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Contribution to the inventory of forest soils beetles in El-Kala National Park (Northeast Algeria)

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Abstract

This study is part of the forest ecosystem research program initiated since 2005 by the laboratory Ecology of Terrestrial and Aquatics Systems Laboratory (Eco STAq). The objective of this study is to characterize the composition and organisation of the *edaphic fauna (beetles)* which is necessary for the proper functioning of these ecosystems. For that purpose, an entomological inventory has been performed under five forest groupings of El-Kala National Park (EKNP) in Northeast of Algeria. where one hundred and eight (108) species of insects have been captured, using two trapping methods; namely, Barber traps and cover plates. These taxa have been classified into 10 families (Brachyceridae, Carabidae, Curculionidae, Dynastinae, Geotrupidae, Pachypodidae, Scarabaeidae, Staphylinidae, Tenebrionidae, and Trogidae) and divided into four (04) groups, following their diet (coprophage, phytophage, predator and decomposer). The beetle population in the cork oak forest consists of 34 species, belonging to 09 families. The majority of insects are represented by the Carabidae (32.41%), followed by Scarabaeidae (19.44%); Tenebrionidae (15.74%); Geotropidae (10.19%), Curculionidae (5.56%), Trogidae and Dynastidae (4.63% each); Staphylinidae (3.70%); Pachypodidae (2.78%) and finally Brachyceridae (0.92%). The calculation of the specific diversity varies between 2.85 and 3.41 bits reflecting a significant structuring of the environment.

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Introduction

Natural ecosystems are diverse; they are mainly presented by forests, savannas, steppes, seas, rivers also lakes, marshes and ponds; these environments are highly valuable for the continuity of human, animal and plant life. El-Kala is located in the Northeast of Algeria, which is the most watered region of the country; with an average annual rainfall of 723 mm (Climate-data, 2017).

This wetlands area in one of the most important areas in North Africa and Mediterranean basin, by its position on migration routes and its high biodiversity (Ramdani, 2007).

The El-Kala National Park is located in the province of El-Tarf, in the extreme Northeast of the country; covering an area of 76,438 ha (Rouag and Benyacoub, 2006). Delimited by the Mediterranean Sea to the North, the Algerian-Tunisian borders to the East, the plains of Annaba to the West, and the mountains of Medjerda to the South.

It consists of a mountain massif, plains, lakes and a very diverse coast; separated locally from the plain by a dune cord with low vegetation.

From north to south, we find a coastline of 40 km long, maquis and forests of pines, eucalyptus, Cork oak (*Quercus suber* L.) and Algerian oak or Mirbeck's oak (*Quercus canariensis* Willd.); with an altitude ranging from 700 m to 1,202 m (Toubal, 1986).

El-Kala is characterized by a warm Mediterranean climate, where the lowest temperatures are recorded in winter on the mountain of Ghorra. The cold period extends from January to February, while July to August is the hot period. The rainfall is highly governed by the altitude and the most watered points are the summital areas, such as the mountain of Ghorra with an average pluviometry of 900 mm / year (de Belair, 1990). Many species of insects live in these forests; they are highly diverse with a vital role for the ecosystems (Dajoz, 2017).

This Coleopterology cal study aims to answer two main questions: do beetles differ from one station to another and do they vary according the soil type? Beetles in Algeria have been subject to many studies such as Benia (2010), Mecheri *et al.* (2014) and Dass *et al.* (2016). However, few of these studies have been interested in the comparison of the soil beetles communities in different forest ecosystems. Our study aims to filling this insufficiency by providing the first database on the *edaphic fauna (beetles) of five ecological units of EKNP. Its objective is therefore to assess* the diversity of this fauna and to edentify the abiotic parameters structuring these stands.

Material and methods

Sites selection and description

Large area in EKNP has been subjected to the exhaustive inventory; nonetheless five (05) sampling sites have been defined, for the characterization of settlements organization (Table 1), given the large surface of the studied area and its physiographic diversity (Rouag and Benyacoub, 2006) . The selection has been done following single criterion, related to the vegetal formation in closed environments (Cork oak, Kermes oak, Algerian oak, pine and alder) (Fig. 1).

Cork oak forest of Fed Allaguia (FED): This ecosystem corresponds to the forest in the strict sens, with wooded, bushy and herbaceous strata; the tree stratum is composed of Cork oak (*Quercus suber* L.), with trees reaching 8 m height and average recovery of about 60%; the undergrowth is high and dense, with the presence of *Phillyrea angustifolia* L., *Pistacia lentiscus* L., *Rubus ulmifolius* Schott , *Crataegus monogyna* Jacq. and *Erica arborea* L. (Rouag and Benyacoub, 2006).

Kermes oak forest of Tonga watershed (TGAWS1): Kermes oak, or garrigue oak, (*Quercus coccifera* L.) is associated with *Juniperus oxycedrus* L., *Pistacia lentiscus* L. and other secondary tree species; it forms, however, a very extensive massif on the dunes, between Annaba and El-Kala (Benyacoub, 1993).

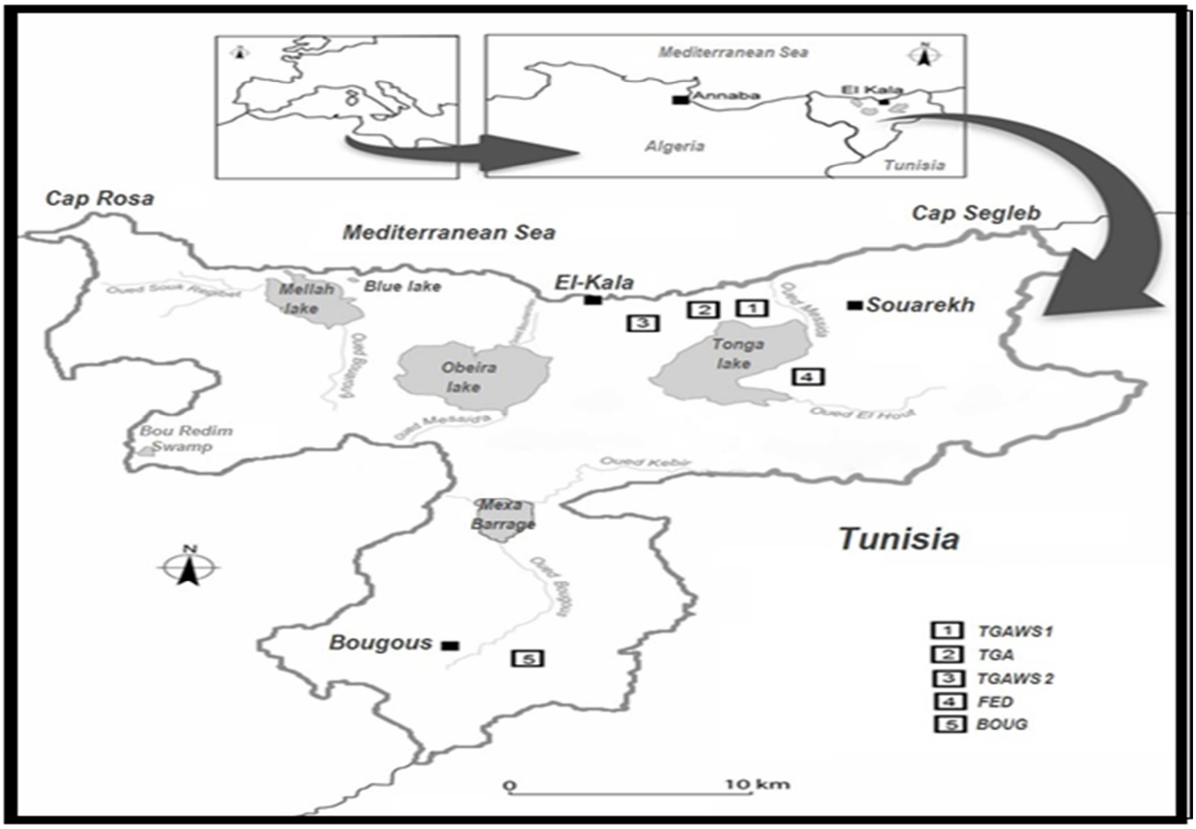

Fig. 1. Map showing geographic location of EKNP and study sites (Benyacoub, 1993; modified).

Algerian oak *forest* of Bougous (BOUG):The Algerian oakor Mirbeck's oak (*Quercus canariensis* Willd.) trees have an average height of 18 m and can reach 30 m; their high density gives a recovery of about 70%;as a result, the undergrowth is poorly developed, with the presence of *Cytisus triflorus* Lam, *Rubus ulmifolius* Schott, *Crataegus monogyna* Jacq. and *Lorus nobilis* L. (Rouag and Benyacoub, 2006).

Maritme Pine forest of Tonga watershed (TGAWS2): Corte pines or Mesogean pines (*Pinus pinaster* Aiton, *Pinus maritima* Miller, *Pinus mesogeensis* Fieschi & Gaussen) reach 10 m high and average recovery of 60%. The undergrowth is composed of *Myrtus communis* L., *Pistacia lentiscus* L. and *Halimium halimifolium* (L.) Willk. (Rouag and Benyacoub, 2006).

Alder of the Tonga Lake (TGAL):Glutinous alders (*Alnus glutinosa* (L.) Gaertn.) are associated with the female fern (*Athyrium filix-femina* (L.) Roth); royal osmunda (*Osmunda regalis*), also called royal fern or flowering fern (*Osmunda regalis* L.); eagle fern, or great fern, (*Pteridium aquilinum* (L.) Kuhn); perforated St. John's wort (*Hypericum perforatum* L.) and holly (*Ilex aquifolium* L.) (Meddour and Laribi, 1999).

Physico-chemical parameters of the soil

The physico-chemical analyzes have been performed at the Laboratory of Soil and Sustainable Development of BADJI Mokhtar-Annaba University. Five (05) parameters have been evaluted: the pH (using a portable pH meter of WTW type); the conductivity (using conductivity meter WTWLF538), expressed in µS/m; the hygroscopic humidity, using the method of mass loss, after drying at 105°C; the organic matter, determined by loss on ignition Pepin and (Pepin *et al.*,1996); and the granulometry, which is one of the traditional methods used in textural analysis (Robinson pipette and densimetry).

Entomological sampling

To maximize the insects collection, the capture has been carried out using Barber traps, shelter plates and direct capture. Sixty (60) Barber traps were buried to the ground; slightly formulated water was poured into the pots to retain the insects in the traps; the pots consist of polystyrene cups (20 cl) buried to the upper edge to create a well to retain walking insects, then a plate (stone or bark), was placed one centimeter above the upper edge of the trap for the protection (Colas, 1950). These traps are very effective for the Carabidae and Silphidae; they are unfortunately easily dislocated and destroyed by ungulate, wild and domestic mammals (Colas, 1950).

Shelter plates, of agglomerated wood 60 x 40 cm and 22 mm thick, have been placed on the ground, the plates absorb water and conserve humidity for a long time during drought period to keep the soil fauna (Coleoptera Carabidae, Arachnidae and Myriapoda); these plates are non-destructive and can be left in place for long periods;however, they are easily identifiable and sometimes subject to vandalism acts (Colas, 1950).

The third sampling method is the direct capture, requiring the presence of the operator on site at the time of capture; this method provides information on the specific composition and richness (Clavel, 2011).
The traps have been checked every ten (10) days from March 2013 to February 2014, where 33 surveys have been done in total.

The scientific value of an insect specimen is often related to the way in which it is prepared and preserved (Perron, 1994). The captured specimens have been conserved in 70% alcohol solution for ulterior identification. Some species have been identified at the Laboratory of Badji Mokhtar-Annaba University and the Laboratory of Biodiversity, using the determination keys such as those of Coleoptera (Perrier and Delphy, 1932). Others have been identified at the Engineering School of Purpan-Toulouse (France) in partnership with the Conservatory of Natural Spaces of Midi-Pyrenees (CNS-MP).

Results analysis

The results obtained have been treated using Excel software; they were first subjected to the sampling quality test, then exploited by the calculation of ecological parameters, which allows deducing the orientations and suggestions for the management and development of different vegetal formations in EKNP. According to Barbault (1995). The measurements of taxonomic richness, diversity, and equitability are useful for the settlement characterization. The global comparison of settlement is different from the study of the same settlement at different times.

A Canonical Correspondence Analysis has been carried out using CANOCO (Canonical Community Ordination, version 4.0) software; taking into account the biotic (10 zoological families of insects) and the abiotic data (5 physico-chemical parameters) obtained during the sampling.

Sampling quality : The sampling quality is the rapport between the number of one-time recorded species and the total number of records (Blondel, 1975).

$$\text{Sampling quality } = \frac{a}{N}$$

a: number of one-time recorded species throughout the observation period.

N: number of records.
The lower the rapport a/N, the higher the sampling quality (Blondel, 1975; Ramade, 1984).

Ecological Indices:The indices based on the information theory suppose that the diversity in the ecosystem can be measured as an information contained in a message or code. The Shannon-Weaver Index (1949) is the simplest and the most used in its category.

This index is calculated as follows:

$$H' = -\sum_{i=1}^{S} pi \; \log_2 pi$$

Among the ecological structure indices, only Shannon-Weaver diversity (1949) and equitability indices are used. The calculation of this index allows evaluating the faunal diversity of a given environment and to compare the fauna from different environments, even when the number of individuals is different (Dajoz, 2006).

The Shannon-Weaver (1949) and equidistribution indices are expressed by the following formulas:

With:

H': Shannon biodiversity index (expressed in bits); the higher the value of this index, the greater the diversity.

i: a species of the study environment,

pi = proportion of a species *i* relative to the total number of species (S) in the study environment (or specific richness of the environment), which is calculated as follows: *p (i) = ni / N*

Where *ni* is the number of individuals for species *i* and *N* is the total number (individuals of all species).

The Shannon-Weaver Index allows measuring the specific diversity (Spelleberg and Fedor, 2003).

Which is one of the biodiversity components, in case of native species in their natural repartition area.

$$H'_{max} = \log_2 S$$

H'_{max}: maximum diversity (expressed in bits),

S: number of species.

The relative abundance structures of species determine the equitability or the dominance component of the diversity. Given a zoocenosis composed of (*S*) species, the diversity is higher if all the species (*S*) are well represented (high equitability, low dominance) than if a small number of species, called (*T*), are very common and that the rest (*S*-*T*) are present but rare (low equitability, high dominance). Equitability assessment (Peet, 1974) is useful for detecting the changes in the structure of a community and has sometimes proved effective for detecting the changes of anthropogenic origin. The measure of equitability (*E*) corresponding to the Shannon-Weaver index (Shannon and Weaver, 1949) is done according to the following formula:

$$E = \frac{H'}{H'_{max}}$$

E: equitability,

H ': Shannon-Weaver index (in bits),

H'_{max}: maximum diversity (in bits).

Trophic composition

The beetles species identified have been classified according to the diet of adult or larval forms (if the adult is not feeding), to determine the role of each species.

Results

Physico-chemical analyzes

According to the soil pH range of Buckman and Brady, the pH of the soils analyzed varies between 4.33 and 5.92; which is indicator of moderate to quite high acidity (Table 2) except for the second depth in Bougous site, where a low acidity has been recorded (pH = 6.01) unlike other depths.

Table 1. List of studied sites.

Sites	Codes	Forest groupings	Towns	Altitudes (m)	Geographical coordinates (GPS)
Tonga watershed1	TGAWS1	Maritime Pine	El-Kala	160	36°53'18.29" 8°28'44.76"E
Tonga watershed2	BVTGA1	Kermes Oak	El-Kala	160	36°52'53.89"N 8°29'56.80"E
Tonga lake	TGAL	Glutinous Alder	El-Kala	150	36°52'42.28"N 8°29'53.45"E
Fed Allaguia	FED	Cork oak	El-Kala	---	36°51'37.34"N 8°28'32.59"E
Bougous	BOUG	Algerian oak	Bougous	183	36°39'02.44"N 8°21'54.55"E

The electrical conductivity (EC) is variable (Table 2); but does not exceed 4.86 S·m⁻¹ for the majority of soil depths studied; except the three surface horizons (0-18 cm) where EC> 5 S·m⁻¹ has been registered; EC = 2.65 S·m⁻¹ has also been recorded in the 3rd soil profile of the cork oak forest.

Table 2. Edaphic parameters over five sites.

Sites	Profils	Clays (%)	Coarse silts(%)	Fine silts (%)	Sands (%)	pH	EC(S·m⁻¹)	H (%)	OM (%)
Fed Allaguia	1	20.80	30.40	26.32	22.48	5.03	3.13	4.93	07.64
	2	31.80	31.20	29.92	20.08	4.76	2.79	5.06	05.36
	3	20.00	28.00	25.57	26.43	4.41	2.65	5.06	05.55
Tonga watershed2	1	10.80	03.20	01.50	84.95	5.11	3.58	0.53	01.41
	2	11.20	01.60	00.66	86.54	5.21	3.44	0.33	00.66
	3	10.40	02.00	01.30	86.15	4.38	3.34	0.60	00.26
Bougous	1	03.20	39.60	06.45	50.75	5.20	3.34	2.20	03.95
	2	04.00	39.20	07.01	49.79	6.01	3.41	2.00	05.37
	3	02.00	35.60	11.92	50.48	5.86	3.24	1.33	02.50
Tonga watershed1	1	08.00	08.00	00.40	83.60	4.86	4.86	0.33	01.26
	2	08.00	06.00	01.90	84.10	4.64	4.17	0.60	00.81
	3	08.00	04.00	01.30	86.70	4.33	5.40	0.46	00.60
Tonga lake	1	15.60	14.40	20.83	49.17	4.79	3.01	0.93	23.44
	2	20.00	12.00	18.58	49.42	4.72	2.87	0.66	18.18
	3	27.60	10.00	09.23	53.17	4.75	2.82	0.66	14.68

The organic matter (OM) is also variable (Table 2);the soil of the Tonga alder is highly rich in OM with a rate of 23.44% for the surface horizon. However ,the pine forest and the kermes oak of the TGAWS, revealed a low OM content with a maximum rate of 3.95%; also the OM rate in the cork oak forest varies between 5.36 and 7.64%, which indicates a variation in the organic matter contents; the OM rate is high in the profile 1 and decreases in the profiles 2 and 3.

The determination of hygroscopic humidity (H) revealed that the soils are very dry and retain only a small proportion of water, ranging from 0.33 to 5.06% for all the profiles of the studied stations (Table 2).

The granulometric analyzes have been interpreted using the USDA textural triangle:

The cork oak floor is silty. The soils of the kermes oak and the pine forest are sandy-loamy. The soil of the Algerian oak is sandy-loamy.

The soil of the alder is silty up to 30 cm and sandy-loamy-loamy, more deeply.

Influence of edaphic parameters on the distribution of Coleoptera families

Redundancy Analysis (RDA) has been realized between the edaphic parameters (texture, pH, electrical conductivity, hygroscopic humidity and organic matter) and the distribution of the Coleoptera families: Brachyceridae, Carabidae, Curculionidae, Dynastinae, Geotrupidae, Pachypodidae, Scarabaeidae, Staphylinidae, Tenebrionidae, and Trogidae (Fig. 2).

The Redundancy Analysis (RDA) was developed by Van den Wollenberg (1977) as alternative to the Canonical Correlation Analysis (CCorA); this analysis makes it possible to study the relationship between two tables of Y and X variables; it is an asymmetrical method; while, the CCorA is symmetrical.

On the axis I, we note a strong positive association between the Coleoptera and the edaphic parameters (texture, electrical conductivity and pH); whereas, on the axis II, we notice a positive correlation between the hygroscopic moisture and the organic matter.

Table 3. Specific composition of beetles caught in the cork oak forest.

Families	Species
Carabidae	*Amara familiaris* Duftschmid
	Carabus latus Dejean
	Carabus pyrenaeus Audinet-Serville
	Dixus interruptus Fabricius
	Dixus obscurus Dejean
	Harpalus dimidiatus P. Rossi
	Leistus fulvibarbis Dejean
	Oreonebria angusticollis Bonelli
	Platyderus depressus Audinet-Serville
	Poecilus cupreus Linnaeus
	Scarites planus Bonelli
	Scarites terricola Bonelli
Curculionidae	*Anisorhynchus barbatus* Rossi
	Brachycerus algirus Olivier
Dynastidae	*Heterogomphus coriaceus* Prell
Geotrupidae	*Baraudia geminata* Gené
	Sericotrupes niger Marsham
	Thorectes brullei africanus Baraud
	Thorectes marginatus Poiret
Pachypodidae	*Pachypus caesus* Erichson
Scarabaeidae	*Anomiopsoides cavifrons* Burmeister
	Euonthophagus amyntas Olivier
	Heliocopris antenor Olivier
	Scarabaeus sacer Linnaeus
Staphylinidae	*Ocypus brunnipes* Fabricius
	Ocypus olens Müller
Tenebrionidae	*Allophylax picipes* Olivier
	Alphasidasolieri Rambur
	Lagria hirta Linnaeus
	Opratum sp
	Pimelia cribripennis Solier
Trogidae	*Omorgus obesus* Scholtz
	Trox scaber Linnaeus
	Trox perlatus Geoffroy

Sampling quality

The value of the sampling quality is 0.41 for the cork oak forest; 0.26 for the kermes oak *forest*; 0.32 for the Algerian oak forest, 0.29 for the pine forest and 0.17 for the alder. The values vary between 0.17 and 0.41 in the five studied stations, the values obtained are less than 1 and can be considered as good; therefore, sampling is sufficient.

Composition of beetles settlements

The inventory of beetles settlements has been done in five (5) different forest groupings (Cork oak, Kermes oak, Algerian oak, Maritime pine and alder); it concerned one hundred and eight (108) species of beetles in total, belonging to ten (10) families. The Fig. (3) resumes the relative abundance of different families of Coleoptera in the stations.

Table4. Specific composition of beetles caught in the Algerian oak forest.

Families	Species
Carabidae	*Clivina fossor* Linnaeus
	Harpalus dimidiatus P. Rossi
	*Leistus fulvibarbis*Dejean
	Ophunus laticolis Mannerheim
	Paranchus albipes Fabricius
	Percus lineatus Solier
	Poecilus cupreus Linnaeus
	Scarites terricola Bonelli
Curculionidae	*Choerorhinus squalidus* Fairmaire
	Dichromacalles dromedarius Boheman
	Otiorhynchus salicicola Heyden
Geotrupidae	*Anoplotrupes hornii* Blanchard
	Anoplotrupes stercorosus Scriba
	Typhaeus hostius Gene
	Typhaeus typhoeus Linnaeus
	Trypocopris vernalis Linnaeus
Pachypodidae	*Pachypus melonii* Sparacio
	Pachypus siculus Castelnau
Scarabaeidae	*Bubasbubalus* Olivier
	Catharsius molossus Linnaeus
	Sisyphus schaefferi Linnaeus
Tenebrionidae	*Asida dejeani* Solier
	Diaperis boleti Linnaeus
	Tentyria excavata Solier
Trogidae	*Trox clathratus* Reiche
	Trox sabulosus Linnaeus

The majority of insects are represented by the Carabidae (32.41%), followed by Scarabaeidae (19.44%); Tenebrionidae (15.74%); Geotropidae (10.19%), Curculionidae (5.56%), Trogidae and Dynastidae (4.63% each); Staphylinidae (3.70%); Pachypodidae (2.78%) and finally Brachyceridae (0.92%).

Table 5. Specific composition of beetles caught in the maritime pine forest.

Families	Species
Brachyceridae	*Brachycerus algirus* Olivier
Carabidae	*Abax beckenhauptii* Duftschmid
	Abax parallelepipedus Piller & Mitterpacher
	Carabus laevigatus Scriba
	Dyschiriodes macroderus Chaudoir
	Licinus depressus Paykull
	Macro thorax morbillosus Fabricius
	Molops piceus Panzer
	Nebria brevicollis Fabricius
	Pristonychusalgerinus Gory
	Scarites buparius J.R. Forster
Curculionidae	*Sphenophorus abbreviatus* Fabricius
Dynastidae	*Callicnemis latreillei* Castelnau

	Heteroligus meles Billberg
	Phyllognathus excavatus Forster
Geotrupidae	*Bolbaffer bremeri* Nikolajev
Scarabaeidae	*Copris hispanus* Linnaeus
	Copris lunaris Linnaeus
	Heteronitistridens Castelnau
	Kheper subaeneus Harold
	Kheper venerabilis Harold
	Scarabaeus catenatus Gerstaecker
	Scarabaeus cristatus Fabricius
	Scarabaeus laticollis Linnaeus
	Sulcophanaeus faunus Fabricius
Staphylinidae	*Coprophilus striatulus* Fabricius
	Megarthrus depressus Paykull
Tenebrionidae	*Asida ochsi* Ardoin
	Belopus procerus Mulsant
	Blaps gigas Linnaeus
	Blaps lusitanica Herbst
	Erodiusnitidicollis Calwer
	Pachychila germari Solier
	Tentyria excavata Solier

The beetle population in the cork oak forest consists of 34 species, belonging to 09 families (Table 3); characterized by the dominance of the Carabidae (35.29%); mainly represented by: *Harpalus dimidiatus* P. Rossi, *Carabus latus* Dejean and *Carabus pyrenaeus* Audinet-Serville; followed by the Tenebrionidae (14.71%), the Scarabaeidae and the Geotrupidae (11.77% each); Trogidae (8.82%) and finally the Pachpodidae, Dynastidae, Curculionidae, Staphylinidae with almost the same number of species (Fig. 4).

In the Algerian oak forest, we noted 26 species of insects belonging to 07 families (Table 4), where the family Carabidae is the most presented by 08 species, followed by Geotrupidae by 05 species (Fig. 5).

In the maritime pine forest, we identified 34 species; belonging to 08 families (Table 5);three (03) families are dominant: Carabidae by 10 species, Scarabaeidae by 10 species and Tenebrionidae by 07 species (Fig. 6).

In the kermes oak, we captured 31 species; belonging to 05 families (Table 6); dominated by the Carabidae, the Scarabaeidae and the Tenebrionidae (Fig. 7); some species of beetles are common between the coccifera and the pine forest.

Table 6. Specific composition of beetles caught in the kermes oak forest.

Families	Species
Carabidae	*Abax beckenhauptii* Duftschmid
	Abax parallelepipedus Piller & Mitterpache
	Acinopus laevigatus Menetries
	Darodilia longula Tschitscherine

	Dyschiriodes macroderus Chaudoir
	Licinus depressus Paykull
	Macro thorax morbillosus Fabricius
	Molops piceus Panzer
	Nebria brevicollis Fabricius
	Scarites buparius J.R. Forster
Dynastidae	*Bothynus cribrarius* Fairmaire
	Phyllognathus excavatus Forster
Scarabaeidae	*Copris lunaris* Linnaeus
	Heteronitis tridens Castelnau
	Euonthophagus amyntas Olivier
	Kheper subaeneus Harold
	Kheper venerabilis Harold
	Oogenius virens Solier
	Pachylomera femoralis Kirby
	Scarabaeus catenatus Gerstaecker
	Scarabaeus cristatus Fabricius
	Scarabaeus laticollis Linnaeus
Staphylinidae	*Coprophilus striatulus* Fabricius
	Megarthrus depressus Paykull
Tenebrionidae	*Adesmia dilatata* Klug
	Asida ochsi Ardoin
	Blaps gigas Linnaeus
	Centorus procerus Mulsant
	Erodiusnitidicollis Calwer
	Pachychila germari Solier
	Pterolasia squalida Solier

In alder, we counted only 18 insect species belonging to 03 families (Table 7). Carabidae (50%), Scarabaeidae (27.78%) and Geotrupidae 22.22% (Fig. 8).The families and the species obtained in this study are presented in the Table 8. Among 10 families and 108 species of beetles, the family Carabidae is represented by 35 species; followed by the Scarabaeidae, the Tenebrionidae and the Geotrupidae with 21.17 and 11 species respectively.

Table 7. Specific composition of beetles caught in the alder forest.

Families	Species
Carabidae	*Agonum fuliginosus* Panzer
	Carabus fasciolatus Ross.
	Carabus scheidleri Panzer
	Chlaenius festivus Panzer
	Chlaenius velutinus Duftschmid
	Epomis circumscriptus Duftschmid
	Macrothorax morbillosus Fabricius

	Nebria brevicollis Fabricius
	Nebria picicornis Fabricius
Geotrupidae	*Geotrupes puncticollis* Malinowsky
	Sericotrupes niger Marsham
	Trypocopris pyrenaeus Charpentier
Scarabaeidae	*Gymnopleurus flagellatus* Fabricius
	Helictopleurus marsyas Olivier
	Onthophagus furcatus Fabricius
	Onthophagus taurus Schreber
	Scarabaeus sacer Linnaeus
Staphylinidae	*Megarthrus depressus* Paykull

The number of beetles species ranges from 3 to 6 for the the Curculionidae, the Dynastidae, the Pachypodidae, the Staphylinidae and the Trogidae; however the family Brachyceridae is represented by a single species (*Brachycerus algirus* Olivier).

Table8. Total species list of beetles caught in the studied sites.

Families	Species
Brachyceridae	*Brachycerus algirus* Olivier
Carabidé	*Abax beckenhauptii* Duftschmid
	Abax parallelepipedus Piller & Mitterpacher
	Acinopus laevigatus Menetries
	Agonum fuliginosus Panzer
	Amara familiaris Duftschmid
	Carabus fasciolatus Ross.
	Carabus laevigatus Scriba
	Carabus latus Dejean
	Carabus pyrenaeus Audinet-Serville
	Carabus scheidleri Panzer
	Chlaenius festivus Panzer
	Chlaeniusvelutinus Duftschmid
	Clivina fossor Linnaeus
	Darodilia longula Tschitscherine
	Dixus interruptus Fabricius
	Dixus obscurus Dejean
	Dyschiriodes macroderus Chaudoir
	Epomis circumscriptus Duftschmid
	Harpalus dimidiatus P. Rossi
	Leistus fulvibarbis Dejean
	Licinus depressus Paykull
	Macro thorax morbillosus Fabricius
	Molops piceus Panzer
	Nebria brevicollis Fabricius
	Nebria picicornis Fabricius
	Ophunus laticolis Mannerheim
	Oreonebria angusticollis Bonelli
	Paranchus albipes Fabricius
	Percus lineatus Solier
	Platyderus depressus Audinet-Serville
	Poecilus cupreus Linnaeus

	Pristonychusalgerinus Gory
	Scarites buparius J.R. Forster
	Scarites planus Bonelli
	Scarites terricola Bonelli
Curculionidae	*Anisorhynchus barbatus*Rossi
	Brachycerus algirus Olivier
	Choerorhinus squalidus Fairmaire
	Dichromacalles dromedarius Boheman
	Otiorhynchus salicicola Heyden
	Sphenophorus abbreviatus Fabricius
Dynastidae	*Callicnemis latreillei* Castelnau
	Bothynus cribrarius Fairmaire
	Heteroligus meles Billberg
	Heterogomphus coriaceus Prell
	Phyllognathus excavatus Forster
Geotrupidae	*Anoplotrupes hornii* Blanchard
	Anoplotrupes stercorosus Scriba
	Baraudia geminata Gené
	Bolbaffer bremeri Nikolajev
	Geotrupes puncticollis Malinowsky
	Sericotrupes niger Marsham
	Thorectes brullei africanus Baraud
	Thorectes marginatus Poiret
	Trypocopris pyrenaeus Charpentier
	Typhaeus hiostius Gene
	Typhaeus typhoeus Linnaeus
Pachypodidae	*Pachypus caesus* Erichson
	Pachypus melonii Sparacio
	Pachypus siculus Castelnau
Scarabaeidae	*Anomiopsoides cavifrons* Burmeister
	Bubas bubalus Olivier
	Catharsius molossus Linnaeus
	Copris hispanus Linnaeus
	Copris lunaris Linnaeus
	Euonthophagus amyntas Olivier
	Gymnopleurus flagellatus Fabricius
	Heliocopris antenor Olivier
	Heteronitis tridens Castelnau
	Kheper subaeneus Harold
	Kheper venerabilis Harold
	Onthophagus furcatus Fabricius
	Onthophagus taurus Schreber
	Oogenius virens Solier
	Pachylomera femoralis Kirby
	Scarabaeus catenatus Gerstaecker
	Scarabaeus cristatus Fabricius
	Scarabaeus laticollis Linnaeus
	Scarabaeus sacer Linnaeus
	Sisyphus schaefferi Linnaeus
	Sulcophanaeus faunus Fabricius
Staphylinidae	*Coprophilus striatulus* Fabricius
	Megarthrus depressus Paykull
	Ocypus brunnipes Fabricius
	Ocypus olens Müller
Tenebrionidae	*Adesmia dilatata* Klug

	Asida dejeani Solier
	Asida ochsi Ardoin
	Allophylax picipes Olivier
	Alphasidasolieri Rambur
	Belopus procerus Mulsant
	Blaps gigas Linnaeus
	Blaps lusitanica Herbst
	Centorus procerus Mulsant
	Diaperis boleti Linnaeus
	Erodiusnitidicollis Calwer
	Lagria hirta Linnaeus
	Opratum sp
	Pachychila germari Solier
	*Pimelia cribripennis*Solier
	Pterolasia squalida Solier
	*Tentyria excavata*Solier
Trogidae	*Omorgus obesus* Scholtz
	Trox clathratus Reiche
	Trox scaber Linnaeus
	Trox perlatus Geoffroy
	*Trox sabulosus*Linnaeus

The inventory carried out on the 05 forest groupings includes 108 species of beetles belonging to 10 families (Table 8 and Fig.9), which are mainly presented by the family Carabidae 32.41%, followed by the Scarabaeidae with 19.44%, and the Tenebrionidae with 15.74%; the rest is divided between the Geotropidae with 10.19%, the Curculionidae with 5.56%, the Dynastidae and the Trogidae with 4.63%, and finally the Staphylinidae, the Pachypodidae and the Brachyceridae with 3.70%; 2.78% and 0.92% respectively.

Table9. Betteles structural parameters of deferent groupings forest.

Groupings forest	Shannon-Weaver Index*H'* (in Bits)	Equitability
Cork oak	3.41	0.97
Kermes oak	3.28	0.95
Algerian oak	3.14	0.96
Maritime pine	3.39	0.96
Glutinous Alder	2.85	0.98

The beetle population of the cork oak forest consists of 31 species belonging to 09 families (Table 3); characterized by the dominance of the Carabidae, with 35.29% presented mainly by *Carabus latus* Dejean, *Carabus pyrenaeus* Audinet-Serville and *Harpalus dimidiatus* P. Rossi; the Tenebrionidae with 14.71%, the Scarabaeidae and the Geotrupidae with 11.77% each and the Trogidae with 08.82%; whereas the Pachpodidae, the Dynastidae, the Curculionidae and the Staphylinidae have almost the same number of species (Fig. 4).

In the kermes oak forest, we counted 31 species belonging to 05 families (Table 4); this ecosystem is dominated by the Carabidae and the Scarabaeidae with 10 species; while the Tenebrionidae is presented by 07 species (Fig. 5); some species of Coleoptera are common with the TGAWS pine forest.

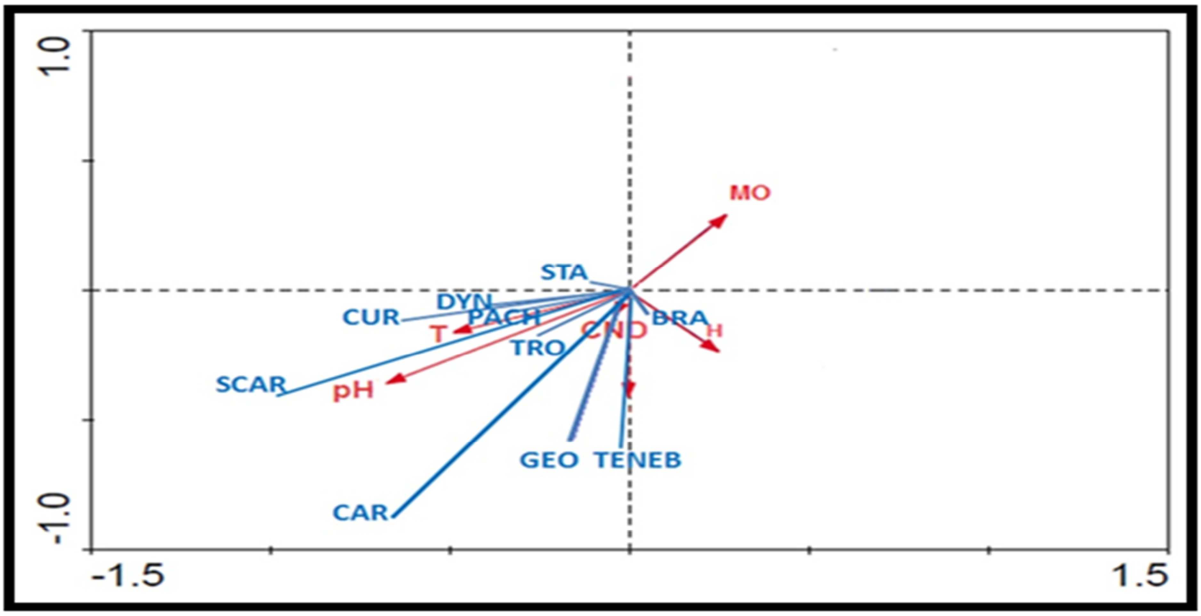

Fig. 2. Canonical correspondence analysis (RDA, CANOCO 4.0 program) of 10 beetle families and EKNP edaphic variables.

In the Algerian oak forest, we counted 26 species belonging to 07 families (Table 5), dominated by the Carabidae, with 08 species; five (05) other species of beetles belong to the family Geotrupidae were also noted (Fig. 6).

The maritime pine forest revealed the presence of 34 species belonging to 06 families (Table 6), dominated by 03 families: the Carabidae with 10 species, the Scarabaeidae with 09 species and the Tnebrionidae with 07 species (Fig. 7).

The alder houses 18 species belonging to 04 families (Table 7), namely the Carabidae (50%), the Scarabaeidae (27.78%), the Geotrupidae (16.67%) and the Staphylinidae (5.55%) (Fig. 8).

Structure of beetles settlements

A total of about 3,000 specimens of insects have been captured in the El-Kala National Park on 05 forest groupings Cork oak, Kermes oak, Algerian oak, Maritime pine and Glutinous alder). The quantitative distribution of beetles in these biotic environments is as follows:

The quantitative distribution of beetles in these biotic environments is as follows: more than 700 specimens in Cork oak forest, more than 400 specimens in Algerian oak forest, around 700 specimens in Kermes oak forest; and around 200 specimens in Glutinous alder forest.

The results obtained prove that the cork oak forest and the pine forest house the largest number of beetles; while the kermes oak and the Algerian oak forest have almost the same number of beetles, with more than 400 individuals, finally the alder counts about 200 individuals.

The quantitative variability of beetles settlements is higher than the qualitative variability for the Cork oak forest, the Kermes oak forest and the pine forest; where the species are represented by a large number of individuals; conversely, the qualitative variability remains important as the quantitative variability for the Algerian oak forest and the Glutinous alder, because the specie are presented by a small number of individuals.

Among the structure ecological indices, the calculation of Shannon-Weaver diversity index (1949) allowed evaluating the entomological diversity of El-

Kala region and comparing the beetles populations in the studied sites, to note the differences between the individuals; this index reaches the highest value for the cork oak forest (H'= 3.41 bits) where large number of beetles (*Scarabaeus catenatus*, *S. cristatus*, *S. laticollis* and *S. sacer*) has been noted; they are constant and abundant entomological taxa; nevertheless a low value has been recorded for the kermes oak forest (*H'* = 3.28 bits) and reach even a lower value for the Algerian oak forest (H '= 3.14 bits); finally this index reaches 2.85 for the alder (Table 9).

The equitability index (Peet,1974). allowed establishing the rapport between the measured diversity (H') and the maximum theoretical diversity (H'_{max}), for a sample size of 2,859 individuals belonging to 108 species and 10 families.

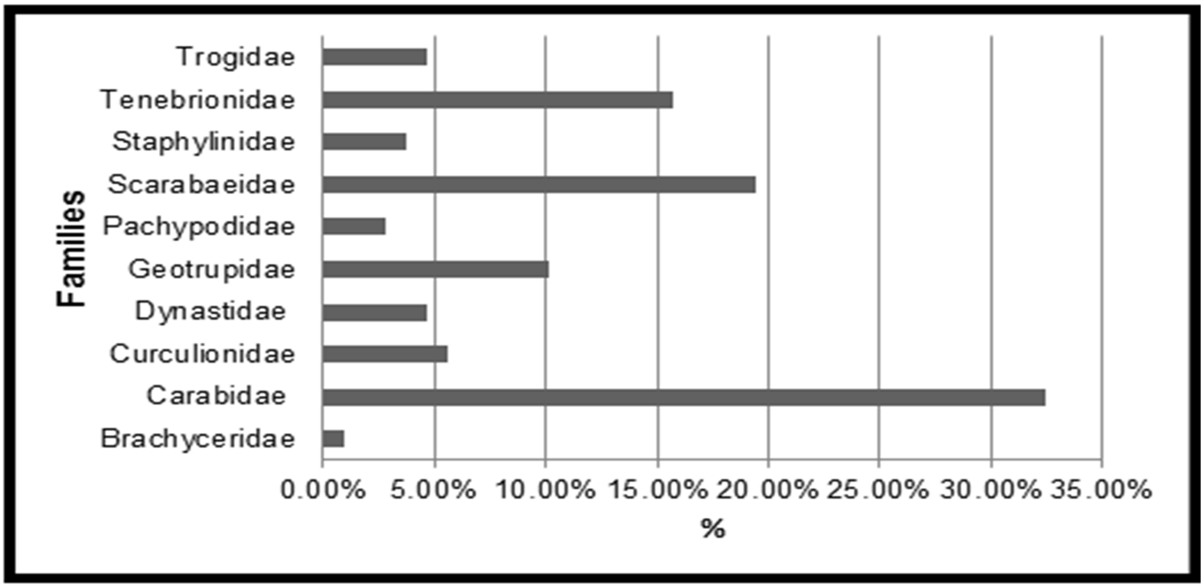

Fig. 3. Therelative abundance of coleoptera families in the EKNP.

The highest value of this index (*E* = 0.98) is recorded in the alder(Table9); which proves that the species tend to be in equilibrium (*E* between 0.95 and 0.98).

Trophic organization

The different devices (Barber traps and shelter plates) used gave a list of more than 100 species, that are mostly coprophagous beetles (38.23% to 50%) and predators (30.37% to 50%) belonging to the families Carabidae and Staphylinidae; these species are accompanied by many other species, present on the different sites, belonging to the decomposers (11.54% to 22.58%) and the phytophages 5.88% to 11.54%) (Fig. 9).

Discussion

El Kala National Park has been subjected to another global entomological inventory in 2016 by Daas *et al.* (2016) counting a total of 228 individuals, belonging to 68 species and 19 families, dominated by the family Scarabaeidae; compared to this inventory, our study revealed a fewer number of families (10) but with a wider variety of species (108).

The family Carabidae is the most presented with 32.41%, followed by the Scarabaeidae (19.44%), the Tenebrionidae (15.74%); the rest is presented by the Geotropidae (10.19%); the Curculionidae (5.56%), the Trogidae and the Dynastidae (4.63% each) and finally the Staphylinidae, the Pachypodidae and the Brachyceridae with 3.70%, 2.78% and 0.92% respectively.

The dominance of the Carabidae is probably related to the favorable environment because these insects are present in all habitats except deserts.

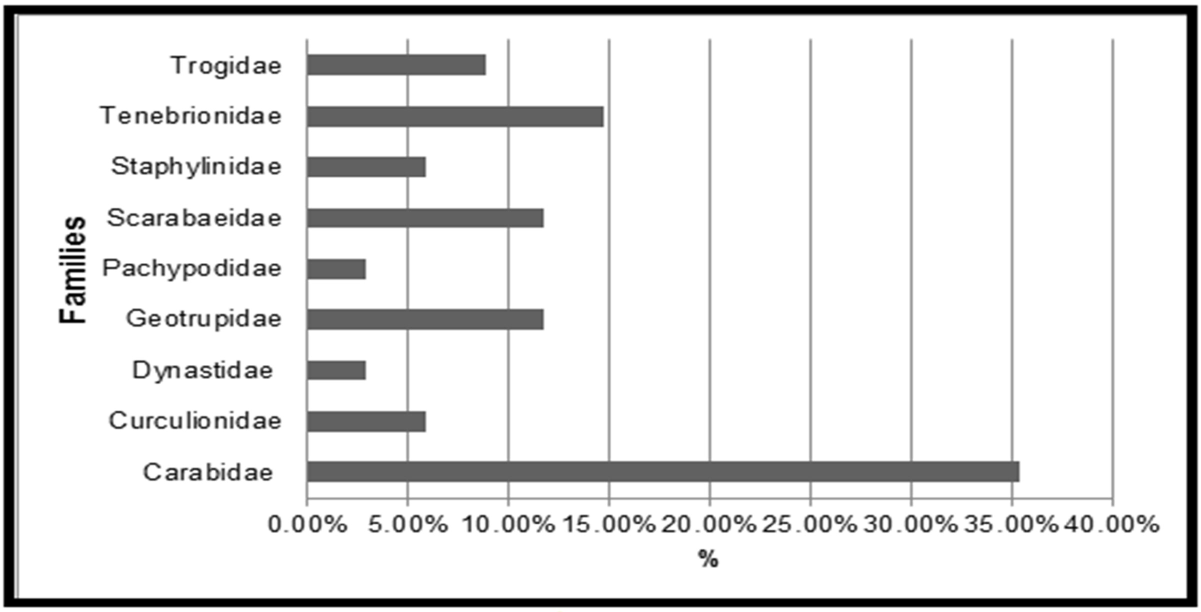

Fig. 4. Therelative abundance of coleoptera families in the cork oak forest.

Many studies noted the high influence of environmental factors on the distribution of Carabidae , especially the vegetation Southwood *et al.* (1979), Butterfield *et al.* (1995), Boulinier *et al.*(1998), McCracken (1994). Furthermore Hengeveld and Haeck (1979) reported the effect of edaphic factors, especially the soil acidity on the distribution of these insects.

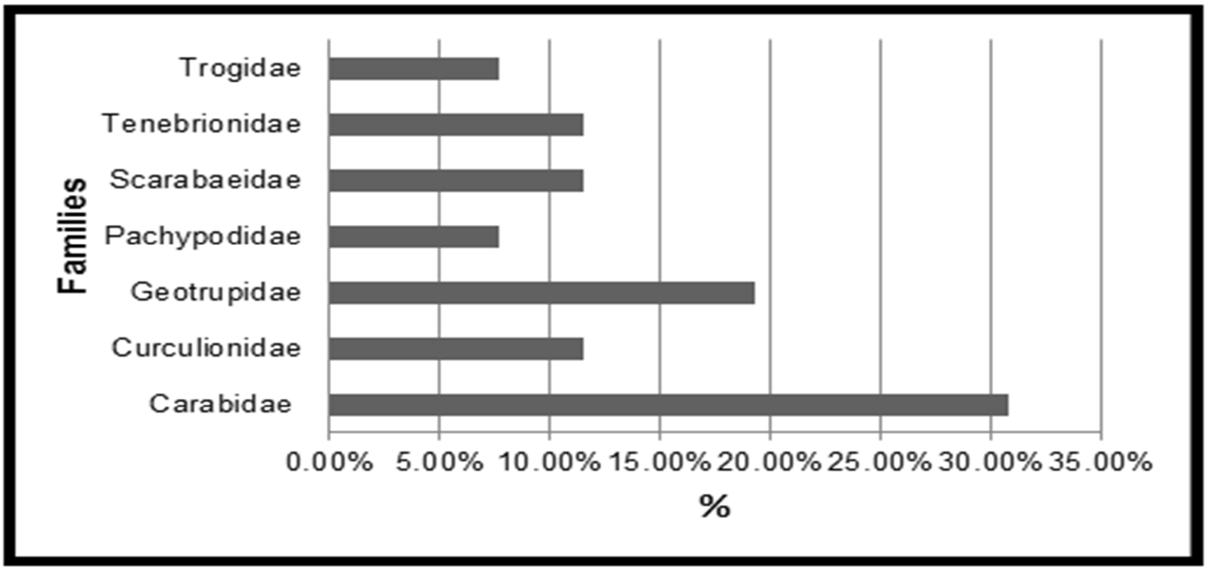

Fig. 5. The relative abundance of coleoptera families in the algerian oak forest.

The Carabidae in EKNP are slightly tolerant to acidity; indeed, all the soil beetles in the five forest groupings are affected by a pH ranging between 5 and 6.

Other abiotic factors have also an effect on the distribution of these insects, especially the salinity where the specific richness is inversely proportional to the salinity rate; the lowest biotopes house a less rich fauna, presented by salinity- tolerant species (Hengeveld and Haeck, 1979). This environment attracts especially the Carabidae, who find there the necessary brightness and humidity (Soldati, 2000).

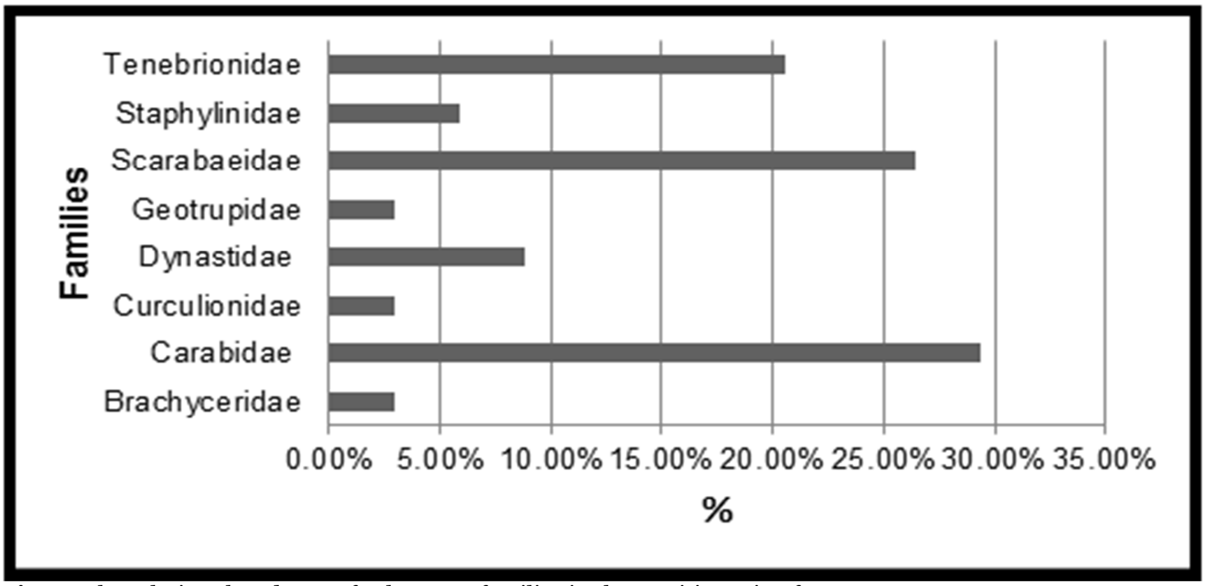

Fig. 6. The relative abundance of coleoptera families in the maritime pine forest.

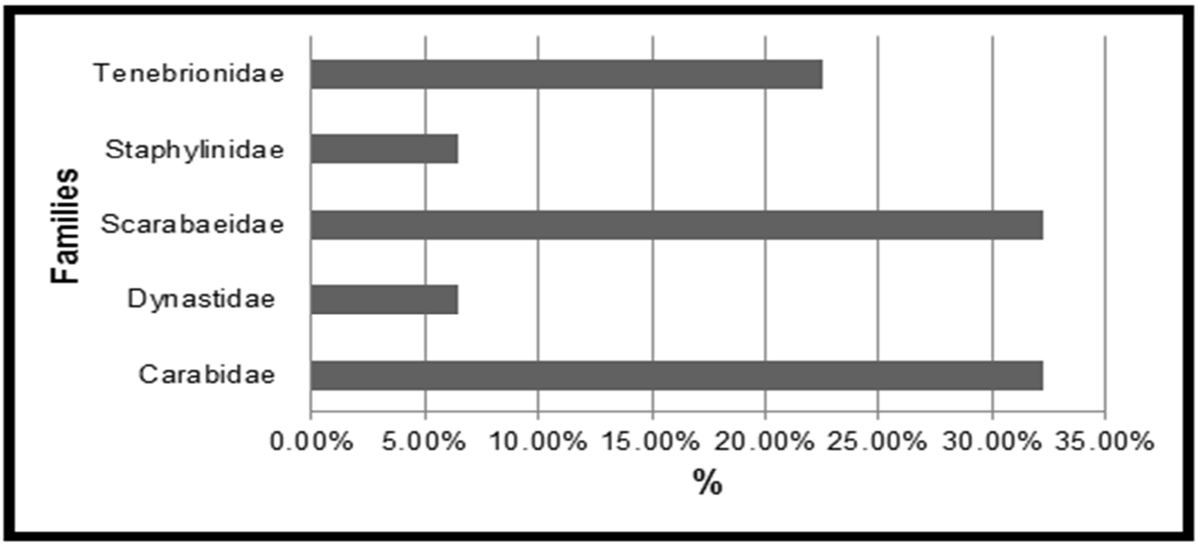

Fig. 7. The relative abundance of coleoptera families in kermes oak forest.

The density of the families recorded is positively correlated to the soil texture; the beetles serve often as indicators for pedobiologists. According to Coiffait (1960), the soils with high content of fine elements (clays and silts) is favorable for beetles.

The Canonical Correspondence Analysis (CCorA) confirms this hypothesis, by indicating a positive correlation between the ten families of beetles (Brachyceridae, Carabidae, Curculionidae,...) and pH, which is also related to the conductivity and the soil texture ; thus the pH - conductivity - texture complex affects the beetles proliferation.

The results revealed a ratio a / N <1, therefore, the sampling effort was sufficient (Blondel, 1975; Ramade, 1984).

The Shannon-Weaver index (1949) allows estimating the richness and complexity of beetle settlements; it indicated a biotope favorable to the installation of various species of beetles with tolerable climate variable food resources.

The distribution of species according to their diet takes into account the diet type of adults, although, there is no absolute trophic specialization in nature, because the trophic chains become complex, under the direct and indirect environmental influence on the trophic behavior of each species; consequently, the larval and the adult diets are identical for many species (Du Chatnet, 1986).

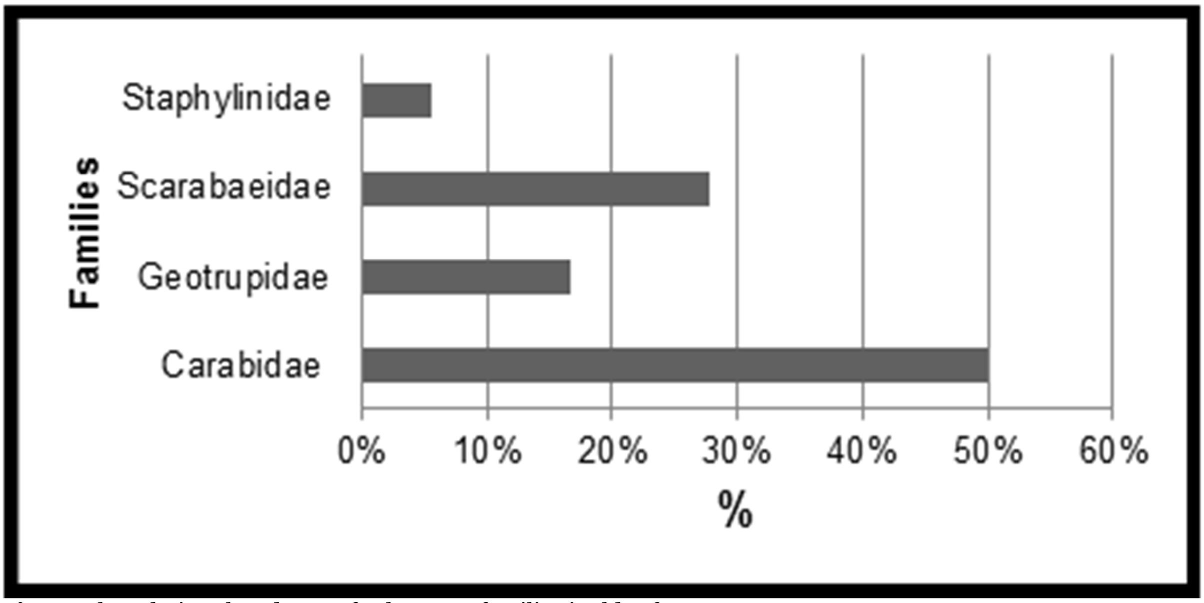

Fig. 8. The relative abundance of coleoptera families inalder forest.

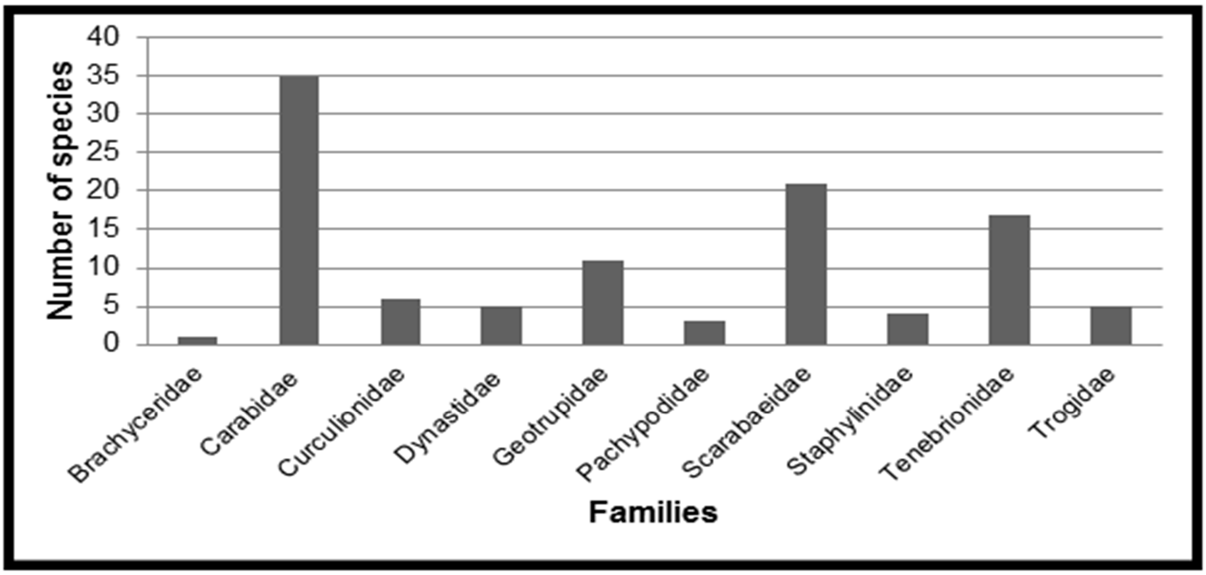

Fig. 9. Distribution of the number of species per family of beetles.

Our inventory revealed a dominance of coprophages (58 species), indicating a high pasture activity; which is an important part of the socio-economic activities of the population in EKNP (Daas *et al.,* 2016).

The feces deposited on the ground occupy a certain surface, decreasing then the pasture surfaces (Waterhouse, 1974).. In this context, the role of coprophagous insects is indispensable, where Scarabaeidae are most actively involved in the fragmentation and vertical transport of feces, as these organisms are active for a large part of the year (Kirk and Ridsdill-Smith, 1986; Klemperer, 1983). Moreover, the dung burial by insects enriches the underlying edaphic horizons (Kalisa and Stone, 1984).

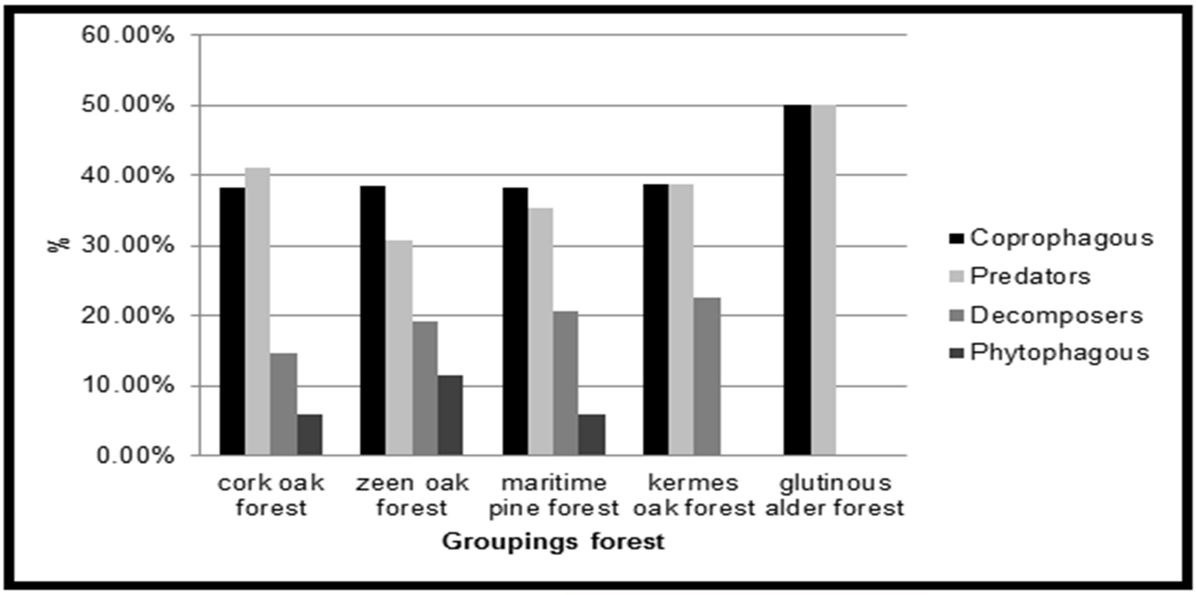

Fig. 10. Trophic distribution of the entomofauna registered in the five groupings forest.

We noted also the presence of a large cohort of beetles; including predators (44 species) like Carabidae and Staphylinidae; which are at the same time indicators for the abundance of coprophages (Meriguet, 2007; Meriguet *et al.,* 2010). Carabidae ensure the balance of the trophic chain because these predators feed on other insects (Haffaf, 2011). They belong mainly to the family Carabidae (*Carabus scheidleri* Panzer, *Carabus pyrenaeus* Audinet-Serville, *Poecilus cupreus* Linnaeus,...) and Staphylinidae.

Finally, it is noteworthy that two species of beetles; namely the common dung beetle (*Scarabaeus laticollis* Linnaeus) and the great dung beetle (*Onthophagus taurus* Schreber) are included in the provisional list of protected non-domestic animal species in Algeria; according to Executive Decree No. 12-235 of 24 May 2012 fixing the list of protected non-domestic animal species (2012).

The protection and in-situ conservation of beetles and ecosystems in their natural environment are of particular importance for the study area which is forest and agricultural.

Conclusion

The results obtained in this study proved clearly the richness and the diversity of entomological settlements in the EKNP, with 108 species, belonging to 10 families and equilibrated abundance distribution. The dominant family is Carabidae; followed by the Scarabidae, the Tenebrionidae and the Geotrupidae; other families are presented by a low number of species and even by single species, such as the family Brachyceridae.

The edaphic parameters have a major influence on the distribution of soil beetles in EKNP.

The majority of beetles identified are coprophagous (50%) and predators (40%); with high biodiversity and wide spread in the forest ecosystems (Cork oak, Kermes oak, Algerian oak, pine and alder); with a notable diet diversity: coprophagous, phytophagous, predator, decomposer and even xylophagous.

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