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Diversity of the terrestrial gastropods in the Northeast Algeria: Spatial and temporal distribution

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ABSTRACT

A survey of terrestrial gastropods was carried out monthly in three sites located in the Northeast Algeria (El Hadjar, Sidi Kaci, El Kala) during the period of February 2010 January 2011. The sites were chosen according to their proximity of factories and other potential sources of pollution. Totally 8463 individuals were collected and 14 species identified (12 species of snails and 2 species of slugs) belonging to six families: Milacidae, Helicidae, Subulinidae, Cochlicellidae, Enidae and Hygromiidae. Among the species identified 4 are constant: *Helix aspersa* (Müller, 1774), *Otala lactea* (Müller, 1774), *Trochoidea elegans* (Gmelin, 1791), *Rumina decollate* (Linnaeus, 1758), 3 are accessory: *Helix aperta* (Born, 1778), *Helicella virgata* (Da Costa, 1780) and *Theba pisana* (Müller, 1774), and 7 are accidental: *Cepaea vendobonensis* (Ferussac, 1821), *Zebrina detrita* (Müller, 1774), *Dupotetia A zonata* (Pallary, 1926), *Cochlicella barbara* (Linnaeus, 1758), *Milax gagates* (Draparnaud, 1801), *Milax nigricans* (Phillipi, 1836), *Cepaea nemoralis* (Linnaeus, 1758). The specific richness of the gastropod species was found to vary between sites and by season. General seasonal peak was recorded during Spring and Winter while the lowest abundance observed during Summer. *Helix aspersa* is the most abundant species in all prospected sites and will be used as a bioindicator of soil pollution.

Keywords: Gastropods, Northeast Algeria, Snails, Slugs, Diversity.

INTRODUCTION

After the Arthropoda, the Mollusca is considered to be the second most diverse of all metazoan phyla, and the gastropods represent the most diverse group of mollusks [1]. Traditionally, gastropods were classified based on the presence and position of their respiratory apparatus into three groups: Prosobranchia (gills in-front of the heart), Opisthobranchia (gills behind the heart), and Pulmonata (lack gills, but use a highly vascularized mantle for respiration). [2] estimated that there are some 20,500 land pulmonates world-wide, nearly twice the earlier estimate provided by [3].

About 30,000 to 35,000 species of terrestrial gastropods are reported in the world [4]. In Algeria, there are few reports on the terrestrial gastropods. The rare studies concerned with the diversity and ecology of the terrestrial gastropods and have led to our general knowledge of fauna in particular localities in the Northwest [5-7] and in the Northeast Algeria [8]. Previously, [8] reported 13 species of terrestrial gastropod species at El Kala (Northeast Algeria).

Land snails have also been widely used as a sentinel species for the assessment of metallic pollution in terrestrial ecosystems [9-12]. One species in particular, *Helix aspersa* Müller, 1774 (Mollusca, Pulmonata, Helicidae) is a good bioindicator of metal and organic soil contamination [13, 14]. In this study we examine terrestrial gastropod abundance and diversity on three sites located in the Northeast Algeria with respect to season as well as sites. The attempt information contributes to our knowledge of regional gastropod fauna and permits us to choose a gastropod species as bioindicator for terrestrial ecosystem health assessment.

MATERIALS AND METHODS

2.1. Sites of investigation

Sampling sites used in this study were located in the Northeast Algeria. The three sites belong to the same climatic level (sub-humid) and have the similar climatic characteristics (Table 1). Each site was chosen according to their proximity to several types of factories, including those involved in the production of phosphoric fertilizers (Fertial), pesticides (Asmidal), steel products (ArcelorMittal) and metallic construction (Feroval). El Hadjar (36 ° 48 'N, 7 ° 44' E), one of the most polluted sites of Annaba, was selected in addition to Sidi Kaci (36 ° 45 'N, 7 ° 58' E). The El Kala site (36 ° 53 'N, 8 ° 26' E) is situated in a national park and was used as a control site. Indeed, it located far from road traffic and other anthropogenic sources of metal contamination. The geographical positions of different sites are given in figure 1.

Table 1. Climatic characteristics of the three studied sites (monthly mean values established on data from year 2011)

Parameters	El Hadjar	Sidi Kaçi	El Kala
Rain fall (mm)	109	101	114
Humidity (%)	82	80	78
Temperature (°C)	25	24	23

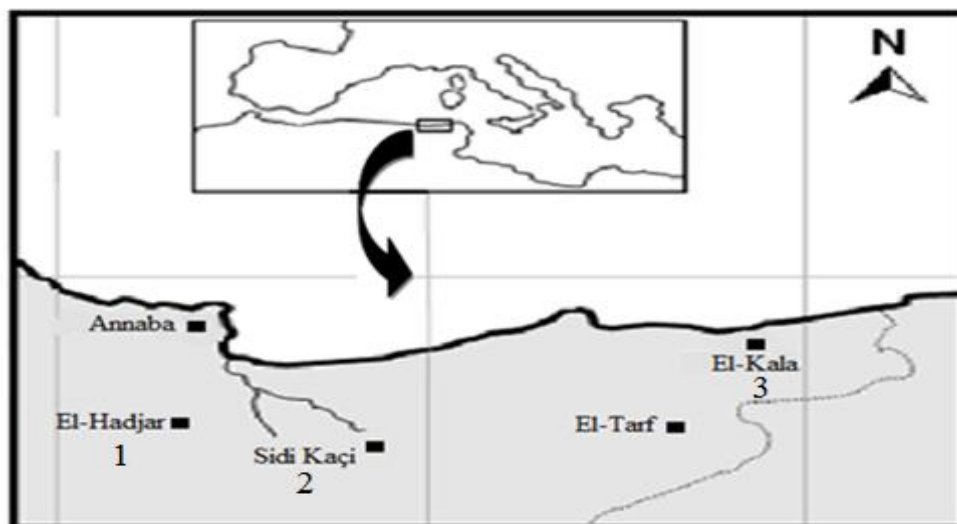


Fig 1. Geographical location of sampling sites (1: El Hadjar, 2: Sidi Kaci and 3: El Kala)

2.1. Sampling and identification of gastropods

In the field, 12 monthly samples were randomly collected from the three sites during a period of one year (from February 2010 till January 2011). Sampling was carried out during 1 hour at each site. The collected specimens were brought to the laboratory, counted and identified and identified using appropriate literatures [15, 16], then preserved in 70% ethyl alcohol.

2.3. Ecological parameters

The composition and structure of terrestrial gastropod population was studied. The following composition parameters were determined: specific richness and mean richness [17], frequency and constancy [18]. The diversity index of Shannon-Waever was calculated according to [19] while the fairness was determined following [20].

2.4. Statistical analysis

Data are expressed by the mean \pm standard deviation ($m \pm SD$) and were subjected to two way analysis of variance (ANOVA). Differences between sites were determined by Tukey's test. All statistical analyses were performed using Minitab Software (Version 15, Penn State College, PA, USA) with $p < 0.05$ considered as a statistically significant difference.

RESULTS

3.1. Survey

In total 8463 specimens were collected from the sites of investigation during the study period, representing 14 species and 11 genera belonging to 6 families Milacidae, Helicidae, Subulinidae, Cochlicellidae, Enidae and Hygromiidae under class Gastropoda. The list of gastropod species recorded in the three sites is presented in table 2.

Table 2. List of terrestrial gastropod species identified in the different sites located in the Northeast Algeria.

Family	Species
Milacidae	<i>Milax gagates</i> (Draparnaud, 1801)
	<i>Milax nigricans</i> (Phillipi, 1836)
Helicidae	<i>Helix aspersa</i> (Müller, 1774)
	<i>Helix aperta</i> (Born, 1778)
	<i>Cepaea nemoralis</i> (Linnaeus, 1758)
	<i>Dupotetia A zonata</i> (Pallary, 1926)
	<i>Cepaea vendobonensis</i> (Ferussac, 1821)
	<i>Otala lactea</i> (Müller, 1774)
	<i>Theba pisana</i> (Müller, 1774)
Hygromiidae	<i>Trochoidea elegans</i> (Gmelin, 1791)
	<i>Helicella virgata</i> (Da Costa, 1780)
Cochlicellidae	<i>Cochlicella barbara</i> (Linnaeus, 1758)
Subulinidae	<i>Rumina decollata</i> (Linnaeus, 1758)
Enidae	<i>Zebrina detrita</i> (Müller, 1774)

3.2. Seasonal distribution of terrestrial gastropods

Seasonally, the species richness showed its highest value during Winter, followed by Spring, then Autumn, whereas the least catch was recorded in Summer in all studied sites (Fig. 2). Winter and Spring showed the highest values coinciding with the optimal temperature required for breeding and reproduction of snails. Moreover, at sites located near pollution sources, samples showed higher diversity compared to those from the reference site (El Kala). Two way ANOVA shows significant effects of site ($F = 12.59$, $df = 2, 24$; $p = 0.001$) and season ($p = 0.000$) ($F = 56.79$, $df = 3, 24$) and a significant season x site interaction ($F = 3.39$, $df = 6, 24$; $p = 0.015$).

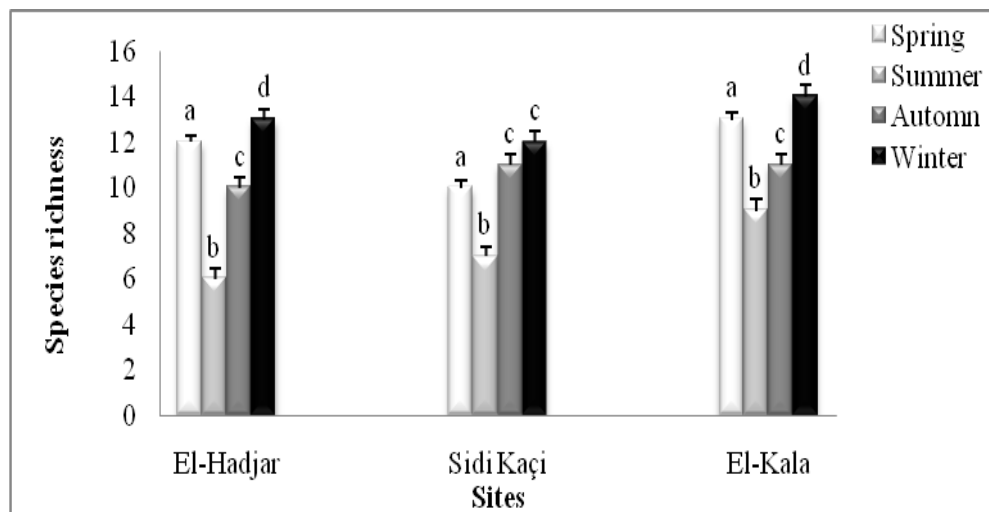


Fig 2. Seasonal variation in species richness of terrestrial gastropods collected in the three sites located in the Northeast Algeria ($m \pm SD$; $n = 3$; for each site values affected with a different letter are significantly different at $p < 0.05$).

3.3. Composition and structure of terrestrial gastropod population

As shown in Table 2, the total number of the collected snails was 8463 specimens, from which 2647, 2511 and 3305 individuals were recorded at El Hadjar, Sidi Kaci and El Kala sites, respectively. Specific-richness was expressed by 13 malacological species at El Hadjar, 12 at Sidi Kaçi and 14 at El Kala. Concerning the mean richness, the maximum value was observed in El-Kala site (263.08) while the minimum value (209.25) was recorded in Sidi Kaçi (Table 3).

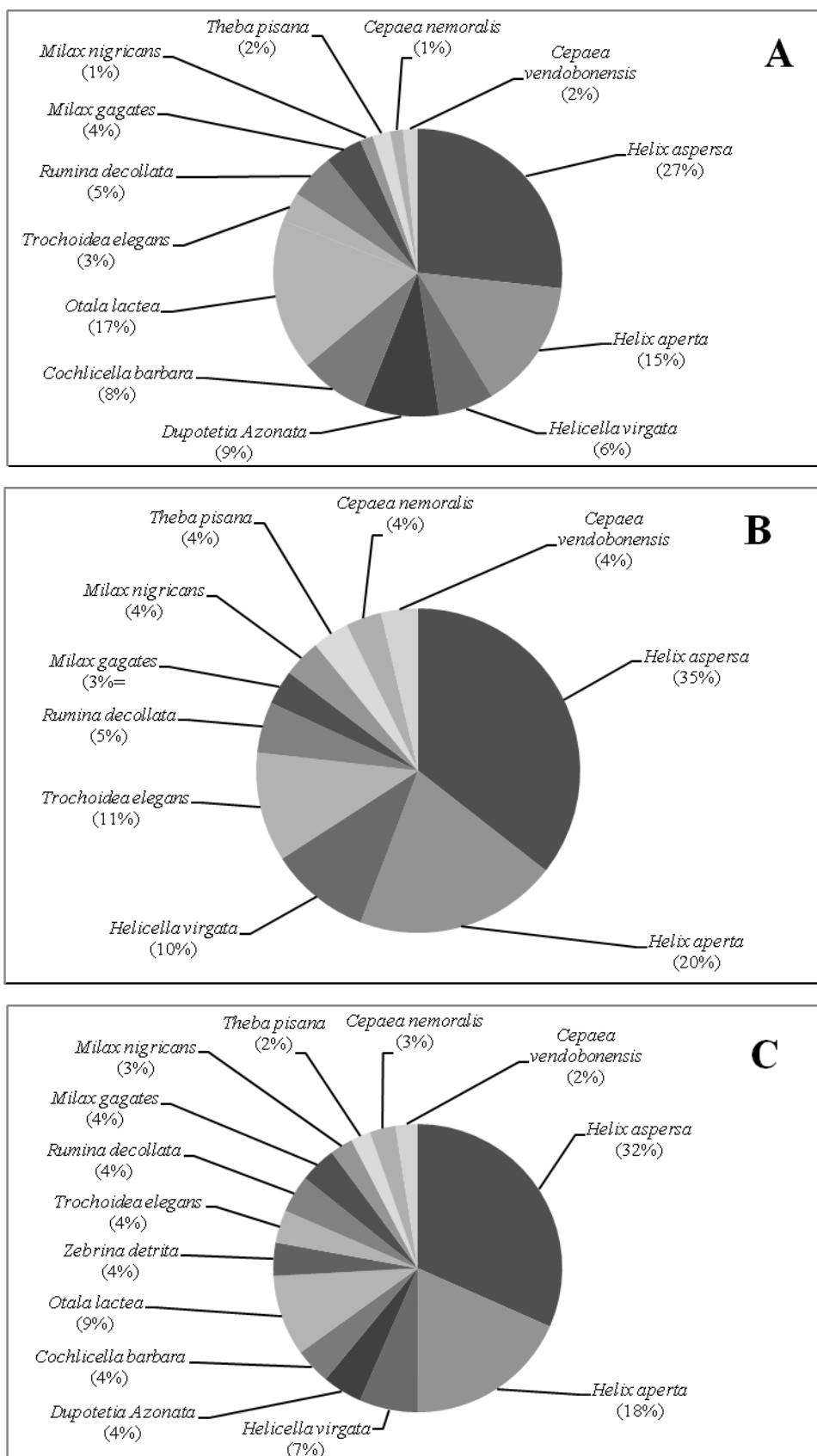


Fig 3. Gastropod species collected at El Hadjar (A), Sidi Kaci (B) and El Kala (C)

Table 3. Total and mean richness of terrestrial gastropod population in the three study sites

Parameters \ Sites	El Hadjar	Sidi Kaçi	El Kala
Specific richness (S)	13	12	14
Total number of individuals	2647	2511	3305
Number of samples	12	12	12
Mean richness (S')	220.58	209.25	263.08

The frequency varies between a minimum value of 1.51% for slugs and a maximum value of 32.77% for *Helix aspersa* (Table 4). This variation depends on the weather conditions. *Helix aspersa* present a value superior to 25%, so it is a common species.

Table 4. Frequency (%) of terrestrial gastropod species in the three sites located in the Northeast Algeria

Species / Sites	El Hadjar	Sidi Kaçi	El Kala
<i>Helix aspersa</i>	27.83	32.77	30.11
<i>Helix aperta</i>	15.27	17.33	16.31
<i>Helicella virgata</i>	6.70	10.22	7.88
<i>Dupotetia A zonata</i>	9.85	-	4.56
<i>Cochlicella barbara</i>	8.01	-	4.51
<i>Otala lactea</i>	10.41	6.55	8.13
<i>Zebrina detrita</i>	-	-	4.51
<i>Trochoidea elegans</i>	3.70	7.72	4.11
<i>Rumina decollata</i>	5.76	5.23	4.13
<i>Milax gagates</i>	4.56	3.51	4.69
<i>Milax nigricans</i>	1.62	4.88	3.11
<i>Theba pisana</i>	2.22	4.37	2.50
<i>Cepaea nemoralis</i>	1.51	3.11	3.22
<i>Cepaea vendobonensis</i>	2.56	4.31	2.43

According to the constancy values (Table 5), it appears that two species (*Helix aspersa* and *Helix aperta*) are ubiquitous in all sites and *Helicella virgata* is omnipresent at El Hadjar and Sidi Kaçi; however, *Rumina decollata* is an accidental species at El Kala site. Lastly, *Milax gagates* and *Milax nigricans* are accidental and *Zebrina detrita* is rare at all sites.

Table 5. Constancy (%) of terrestrial gastropod species in the three sites located in the Northeast Algeria

Species / Sites	El Hadjar	Sidi Kaçi	El Kala
<i>Helix aspersa</i>	100	100	100
<i>Helix aperta</i>	100	100	100
<i>Helicella virgata</i>	87.5	87.5	100
<i>Dupotetia A zonata</i>	22.5	22.5	37.5
<i>Cochlicella barbara</i>	22.5	22.5	37.5
<i>Otala lactea</i>	62.5	62.5	100
<i>Rumina decollata</i>	87.5	62.5	87.5
<i>Zebrina detrita</i>	2.5	2.5	2.5
<i>Trochoidea elegans</i>	62.5	100	62.5
<i>Milax gagates</i>	22.5	22.5	22.5
<i>Milax nigricans</i>	22.5	22.5	22.5
<i>Theba pisana</i>	22.5	37.5	62.5
<i>Cepaea nemoralis</i>	37.5	22.5	62.5
<i>Cepaea vendobonensis</i>	37.5	22.5	62.5

The index of Shannon-Weaver realizes the level of diversity of species present in the different sites. So it is the highest value (2.91) was recorded in El-Kala site with 14 species identified. This lowest value was found in El Hadjar (2.58) with 8 species. Similarly, the maximum value of the fairness was also found in El Kala (Table 6).

Table 6. Diversity index of Shannon-Weaver and fairness in the three sites located in the Northeast Algeria

Index / Sites	El Hadjar	Sidi Kaci	El-Kala
Shannon-Weaver	2.58	2.62	2.91
Fairness	0.73	0.79	0.86

DISCUSSION

Our result on terrestrial gastropods shows that the El Kala site presents the highest value of the species richness; it is followed by the El Hadjar and Sidi Kaci sites. The richness varies as seasonally since the lowest value was found in

Summer. This agrees with previous report of [21]. Previously, Boudchiche [8] reported 13 species of terrestrial gastropod species at El Kala (Northeast Algeria): *Helix aspersa* (Müller, 1774), *Otala lactea* (Müller, 1774), *Trochoidea elegans* (Gmelin, 1791), *Rumina decollate* (Linnaeus, 1758), *Helix aperta* (Born, 1778), *Helicella virgata* (Da Costa, 1780), *Cepaea vendobonensis* (Ferussac, 1821), *Zebrina detrita* (Müller, 1774), *Dupotetia A. zonata* (Pallary, 1926), *Cochlicella barbara* (Linnaeus, 1758), *Milax gagates* (Draparnaud, 1801), *Milax nigricans* (Phillipi, 1836) and *Cepaea nemoralis* (Linnaeus, 1758). In our current survey we found 14 species among them *T. pisana* (Müller, 1774) is a new species not signaled previously [8] in the same locality (El Kala).

A sampling carried out at Tlemcen [22], a semi-arid region located in the Northeast Algeria, yielded only 8 species: *Helix aspersa* (Müller, 1774), *Otala lactea* (Müller, 1774), *Rumina decollate* (Linnaeus, 1758), *Helix aperta* (Born, 1778), *Helicella virgata* (Da Costa, 1780) *Zebrina detrita* (Müller, 1774), *Dupotetia A. zonata* (Pallary, 1926), *Cochlicella barbara* (Linnaeus, 1758). Thus, the species richness is lower in Tlemcen as compared with El Kala. Indeed, El Kala is situated in a sub-humid area characterized by optimal ecological factors such as temperature and humidity required for breeding and reproduction of snails. Accordingly to Ondina et al. [23], the presence or absence of certain species could be attributed to the influence of environmental conditions including soil and climatic conditions.

Molluscan species are efficient indicators for ecosystem health and species diversity [24, 25]. The high level of civilization related soil pollution has recently become a major issue [26]. Among the pollutants, heavy metals have received considerable attention due to their toxicity and potential bioaccumulation in several organisms [27]. Environmental concentrations of heavy metals depend on both natural and anthropogenic factors [28]. Soil contamination stems from two sources: agricultural activities (fertilizers, pesticides) and runoff produced by atmospheric pollutants [29, 30]. In agriculture, heavy metal contamination can affect food quality and safety [31] with other environmental toxicities prevalent as determined by several physicochemical and biological factors [32]. According to ecological data, *Helix aspersa* is suitable for use as sentinel organism for monitoring ecotoxicologic effects of urban pollution on the soil quality.

Conclusively, the study of the malacological fauna in the three sites located in the Northeast Algeria revealed 14 terrestrial gastropod species. The specific richness of the gastropod species was found to vary between sites and by season. The highest value was recorded in El Kala site located far from road traffic and other anthropogenic sources of metal contamination. Moreover, *Helix aspersa* is the most abundant species in all studied sites and will be used as bioindicator organism for monitoring heavy metal soil contamination in the Northeast Algeria.

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