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Inventory of Land Snails in Some Sites in the Northeast Algeria: Correlation with Soil Characteristics

Louiza Douafer and Noureddine Soltani

Laboratory of Applied Animal Biology, Department of Biology, Faculty of Sciences, Badji-Mokhtar University of Annaba 23000-Annaba, Algeria

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ABSTRACT

The objective of this work is the survey of terrestrial gastropods (snails and slugs) at several sites in the Northeast Algeria: Guelma, Nechmaya, Sidi Ammar, El Bouni and El Kala (National Park of El Kala, NPK). Therefore, random sampling was performed monthly during the period extending from November 2012 to June 2013. The inventory revealed the occurrence of 9 species belonging to 6 families. *Helix aspersa* (Müller, 1774) is the most abundant and widespread species in the different sites. Some ecological indexes are measured. The specific richness was 11 species (9 species of snails and 2 species of slugs) and the diversity index of Shannon-Weaver is high (3.05) in NPK. Various biometric measurements were made such as animal weight, height and diameter of the shell. *H. aspersa* presented the highest weight (10.94 ± 5.27 g) with a largest shell diameter (33.51 ± 9.55 mm) at the NPK. These results were correlated with the physico-chemical characteristics of soils (texture, organic matter, pH Water, conductivity, limestone and porosity) and climate data (temperature, precipitation and humidity) of each site. The information regarding the diversity of land snails permit us to choice bioindicator species for the assessment of pollution in terrestrial ecosystems.

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INTRODUCTION

The Northeast Algeria is a Mediterranean biotope characterized by a rich variety of flora and fauna, mainly at the National Park of El Kala (NPK) [1]. Biodiversity is a major concern for sustainable development and is a continuous threat, when human activities pose major risks in several animal species. In addition, the mollusks are mainly edible snail species. In fact, successive pickups unauthorized snails, and the environmental pollution resulting from agricultural and industrial activities as well as causing the gradual disappearance of certain species [2].

Efforts to inventory natural resources in Algeria have led to the discovery of a rich land snail fauna. In fact, inventories of land snails were performed in several biotopes: in Tlemcen (Northwest Algeria) [3, 4, 5], in El kala (Northeast Algeria) [1, 6]. More recently, a survey was conducted (February 2010 to January 2011) at three sites located in the Northeast Algeria (El Kala, Sidi Kaci, El Hadjar) [6]. *Donax trunculus* (Mollusca, Donacidea), a locally prevalent edible mollusk, has been successfully used as a bioindicator of marine pollution [7, 8] through the direct measurement of several biomarkers [9]. Land snails have also been widely used as a sentinel species for the assessment of metallic pollution in terrestrial ecosystems [10]. *Helix aspersa* was also considered as a bioindicator for atmospheric pollution with heavy metals from several industries and vehicular traffic [11].

In continuation to previous reports, the present study aimed the inventory of terrestrial snails in order to precise their structure in different sites. The sampled sites (Guelma, Nechmaya, Sidi Ammar, El Bouni and National Park of El Kala) are located along a gradient (South-West North-East) according to their proximity of factories and other potential sources of pollution. The attempt results permit us to choice a bioindicator snail species for the assessment of soil pollution.

MATERIALS AND METHODS

Sites of investigation:

Corresponding Author: Noureddine Soltani, Professor Laboratory of Applied Animal Biology Faculty of Sciences, Department of Biology University of Annaba 23000-Annaba, Algeria
Tel: + 773 38 76 33 E-mail: noureddine.soltani@univ-annaba.dz

This study takes place in the northern region of the country, in the municipality of El Kala: Site NPK (36° 53 'N, 8° 26 'E) it was used as a reference site, in the department of Annaba two sites: Sidi Ammar (36° 82 'N, 007° 72 'E) and El Bouni (36° 84 'N, 007° 73 'E), the epratment of Guelma: two sites are considered: one in the town of Guelma (36° 59 'N, 007° 32 'E) and the other is to Nechmaya (36° 60 'N, 007° 51'E). These are located along a gradient (South-West North-East) according to their proximity of factories and other potential sources of pollution (Fig. 1). The studied area has a Mediterranean climate with monthly variations in climate parameters (temperature, rainfall and humidity) (Table 1).

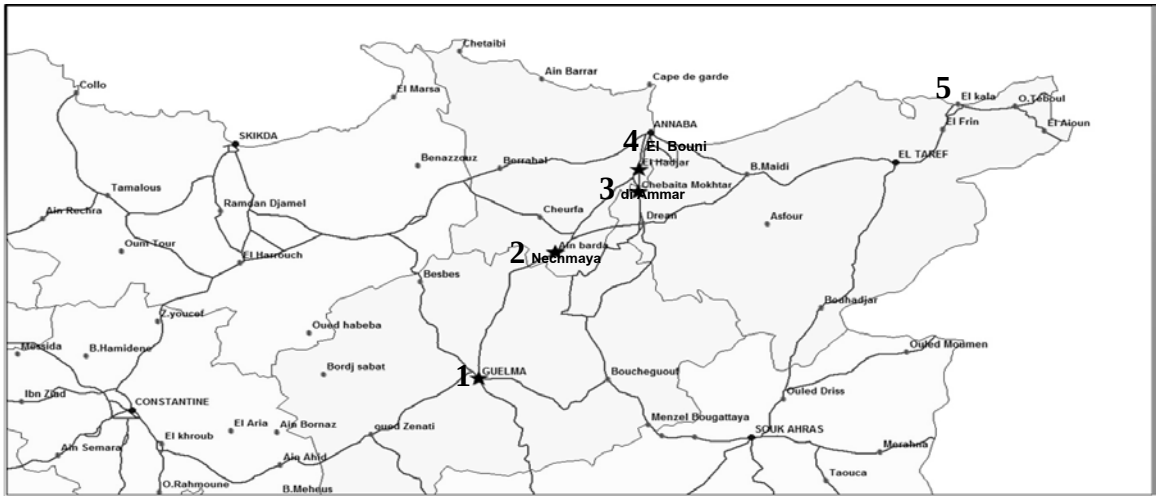

Fig. 1: Geographical location of sampling sites in the North-East of Algeria (**1**: Guelma, **2:** Nechmaya, **3**: Sidi Ammar, **4:** El Bouni, and **5:** NPK).

Table 1: Monthly climatic values (November 2012-June 2013) recorded in the different studied sites.

Parameters	Guelma	Annaba	El Kala
Temperature (°C)	14.83	14.85	14.60
Humidity (%)	72.62	72 .76	80.00
Rainfall (mm)	88.36	101.60	146.00

Sampling and identification of snails:

Random sampling of snails was carried out during the period ranging from November 2012 to June 2013 in various sites. The capture of live mollusks depends on climatic conditions (rainfall, humidity). Biometric measurements are also taken into account such as fresh body weight of individuals, and diameter and height of shells [12]. The identification of species is based on the color and the number of spiral bands in the shells [13, 14]. In addition, anatomical characters including the genital tract are also considered [15, 16].

Ecological indices:

To characterize the population of snails in all sites, ecological indices are calculated to treat our results: specific richness and mean richness [17], frequency centesimal and constancy [18], diversity index of Shanon-Weaver [19] and fairness [20].

Physico-chemical properties of soils:

The terrestrial ecosystem is the habitat of the snail; its quality and physico-chemical influence on the distribution and growth of individuals. The following physico-chemical characteristics are determined: texture and water pH [21], organic matter [22], electrical conductivity and porosity [23], and active and total limestone [24].

Statistical analysis:

Data were expressed as mean and standard deviation (m ± SD). The data have been analysis of variance (ANOVA) followed by Tukey's test. These statistical analyzes were performed using MINITAB software (version 16, Penn State College, PA, USA) and $p < 0.05$ indicates a statistically significant difference.

Results:

Inventory and structure of terrestrial gastropods in different sites:

The inventory conducted in the five sites reveals the occurrence of 11 species belonging to 6 families of terrestrial gastropods (Milacidae, Helicidae, Cochlicellidae, Subulinidae, Enidae, and Hygromiidae) (Table 2).

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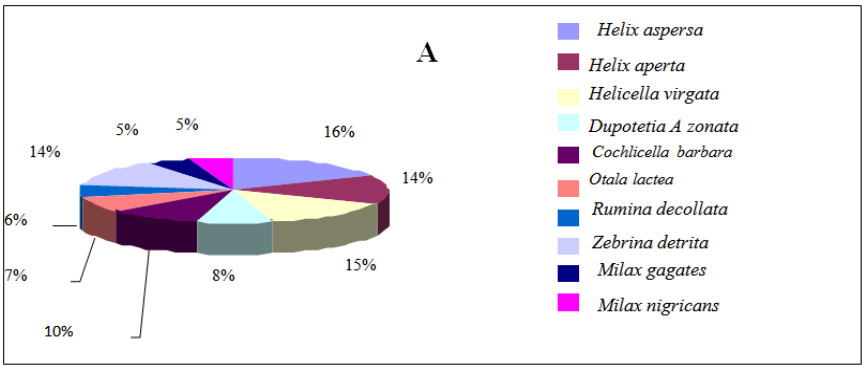
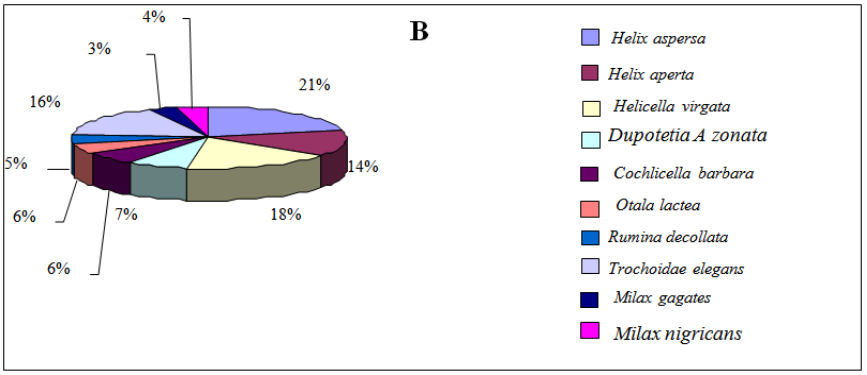
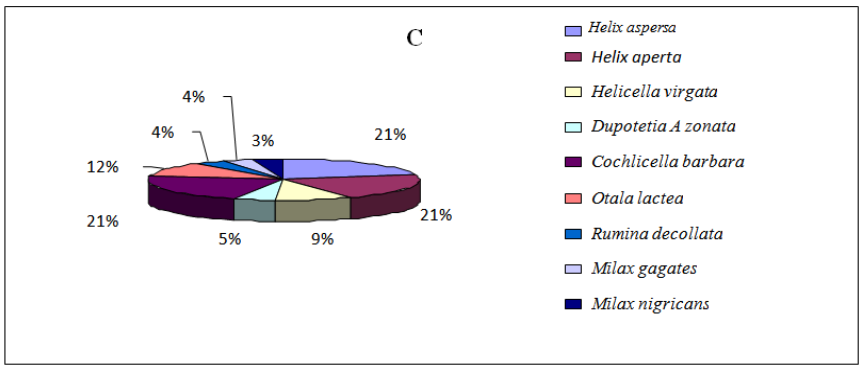
Table 2: Systematic list of gastropods species identified in the five sites of study.

Family	Species
Milacidae	*Milax gagates* (Draparnaud, 1801)
	Milax nigricans (Phillipi, 1836)
Helicidae	*Helix aspersa* (Müller, 1774)
	Helix aperta (Born, 1778)
	Dupotetia Albastra zonata (Pallary, 1926)
	Otala lactae (O F Müller, 1774)
Hygromiidae	*Helicella virgata* (Da Costa, 1778)
	Trochoidae elegans (Gmelin, 1791)
Cochlicellidae	*Cochlicella barbara* (Linnaeus, 1758)
Subulinidae	*Rumina decollata* (Linnaeus, 1758)
Enidae	*Zebrina detrita* (Müller, 1774)

The family of Helicidae is the more rich specifically with 4 species, while the Hygromiidae and Melacideae contain two species; the families of Enideae, Subulinidae, and Cochlicellidae are represented by a species each. *Trochoidea elegans* was found only at the site of Nechmaya. We note that the following sites NPK, Guelma and Nechmaya contain 10 species; NPK seems the more abundant site with 3502 individuals collected, the sites: Sidi Ammar and El Bouni have 9 species. The family of Helicidae is present in all sites, thus the species of Hygromiidae: *Helicella virgata* was found in all sites. *Helix aspersa* presents a large percentage in the structure of mollusks at the level of all sites followed by the species *Helix aperta* (Fig. 2).







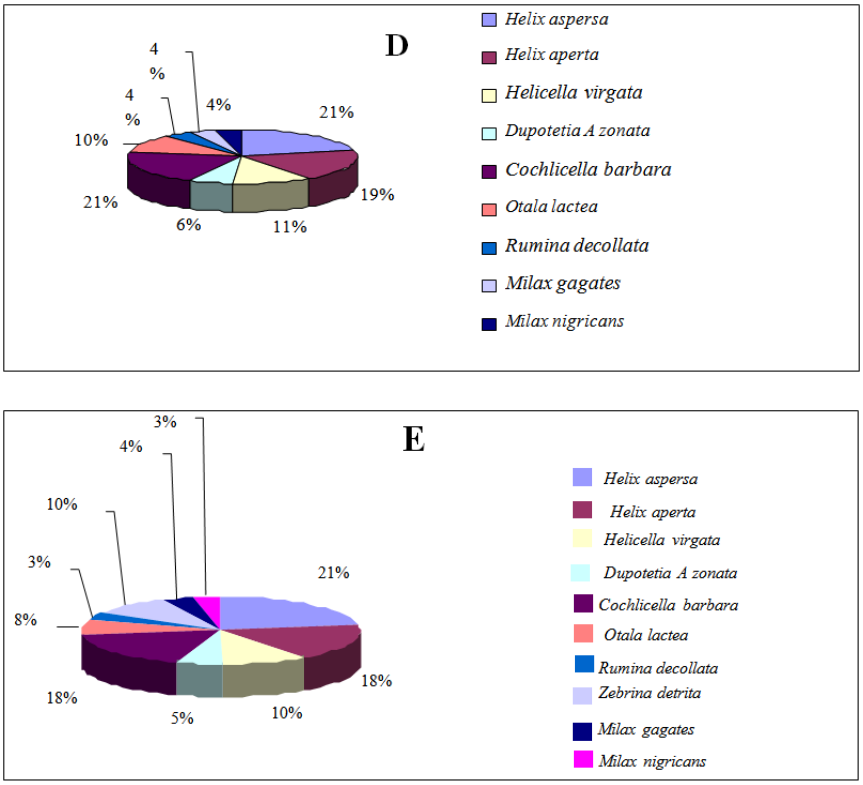


Fig. 2: Structure of gastropod species collected at Guelma **(A)**, Nechmaya **(B)**, Sidi Ammar **(C),** El Bouni **(D)** and NPK **(E).**

Biometrics of species:

The average body weight of different gastropods is listed in Table 3. The results show that the highest weight is recorded in *Helix aspersa* at NPK (10.94 ± 5.27 g) and the lowest weight was found in Nechmaya (7.72 ± 2.17 g). *Cochlicella barbara* (0.09 ±0.03g) and *Zebrina detrita* (0.09±0.007g) are characterized by low weights compared to other species. Slugs have nearly a similar weight in all sites.

Table 3: Average body weight (m ± SD, g) of terrestrial gastropods collected in the study sites (n = 100).

Species/ Sites	Guelma	Nechmaya	Sidi Ammar	El Bouni	NPK
Helix aspersa	8.93 ± 5.01	7.72 ± 2.17	9.99 ± 4.50	10.57 ± 5.20	10.94 ± 5.27
Helix aperta	5.15 ± 4.66	5.08 ± 3.27	6.27 ± 4.06	5.61 ± 3.38	6.45 ± 3.80
Helicella virgata	1.18 ± 0.77	1.64 ± 0.99	1.11 ± 0.59	0.14 ± 0.09	2.02 ± 1.23
Dupotetia Alabastra zonata	4.96 ± 0.93	4.58 ± 1.02	4.02 ± 1.01	4.20 ± 0.66	5.87 ± 0.97
Cochlicella barbara	0.08 ± 0.02	0.07 ± 0.03	0.15 ± 0.08	0.10 ± 0.08	0.09 ± 0.06
Otala lactea	2.47 ± 1.64	2.55 ± 1.45	4.04 ± 3.23	3.32 ± 2.38	4.45 ± 2.28
Rumina decollata	3.13 ± 1.14	4.05 ± 1.17	2.10 ± 0.50	2.81 ± 1.14	2.14 ± 0.66
Zebrina detrita	0.09 ± 0.04	-	-	-	0.10 ± 0.05
Trochoidea elegans	-	2.10 ± 0.96	-	-	-
Milax gagates	2.04±0.26	1.78±0.20	1.85±0.17	2.02±0.18	2.26±0.27
Milax nigricans	1.88±0.22	1.93±0.25	1.98±0.23	2.13±0.29	2.24±0.30

H. aspersa presents a large diameter (33.51 ± 9.55 mm) at the NPK against a lowest diameter recorded in Nechmaya (3.35 ± 1.09 mm). *Cochlicella barbara* and *Zebrina detrita* are characterized by a small shell diameter (Table 4).

Table 4: Mean shell diameters (m ± SD, mm) of terrestrial gastropods collected in the study sites (n = 100).

Species/ Sites	Guelma	Nechmaya	Sidi Ammar	El Bouni	NPK
Helix aspersa	29.61 ± 7.76	27.41 ± 4.36	32.50 ± 8.15	32.80 ± 8.96	33.51 ± 9.55
Helix aperta	22.73 ± 5.43	16.44 ± 7.70	23.71 ± 6.26	23.02 ± 6.82	24.72 ±7.81
Helicella virgata	12.96 ± 0.21	14.89 ± 3.21	10.05 ± 2.76	10.66 ± 0.57	14.91 ± 2.19
Dupotetia A. zonata	20.18 ± 6.07	19.77 ± 6.52	15.94 ± 4.72	16.46 ± 4.53	20.84 ± 6.89
Cochlicella barbara	03.89 ± 0.80	3.35 ± 1.09	4.50 ± 1.29	4.18 ± 0.49	3.93 ± 1.36
Otala lactea	20.33 ± 2.98	21.03 ± 6.17	26.19 ± 5.05	25.44 ± 8.77	27.62 ± 6.68
Rumina decollata	13.40 ± 9.61	14.74± 10.06	9.62 ± 2.95	12.66 ± 1.57	9.70 ± 3.20
Zebrina detrita	3.50 ± 0.57	-	-	-	3.69 ± 0.70
Trochoidea elegans	-	9.87 ± 2.20	-	-	-

The highest shell height was recorded at Nechmaya for *Rumina decollata* (28.04 ± 8.29 mm), while the lowest for *Cochlicella barbara* (5.12 ± 2.86 mm) in the same site (Table 5).

Table 5: Average shell height (m ± SD, mm) of terrestrial gastropods collected in the studied sites (n = 100).

Species/ Sites	Guelma	Nechmaya	Sidi Ammar	El Bouni	NPK
Helix aspersa	20.98± 4.62	19.52 ± 3.29	22.43 ± 5.15	22.99 ± 5.43	24.64 ± 4.16
Helix aperta	15.44± 3.71	11.03 ± 5.25	17.66 ± 5.33	17.26 ± 4.52	18.30 ± 5.30
Helicella virgata	7.88 ± 0.87	8.65 ± 2.23	5.92 ± 1.77	6.17 ± 1.15	9.32 ± 2.32
Dupotetia Alabastra zonata	16.54± 4.43	14.9 ± 6.50	12.02 ± 4.80	12.59 ± 4.39	16.92 ± 5.26
Cochlicella barbara	7.33 ± 0.57	5.12 ± 2.86	9.00 ± 2.58	8.36 ± 1.83	7.52 ± 1.57
Otala lactea	14.40 ± 3.84	15.00 ± 3.79	20.00 ± 6.92	18.30 ± 4.33	21.90 ± 7.68
Rumina decollata	27.89 ± 8.72	28.04 ± 8.29	21.43 ± 7.98	26.9 ± 5.75	22.09 ± 11.69
Zebrina detrita	12 ± 0.81	-	-	-	12.32 ± 1.81
Trochoidea elegans	-	8.78 ± 2.11	-	-	-

Ecological indexes:

The specific richness (total) is represented by 10 gastropod species in NPK, Guelma, Nechmaya, respectively, and 9 species in the other sites. Concerning the mean richness**,** the maximum value (508) is obtained in NPK and the minimum value (391) in Nechmaya (Table 6).

Table 6: Specific and mean richness of terrestrial gastropods in the five studied sites.

Parameters/ Sites	Guelma	Nechmaya	Sidi Ammar	El Bouni	NPK
Specific richness	10	10	9	9	10
Total number of individuals	3502	3135	3305	3146	4064
Number of samples	8	8	8	8	8
Mean richness	437.75	391.87	413.12	393.25	508

The centesimal frequency varies between a minimum value of 3.34% for slugs and a maximum value of 22.14% for *Helix aspersa* (Table 7).

Table 7: Centesimal frequency (%) of terrestrial gastropods in the five studied sites.

Species/Sites	Guelma	Nechmaya	Sidi Ammar	El Bouni	NPK
Helix aspersa	17,13	20,73	20,87	21,13	22,14
Helix aperta	14,27	14,35	21,18	19,07	20,48
Helicella virgata	14,70	17,54	9,07	11,12	11,38
Dupotetia Alabastra zonata	7,85	7,01	4,84	6,10	6,11
Cochlicella barbara	9,99	6,37	21,18	20,66	20,54
Otala lactea	7,42	6,06	12,10	10,17	8,87
Rumina decollata	5,71	4,78	3,63	4,13	3,55
Zebrina detrita	13,70	-	-	-	9,84
Trochoidea elegans	-	13,70	-	-	-
Milax gagates	4,56	3,34	3,63	3,78	4,26
Milax nigricans	4,62	3,82	3,47	3,81	3,41

According to the constancy classification [16], two ubiquitous species (*Helix aspersa* and *Helix aperta*) were observed in all sites while *Helicella virgata* is omnipresent at Guelma, Nechmaya and NPK; however *Cochlicella barbara* is omnipresent at sites: Sidi Ammar, El Bouni and The NPK. *Otala lactea* is constant at all sites except Nechmaya. *Trochoidea elegans* is constant at Nechmaya. *Rumina decollata* is a regular species in all sites, while *Zebrina detrita* is a regular at both sites: Guelma and NPK. Slugs are accessory species in all sites (Table 8).

Table 8: Constancy (%) of terrestrial gastropods in the five studied sites.

Species / Sites	Guelma	Nechmaya	Sidi Ammar	El Bouni	NPK
Helix aspersa	100	100	100	100	100
Helix aperta	100	100	100	100	100
Helicella virgata	100	100	87.5	87.5	100
Dupotetia Alabastra zonata	87.5	87.5	62.5	62.5	75
Cochlicella barbara	87.5	87.5	100	100	100
Otala lactea	75	62.5	87,5	87.5	87.5
Rumina decollata	75	75	50	50	50
Zebrina detrita	62.5	00	00	00	50
Trochoidea elegans	00	75	00	00	00
Milax gagates	37.5	37.5	37.5	37.5	37.5
Milax nigricans	37.5	37.5	37.5	37.5	37.5

The diversity index of Shannon-Weaver is relatively very important at the NPK (3.05) with 10 species but low in Sidi Ammar (2.70) with 9 species. The value of fairness was high at NPK, and the lowest was found in Sidi Ammar. (Table 9).

Table 9: Diversity index of Shanon-Weaver and fairness of terrestrial gastropods in the five study sites.

Index /Sites	Guelma	Nechmaya	Sidi Ammar	El Bouni	NPK
Shanon-Weaver	2.99	2.90	2.70	2.77	3.05
Fairness	0.90	0.87	0.85	0.87	0.91

Physico-chemical characteristics of soils in different study sites:

The physico-chemical parameters of soils from different study sites given in table 10. The studied soils are slightly alkaline (pH> 7.5). Moisture values vary between 48.07 and 75.70% and the soils present a clay-loam texture at NPK, Guelma, Nechmaya and El Bouni, and silty clay in Sidi Ammar (41.66%). The conductivity varies between 0.11 and 0.43 which is less than 0.6 mS/cm, so the soil is not salted. The two types of limestone measured in soils indicate that the soils have a very active limestone. The studied soils contain a higher percentage of organic matter (>5%) except for the site of El Bouni (4.87%). Soils prestent a low porosity (< 10 %) in all sites.

ANOVA reveals a significant effect of site regarding pH water ($F_{4, 10}$ = 105.36; p = 0.0001) and conductivity ($F_{4, 10}$ = 78.77; p = 0.0001), soil texture ($F_{4, 10}$ = 4.09; p = 0.032), porosity (F4, 10 = 5.55; p = 0.013) and organic matter ($F_{4, 10}$ = 3.57; p = 0.047).

Table 10: Physico-chemical characeristics of soils from the five studied sites (m ± SD, n = 3).

Parameters/ Sites	Guelma	Nechmaya	Sidi Ammar	El Bouni	NPK
pH water	8.47 ± 0.02	8.71 ± 0.07	7.89 ± 0.08	8.28 ± 0.07	7.79 ± 0.09
Texture (%)	58.02 ± 8.44	48.07 ± 9.77	41.66 ± 8.02	62.83 ± 17.18	75.7 ± 10.73
Conductivity (mS/cm)	0.13 ± 0.005	0.15 ± 0.04	0.11 ± 0.01	0.15 ± 0.02	0.43 ± 0.02
Organic matter (%)	6.11 ± 1.88	5.87 ± 1.32	5.83 ± 1.35	4.87 ± 1.44	7.69 ± 0.19
Active limestone (%)	38.33 ± 5.05	39.74 ± 9.39	31 ± 3.77	31.25 ± 4.50	31.66 ± 4.60
Total limestone (%)	24.94 ± 0.03	24.90 ± 0.01	24.94 ± 0.02	24.90 ± 0.02	24.93 ± 0.01
Porosity (%)	9.39 ± 2.01	16.61 ± 1.49	11.77 ± 3.54	18.23 ± 3.56	17.17 ± 2.86

Discussion:

Some inventories of land snails were recently performed in different biotopes in Algeria [1, 3, 4, 5, 6]. The present survey conducted in some sites (Guelma, Nechmaya, Sidi Ammar, El Bouni and El Kala) located in the Northeast Algeria, shows a relatively high diversity of terrestrial gastropod fauna, particularly in the NPK. Thus, the specific richness was expressed by 2 species of slugs and 9 species of snails. In previous studies made in the Northeast Algeria, 13 species of terrestrial gastropods were observed in El Kala [1], and also in El Hadjar, Sidi Kassi and El Kala [6], while, in the in the region of Tlemcen located in the northwestern part of Algeria and characterized by a arid climate 8 species [4], and 12 species [3] were reported respectively in 2005 and 2008. More recently, a survey was performed on four aromatic species belonging to the family Labiatae and shows the following gastropod richness: 19 for thyme, 18 for rosemary, 16 for lavender, and finally 7 for horehound [5]. Bigot [25] reported 8 gastropod species in Sansouire, while 66 species were found in the West Virginia [26], and 39 species in an urbanizing city of Turkey [27].

Our results indicate that *Helix aspersa* is the most dominant in all sites particularly at the NPK (21%). This value is similar to that obtained in a recent survey conducted in NPK on 2007 [1]. Based on our observations, we notice that the dark-shelled species (*Helix aspersa*, *Helix aperta, Otala lactae, Cochlicella barbara*) are more abundant at NPK, Sidi Ammar and El Bouni, respectively. These sites are characterized by high values of humidity and rainfall, while species with clear shells (*Dupotetia Alabastra zonata, Trochoidae elegans, Rumina decollata, Helicella virgata, Zebrina detrita*) are in contrast more abundant in the sites of Nechmaya and Guelma presenting a low humidity. This agrees with the observations of Chevalier [14]. Terrestrial gastropods occupied a wide range of habitats and show great differences in life history [28]. Variations within species (biometric parameters: weight, height and diameter of the shell) depend on habitat, seasonality, climate, ecological tolerance, adaptation and life stage of the parental individuals [28]. Damerdji [3] also find seasons and monthly variations in the size and distribution of gastropods between various sites in Tlemcen (Northwest Algeria).

The current study reveals differences in ecological indexes between sites. Indeed, concerning the constancy it was obtained two ubiquitous species (*Helix aspersa* and *Helix aperta*) in all sites studied. Damerdji [3] reported three constant species at Tlemcen, a semi arid area located in Southwest Algeria. The diversity index of Shanon-Weaver is highest at the NPK (3.05), it was reported a value of 2.91 at El Kala [6], while it is low (0.26) at Tlemcen [3]. Regarding fairness, it varied between 0.85 and 0.91 suggesting that the different land snail populations are not in equilibrium [20]. Similar results was also obtained at El Kala [5], while at Tlemcen (Northwest Algeria), the fairness is less than 0.50 [3]. The presence or absence of certain gastropod species could be attributed to the influence of environmental conditions, including soil and climatic parameters [29, 30].

The NPK presents an ideal biotope for the gastropods; it characterized by optimal ecological factors (sub-humid climate) [1, 5], such as temperature and humidity required for breeding and reproduction [31]. Damerdji [3] find seasons and monthly variations in the size and distribution of gastropods between various sites in Tlemcen.

Soil is the habitat for a multitude of permanent living being [32]. These physicochemical properties provide a good habitat for snail survival and its biological activities. Among soil invertebrates, pulmonate gastropods are frequently described as bioindicators for the assessment of pollution by metallic elements and pesticides in terrestrial ecosystems [33, 34]. Several studies show that soil characteristics including pH, organic matter content, and moisture affect the bioavailability of metals in soil [35, 36]. The contamination of soil by different pollutants can affect food quality and safety [37]. Ingestion of metals was found to induce dose-dependent toxic effects on growth of gastropods [38] and reproduction [39]. Two species of land snail (*Helix aspersa* and *Helix vermiculata*) were used to test their suitability as sentinels for primary DNA damage in polluted environments [40]. Accordingly to ecological data obtained, *Helix aspersa* is suitable for use as sentinel species for the assessment of soil pollution.

Conclusion:

The inventory made in 5 five different sites located in the Northeast Algeria revealed 11 gastropod species in 6 families. The diversity index of Shannon-Weaver is important particularly in NPK. Changes observed in biometric parameters (weight, height and diameter of the shell) and distribution of species could be attributed to the influence of climate and soil characteristics that in turn affect the biology and physiology of snails. Based on ecological indexes, *Helix aspersa*, is the most abundant and widespread species in the different sites. This is a relevant bioindicator for the assessment of the quality of soils.

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