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Diversity of Ground Beetles (Coleoptera Carabidae) in the Ramsar wetland: Dayet El Ferd, Tlemcen, Algeria

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ABSTRACT

A study on diversity of ground beetle communities (Coleoptera Carabidae) was conducted between March 2011 and February 2012 in the temporary pond: Dayet El Ferd (listed as a Ramsar site in 2004) located in a steppe area on the northwest of Algeria. The samples were collected bimonthly at 6 sampling plots and the gathered Carabidae were identified and counted. A total of 55 species belonging to 32 genera of 7 subfamilies were identified from 2893 collected ground beetles. The most species rich subfamilies were Harpalinae (35 species, 64%) and Trechinae (14 species, 25.45%), others represented by one or two species. According to the total individual numbers, Cicindelinae was the most abundant subfamily comprising 38.81% of the whole beetles, followed by 998 Harpalinae (34.49%), and 735 Trechinae (25.4%), respectively. The dominant species was *Calomera lunulata* (Fabricius, 1781) (1087 individuals, 37.57%) and the subdominant species was *Pogonus chalceus viridanus* (Dejean, 1828) (576 individuals, 19.91%).

KEY WORDS Algeria; Carabidae; Diversity; Ramsar wetland “Dayet El Ferd”.

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INTRODUCTION

Mediterranean temporary ponds (MTP) are priority habitats according to the Natura 2000 network of the European Union and are located in various Mediterranean countries. Priority habitats are those habitat-types or elements with a unique or important significance to a diverse group of species (Zacharias & Zamparas, 2010).

In Mediterranean regions, and more particularly in North Africa, wetlands contain a very rich, but declining biodiversity (Bouldjedri et al., 2011). The temporary ponds appear as real laboratories of survey of the living world but are poorly known as regards to vegetation and especially fauna, in particular arthropods. This is especially regrettable than they became very rare and are threatened of disappearance. The industrialization, the change of the hydrologic performance, the irrational use of their resources and the development of the tourism on the Mediterranean periphery are as many menacing factors (Hanene et al., 2008). In Algeria, wetlands are very rarely protected from anthropogenic disturbances, even if they are recognised as conservation priorities, for instance through the ‘Ramsar site’ status. In North West Africa, the term “Daya” is generally applied to define temporary ponds. The wide range of climatic and altitudinal conditions across Algeria prevent making further generalization except that a "Daya" is, usually, a temporary wetland (Cherkaoui et al., 2003). Many of these wetlands, located along the North of Algeria, are important stop-overs for wildfowl on the migratory route that connects Africa and Europe (Boix, 2000). Temporary ponds provide forage, refuge, and a place for overwintering or estivation for many species, including soil macrofauna and microfauna, insects, and birds (Kato, 2001; Thomas et al., 2004; Katoh et al., 2009; Paik et al., 2009).

Among the organism groups inhabiting wetlands, ground beetles are especially useful as environmental indicators because they strongly respond to changes in microhabitat conditions, such as moisture content, light intensity, temperature regime, vegetation density and substrate composition (Rainio & Niemelä, 2003; Lambeets et al., 2008, 2009). Coleoptera are important in terms of ecological research because of their large number of species, cosmopolitan distribution, and ease of capture (Barney & Pass, 1986; Floate et al., 1990; Kromp, 1999). Ground beetles are well known organisms, their habitat choice is very specific and for this reason they are often used to categorize habitats (Lövei & Sunderland, 1996) and can be used as bioindicators (Thiele, 1977). Ground-beetles (Coleoptera: Carabidae) offer strong potential as local scale indicators of disturbance effects (Thiele, 1977; Kimberling et al., 2001; Pearce & Venier, 2006; Gaucherel et al., 2007). Among these, ground beetles except Harpalinae and Zabrinae, are predaceous and feed on small sized invertebrates including earthworms, aphids, moths and snails which play a very important role in the ecosystem (Lövei & Sunderland, 1996; Holland, 2002), especially in mountainous and steppe areas (Kromp, 1999; Holland, 2002).

They are well adapted to dynamic flood prone areas and have a strong flight capacity and, therefore, a high dispersal ability (Desender, 2000), which makes them fast colonizers of emerging or restored habitats (Lambeets et al., 2008).

More specifically, in wet habitats such as temporary pools, wet grasslands, river sides, and lowlands with different vegetation, lower soil pH, and higher soil moisture than surrounding areas, ground beetles can be characterized by species composition, food preference, and habitat selection (Hengeveld, 1987; Luff et al., 1989; Eyre et al., 1990; Do & Moon, 2002; Do et al., 2007).

The study was performed to make specific inventories of ground beetles in the Ramsar wetland (Dayet El Ferd) and to provide fundamental information on diversity and community structure of these beetles.

MATERIAL AND METHODS

Study area and collecting method

The northwest of Algeria comprises a varied set of environments differing in climate, substrate, topography and vegetation (Brague-Bouragba et al., 2007). The study was conducted in the Ramsar wetland "Dayet El Ferd", located right in the heart of the steppe zone, 50 km south of Tlemcen (34°28′N and 1°15′W). It's a permanent endorheic depression with brackish water, surrounded by pastures and cereal fields and situated between two mountain chains. The study area is characterized by a typical vegetation dominated by *Tamarix gallica* L. (Boumezber, 2004). Catching of adult ground-beetles were obtained with interception traps on the ground "Barber traps", on six study plots regularly distributed over each elevation stratum for one year between March 2011 and February 2012.

A total of 6 plots were chosen and each plot was subdivided into two sub-plots from the pond periphery along two linear transects, in each sub-plot three pitfall traps were placed for standardized trapping, resulting in a total of 36 traps. The distance between the sub-plots amounted to at least 1 km, and at each sub-plot, traps were set out in a triangular pattern.

Carabid fauna was collected using pitfall traps, which is an adapted trapping method for this family (Lövei & Sunderland, 1996). Ground beetles mainly live on the surface of ground, and pitfall traps are installed considering these features (unbaited so as to capture the Arthropoda at random without having an effect on their behaviour). Pitfall traps were constructed from round plastic containers with 10 cm height, 7 cm diameter and 200 ml volume fitted with a clear plastic funnel. The traps were covered with plastic lids to keep debris and rain out of the traps. The number of beetles in pitfall traps is a function of both individual activity and population density (Tretzel, 1955; Heydemann, 1957; Chiverton, 1984).

Plots were sampled twice a month and sampling was replicated for 12 months (March 2011 to February 2012). All insects collected were preserved in 70% ethyl alcohol and brought to the laboratory for being dried, mounted, and identified to the species level under a stereo-microscope (Nikon SMZ-745T). Identification to species of the Carabidae was made using the key of Bedel (1895-1914), Du-Chatenet (2005). Nomenclature follows Löbl & Smetana (2003). All specimens once identified were stored in insect storage boxes.

Community Structure Analysis

Diversity was expressed using the Shannon- Weiner index (H') (Magurran, 2004), McNaughton's dominance index (DI, McNaughton, 1967), Margalef's species richness index (RI, Margalef, 1958), Pielou's species evenness index (EI, Pielou, 1975) and Jaccard's similarity index (SJ, Jaccard, 1908). The formulas are as follows:

$H' = -\sum (P_i \times \log_2 P_i)$, when P_i: Relative frequency of species i ($P_i = n_i/N$)

n_i means number of individuals at i-th species and N means total number of individuals (Pielou, 1969).

DI (Dominance index) = $(n_1 + n_2)/N$

n_1 means number of dominant species individuals, n_2 means number of subdominant species individuals, N means total number of individuals (McNaughton, 1967).

RI (Species richness index) = $(S-1)/\ln N$

S means total number of species and N means total number of individuals (Margalef, 1958).

EI (Evenness index) = $H'/\log_2 S$

H' means species diversity index and S means total number of species (Pielou, 1975).

Alternatively, the Jaccard index may be calculated using the following equation:

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

where a: the number of species found in both sites; b: the total number of species in sample 1; and c: the total number of species in sample 2.

The results of calculated similarity are shown as dendrograms obtained by the Minitab 16 software.

RESULTS

A total of 55 species belonging to seven subfamilies were identified from 2893 collected ground beetles in temporary wetland (Dayet El Ferd) located in a natural steppe area (Table 1). Thirty five species of Harpalinae recorded the highest number of subfamily species, followed by 14 Trechinae, 2 Cicindelinae, 2 Scaritinae, and the others subfamilies Carabinae, Siagoninae, Apotominae with 1 species each (Fig. 1). The subfamily Cicindelinae had the maximum number of individuals comprising 38.81% of the total, followed by 998 Harpalinae (34.49%), 735 Trechinae (25.4%), 32 Scaritinae (1.1%), 2 Carabinae (0.07%), 2 Siagoninae (0.07%), and 1 Apotominae (0.03%), respectively (Fig. 2).

At the genus level, 6 species of *Bembidion* Latreille, 1802, 5 species of *Harpalus* Latreille, 1802, 3 species of *Amara* Bonelli, 1810, *Microlestes* Schmidt-Goebel, 1846, *Poecilus* Bonelli, 1810, 2 species of *Acinopus* Dejean, 1821, *Acupalpus* Latreille, 1829, *Calathus* Bonelli, 1810, *Chlaenius* Bonelli, 1810, *Cymindis* Latreille, 1806, *Ditomus* Bonelli, 1810, *Emphanes* Motschulsky, 1850 and *Pogonus* Dejean, 1821, were collected. The other 19 genera were all represented by single species. 1087 individuals of *Calomera* Moutschulsky, 1862 and 593 individuals of *Pogonus* were collected, followed by *Harpalus* and *Poecilus* with 370 and 190, respectively. The number of individuals of each species was pooled per plots. The number of ground beetle species in each surveyed plot varies from 20 (Plot 6), to 33 (Plot 1) (Fig. 3).

The dominant species was *Calomera lunulata* (1087 individuals, 37.57%) and the subdominant species was *Pogonus chalceus* (576 individuals, 19.91%), these two species represented 57.48% of the total catch. Eight of the 55 species occurred in all 6 plots namely; *Bembidion varium*, *Pogonus chalceus*, *Harpalus tenebrosus*, *Harpalus lethierryi*, *Harpalus oblitus*, *Laemostenus algerinus*, *Syntomus fuscomaculatus*, and *Poecilus* sp. On the other hand, more than 70% of the species were recorded in less than five plots, including 15 species recorded in only one plot.

The Dominance index (DI) for each site varied between 0.48 and 0.74, and the average dominance index was in the order of Pt.6 > Pt.4 > Pt.5 > Pt.1 > Pt.3 > Pt.2, respectively.

The species diversity index (H') for each site ranged from 1.56 to 2.53, and the average species diversity index was in the order of Pt.2 > Pt.1 > Pt.3 > Pt.5 > Pt.4 > Pt.6, respectively.

Subfamily	Species	indivi-duals	Pt 1	Pt 2	Pt 3	Pt 4	Pt 5	Pt 6
Cicindelinae	*Calomera lunulata* (Fabricius, 1781)	1087		4	240	447	180	216
	Lophyra flexuosa flexuosa (Fabricius, 1787)	36			24	11	1	
Carabinae	*Calosoma inquisitor* (Linnaeus, 1758)	2		2				
Siagoninae	*Siagona europaea europaea* (Dejean, 1826)	2		2				
Scaritinae	*Dyschirius chalybeus chalybeus* (Putzeys, 1846)	14	3		1	2	6	2
	Distichus planus (Bonelli, 1813)	18		1	6	5	4	2
Apotominae	*Apotomus rufithorax* (Pecchioli, 1837)	1					1	
Trechinae	*Amara* (*Acorius*) *metallescens* (Dejean, 1831)	5	1		3	1		
	Amara (*Paracelia*) *simplex* (Dejean, 1828)	5		2	1	2		
	Amara sp.	10		1	4	4	1	
	Zabrus (*Aulacozabrus*) *distinctus* (Lucas, 1842)	7	2		4		1	
	Bembidion (*Peryphus*) *andreae* (Fabricius, 1787)	2	1					1
	Bembidion (*Nega*) *ambiguum* (Dejean, 1831)	14	11		1		1	1
	Bembidion (*Emphanes*) *latiplaga mateui* (Antoine, 1953)	3	3					
	Bembidion (*Emphanes*) *minimum* (Fabricius, 1792)	15			1	10	4	
	Bembidion (*Notaphemphanes*) *ephippium* (Marsham, 1802)	9				5		4
	Bembidion (*Notaphus*) *varium* (Olivier, 1795)	70	3	1	1	35	8	22
	Emphanes sp.1	1						1
	Emphanes sp.2	1					1	
	Pogonus chalceus viridanus (Dejean, 1828)	576	6	55	86	164	190	75
	Pogonus luridipennis (Germar, 1823)	17		1		3	5	8
Harpalinae	*Acinopus* (*Oedematicus*) *megacephalus* (P. Rossi, 1794)	2	1	1				
	Acinopus sp.	1	1					
	Daptus vittatus (Fischer von Waldheim, 1823)	9	1		4	4		
	Harpalus (*Cryptophonus*) *tenebrosus* (Dejean, 1829)	42	9	10	11	6	3	3
	Harpalus lethierryi (Reiche, 1860)	96	7	12	41	16	18	2
	Harpalus microthorax (Motschulsky, 1849)	2	2					

Table 1/1. List of ground beetles collected in Dayet El Ferd, Algeria.

Subfamily	**Species**	**indivi-duals**	**Pt 1**	**Pt 2**	**Pt 3**	**Pt 4**	**Pt 5**	**Pt 6**
Harpalinae	*Harpalus oblitus patruelis* (Dejean, 1829)	184	14	40	44	60	21	5
	Harpalus sp.	19	3	7	3	4	2	
	Acupalpus (*stenolophus*) *elegans* (Dejean, 1829)	1				1		
	Acupalpus maculatus (Schaum, 1860)	2	1				1	
	Amblystomus metallescens (Dejean, 1829)	1			1			
	Anisodactylus (*Hexatrichus*) *virens winthemi* (Dejean, 1831)	11	1	1	5	4		
	Ditomus sp.	2		2				
	Ditomus sphaerocephalus (Olivier, 1795)	2		1	1			
	Calathus fuscipes algericus (Gautier des cottes, 1866)	110	69	4	36		1	
	Calathus (*Neocalathus*) *mollis atticus* (Gautier des Cottes, 1867)	15	1	14				
	Laemostenus (*Pristonychus*) *algerinus algerinus* (Gory, 1833)	22	1	1	6		11	3
	Agonum marginatum (Linnaeus, 1758)	7	1	2		2	2	
	Chlaenius (*Trichochlaenius*) *chrysocephalus* (P. Rossi, 1790)	10	1		8	1		
	Chlaenius velutinus (Duftschmid, 1812)	85		1	16	16	21	31
	Cymindis suturalis pseudosuturalis (Bedel, 1906)	3	1		1			1
	Cymindis setifeensis brevitarsis (Normand, 1933)	7	7					
	Lebia (*Lebia*) *trimaculata* (Villers, 1789)	2	1	1				
	Microlestes corticalis (L. Dufour, 1820)	35		3	6	12	12	2
	Microlestes sp.1	32	11	6	7	8		
	Microlestes sp.2	1	1					
	Philorhizus sp.	2	2					
	Syntomus fuscomaculatus (Motschulsky, 1844)	87	53	9	8	3	11	3
	Graphipterus exclamationis exclamationis (Fabricius, 1792)	1	1					
	Orthomus sp.	10	1	6		3		
	Poecilus (*Carenostylus*) *purpurascens* purpurascens (Dejean, 1828)	103		2	18	22	60	1
	Poecilus sp.	80	2	2	12	21	35	8
	Poecilus (*Ancholeus*) *nitidus* (Dejean, 1828)	7					7	
	Zuphium olens olens (P. Rossi, 1790)	5		2	3			

Table 1/2. List of ground beetles collected in Dayet El Ferd, Algeria.

The species richness index (R') for each site ranged between 3.18 and 5.91, and the average species richness index was in the order of Pt.1 > Pt.2 > Pt.3 > Pt.5 > Pt.4 > Pt.6, respectively.

The species evenness index (E') for each site was calculated between 0.36 to 0.51, and the average species evenness index was in the order of Pt. 2 > Pt.1 > Pt.3 > Pt.5 > Pt.4 > Pt.6, respectively (Table 2).

Between most plots, species similarity (Jaccard index) does not exceed 50% (Table 3). According to the results of cluster analysis, the Carabid faunas between plot 3 and plot 4 and between plot 5 and plot 6 are quite similar and separated from those of the plots 1 and 2 (Fig. 4).

DISCUSSION

There are few published references on the diversity of terrestrial beetles specific to temporary ponds (Lott, 2001). However, recent work in the salt marsh of Rechgoun, Algeria, has revealed some interesting patterns. Wetlands, temporary submersions, are particularly attractive to terrestrial beetles. Thus, Soldati (2000) lists 32 species in the marshes of Romelaëre (Pas-de-Calais, France), dominated mainly by Carabidae and Staphylinidae. The Carabidae family is best known taxonomically and ecologically, and includes usually good bio-indicators (Lövei & Sunderland, 1996). Jacquemin (2002) cites 19 species in salt marshes of Lorraine (France). 60 species were identified in the marsh of Frocourt (France) during the months of June and July 2005 by Borges & Meriguet (2005) against 157 species identified in the mouth of the Moulouya in Morocco at numerous fragmentary studies by Chavanon and Mahboub (1998).

Boukli-Hacene & Hassaine (2009) report 20 terrestrial taxa of Carabidae and only two water beetles in a salt marsh Sebkha of Oran (Algeria) during a preliminary study conducted between January and June 2004. A study of Coleopteran communities was conducted between October 2009 and September 2010 in the salt marsh at the mouth of the Tafna River (Northwest of Algeria), and 3833 specimens belonging to 140 species were inventoried with 40 species of Carabidae. It was noted that

plot	DI	H'	R'	E'
Pt. 1	0.54	2.4	5.91	0.47
Pt. 2	0.48	2.53	5.49	0.51
Pt. 3	0.54	2.27	4.68	0.45
Pt. 4	0.7	1.82	3.98	0.37
Pt. 5	0.6	2.08	4.05	0.43
Pt. 6	0.74	1.56	3.18	0.36

Table 2. Various diversity indices calculated for each surveyed plot. DI: Dominance index, H': Diversity index, R': Species richness index, E': Evenness index.

	P1	P2	P3	P4	P5	P6
P1	1.000					
P2	0.3695	1.000				
P3	0.4318	0.525	1.000			
P4	0.3555	0.5263	0.6388	1.000		
P5	0.3333	0.4615	0.5675	0.5277	1.000	
P6	0.2926	0.3888	0.4571	0.4545	0.5161	1.000

Table 3. Similarity matrix at plot-scale (Jaccard Index; black: > 50%; striped: 40-49%; grey: < 40%).

the large majority of species is represented by a small number of individuals; this same observations were made by Menet (1996), Soldati (2000), Boukli-Hacene et al. (2012), and on inventories of terrestrial beetles. The result of this research indicated that there is a diverse fauna of Carabidae in the wetland of Dayet El Ferd.

Carabid beetles are increasingly used as taxonomic study group in biodiversity and as bio-indicators in monitoring or site assessment studies for nature conservation purposes (Luff et al., 1989, 1992; Luff, 1990; Erwin, 1991; Desender et al., 1991, 1992; Loreau, 1994; Heijerman & Turin, 1995). The very high number of species, estimated some ten years ago at about 40000 described species (Atamehr, 2013), as well as the well-studied pronounced habitat or even microhabitat preference of many of these (Thiele, 1977) are important reasons for the increasing interest they get. Furthermore, the majority of carabid beetles (at least in steppe areas) are relatively easily collected in a more or less standardized way by means of pitfall trapping. Nevertheless, much discussion remains on the necessary methodologies in sampling (details of techniques, intensity and duration of trapping) as well as in diversity assessment (Southwood, 1978). One problem related to the study of carabid diversity is to assess which part of the species caught at a certain site actually belongs to the local fauna and has reproducing populations (Finch, 2005). Related to this problem is the question of observed turnover in species richness from year to year on a given site.

A short review of the literature shows that most authors either deny the problem (i.e. assume that all species caught on a site belong to the local fauna and/or that species caught in low numbers have a small local population) or use a more or less arbitrary limit between so-called local species and accidentally caught species. Surprisingly, there have been few attempts to discriminate between the two by means of long term population studies or by investigating additional aspects of the biology (dispersal power and reproductive characteristics) and ecology (occurrence in surrounding or nearby other habitats) (Niemels & Spence, 1994; Konjev & Desender, 1996). Several species were frequent, thus they can be regarded as regular inhabitants of steppe areas. It has been hypothesised that heterogeneous landscapes have a higher regional diversity, because meta-community dynamics lead to a faster recolonisation of vacant niches (Duelli, 1997). Apart from the density of temporary wetlands, the studied landscape features did not have an impact on regional diversity, which contradicts the mosaic concept. However, communities of wetland are distinct from those of other habitats, primarily because the sites are flooded. The diversity of wetland and habitat-specific species was strongly dependent on the mean duration of flooding. There might be two

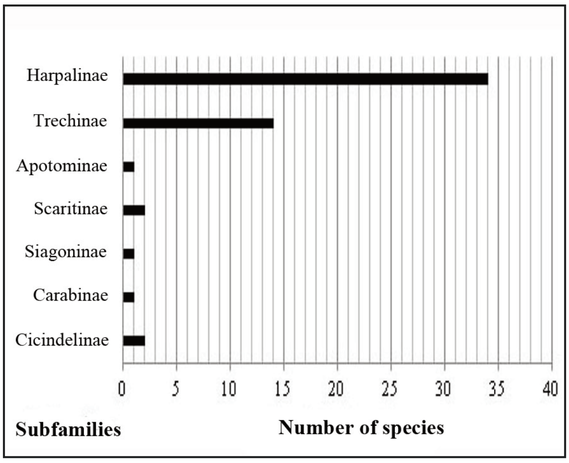

Figure 1. Distribution of the species numbers with respect to subfamilies.

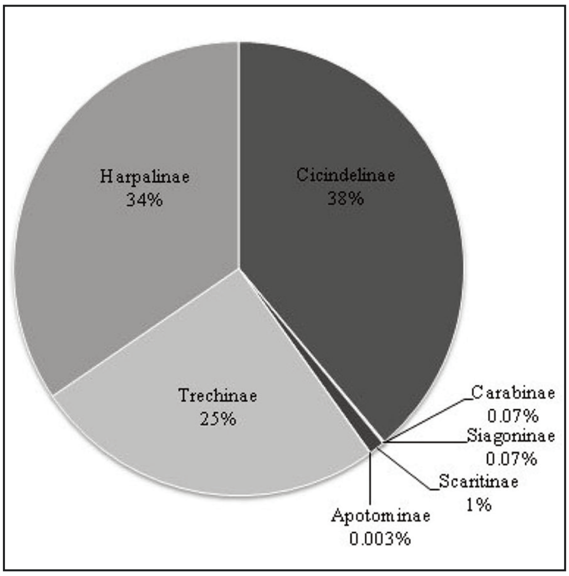

Figure 2. Percentage of the inviduals for each subfamily.

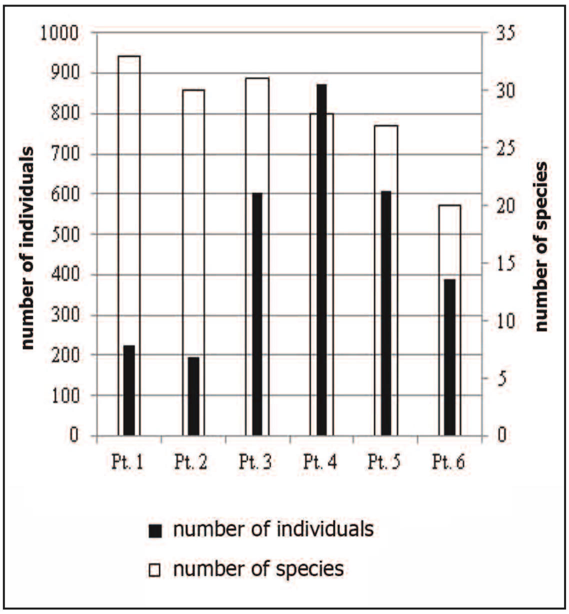

Figure 3. Number of species and individuals in each surveyed plot.

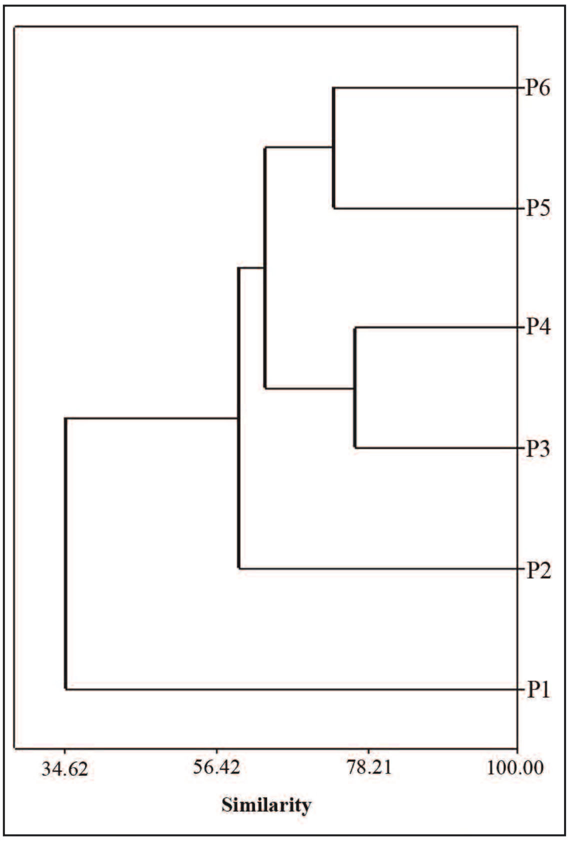

Figure 4. Cluster analysis of collected ground beetles in each surveyed plot.

reasons: (i) a high attractiveness of landscapes with a high mean duration of flooding for potential immigrants and (ii) a generally high number of available niches for hygrophilous species in these landscapes (Duelli, 1997).

Generally, the high diversity of ground-beetle community was found in plots 1 and 2, where the environment was well preserved and never flooded. These conditions created a great number of micro-habitats that were exploited by a higher number of species, in contrast, the plot 6 presented the lowest values of diversity. In accordance with the evenness values, Dominance index was lowest at plot 1 and 2, whereas in plot 6, it reached its highest value (0.74). In the latter, *Calomera lunulata* was definitively a dominant species and prevailed over the others.

In this wetland, although small, the ecological challenge is very important given its international importance (Ramsar wetland) but also because it ensures a hydrological function (sponge area ensuring regulation floods) and biological functions (e.g. high diversity of coleopteran fauna). The high biodiversity and remarkable presence of species are arguments in favor of protection of this area, highly endangered. Therefore, these protected areas are major sites for the development of the carabid fauna and deserve protection. The more effort must be made to get more information about the spatio-temporal distribution of carabid species in similar ecosystems to help to identify and locate endemic species, rare or endangered species for conservation.

Our perspective is to expand the research to an additional number of similar habitats in northern Algeria.

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