Publication du laboratoire d'Etudes et de Recherches Maghreb-Méditerranée. Université de Constantine (Algérie). [*The decline of forests in the Mediterranean: the case of the Belezma Mountains (Algeria).* Publication of the Maghreb-Mediterranean Studies and Research Laboratory. University of Constantine (Algeria)].

Sahli, M. 2004. Protection de la nature et développement: cas du Pare national du Belezma (Monts de Batna, Algérie). [Nature protection and development: the case of the Belezma National Park (Batna Mountains, Algeria)]. *New Medit.* 4: 38–43.

Sahli, M. 2004. Conservation et développement dans le Parc National du Belezma (Wilaya de Batna, Algérie). [Conservation and development in the Belezma National Park (Wilaya of Batna, Algeria)]. *Revue sciences Humaines* 22: 81–91. Université de Constantine, Algérie.

Samraoui, B. 1998. Status and seasonal patterns of adult Rhopalocera (Lepidoptera) in north-eastern of Algeria. *Nachr. entomol. Ver. Apollo* N. F. 19: 285–298.

Smaihi, H., and M. Kalla. 2017. Evolution spatiotemporelle des formations végétales du parc national de belezma de la région Est de l'Algérie. [Spatiotemporal evolution of plant formations in the Belezma National Park of Eastern Algeria]. *Courrier du Savoir* 24: 175–184. Université de Biskra, Algérie.

Tarrier, M. R., and J. Delacre. 2008. *Les papillons de jour du Maroc, guide d'identification et de bio-indication*. [*Moroccan butterflies, a guide to identification and bio-indication*]. Paris: Biotope, Mèze.

Tennent, W. J. 1996. *The Butterflies of Morocco, Algeria and Tunisia*. England: Gem Publishing Company.

Tolman, T., and R. Lewington. 1999. *Guide des papillons d'Europe et d'Afrique du Nord*. [*European and North African Butterfly Guide*]. Paris: Delâchaux et Niestlés.

Weincatner, E., N. Wahlberg, and S. Nylin. 2006. Dynamics of host plant use and species diversity in *Polygonia* butterflies (Nymphalidae). *Journal of Evolutionary Biology* 19: 483–491.