THE DIVERSITY AND ECOLOGY OF BUTTERFLIES (LEPIDOPTERA: RHOPALOCERA) IN THE TEBESSA REGION, ALGERIA

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Abstract. The diurnal butterflies (Lepidoptera: Rhopalocera) were studied in two areas of the Tebessa region: forest (Bekkaria) and open grassland (Gaagaa). During the period November - April 2017-2018, thirty-one species and five families were inventoried, the specific richness is higher in Gaagaa (30 species). The Pieridae family is most abundant at both sites. *Pontia daplidice* and *Pieris rapae* are the most abundant species in Bekkaria, *Pontia daplidice* – only in Gaagaa. The stand reaches its peak of activity in April when the two dominant species are very abundant. The diversity is close in the two sites and the populations are balanced.

Keywords: Rhopalocera, abundance, diversity, *Pontia daplidice, Pieris rapae.*

Rezumat. Diversitatea și ecologia fluturilor (Lepidoptera: Rhopalocera) în regiunea Tebessa, Algeria. Fluturii diurni (Lepidoptera: Rhopalocera) au fost studiați în două situri din regiunea Tebessa: silvicol (Bekkaria) și pajiște deschisă (Gaagaa). În perioada noiembrie-aprilie 2017-2018, au fost semnalate treizeci și una de specii și cinci familii, bogăția specifică fiind mai mare în Gaagaa (30 de specii). Familia Pieridae a fost cea mai abundentă în ambele situri. *Pontia daplidice* și *Pieris rapae* sunt cele mai abundente specii în Bekkaria, *Pontia daplidice* – numai în Gaagaa. Vârful de activitate se atinge în aprilie, când cele două specii dominante sunt foarte abundente. Diversitatea specifică este apropiată în cele două situri, iar populațiile sunt echilibrate.

Cuvinte cheie: Rhopalocera, abundență, diversitate, *Pontia daplidice, Pieris rapae.*

INTRODUCTION

Lepidoptera (Rhopalocera and Heterocera) occupy almost all ecological niches on the planet (HOSKINS, 2016). They have the possibility of moving much more easily even if, as a general rule, they are confined to environments where the presence of the host plants will allow the development of the larva (DEMERGES, 2000). They are integrated into various environmental biomonitoring programmes (TARRIER & DELACRE, 2008). Butterflies of the day are better known today (BELLMAN, 2012) although they are in the minority (LAFRANCHIS, 2000). Several authors around the world have taken an interest in this entomological group such as HERVÉ (2009), MARTIRÉ et al., (2016) and more. There are not many studies in Algeria, we will cite TENNENT (1996), SAMRAOUI (1998), KACHA (2017) and REMINI (2017). No information on this fauna exists in the region of Tebessa hence the interest of this study, whose aim is to establish an inventory in two habitats, to know these insects, the current dynamics of the populations, to highlight the species specialized in these environments in order to broaden future research in all areas that may intervene in the state of health of this group so that they can benefit from management and protection measures as well as sheltered habitats.

MATERIAL AND METHODS

Presentation of the study area. The study was carried out during the period from November 2017 to May 2018, in two sites:

1. Bekkaria Site. The Bekkaria region is located at the east of Tebessa (Fig. 1) at an altitude of 894 meters (north latitude 35°22’20’’and longitude 8°14’32’’). It covers an area of 152 km² and is characterized by a dry and cold semi-arid climate.

The study environment is a forest of Aleppo pine (*Pinus halepensis*), with an area of 5200 ha, located east of the municipality of Bekkaria at 970 m altitude. The forest spreads over Djebel Djebissa and Djebel Bouroumane. This forest is accompanied by a floral procession of herbaceous plants, shrubs such as: *Rosmarinus officinalis* L. (Labiatae), *Genista cinere* DC. (Papilionaceae), *Cytisus triflorus* L’Hérit. (Papilionaceae), *Galactites tomentosa* L. *Silybum marianum* L. (Asteraceae), *Malva sylvetris* L. (Malvaceae), *Sinapis arvensis* L. (Brassicaceae).

The Clear Coverage is 10-30% (BENARFA, 2005).

2. Gaagaa Site. The region of Hammamet (Youks les Bains) belongs to the areas of the high plains of East Algeria, located west of Tebessa (Fig. 1) at 878m (north latitude 35°25’ and longitude 7°55’). It covers an area of 375 km^2. The locality is characterized by different types of relief: mountains, hills and plains.

The study environment is the Gaagaa plain where highly responsive plant formations are found in the form of sub-shrubs such as *Artemisia herba-alba, Thymus algeriensis* (Thyme), *Rosmarinus officinalis* and *Marrubium vulgare*, some in associations with Poaceae. Other plants, in particular medicinal plants, are very popular such as *Peganum harmala, Artemisia campestris* and poorly responded to such as *Teucrium polium* and *Globularia alypum* (HIOUN et al., 2010).

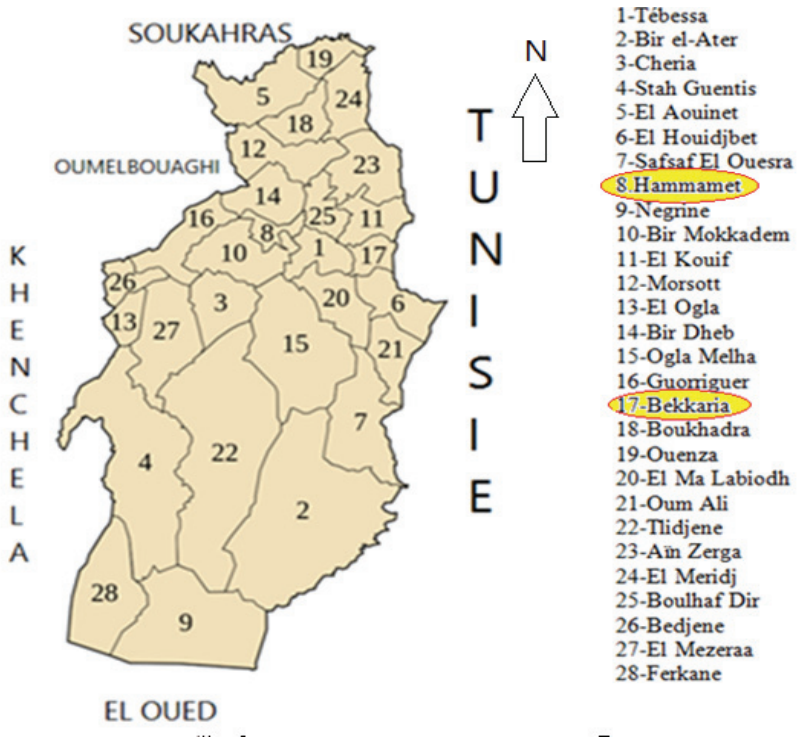

Figure 1. Study area (Sbiki, 2008).

Rhopalocera sampling

Investigations began in November 2017 and ended in May 2018. The harvested species are asphyxiated with acetic ether, in special bottles. The specimens are prepared for identification in the laboratory: they are dried on "butterfly racks" for 15 days to 3 weeks depending on their size and then stored in collection boxes containing mothballs, to prevent the possible development of parasites and molds. The determination is performed under a binocular magnifying glass, using various identification keys such as TOLMAN & LEWINGTON (2008). Sampling is random and lasts two hours on each field trip and butterflies were captured by means of an entomological net.

Data analysis

Percentage frequency or relative abundance (AR %): The centesimal frequency (%) is the percentage of individuals of a species (A) compared to the total number of individuals (N) (DAJOZ, 1971).

$$AR\% = A / N \times 100.$$

The constancy or index of occurrence: the frequency of occurrence Fo (%) which is the ratio between P which is the number of readings containing the studied species, on R which is the number of surveys carried out, multiplied by 100 (DAJOZ, 1982).

$$Fo = P / R \times 100.$$

Specific diversity (Shannon-Weaver index): the Shannon - Weaver Diversity Index provides insight by a sample on the structures of the stand from which it comes, and on the way in which individuals are distributed among several species (DAJOZ, 2003). It is calculated as follows:

$$H' = -\Sigma [Pi \log_2 Pi] \text{ with } Pi = n i / N.$$

Equity is a second fundamental dimension of diversity. It is the ratio between the specific diversity (H') and the maximum diversity (H max) and is expressed as follows:

$$E = H' / H \max \text{ with } H \max = \text{Log } 2 (S).$$

The equipartition index E ranges from 0 to 1. If it tends towards 1, the numbers of species populations are in equilibrium with each other (RAMADE, 1984).

Jaccard Similarity: this analysis demonstrates the degree of resemblance of two inventories. This ratio can vary from 0 (no similarity) to 1 (total similarity).

$$S_J = a/(a + b + c)$$

a: are the common species between the two samples;
b: unique species for the first sample;
c: unique species for the second sample.

RESULTS

A total of 31 species of Rhopalocera belonging to 5 families and 9 sub-families constitute all the fauna identified in the study stations (Table 1).

Table 1. Inventory of the Rhopalocera fauna of the region of Tébessa.

Order	Families	Subfamilies	Genera & Species
	Papilionidae	Papilioninae	*Iphiclides podalirius feisthamelii* (Duponchel, 1832)
			Papilio machaon Linnaeus, 1758
	Nymphalidae	Coliadinae	*Gonepteryx cleopatra* (Linnaeus, 1767)
			Gonepteryx rhamni (Linnaeus, 1758)
			Colias croceus (Fourcroy, 1785)
			Colias phicomone (Esper, 1780)
		Nymphalinae	*Vanessa atalanta* (Linnaeus, 1758)
			Vanessa cardui (Linnaeus, 1758)
			Melitaea phoebe (Denis & Schiffermüller, 1775)
		Satyrinae	*Lasiommata megera* (Linnaeus, 1767)
			Pararge aegeria (Linnaeus, 1758)
			Pyronia cecilia (Vallantin, 1894)
			Melanargia ines (Hoffmannsegg, 1804*)*
	Pieridae	Pierinae	*Anthocharis belia* (Linnaeus, 1758)
Lepidoptera			*Euchloe belemia* (Staudinger, 1861)
			*Euchloe simplonia (*Boisduval, 1832)
			Euchloe charlonia (Donzel,1842)
			Pontia daplidice (Linnaeus, 1758)
			Pieris brassicae (Linnaeus, 1758)
			Pieris rapae (Linnaeus, 1758)
			Pieris napi (Linnaeus, 1758)
	Lycaenidae	Lycaeninae	*Lycaena phlaeas* (Linnaeus, 1761)
			Leptotes pirithous (Linnaeus, 1767)
		Polyommatinae	*Lampides boeticus* (Linnaeus, 1767)
			Maculinea alcon (Denis & Schiffermüller, 1775)
			Aricia cramera (Eschscholtz, 1821)
			Polyommatus icarus (Rottemburg, 1775)
			Pseudophilotes baton (Bergsträsser, 1779)
		Theclinae	*Tomares ballus* (Fabricius, 1787)
	Hesperiidae	Pyrginae	*Pyrgus malvae* (Linnaeus, 1758)
			Carcharodus alceae (Esper, 1780)

The Nymphalidae family is the most diverse with 11 species followed by the Lycaenidae and Pieridae families with 8 species each. The other families are less represented (Table 1). Five families of Rhopalocera are noted in the two sites, Gaagaa is the richest site (30 species), Pieridae is the most abundant family in the two sites followed by Nymphalidae in Bekkaria and Nympahlidae and Lyceanidae – in Gaagaa (Table 2). Pieridae is the richest family in Bekkaria and Gaagaa with 46.97% and 44.44% respectively (Table 2). The majority of families are very constant with the exception of Hesperiidae in Bekkaria and Papilionidae in Gaagaa (Table 2).

Table 2. Richness (R), frequency of occurrence (F), status (ST) and relative abundance (RA) of the Rhopalocera families identified in the study sites.

Sites / Families	Bekkaria				Gaagaa			
	R	F (%)	RA (%)	ST	R	F (%)	RA (%)	ST
Papilionidae	1	42.12	1.01	TC	1	14.28	2.02	C
Nymphalidae	7	57.14	27.78	TC	11	57.14	23.23	TC
Lycaenidae	7	57.14	21.72	TC	8	57.14	27.27	TC
Hesperiidae	2	28.31	2.53	C	2	42.85	3.03	TC
Pieridae	8	71.42	46.97	TC	8	71.42	44.44	TC
Total	**25**				**30**			

The relatively abundant species in Bekkaria are: *Pontia daplidice* and *Pieris rapae*, while in Gaagaa the most abundant species is *Pontia daplidice* followed by *Euchloe belemia*, *Colias crocea* and *Pieris rapae* by a long distance (Table 3).

Table 3. The relative abundance (RA), frequency of occurrence (F) and status (S) of Rhopalocera species according to DAJOZ (1982).

Sites / Species	Bekkaria			Gaagaa		
	RA (%)	F (%)	S	RA (%)	F (%)	S
Iphiclides podalirius feisthamelii	2.02	18.75	ac	0.00	0.00	-
Papilio machaon	0.00	0.00	-	1.01	6.25	f
Gonepteryx cleopatra	2.53	18.75	ac	0.51	6.25	f
Gonepteryx rhamni	0.00	0.00	-	1.52	18.75	ac

Colias croceus	6.57	43.75	tc	8.08	50.0	tc
Colias phicomone	0.00	0.00	-	0.51	6.25	f
Vanessa atalanta	0.00	0.00	-	0.51	6.25	f
Vanessa cardui	3.54	25.0	c	9.09	25.0	c
Melitaea phoebe	0.00	0.00	-	0.51	6.25	f
Lasiommata megera	3.03	25.0	c	2.53	18.75	ac
Pararge aegeria	4.04	37.5	tc	2.02	18.75	ac
Pyronia cecilia	2.53	12.5	ac	1.01	6.25	f
Melanargia ines	1.01	12.5	ac	1.52	12.5	ac
Anthocharis belia	1.01	12.5	ac	1.52	18.75	ac
Euchloe belemia	5.56	43.75	tc	8.59	50.0	tc
Euchloe simplonia	1.01	12.5	ac	2.53	18.75	ac
Euchloe charlonia	3.54	31.25	tc	2.53	25.0	c
Pontia daplidice	13.64	50.0	tc	17.68	62.5	tc
Pieris brassicae	3.54	37.5	tc	4.04	37.5	tc
Pieris rapae	13.13	50.0	tc	8.08	50.0	tc
Pieris napi	3.03	18.75	ac	2.02	12.5	ac
Lycaena phlaeas	5.05	31.25	tc	3.03	18.75	ac
Leptotes pirithous	4.55	6.25	f	0.51	6.25	f
Lampides boeticus	6.06	31.25	tc	5.56	31.25	tc
Maculinea alcon	1.01	6.25	f	2.02	12.5	ac
Aricia cramera	3.54	18.75	ac	5.05	31.25	tc
Polyommatus icarus	4.04	18.75	ac	2.02	12.5	ac
Pseudophilotes baton	0.00	0.00	-	0.51	6.25	f
Tomares ballus	2.02	25.0	c	3.03	25.0	c
Pyrgus malvae	1.52	18.75	ac	1.52	18.75	ac
Carcharodus alceae	1.52	18.75	ac	1.01	12.5	ac

Legend: **f** – frequent; **ac** – fairly common; **c** – common, **tc** – very common.

The study of the ecological status of the species recorded in Bekkaria showed that 2 species are frequent (**f**), 11 – fairly common (**ac**), 3 – common (**c**), 9 – very common (**tc**); while in Gaagaa 8 species are frequent, 11 – fairly common, 2 – common, 8 – very common (Table 3).

Similarity of samples in the study sites. The similarity between the Rhopalocera populations of the two sites is Sj= 0.77 which demonstrates the presence of a big number of common species.

Phenology of Rhopalocera species in the two sites. Absence of species during December and January, maximum in April (49.49%) of the whole sample in Bekkaria. In Gaagaa – absence of species in December, maximum in April (52.02%) of all samples (Fig. 2).

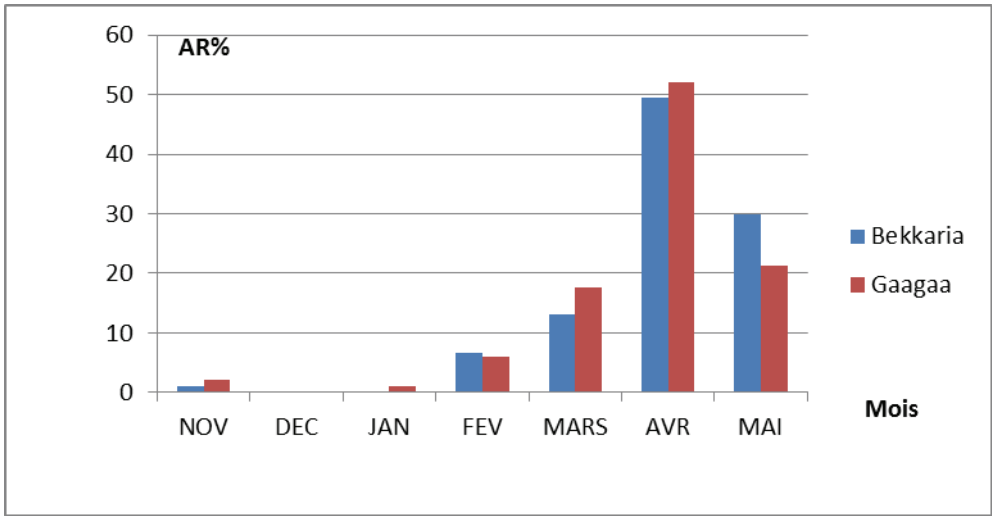

Figure 2. Temporal evolution of the population of Rhopalocera in the study sites.

The *Pontia daplidice* species appears early in November in both sites, its activity peak is noted in April in forest and could be in May in open environment (Fig. 3).

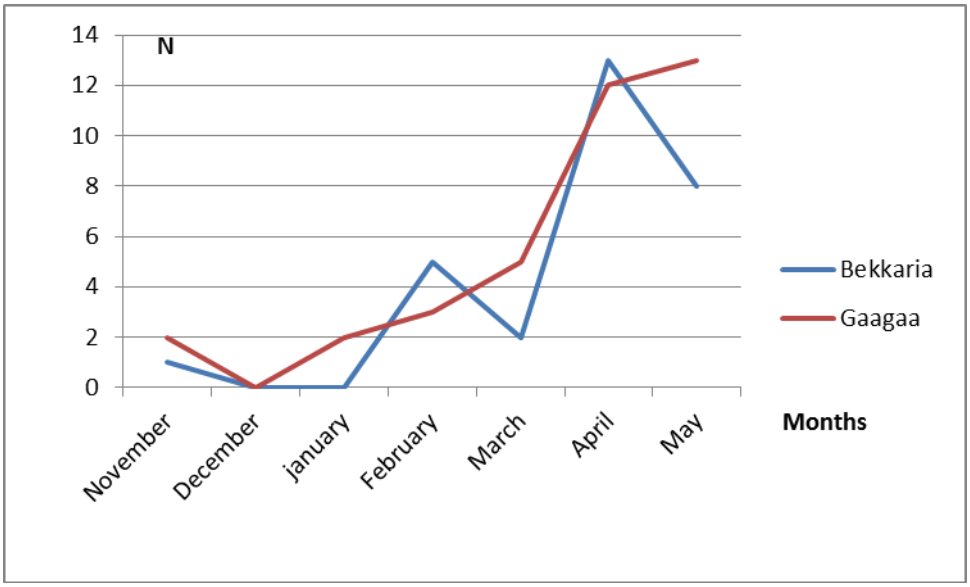

Figure 3. Temporal distribution of *Pontia daplidice* in the two study sites.

The appearance of the species *Pieris rapae* is more evident in January and its maximum activity is noted in April in the two sites with lower numbers in open environment (Fig. 4).

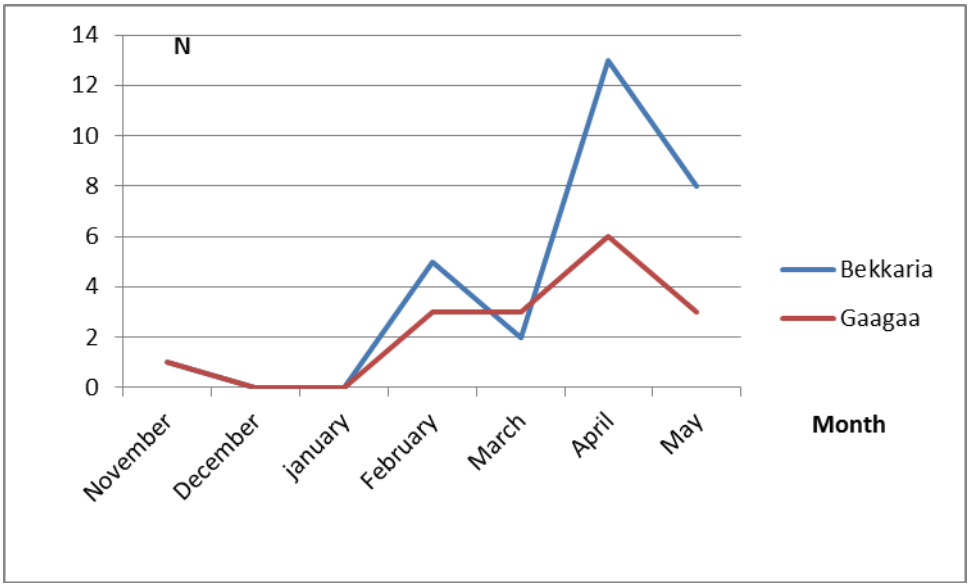

Figure 4. Temporal distribution of *Pieris rapae* in the two study sites.

Ecological indices. The study of the diversity of the Rhopalocera fauna showed that the values of the Shannon Weaver diversity index are close, although the specific richness is slightly different (Table 4).

Table 4. Shannon-Weaver specific diversity index "**H**" and "**E**" team distribution of species in study stations (total **S** of species, total **N** of individuals and **Hmax** the maximum diversity in bits).

Sites / Parameters	Bekkaria	Gaagaa
H' (bits)	4.307	4.244
S	25.0	30.0
N	198.0	198.0
H max (bit)	4.644	4.858
E	0.927	0.874

The stand fairness values of the two sites show that they are balanced, since the values approach 1 but occur more in forests than in an open environment (Table 4).

DISCUSSIONS

The inventory of the Rhopalocera fauna in the forest and grassland sites chosen in the study region allowed us to identify 31 species belonging to 5 families and 9 sub-families (Nymphalidae – 11 species, Lycaenidae and Pieridae – 8 species each, Hesperiidae and Papilionidae – 2 species each); while in the semi-arid region of El Hodna (M'sila) in Algeria (KAMEL & CHAARAOUI, 2020), 11 species were identified in cultivated areas. And in an agrosystem and a natural environment (REMINI, 2017) 35 species were identified, belonging to 5 families. In Jebel Ayachi in the Moroccan High Atlas (TARRIER, 1997) Rhopalocera fauna was inventoried comprising 66 species grouped into 4 families (Papilionidae, Pieridae, Lycaenidae and Nymphalidae) and in the north of France DEMERGES (2000) reported the presence of 47 species of Rhopalocera (Hesperiidae – 4 species, Papilionidae – 3, Pieridae – 7, Lycaenidae – 16 and Nymphalidae – 17 species) (DEMERGES, 2000).

Several recorded species have a wide distribution, occurring in several types of environment such as *Pontia daplidice*, *Euchloe belemia, Colias croceus* and *Pieris rapae*. These species are found in cultivated environment (KAMEL & CHAARAOUI, 2020) in M'Sila; (MERIT, 2014) in the El Hierro island in the Canary Islands archipelago and in open environment (SAMRAOUI, 1998).

Pieridae is the most abundant family in study environments, it is also abundant in cultivated environments (ARIOUA & CHERHABIL, 2020) and in open environments (REMINI, 2017). The *Pontia daplidice* species is the most abundant in our environmental study, as well as in certain cultivated environments (KAMEL & CHAARAOUI, 2020). On the other hand, *Pieris rapae* is the most abundant in other cultivated environments (REMINI, 2017; ARIOUA & CHERHABIL, 2020). According to RICHARDS (1940), this abundance is due to several factors such as the number of generations, food resources, and climate. This species visits the constant flowers in its environment to reduce the time required to search for the source of the nectar (LEWIS, 1986). These two species adopt the same feeding behaviour because they prefer small host plants (FORSBERG, 1987).

In the forest environment, the Pieridae family is the richest in the Rhopalocera species, while in the open environment it is the Nymphalidae family which is richest. Iin the agro-systems and natural environments of Algiers, it is the Pieridae and Lycaenidae families which are the richest (REMINI, 2017).

The diversity of the stands of the two environments is close, confirmed by the Jaccard index which is close to 1. The diversity index of the Rhopalocera population reaches 4.30 bit in a forest environment with an equitability of 0.92 while in an open environment the noted diversity is 4.24 bit with an equitability of 0.87. Diversity is 1.62 bit (bean culture) and 1.82 bit (pomegranate orchard), fairness varies between 0.61-0.81 (ARIOUA & CHERHABIL, 2020). KAMEL & CHAARAOUI (2020) found that the diversity in an alfalfa field is 1.84 bit and in a carrot field 1.28 bit; fairness varies between 0.7-0.84. At the Algiers Zoological Park, the diversity of the Rhopalocera population varies between 2.73 bit and 2.34 bit and fairness between 0.50 and 0.56 (REMINI, 2017). DEMERGES (2000) noted that lepidopteran biodiversity is higher in limestone areas, rich in floristic diversity where heat is important with the presence of drought than in the coastal area. According to KACHA et al. (2017) grass fields turned out to be the most species-rich with 54 species, followed by the pinay – with only 22 species. The Rhopalocera population reached its peak in flight in April, probably in relation to the vegetation cover in the study sites. In agriculture, it is also in April that the peak of species activity reaches its maximum (ARIOUA & CHERHABIL, 2020; KAMEL & CHAARAOUI, 2020). The two stands are balanced in both environments. The temporal distribution of the two dominant species (*Pontia daplidice* and *Pieris rapae*) in the two sites showed that their peak of activity takes place in April for *P. rapae* in the two environments and for *P. daplidice* in forest environment. In open environment the maximum activity will probably take place in May.

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