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Diversity and distribution of antlions (Neuroptera: Myrmeleontidae) in the Northern region of Cameroon (Afrotropical region)

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Abstract

Antlions (Neuroptera: Myrmeleontidae) are insects that larvae prefer dry habitats. They are less known in the Afro-tropical zone and the present study was investigated to determine their diversity in the high Sudano Guinean and Sudano sahelian savannahs of Cameroon. Adults and larvae of antlion were collected in Dang, Mardok, Malang, Tchabal, Garoua, Kaele, Yagoua and Pouss from 2015 to 2017 through adult capture and larval collecting from September to December and from March to April. The present work shows five tribes containing 22 species among them; *Nesoleontini* and *Myrmecaelurini* are specific to the Sudano Sahelian zone. Four species namely *Myrmeleon obscures* Rambur 1842, *Creoleon nubifer* Rambur 1842, *Palpares obscurus* Gerstaecker 1888 *Creleon* sp. Are common to both agroecological zones. *M. obscurus, Myrmecaelurus apicalis* Navas 1912, *P. obsoletus* and *Cueta bourboni* Navas 1935, are the most abundant and abundant species in the high Sudano Guinean and Sudano sahelian savannahs of Cameroon. Fewer or rare species are *Hagenomyia tristis* Walker 1853; *Banyutus hesione* Banks 1911; *Creoleon africanus* Rambur 1842; *Nemoleon* sp. and *Neuroleon striolatum* Navas 1914.

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Introduction

Many antlion species (Neuroptera: Myrmeleontidae) are active in dry season, under arid and dry conditions, when the temperature varies between 25°C and 45°C (Kaiser, 2001; Markert *et al.*, 2003; Maoge *et al.*, 2014). The presence or absence of some species of these xerophilic insects in an inter-tropical environment may be a response to climate change recorded over the last decades (Zeng, 2003).

While antlion larvae live in dust and plant debris on the ground, adults are aerial and characterized by a long cylindrical abdomen and a flat head with two filiform antennae usually ending with clubs (Gretia 2009, Badano and Pantaleoni 2014). They have large membranous wings with a very dense network of nervures, subequal, finely reticulated, narrow and folded in the roof at the rest (Mansell 1999, Gretia 2009). These wings allow them to do a heavy and irregular flight, different from the plane flight of dragonflies. They are pollinivores or predators of small insects, present in the vegetation during the day, they were captured by net or by hand (Ngamo *et al.*, 2016).

Many *Myrmeleontidae* species are present in the world semi-arid areas; a very diverse fauna of antlions take shelter in the Africa southern part; in this region, antlions are an important component of local insect fauna, with several endemic taxa (Mansell 1996). After all, studies conducted in African antlions fauna are rare and limited to specific areas: Southern Africa (Mansell, 1985, 1999, 2000), West Africa (Michel and Letourmy, 2007), and Egypt (El -Hamouly and Fadl, 2011) and on specific antlion groups, mainly on the visually striking subfamily, namely Palparinae (Letardi, 2014). Generally in Cameroon, particularly in the arid and semi-arid northern zone, subject to global warming, the biodiversity of antlions is feebly known, despite some works on constructive funnel larvae in the Sudano Guinean zone of the country (Ngamo *et al.,* 2010, Ngamo and Moagé, 2014, Maoge *et al.,* 2014, Ngamo *et al.,* 2016, Bakoidi *et al.,* 2018). However, all antlion larvae do not build funnels in the soil, besides, the northern zone of Cameroon extends to a Sudano-Sahelian zone in addition to the Sudano-Guinean that is not yet explored. These studies were carried out to inventory the biodiversity of antlions both from captured adults and from larvae collected in the high Sudano Guinean and Sudano sahelian savannas of Cameroon.

Material and method

Presentation of the study area

In Africa, Cameroon is located at the bottom of the Gulf of Guinea between West Africa and Central Africa. Cameroon has situated from South to North between 1°40 and 13° North latitude, for about 1250 km. From east to west, is situated between 8°30 and 16° 10 east longitude, about 860 km. The zone of the study goes from the Adamawa plateau to the northern plains and the Mandara Mountain massifs. It is located between 6° and 13° north latitude and between 11° and 15° parallel east longitude with a Sahelian climate predominantly.

This study area is subdivided into two agroecological zones

The Sudano-Sahelian Zone (Zone I) is between 8°36" to 12°54" North latitude, and 12°30" to 15°42" East longitude. It recovers approximately the northern and far-northern regions. The dry tropical climate (or Sudano-Sahelian) reigns above the 10th parallel and is strongly influenced by the continentality. Rainfall varies between 900 and 300mm per year during only four months on average, whereas, at the north of the 11th parallel (Sahelian range), the dry season often lasts 9 months. Average temperatures are around 28°C. Thermal amplitudes are strong (7.7°) as well as deficits of average saturation and the severity of the climatic conditions announce the Sahelian and desert climates of North Africa (Djoufack Manetsa, 2011).

The high Guinean savannah zone (zone II) is between 5°42" at 8°36" north latitude, and 11°24" at 14°36" east longitude. It recovers mainly the Adamawa region. It is largely constituted by a vast plateau between 900 and 1500m of altitude, with peaks reaching 1800m. The reigning climate in this region has from south to north, the humid tropical zone with Sudanese climate, that average precipitation are about

1500 to 900mm per year. It is characterized by a rainy season which can extend from March to October longer than the dry season (Tchotsoua and Gonné, 2010). The mean monthly temperature ranges from 20 to 28°C (MINEE, 2009). The dry season stretch from November to March, during which the monthly maximum average temperatures are above 30°C.

In the Sudano-Guinean area, four localities in Ngaoundere namely Dang, Tchabal, Mardok, Malang were chosen for collecting of adults and larvae of antlions. As well as four other localities: Garoua, Kaele, Pouss, and Yagoua were also selected as collection sites in the Soudano Sahelian zone (Fig. 1).

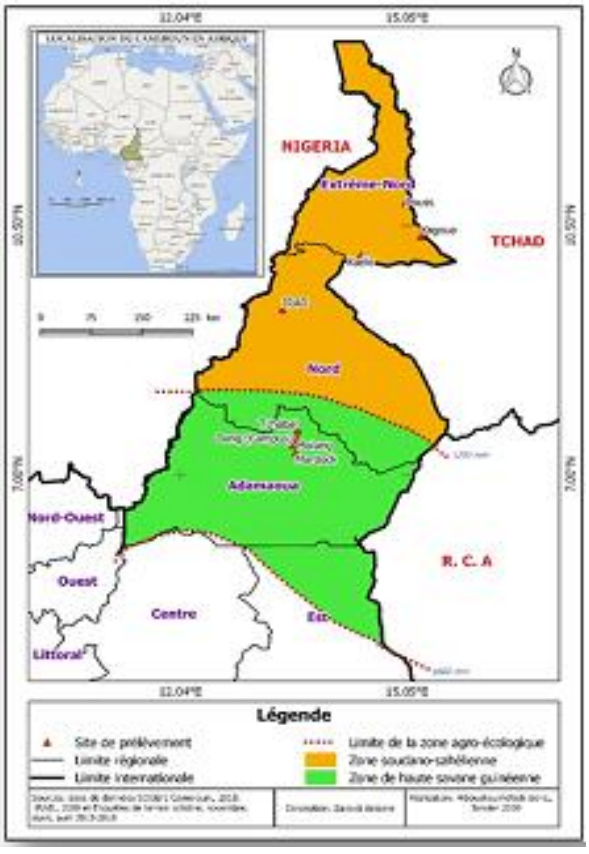

Fig. 1. Location of sampling sites of antlions at the larval and adult stages at the beginning of the dry season in northern Cameroon.

The Capture of antlion adults

Catch periods took place from 2015 to 2017 from September to December. This period marks the transition from wet season to dry season characterized by progressive drying of herbaceous vegetation. In each locality of the eight (8) above (Fig. 1), two sites were identified by the locality where antlion adult capture was made (Table 1). The criterion of site selection for the capture has been a constant and significant presence of funnels in the dry season and the quality of dominant herbaceous vegetation. Captures were made once a week in the middle of the afternoon in fallow land, on tall grass using butterfly nets over an area of more than one hectare.

Collection and monitoring of antlion larvae in the laboratory

Antlion larvae were obtained by extracting from their funnels in the sites of their occurrence at the beginning of the dry season during the period of adult capture, especially in November and the second half of the dry season during March and April in sites taking account of the high density of pit traps. Larvae were extracted from the three habitat types namely: wet habitats that are permanently in the shade, dry habitats that are open areas, without shadows, permanently sunny; and cool habitats that are occasionally shaded areas. On these habitat types, temperatures at which larvae are active were recorded. These larvae after their extraction are brought back to the laboratory and placed in breeding introduced individually into 33cl cups filled to the third of the sieved sea sand with a sieve of 500 microns of mesh. Larvae were fed *ad libitum*, by receiving prey per day, the prey was the larva III of *Tribolium castaneum* (*Coleoptera: Tenebrionidae*) and followed until adults are obtained.

Identification of antlions

Adults of antlion were either taken from the capture or obtained by larvae breeding extracted from the funnels. The resulting adults were killed with ethyl acetate and stored in 95° alcohol for identification. The photography of these captured insects was made with a Nikon Coolpix 3400 digital photography camera and a SUPEREYES 500x 2.0MP 8LED digital microscope. Adults obtained were kept dry, prepared and sent for identification. Identification was realized by Dr. André PROST at the Museum of Natural History of Paris. Then, confirmation of the identification of adults was carried out at the Royal

Museum of Central Africa at Tervuren in Belgium and Italy by Roberto PANTALEONI entomologist at the National Research Center and Professor at the Institute of Agronomy of the University of Sassari (Italy).

Data analysis

Analysis of the abundance and diversity of antlions present in the high Sudano Guinean and Sudano sahelian savannahs of Cameroon was realized by calculating various indices.

i) The degree abundance Pi (%) (Dajoz, 1982) of a given species, was expressed by the ratio of the number of collection (p) containing the species to the total number of the collection (P) carried out on the site. It is evaluated by the following formula:

$$Pi = p / P \times 100$$

Dajoz proposes 4 classes of degree of presence as follows: Pi < 1 accidental or rare species; [1≤ Pi < 25] fewer abundant species [25 ≤ Pi < 50] abundant or accessory species; [50-100] very abundant or constant species.

ii) The SHANNON-WEAVER diversity Index gives information on the diversity of species that make up the population in a habitat. It establishes the link between the number of species and the number of individuals in the same ecosystem or the same community. It is calculated using the formula:

$H' = - \Sigma [(ni / N)] \times \log2 [(ni / N)]$

where H' represents the specific diversity, in bits/ individual; Σ the sum of results obtained for each of the present species; ni the number of the species i; N the total number of individuals considering all the species and log2 the logarithm in base 2.

iii) SIMPSON Index allows estimating the β biodiversity of a community. It is calculated by the following formula : $d = 1 - \Sigma [(ni \times (ni - 1)) / (N \times (N - 1))]$ where ni represents the number of species i, Σ the sum of results obtained for each present species and N the number of individuals in the sample.

iv) The PIELOU J index allows the equitability (or equidistribution) of population species in relation to theoretical distribution equal for all species. It is obtained by the following formula: J = H '/ log2 S where H' is the SHANNON-WEAVER index, log2 the logarithm in base 2 and S the number of present species. According to Rebzani (1992), this index tells us about the equilibrium of the population according to which five classes were established: E > 0.80: population in equilibrium. 0.80 > E > 0.65: population in light imbalance. 0.65 > E > 0.50: unbalanced population. 0.50 > E> 0: population in strong imbalance. E = 0: non-existent population. v) The similarity index of SÖRENSEN S = (2c / (a + b)) is used to compare the different stations with each other (with a = number of species present in the first station, b = number of species present in the second station and c = number of species common to both stations).

vi) The similarity index between two habitats of Jaccard J = a / (a + b + c) was calculated to study the similarity between the two agroecological zones and the different habitats of larvae. **a:** represents the number of species between two habitats, **b:** represents the number of unique species for habitat 1 (ie total minus the number of common species **a**), **c:** represents the number of unique species for habitat 2 (minus the number common species **a**).

If the Jaccard J index increases, a large number of species occur in both habitats, suggesting that inter-habitat biodiversity is low (similar environmental conditions between habitats). In the opposite case, if the index decreases, only a small number of species present on both habitats will be encountered.

Results

Abundance and diversity of antlions in the study area

At the end of three sampling campaigns, 1672 antlions were obtained: 1028 larvae and 645 adults collected (Table 1). Identifications of adults from captures and larvae breeding allowed the grouping of these antlions in five Tribes: *Myrmeleontini*, *Nesoleontini*; *Myrmecaelurini*, *Nemoleontini,* and *Palparini*. The analysis of the abundance and species richness of tribes according to species shows that the *Nemoleontini* tribe is the only abundantly

represented of species (Pi = 36.36%), the other four tribes were fewer abundant with a Pi ranging from 22.72% (*Nesoleontini*) to 4.54% (*Myrmecaelurini*). In opposite, the diversity and the specific abundance analyzed according to individuals captured by tribe shows that the *Myrmeleontini* tribe is the most abundant with 476 adults followed by *Nemoleontini* with 444 adults then *Palparini* with 262 adults; *Myrmecaelurini* with 253 and the *Nesoleontini* with 237 adults (Table 3).

Table 1. Antlion sampling in northern Cameroon from 2015 to 2017 through the extraction of larvae from funnel (NL) and capture of adults (CA) at the butterfly net at the beginning of the dry season.

Agroecological Zone	Localities	Sampling Site	CA	NL
Sudano-guinean (924)	Tchabal	Tchabal amadou	3	
		Tchabal	80	
	Dang	Capus UN	269	274
		Pesage	48	
	Mardok	Aéroport	21	
		Carrefour tibati et maiganga	133	67
	Malang	Lycée sud	7	
		Lycée blingue	22	
Sudano-sahelian (748)	Garoua (120)	Station Irad	77	43
	Kaélé (357)	ENIEG	129	177
		SODECOTON	51	
	Yagoua (187)	Djibetsou		84
		Lycée bingue	103	
	Pouss (84)	Ecole Publique Gaya	48	
		Bagassare	36	
TOTAL (1672)			1028	645

Table 2. Diversity, numerical importance and abundance index of adult antlions from captures or the breeding of larva from funnels.

N°	Antlions from capture or from larvae breeding		Sudano-guinean zone				Sudano-sahelian zone				Captures (ni)	Pi IA
			Dang	Tchabal	Mardok	IA	Garoua	Kaélé	Yagoua	Pouss		
		Myemeleontinae										
1	Myrmecaelurini (253)	*Myrmecaelurus apicalis* Navas 1912					91	51	111		253	15,13
2		*Hagenomyia tristis* Walker 1853*	3		6						9	0.53
3		*Myrmeleon* sp.*	15		27						42	2.51
4	Myrmeleontini (476)	*Myrmeleon obscurus* Rambur 1842*	198		34		12	67	16	46	373	22.3
5		*Myrmeleon quinquemaculatus* Hagen 1853*	52								52	3.11
6		*Banyutus hesione* Banks 1911		3	2						5	0.29
7		*Creoleon africanus* Rambur 1842							5		5	0.29
8		*Creoleon nubifer* Kolbe 1897	68	3	3	6	2	15	7		105	6.27
9		*Creoleon* sp.	14	3			1	7			27	1.61
10		*Distoleon harpalyce* Banks1911	57	9	39	11					116	6.93
11	Nemoleontini (444)	*Nemoleon filiformis* Gertaecker1885	34	3	19	3					56	3.34
12		*Nemoleon* sp.						3			3	0.17
13		*Neuroleon ruber* Michel & Akoudjin 2012	93	19	10	3					125	7.47
14		*Neuroleon striolatum* Navas 1914		2							2	0.11
15		*Cueta bourboni* Navas 1935*					14	123	13	21	171	10.22
16		*Cueta* n.sp.						14		16	30	1.79
17	Nesoleontini (237)	Unknown sp 1							23		23	1.37
18		Unknown sp 2							12		12	0.71
19		Unknown sp 3								1	1	0.05
		Palparinae										
20		*Palpares obsoletus* Gerstaecker 1888	56	41	81	6		5			189	11.3
21	Palparini (262)	*Tomatares clavicornis* Latreille 1829						72			72	4.3
22		*Stenares arenosus* Navas 1924	1								1	0.05
		Total	591	83	221	29	120	357	187	84	1672	100

* Species whose larvae were extracted and bred

According to species diversity and the abundance of the antlion, no species was very abundantly (P i≥ 50%) or abundantly (25% ≤ Pi < 50%) represented. The most observed species are classified as fewer abundant in the study area while sampling: *M. obscurus* (22.3%); *M. apicalis* (15.13%); *P. obsoletus* (11.3%) *C. bourboni* (10.22%); *Neuroleon ruber* Michel & Akoudjin 2012 (7.47%); *Distoleon harpalyce* Banks, 1911 (6.93%) and *Creoleon nubifer* Kolbe, 1897 (6.27%) (Table 2).

Species not widely observed during the study period with more than one capture, but fewer than 13 captures are classified as rare species: Sp non det 1 (Pi = 0.71%) *H. tristis* (Pi = 0.53); *Banyutus hesione* Banks 1911 (0.29); *Creoleon africanus* Rambur 1842 (0.29); *Nemoleon* sp. (0, 17); *Neuroleon striolatum* Navas 1914 (Pi = 0.11); Sp no det 3 and *Stenares arenosus* Navas 1924 (0.05%).

Table 3. Specific richness of tribes according to captured individuals and abundance index according to the number of species per tribe.

	Tribes	Spécific richness (%)	Abondance Index (%)
1	*Myrmecaelurini*	15	5
2	*Myrmeleontini*	28	18
3	*Nemoleontini*	27	36
4	*Nesoleontini*	28	23
5	*Palparini*	16	18

2. Distribution of antlions in the study area

Adults of the captured antlions are distributed differently in the tribes, species, and number of individuals according to agroecological zones and even the sites and the habitats (Table 1). It is important to note that the Sudano-Sahelian zone is richer in tribes (5/5) than the Sudano-Guinean zone with (3/5) because the two tribes *Myrmecaelurini* and *Nesoleontini* are present only in this zone. Although the two sites are not presenting the same species, each zone has the same number, ie 13 species on the 22 observed, the largest part of the individuals was observed in Sudano-Guinean. The two zones have in common four species namely *M. obscurus, C. nubifer* and *P. obsoletus* and *Creleon* sp.

The Shannon index (Table 4) showed that the two zones do not difference according to diversity (H '= 2.96 bits / ind and H' = 2.60 bits / ind). Globally, the Simpson index 0.84 and 0.82 obtained in the two studied areas in the northern part of Cameroon may reflect an absence of a dominant species in this part. The highest value of the equitability index is observed in Sudano-Guinean (0.80) and the lowest value is recorded in Sudano-Sahelian (0.70). Equitability in overall tend to 1, indicating that the antlion populations are balanced in Sudano-Guinean zone, and slightly unbalanced in the Sudano-Sahelian zone, means that all species have essentially the same dominance in the Guinean high savannah and some species in Sudano-Sahelian have slight dominance. The similarity index of Jaccard was very low (J = 0.18) as well as Sorrens index (S = 0.36), which shows that the faunistic from the two zones are very different, therefore, do not present enough similarity in terms of ecological conditions.

Table 4. Distribution and biodiversity of antlions in the two agroecological zones.

	Sahelian	Guinean
Tribes (5)	5 (100%)	3 (60%)
Species (22)	13 (59.09%)	13 (59.09%)
Individuals (1672)	748 (44.73%)	924 (55.26%)
Shannon index	2.96	2.60
Simpson index	0.84	0.82
Piélou index	0.80	0.70
Jaccard /sorrens index	0.18 / 0.36	

Abundance, diversity, and distribution of antlions in the Sudano-Guinean zone

In the Sudano-Guinean zone, a total of 924 specimens was collected with 55.26% of the global population that 591 (63.96%) are in Dang, 221 (23.91%) are in Mardok, 83 are in Tchabal (23%) and 29 in Malang (3.13%). The Dang site is the most diversified with 11 species, followed by Mardok (9 species). Other stations namely Tchabal (8 species) and Malang (5 species) are poorly diversified (Table 5).

The Shannon diversity index is less than 3 in the four sites, reflecting a lower biological diversity in these environments. Nevertheless, the most diversified site is Dang with a Shannon index of 2.82 bits/ind and the

least diversified is Malang (2.14 bits / ind). Overall, the Simpson index obtained at the four sites studied in the Sudano-Sahelian region may reflect an absence of a dominant species in this area. The highest value of the equitability index is observed at Dang (0.82) and the lowest value is recorded at Tchabal (0.69). The equitability in all the sites of the zone is near to 1, revealing that the population of the antlions are balanced or very unbalanced, says that all species have approximately the same dominance in this zone (Table 4). Species identified in this area are most often represented by *M. obscurus* (25.10%), *P. obsletus* (19.91%), *N. ruber* (13.52%), *D. harpalyce* (12.55%), *C. nubifer* (8.65%), *N. filiformis* (6.38%), *M. quinquemaculatus* (5.62%), *Myrmeleon Sp.* (4.54%). The other species are very poorly represented and can be described as rare species in the area.

Table 5. Distribution of tribes, species, and indices of diversity of Antlions in Sudano-Guinean zone.

	Dang	Mardok	Tchabal	Malang
Tribes (3)	3 (100%)	3 (100%)	2 (66.67%)	2 (66.67%)
Species(13)	11 (84.61%)	9 (69.23%)	8 (61.53%)	5 (38.46%)
Individuals (924)	591 (63.96	221 (23.91%)	83 (8.98%)	29 (3.13%)
Shannon index	2.82	2.81	2.15	2.14
Simpson index	0.81	0.93	0.71	0.92
Piélou index	0.82	0.78	0.69	0.77

Abundance, diversity and distribution of antlions in the Sudano-Sahelian zone

In the Sudano-Sahelian section, specimens were collected, representing 44.73% of the total captures (Table 6). Over 748 individuals, 357 specimens are captured at Kaélé, 187 at Yagoua, 120 at Garoua and 84 at Pouss. Kaélé is the most diversified site with 11 species collected followed by Yagoua (7 species). Other stations are weakly diversified with less than 5 species. The Shannon index showed that the Kaélé site (H '= 2.48 bits/ind) is the most diversified zone, so, Garoua (H' = 1.15 bits/ind) is the least diversified. At the three sites, Kaélé, Yagoua, Pouss, the Simpson and equitability indexes obtained are greater than 0.60, improving a slight imbalance population.

The smallest value was recorded in Garoua (0.4), showing a population of antlions in a strong imbalance. The Myrmeleontidae population in this part is dominated by 4 species namely *M. apicalis* (33.82%), *C. bourborni* (22.86%) *M. obscurus* (18.85%) *T. clavicornis* (9.62). The other 7 species are very poorly represented (less than 5%).

Table 6. Biodiversity and distribution of antlions in the Sudano-Sahelian zone.

	Yagoua	Garoua	Kaélé	Pouss
Tribes (5)	4 (80%)	4 (80%)	5 (100%)	2 (40%)
Species (13)	7 (53.84)	5 (38.46)	11 (84.61)	4 (30.76)
Individuals (748)	187 (25%)	120 (16.04%)	357 (47.72%)	84 (11.22)
Shannon index	1.96	1.15	2.48	1.15
Simpson index	0.69	0.49	0.78	0.75
Piélou index	0.61	0.40	0.78	0.60

III.5. Characteristics of larval habitats of antlions

Antlion larvae collected in the northern areas of Cameroon at the beginning of the dry season and the middle of the dry season belong to two tribes: *Myrmeleontini* and *Nesoleontini*. *Myrmeleontini* is represented by four species: *M. quinquemaculatus*, *H.tristis*, *M.obscurus,* and *Myrmeleon sp.* Larvae of these antlions were extracted from funnels built in moist habitats, with an average temperature of activity 22.18°C between 11 am and 14 pm are *M. quinquemaculatus*; fresh habitats with an average temperature of activity 27.49°C between 11 am and 14 pm, are *H. tritis, M.obscurus,* and *Myrmeleon* sp. *M. obscurus* is the only *Myrmeleontini* that in the Sudano-Guinean space is observed in dry conditions with an average temperature of activity 34.5°C. In the Sudano-Sahelian field, *M. obscurus* appears in cool habitats where the average temperature of activity is 42.24°C (Tabeau 7).

Larvae of *Nesoleontini* are collected exclusively in the Sudano-Sahelian zone in dry conditions where the average temperature of activity is 49.0°C for all four species: *Cueta Bourboni* Navas 1935, *Cueta n.sp*, *Sp* und *det 2* and *Sp* not *det 1*; only the undetermined species *Sp* not *det 1* in this ecological zone is found in fresh habitats where the average temperature of activity is 42.24°C.

The Jaccard similarity index is low between the two agroecological zones, ie 0.12, indicating a very low similarity between the two zones. The values of the Jaccard similarity index between the different habitats, between agroecological zone and intra-agroecological zone, show that the habitats are distinct from each other. However, the Jaccard index is highest (0.5) between dry habitats in Sudano-Guinean and fresh in Sudano-Sahelian habitats followed by 0.33 between fresh and dry habitat in Sudano-Guinean, and the lowest 0.25 between the fresh habitats of the two zones and at the end 0.2 for fresh and dry habitats in the Sudano-Sahelian zone (Table 8).

Table 7. Correspondence between the ecological characteristics of Antlion larval habitats and the diversity of species collected.

Resulted antlions at larval period from funnels	Guinean (900 to 1400 mm precipitation/year)			Sahelian (400 to 700 mm precipitation/year)	
	Moist (22.18°C)	Fresh (27.49°C)	Dry (34.5)	Frech (42.24°C)	Dry (49.0°C)
Myrmeleontini					
1 *Hagenomyia tristis*					
2 *Myrmeleon quinquemaculatus*					
3 *Myrmeleon obscurus*					
4 *Myrmeleon* sp					
Nesoleontini					
5 *Cueta bourboni*					
6 *Cueta* n.sp.					
7 Unknown sp 1					
8 Unknown sp 2					

Table 8. Jaccard indexes calculated from the larval matrix collected in northern Cameroon.

		Sahelian Zone			
		Sahelian Moist	Fresch	Dry	
Guinean Zone	Guinean Moist	0,12			
	Fresch		0.00	0.00	0.00
	Dry		0.0	0.25	0.0 (0.33)
			0.0	0.5 (0.2)	0.0

Values in bold and in bracket indicate the index between the two Sudano-Sahelian habitats and those in red indicate those between two habitats in Sudano-Guinean.

Discussion

Antlions of northern Cameroon are divided between 5 tribes and 22 species, with a dominance of *Nemeleontini* tribe along to species involving that this tribe is ubiquitous to collecting localities. The *Nemeleontini* tribe is the largest in species and the genus of all the antlion tribes in the world and is the most distributed in the tropics (Stange, 2004, Michel *et al.,* 2017). Our work is in agreement with the work of (Michel *et al.*, 2007) who showed in a study realised in Mali that the tribe of *Nemoleontini* represents the most diversified tribe with 26 species among which *C. africanus*, *C. nubifer* and *N. filiformis* obtained in our study followed by the tribe of *Nesoleontini* with 7 species which were species of our study also, *C. bourborni* was present, then the tribe of *Myrmecaelurini* presented by three (03) species. The most abundant species are the most distributed species in the study area, eg *M. obscurus* was ubiquitous at collecting localities during this transition phase; wet season-dry season with fresh vegetation that dries progressively and even in the dry season. The presence of adult antlions would be strongly related to the types of environments, vegetation and a period in the season because; the number of species varies according to the localities. The rare species in the study area are species captured for the first time in Cameroon except for *H. tristis* (Ngamo *et al.,* 2010, 2016; Maoge *et al.,* 2014). In addition, *P. obsoletus* and *D. harpalyce* are generally found in tall grasses with high vegetation in average and appear shortly after the beginning of grass bloom (end of September to early October). While *N. ruber, Creleon sp* and *B. hesion* are generally found in small weeds, open places and appear at the same time as *P. obsoletus,* and *D. harpalyce*. Thus, *C. nubifer*, and *N. filiformis* are more common in dry grass of open habitats and their presence is observed from the end of October to December when the daily temperature is above 25°C. The work of Snow and Vince (1984) showed that the type of vegetation is characteristic of each species of ants.

The distribution of tribes and species is a function of climate; therefore; there are specific tribes characteristic of determined zones; because *Nesoleontini* and *Myrmecaelurini* with their all species are characteristic of the Sudano-Sahelian zone which differs from the Sudano-Guinean zone by the higher average temperature which oscillates around 28°C with an amplitude of 7.7° and a long dry season of 09 months.

The low Jaccard and sorrens similarity indexes between the two agroecological zones reflect a low number of species common to both zones and explain the difference in environmental conditions between these zones. These results agree with the work of Güsten (2002) on the biodiversity and ecology of antlions in two areas including a savannah zone (Bou Hedma) and a semi-desert zone (Jbil). His research shows that savannah fauna is more diversified with 26 species compared to 21 species in Jbil, which is a semi-desert zone with 5 species common to both study sites. In South Africa, *Palparinae* are more diversified in the western part more desert than the eastern part. By contrast, the *Myrmeleontinae* are more diversified in the eastern part with 52% of species against 42% of the western part (Mansell, 1988). However, it should be noted that within the same agroecological zone with the same environmental characteristics, the difference in specific diversity is low. The low diversity observed in the Sudano-Sahelian zone could also be due to the quality of the sampling and the indirect impact of the effects of environmental exploitation. Similarly, the very low equitability indexes observed in Garoua would result in an unbalanced settlement in this condition, which will be explained by the fact that this station is at the boundary between the two agroecological zones. Other stations showed a balanced population (E > 0.6) and the Simpson index showed no dominant taxon among the collected population. These results confirm those of equitability index which showed that populations of the stations are balanced along to species.

A study on antlions revealed that antlion population dynamic and flight period vary by region and month (Michel and Letourmy 2007). In Hungary (Szentkirályi and Kazinczy, 2000) Tunisia (Güsten, 2002), adults fly from April-May to October and from May to September respectively; in the Cape Verde Islands, they fly from January to October (Hölzel and Ohm, 1990); in California, from March to October (Stange, 1970); in Australia, adult activity has been reported from September to April (Mackey, 1988). In northern Cameroon, the beginning of the dry season corresponds to the period of flight of 22 species encountered.

Analysis from the collected larvae in the two agroecological zones shows that the distribution of antlion larvae is a function of habitat types and type of agroecological domain. However, the two zones share only one *M. obscurus* species of the *Myrmeleontini* tribe, and all the species of the *Nesoleontinine* tribe are present only in the Sahelian zone. The similarity index of Jaccard appreciates better this dissimilarity between the two zones with a very low index (0.12). This can be explained by the difference in soil characteristics and the level of environmental degradation, and especially by the difference in temperature ranges and preferences. The literature review of the sites on which traps were observed was carried out by Fertin (2007) and showed that larvae of *Myrmeleontini* tribe construct their funnels in the temperature range from 15.5°C to 28°C; approximative condition to the Sudano-Guinean domain of our study, but deviated by the *M. obscurus* species which extended its activity in the Sudano-Sahelian zone with the average temperature up to 42.24°C. The ubiquitous *M. obscurus* can be explained by the studies of Bakoidi *et al.,* 2018 which showed that this species can live in the thermal range of 22°C to 45°C with its optimum observed at 35°C. The *cueta* genus of the *Nesoleontini* tribe is the one that occurs in the desert zone where the area temperature can range from 27°C to 68°C (Marsh 1987, Cain 1987). The different habitats of antlion larvae are different from each other and the covered habitat is separated into two habitats, namely freshly covered habitat and moist covered habitat, which is differentiated by the species present and the temperatures recorded. For the same species; the choice of a protected habitat may vary, as is the case of *M. obscurus*. Although the ideal conditions for trap construction must be fine sand and dry (Fertin 2007), antlions are extremely dependent on a specific microhabitat (Sharf and Ovadia 2006, Mansell 1996, 199).

Conclusion

The diversity of antlions estimated through the identification of 1672 captured adults and larvae extracted from the funnels during the campaigns in the North zone of Cameroon is materialized by the presence of 22 species distributed in 5 tribes. The two tribes of *Nesoleontini* and *Myrmecaelurini* are specific to the Sudano-Sahelian zone which characterizes the

climate of this zone. The most abundant and abundant species are *M. obscurus, M. apicalis, P. obsoletus,* and *C. bourboni*. The fewer or rare species in this period are *H. tristis; B. hesione; C. africanus; Nemoleon sp.* and *N. striolatum*. The four *M. obscurus, C. Nubifer,* and *P. obsletus Creleon* sp. species are common to both agroecological zones and are tolerant species. Antlion habitats are divided into three categories with larvae that are characteristic of them.

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References

Bakoidi A, Djibo I, Dobo F, Maoge J, Tinkeu LSN. 2018. Identification of the Optimum Temperature of *Myrmeleon obscurus* (Rambur, 1842). Entomol Ornithol Herpetol **8,** 216.

Badano D and Pantaleoni RA. 2014. The larvae of European Myrmeleontidae (Neuroptera). Zootaxa **3762(1),** 71 p

Cain ML. 1987. Prey capture behaviour and diet movement of *Brachynemurus* (Neuroptera: Myrmeleontinae) antlion larvae in South Central Florida. The Florida Entomologist **70,** 397-400.

Dajoz R. 1982. Précis d'écologie. Ecologie fondamentale et appliquée Ed. Gauthier Villers paris 503 p.

Djoufack Manetsa V, Brou T, Fontaine B, Tsalefac M. 2011. Variabilité intra saisonnière des précipitations et de leur distribution: impacts sur le développement du couvert végétal dans le Nord du Cameroun (1982-2002). Sécheresse **22,** 159-70.

El-Hamouly H, Fadl HH. 2011. Checklist of order Neuroptera in Egypt, with a key to families. African J. Biol. Sci **7(1),** 85-104 (2011) ISSN 1687-4870

Fertin A. 2007. Ecologie physique du piège des fourmilions: une construction en milieu granulaire. Thèse de doctorat, Université de Tours (France) 92 p.

Gretia. 2009. Etat des lieux des connaissances sur les invertébrés continentaux des Pays de la Loire; bilan final. Rapport GRETIA pour le Conseil Régional des Pays de la Loire 396p.

Güsten R. 2002. Antlion assemblages (Neuroptera: Myrmeleontidae) of two arid habitats in Tunisia. Acta Zoologica Academiae Scientiarum Hungaricae **48,** 99-120.

Hölzel et Ohm. 1990. Verbreitung und Phänologie kapverdischer Neuropteren (Insecta: Planipennia). Courier Forschungsinstitut Senckenberg **129,** 139-145.

Kaiser J. 2001. Bioindicators and Biomarkers of Environmental Pollution and Risk Assessment (Enfield: Sciences publishers inc.) 32 p.

Letardi A. 2014. Note on some antlions from Mozambique (Neuroptera: Myrmeleontidae). Biodiversity Data Journal **2,** 1-5.

Mackey AP. 1988. Phenology of some Myrmeleontoid (Neuroptera) species from Rockhamp-ton (Central Queensland). Australian Entomological Magazine **5,** 87-90.

Mansell MW. 1985. The ant-lions of southern Africa (Neuroptera: Myrmeleontidae). Introduction and genus Bankisus Navas. Journal of the Entomological society of southern Africa **48,** 189-212 p.

Mansell MW. 1996. Predation strategies and evolution in antlions (Insecta: Neuroptera: Myrmeleontidae), International Symposium on Neuropterology. Cairo, Egypt, pp. 161–169.

Mansell MW. 1999. Evolution and success of antlions (Neuropterida: Neuroptera, Myrmeleontidae). Stapfia **60,** 58 p.

Mansell MW. 2000. Neuroptera (Insecta). Pp. 163-176. *In* Kirk-Spriggs, A.H. & Marais, M. (eds) Dâures - Biodiversity of the Brandberg Massif, Namibia. Cimbebasia Memoir **9,** National Museum of Namibia, Windhoek.

Mansell MW. 2002. The Southern African Lacewing Monitoring Programme. Acta Zoology of Hungria 48(2)165-173p.

Maogé J, Ngamo TLS, Michel B and Prost A. 2014. Spatial distribution of the pit builders antlion's larvae (Neuroptera: Myrmeleontidae) in the septentrional regions of Cameroon (Central Africa). International Journal of Scientific and Research Publications **4,** 10 p.

Markert BA, Breure AM and Zechmeister HG. 2003. Définitions, strategies and principles for bioindication/biomonitoring of the environment. Bioindicators and biomonitors: principles, concepts and applications (Oxford: Elsevier Science Limited), 3-39 p.

Marsh A. 1987. Thermal responses and temperature tolerance of a desert ant-lion larva. Journal of Thermal Biology **12,** 295-300.

Michel B and Letourmy P. 2007. Characterisation of a West African Myrmeleontinae assemblage (Neuroptera Myrmeleontidae): first evidence of a relationship between adult occurrences and climatic conditions. Tropical Zoology **20,** 197-209.

MINEE. 2009. Plan d'action national de gestion intégrée des ressources en eau (PANGIRE), état des lieux du secteur eau et environnement. Global water partnership, 235p.

Ngamo Tinkeu LS, **Maogé J and Koda T.** 2016. Diversity of pit building ant lions (Neuroptera: Myrmeleontidae) and their potential preys in the sudano Guinean zone of Cameroon. Journal of Entomology and Zoology Studies **4(1),** 198-202 p.

Ngamo Tinkeu LS, **Maogé J.** 2014. Chetae of larva of antlions (Neuroptera: Myrmeleontidae) *Hagenomyia tristis* Walker 1853 and *Myrmeleon obscures* Rambur 1842 involve in the construction of pitfall traps. Journal of Biodiversity and Environmental Sciences **5(4),** 511-519 p.

Ngamo Tinkeu LS, Maogé J, Aminatou Boubakary AB. 2010. Predation of *Myrmeleon obscurus* Navas 1912 (Neuroptera : Myrmeleontidae) on the ground ant *Myrmicaria opaciventris* EMERY (Formicidae : myrmicinae). International Journal of Biological and Chemical Sciences **4(2),** 509-514 p.

Prost A. 1998. Les Acanthaclisinae d'Afrique occidentale et centrale (Neuroptera, Myrmeleontidae). Revue Française d'Entomologie **20,** 173 p.

Rebzani-Zahaf C. 1992. Le peuplement macrobenthique du port d'Alger: impactde la pollution, Hydroécol. Appl **4,** 91-103.

Sharf F, Ovadia O. 2006. Factors influencing site abandonment and site selection in a sit-and-wait predator: a review of pit-building antlion larvae. Journal of Insect Behaviour **19,** 197-218.

Snow AA, Vince SW. 1984. Plant zonation in an Alaskan salt marsh. II. An experimental study of the role of edaphic conditions. Journal of Ecology **72,** 669-684.

Stange LA. 1970. Revision of the antlion tribe Brachynemurini of North America (Neuroptera: Myrmeleontidae). University of California Publication in Entomology **55,** 1-192.

Stange LA. 2004. A systematic catalog, bibliography and classification of the worldantlions (Insecta: Neuroptera: Myrmeleontidae). Mem. Am. Entomol. Inst **74,** 1-565.

Szentkirályi F, Kazinczy L. 2000. Seasonal flight patterns of antlions (Neuroptera, Myrmeleontidae) monitored by the Hungarian light trap network. Acta Zoologica Academiae Scientiarum Hungaricae **48(Supplement 2),** 311 -328.

Tchotsoua M, Gonne B. 2010. Des crises socio-économiques aux crises environnementales sur les hautes terres de l'Adamaoua, Cameroun. Savanes africaines en développement: innover pour durer, Cirad Cameroun, 9 p.

Zeng N. 2003. Drought in the Sahel. Science **302,** 999-1000.