

Taxonomic Diversity and Structure of Gastropods in Stations at *Salvia officinalis* L. (Lamiaceae) in the Gardens of Tlemcen Park (Tlemcen Mounts, Algeria)

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Abstract

The Tlemcen region is located in north-western Algeria and is characterized by a semi-arid bioclimate. An approach to the diversity of the malacofauna associated with *Salvia officinalis* was carried out in three stations belonging to this area from February to June 2015. The specific richness of the Gastropods is 9 divided into three families: Milacidae, Helicidae and Subulinidae. The second includes two subfamilies including that of Helicinae and that of Helicellinae. Two species are constant, 01 is incidental and the 06 others are very accidental. The relative importance of snails fluctuates according to the stations and according to the months and the seasons. In winter, in the first station the malacological richness is equal to 6. In February, the specific richness is relatively important in the 2nd station with a value equal to 7. *Milax nigricans* (Milacidae) has a frequency of 10% in station 1 and has a density of 0.1 in this same station. It is absent in the other two stations. *Euparypha pisana* has a frequency of 60% in station 3 and an abundance of 0.57 in this same station.

Keywords

Salvia officinalis, Malacofauna, Diversity, Bioecology, Seasons, Months, Vertical Distribution, Garden's Park of Tlemcen

1. Introduction

Regarding the work on wildlife in the Tlemcen region, several of them have been undertaken on different species of host plants. In fact, in the steppe region lo-

cated south of Tlemcen, a bioecological study on the fauna of *Stipa tenacissima* L. (Poaceae) including in particular Gastropods [1] preceded a publication on Arthropods in the same region [2]. Bioecological studies on fauna are subsequently undertaken on *Ampelodesma mauritanicum* in the Tlemcen region by DAMERDJI and ADJLANI [3] and DAMERDJI [4], on the doum *Chamaerops humilis* still around Tlemcen by DAMERDJI [5] and DAMERDJI and BOUHELLOU [6]. On Thyme, *Thymus ciliatus* Desf. (Labiatae) a study is made on the malacofauna by DAMERDJI [7]. On Broom (Fabaceae), a malacological study is carried out by DAMERDJI [8]. On the other hand, in the park's gardens, very little work concerning wildlife has been carried out.

Authors have worked on the taxonomy and biogeography of gastropods from the Iberian Peninsula and the Balearic Islands [9] [10] [11]. Other authors have carried out studies on terrestrial molluscs in very specific regions such as the Najerilla valley [12] and the municipality of Valence [13] [14]. GOMEZ [9] has drawn up a catalog of species from the Iberian region. BIGOT and AGUESSE [15] deal with structural variations of 7 Mediterranean ecosystems highly characteristic of the Rhône delta (Camargue).

On the malacofauna proper, DAMERDJI [16] examines a bioecological study in the steppe zone of the region of Tlemcen, work that the author completes at the level of the Tlemcen Mountains [17] and taking into consideration the impact of edapho-climatic factors on the conchology characteristics of the terrestrial malacological population in the same region [18] Here again, no work has been done on the Gastropods living on *Salvia officinalis*, a plant of medical interest. This gap justifies the present work.

2. Methodology

Three parts are presented, the first concerns the choice of plant material, the second the presentation of the study stations and the third the adopted methodology which includes first the field work and then the techniques used to exploit the results obtained.

2.1. Choice of Plant Material

Sage is a perennial plant with a woody stem at the base, forming a bush sometimes exceeding 80 cm, green-whitish branches. The leaves are quite large, thick, green-whitish, and opposite; the light purplish blue flowers in loose terminal spikes, arranged by 3 to 6 in spaced whorls. The bell-shaped calyx has 5 long teeth and upper bilabial corolla in helmet and lower trilobed lip. The root of the sage is brownish and fibrous. The stem, 20 to 30 cm high, is very branchy. The leaves are opposite oblong to oval, stiff, with rounded teeth, gray blue to gray green, tomentose and decussate, velvety to the touch, thick but soft. They are up to 7 cm long. Persistent, they fall if the winter is very harsh.

The flowers are arranged in 6 to 8 whorls of 4 to 10 flowers and inflorescence on the spike. They are large (20 to 35 mm long), bilabial, with short peduncles,

pale or dark purple, sometimes pink or white.

The fruit, in the shape of a tetrakene, is invisible, composed of fine green marbles lodged at the bottom of the involucre as soon as flowering; they will quickly turn into black seeds.

According to GUIGNARD and DUPONT [19] the systematic position of sage is as follows:

Branch Spermaphytes
 sub-Branch. Angiosperm
 Class. Eudicots
 sub Class. Asteridae
 Order. Lamiales
 Family. Lamiaceae
 Genus. *Salvia*
 Genus species. *Salvia officinalis*
 French name: Spanish sage, Lavender leaf sage
 Arabic name: El Mayramiya, Khzyet Djourhât

2.2. Choice of Study Stations

The choice of stations is made taking into account the presence but above all the abundance of *Salvia officinalis*. Other factors were taken into account (altitude, slope).

Station 1:

This station is located northeast of the national park garden with an exposure of 34°52'02.08" North 1°19'08.72" West, it represents a slope of about 0.8%, an approximate altitude of 1290 m and a recovery rate of 65% - 75%.

The plant species which dominate station 1 are: *Salvia officinalis* L. (Lamiaceae); *Euonymus japonicus* L. (Celastraceae); *Lavandula angustifolia* L. (Lamiaceae); *Cupressus sempervirens* L. (Cupressaceae).

Station 2:

This station is located east of the national park garden with an exposure of 34°51'59.34" North 1°19'08.30" West, it represents a slope of about 0.8% with an approximate altitude of 1290 m and an estimated recovery rate of 75%. The plant species which dominate station 2 are: *Salvia officinalis* L. (Lamiaceae); *Euonymus japonicus* L. (Celastraceae); *Senecio cineraria* L. (Asteraceae); *Pinus pinea* L. (Pinaceae).

Station 3:

This station is located south of the national park garden with an exposure of 34°51'55.00" North 1°19'19.00" West, it represents a slope of about 0.8% with an approximate altitude of 1290 m and a rate of 60% recovery. The plant species which dominate station 3 are: *Salvia officinalis* L. (Lamiaceae); *Chamaerops humilis* L. (Arecaceae); *Pinus halepensis* Mill. (Pinaceae); *Cupressus sempervirens* L. (Cupressaceae).

The following **Table 1** indicates the characteristics of the three stations studied.

Table 1. Abiotic and biotic data of three prospected stations.

Prospected Stations	Slope	Altitude	Exposition	Recovery rate
Station 1	0.8%	1290 m	Nord-est	65-75%
Station 2	0.8%	1290 m	Est	75%
Station 3	0.8%	1290 m	Sud	60%

From a bioclimatic point of view, the stations studied are part of the semi-arid stage in temperate winter.

2.3. Methodology

In the field, 10 samples have been taken since February to June 2015. The samples are brought back to the laboratory where live individuals and empty shells are separated. These are put in plastic bags. Smaller species are kept in generally glass tubes. Morphological and anatomical characters do not have the same importance from a systematic point of view. However, the shape, size, coloring and ornamentation of the shell are taken into account, as many morphological differences can help in the determination. Furthermore, the anatomical characters, in particular of the genital tract, remain determining criteria for the identification of species. In this regard, the morphological description is based on the biosystematic study of the terrestrial pulmonary gastropod molluscs of the Tlemcen region drawn up by DAMERDJI [20].

2.4. Ecological Indices

Among the ecological composition indices used to exploit the results, mention should be made of the frequency of occurrence, abundance or centesimal frequency.

The frequency of occurrence of a species is the ratio expressed as a percentage of the number of samples where this species is noted to the total number of samples taken:

$$F = \frac{P_a}{P} \times 100$$

F is the frequency of occurrence of the species. P_a is the total number of samples containing the species considered. P is the total number of samples taken. In terms of consistency [21] distinguishes three groups. The species in the first group are qualified as constant when they are found in 50% or more of the surveys carried out in the same community. Those of the second group are incidental because they are only present in 25% to 49% of samples. Finally, accidental species have a frequency of occurrence of less than 25%.

The relative abundance of a species corresponds to the ratio of the number of individuals of this same species to the total number of individuals of all species combined:

$$A_{rel} = \frac{Na}{Na + Nb + Nc + N...} \times 100$$

is the relative abundance of the species considered. N_a , N_b , N_c , are the numbers of individuals of species a , b , c .

The relative abundance provides information on the importance of each species compared to all of the species present.

The density of a stand is the number of living individuals of all species per unit area.

$$D = \frac{N}{P}$$

D = Density of the species. N = Total number of individuals of a species harvested "a" in the stand considered. P = Total number of samples taken from the stand considered.

Among the ecological structure indices only the Shannon-Weaver diversity and equity indices are used. The calculation of this index makes it possible to evaluate the fauna diversity of a given environment and to compare among them, the faunas of different environments even when the numbers of individuals collected are very different [21].

The Shannon-Weaver and evenly distributed indices are expressed by the following formulas:

$$H' = -\sum q_i \log_2 q_i$$

$$H'_{\max} = \log 2S \quad (S = \text{number of species})$$

H' = Diversity index expressed in bits.

H'_{\max} = Maximum diversity expressed in bits.

Fairness (E) is defined as the ratio of calculated diversity to maximum diversity.

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

3. Results

The results relate to the inventory of gastropods harvested from sage, their relative seasonal and monthly importance, and the calculation of ecological indices and the vertical distribution of these species.

3.1. Diversity of Malacological Species Harvested from *Salvia officinalis*

Based on the classification of GERMAIN [22] [23] a systematic list of the species found on sage is established.

The results concerning the inventory of malacological species are recorded in the following list.

List of pulmonary gastropod species listed on *Salvia officinalis* in 3 stations

Milacidae

Milax nigricans Draparnaud, 1801

Helicidae

Helicinae

Archelix punctata Müller, 1774

Euparypha pisana Müller, 1774

Helicellinae

Helicella (Cernuella) virgata Da Costa, 1778

Helicella (Trochoidea) pyramidata Draparnaud, 1805

Helicella (Cernuella) acompisia Bourguignat, 1864

Helicella terveri Michaud, 1831

Helicella lauta Lowe, 1831

Subulinidae

Rumina decollata Linné, 1758

During our outings which spanned from February to June 2015, we met 49 animal species at the 3 stations surveyed. They are grouped into several classes which are: Gastropods, Annelids, Crustaceans, Arachnids, Myriapods and Insects [24]. The specific richness of Gastropods is 9. They are divided into 3 families: Milacidae, Helicidae and Subulinidae. The first family is *Milax nigricans*. The family of Helicidae comprises two subfamilies: Helicinae with two species belonging to 2 genera namely: *Archelix* and *Euparypha*, and that of Helicellinae with 5 species all belonging to the genus *Helicella*. *Rumina decollata* represents the family of Subulinidae.

3.2. Variations of the Gastropods Found in Depending on the Season

The results obtained are given in the following **Figure 1**.

In winter, station 1 includes 6 malacological species. The malacological richness is estimated at 3 in the second station and 5 in the third station.

In spring, the Gastropods are relatively important in the 3rd station with a richness equal to 9. The 2nd station has eight species. In summer, the climatic conditions becoming drier, the 3 stations include respectively only one species.

3.3. Monthly Variations in the Wealth of Gastropods

The results concerning the monthly size of the Gastropods are given in the following **Figure 2**.

At first glance, the Gastropods seem to be present during the various months of prospecting. In February, the 1st presents 7 species. In June, we count only one

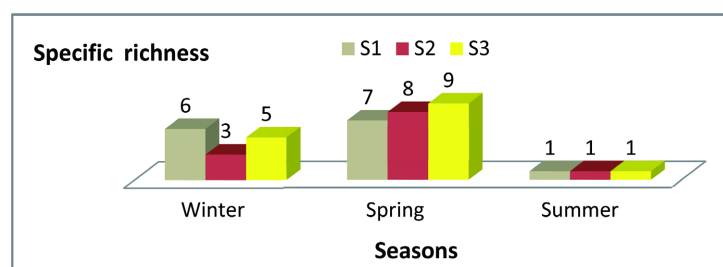


Figure 1. Seasonal importance of Gastropods according to the specific richness in the 3 stations.

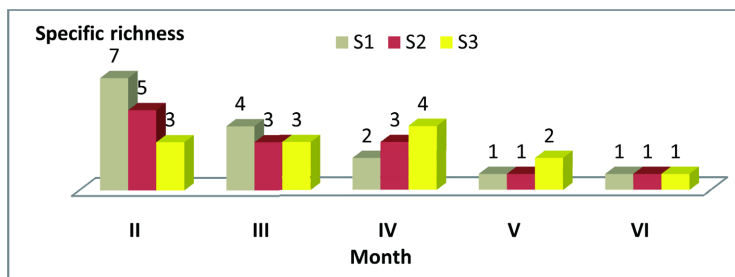


Figure 2. Monthly importance of Gastropods according to the specific richness in the 3 stations.

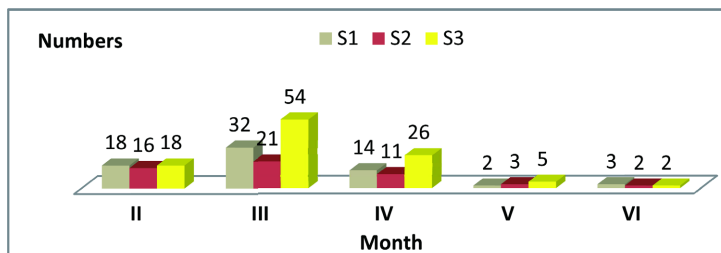


Figure 3. Monthly importance of Gastropods according to the numbers in the 3 stations.

species in each of the stations.

3.4. Monthly Variations in the Numbers of Snail Individuals Recorded on *Salvia officinalis* in the Three Stations

The results obtained are shown in **Figure 3**. They show the importance of the snails month by month, in the 3 stations.

They have a workforce that varies during the different prospecting months. The fluctuations are between 54 individuals in March and 2 in June in the three stations. It should be noted that the Gastropods decreased in the fifth and sixth month.

3.5. Exploitation of the Results by Ecological Indices

All the malacological species inventoried are taken into account for the calculation of the ecological indices. The results concerning the ecological indices are placed in **Table 2**.

3.5.1. Application of the Frequency of Occurrence to Snail Species

Two species of Gastropods are constant, namely: *Euparypha pisana* and *Rumina decollata*. *Helicella virgata* is an accessory species and the 6 others are very accidental including *Helicella pyramidata* and *H. terveri*.

3.5.2. Relative Abundance of Snails

In the present case, this criterion sheds light on the biology of the malacofauna harvested from sage.

3.5.3. Diversity or Shannon Index-Weaver

The data in **Table 3** allows us to calculate the SHANNON-WEAVER index in the 3 stations.

Table 2. Relative abundance, frequency of occurrence and density of malacological species observed in the 3 stations.

Stations Malacological species	Station1			Station2			Station3			Moy. (F%)	Classe of constance
	A%	F%	D	A%	F%	D	A%	F%	D		
<i>Milax nigricans</i>	1	10	0.1	0	0	0	0	0	0	3.33	Very accidental
<i>Archelix punctata</i>	0	0	0	1	10	0.2	0	0	0	3.33	Very accidental
<i>Euparypha pisana</i>	0.29	50	3.2	0.14	40	1.6	0.57	60	6.4	50	Constant
<i>Helicella virgata</i>	0.28	30	1	0.22	40	0.8	0.5	60	1.8	43.33	Accessory
<i>Helicella pyramidata</i>	1	10	0.2	0	0	0	0	0	0	3.33	Very accidental
<i>Helicella acompsia</i>	0.29	10	0.2	0	0	0	0.71	10	0.5	6.66	Very accidental
<i>Helicella terveri</i>	0	0	0	0	0	0	1	20	0.3	6.66	Very accidental
<i>Helicella lauta</i>	0.5	10	0.1	0	0	0	0.5	10	0.1	6.66	Very accidental
<i>Rumina decollata</i>	0.35	70	2.1	0.42	70	2.5	0.23	60	1.4	66.66	Constant

Table 3. Numbers, indices (H' , H'_{max} , E) of the different malacological species encountered in the three stations.

STATIONS	STATION 1	STATION 2	STATION 3
Total	69	51	105
Present species	7	4	6
H' (bits)	2.56	1.39	2.29
H'_{max} (bits)	2.81	2	2.58
E	0.91	0.7	0.89

The Shannon-Weaver index is high in the station1. It equals 2.56 in this station. The lowest value of 1.39 is observed in the second station. Seven species are present in the first, six in the third station and 4 species in the second station.

3.5.4. Evenly Distributed Index Applied to Snail Species

E : fairness greater than 0.5 tends to 1 for each of the three stations studied. The population of gastropods is in balance. The 1st station is slightly more balanced compared to the other two stations ($E = 0.91$). Therefore, the numbers of different species tend to be in balance with each other.

3.6. Vertical Distribution of Gastropods on *Salvia officinalis*

The following **Table 4** shows the vertical distribution of the Gastropod species on the sage.

*At the root level

Only one malacological species has been found. It is *Milax nigricans* (Milacidae) which seeks certain humidity at this level.

*At ground level

This pedofauna is made up of molluscs which remain a particularly characteristic

Table 4. Distribution of malacological species collected on the different strata of *Salvia officinalis*.

Genus species	Root	Soil surface	Stem	Leaves
<i>Milax nigricans</i>		+		
<i>Archelix punctata</i>		+		
<i>Euparypha pisana</i>		+	+	
<i>Helicella virgata</i>		+		
<i>Helicella pyramidata</i>		+		
<i>Helicella acompisia</i>		+		
<i>Helicella terveri</i>		+		
<i>Helicella lauta</i>		+		
<i>Rumina decollata</i>		+		

+: Presence of the species.

group of this stratum. We meet there *Milax gagates* but also *Archelix punctata* and *Euparypha pisana* (Helicinae, Helicidae) and the 3 species belonging to the genus *Helicella* (Helicellinae, Helicidae).

*At the level of the stem

Gastropods are one of a number (it is mainly *Euparypha pisana* at the level of the stem. Gastropods manufacture their epiphragms to be able to survive in extreme conditions.

*At leaf level

Very rare are the species encountered in this leaf stratum of sage.

4. Discussion

On *Calycotome spinosa* in 2008, DAMERDJI [8] recognized 21 malacological species whereas [7] observes 19 on *Thymus ciliatus*. On *Rosmarinus officinalis* (Rosemary) there are 18 species of Gastropods [25].

In the Tlemcen Mountains, DAMERDJI [17] collected 27 species of snails. Similarly in the steppe zone located south of Tlemcen, DAMERDJI in 1996 [16] has 15 species belonging to the malacofauna while [1] only one was noted with *Leucochroa candidissima*. This species currently called *Sphincterochila candidissima* is particularly fond of limestone rocks [20]. The latter shows a strong morphological adaptation for its thick and white test which must protect it from the high temperatures that can prevail in these lawns; it closes in summer with a horny epiphragm, which protects it from diapause. The bioecology of the malacofauna found in 2 stations (Hafir and Zarifelt [26]) in the Tlemcen Mountains indicates the presence of 34 species in Hafir and 19 species in Zarifelt during the years 1999 and 2000. Some particular conchological characters whose size and color distinguish the species liable to rise in altitude [26] During this same period, a study on the distribution of coastal malacological species (Ghazaouet),

passing through Tlemcen (urban center), the mountains (Hafir and Zarifelt), Maghnia (plain) to the southernmost area and steppe (El-Aricha) identified 5 common species in these different ecosystems: *Sphincterochila candidissima* (Sphincterochilidae); *Archelix lactea*, *A. punctata* and *A. zapharina* (Helicidae); and *Rumina decollata* (Subulinidae).

It should be noted that 20 species are considered to be specific, including 14 Helicidae [27]. As an example, the 5th ecosystem considered (the steppe zone), we find there 2 species of Helicidae (*Archelix bailloni* and *Helicella lemoinei*).

In his quantitative ecology essay on Camargue Sansouire Invertebrates, BIGOT [28] indicates the number of molluscs collected in the main environments of the Camargue. In Sansouire, the specific richness is estimated at 8. Abiotic and biotic factors remain important in the variation in the size of the shells of *Sphincterochila candidissima* [29]. This species has a high abundance in xerophilic medium as in El-Aricha. However, this is linked to the degradation of the environment [18]. *L. candidissima* is much localized in Camargue where it is known in the area of the Tour du Valat and its surroundings [30]. The population of *L. candidissima* in the Camargue tends to show a clear detachment of the turns of its shell [31]. ENGEL [32] indicates its presence mainly in the low and salty Sansouire with *Arthrocnemum glaucum*.

On the other hand, *E. pisana* is common throughout the Camargue where its tests are collected under the *Salicornia fruticosa* and harbor many invertebrates [30]. On the other hand, the impact of the edapho factors has been demonstrated -climate on the conchology characters of the population of terrestrial gastropods in the region of Tlemcen [18]. According to BIGOT [33] an important fauna representing the major part of the orders of Invertebrates and almost all the orders of known insects in Camargue, took refuge in the empty shells. These tests play a big role as shelters. Wildlife finds an ideal refuge there from the cold winter temperatures and from the heat wave. These tests are also used as a food source, or even as a place for lay and metamorphosis. In 1971 SACCHI [34] studied the comparative ecology of pulmonary gastropods from the Mediterranean and Atlantic dunes.

At the same time, it should be noted that [5] found that in winter, the specific richness of snails is high on *Chamaerops humilis* with 12 species. In addition, *Macularia hieroglyphicula* also is in winter on the Diss [4].

On Rosemary, the fluctuations are between 125 individuals in April and 31 in December [25].

The phenomenon of “clusters” is an adaptive mark pushed towards the environment for species that are not very resistant to the isolated state. It occurs every year in the Rhône delta for at least 2 or 3 weeks and sometimes over several months [15].

On Rosemary, DAMERDJI *et al.* [25] find the high diversity index in the 3rd station which decreases in the 1st station. The largest population concerns *Euparypha pisana* with 137 individuals in the 1st station and 212 individuals in the 3rd station. DAMERDJI *et al.* [25] found the highest equal distribution in the third

station in Rosemary.

At ground level, the majority of the inventoried Gastropods are found there. *Macularia*, *Archelix* (Helicidae) and *Milax gagates* are counted among the pedofauna [3]. At the Diss stem, 4 species of Gastropods are noted. These species use this part of the plant to make their epiphragm and settle there [4]. Only the species *Euparypha pisana*, difficult to recognize with its polymorphism is found on the stipe of the doum [5].

On the diss, we found 2 species of Helicidae considered as phytophagous. According to KHELIL [2], individuals of *Leucochroa candidissima* are consumers of alfa foliage. On the Doum, the leaf surface being rough, the Gastropods manufacture their epiphragms to be able to survive in extreme conditions. On the Sage, very rare are the malacological species found on the limbus.

5. Conclusion

The bioecological study of the malacological fauna of *Salvia officinalis* in the 3 stations of the Tlemcen Parc enabled us to inventory 9 species during the samples taken from February to June 2015. In spring, station 3 has a specific richness equal to 9. Gastropods are found everywhere except during the month of June. In terms of staff, this is the 3rd station and in March we meet the maximum number of samples. Of the 9 malacological species analyzed, 2 are constant, 1 accessory and the other 6 very accidental. The SHANNON-WEAVER index calculation varies between 1.39 and 2.56 bits. It is the weakest in the 2nd station. The even distribution (between 0.7 and 0.91) indicates a balance between the numbers of the different species present. With regard to the distribution of Gastropods on sage, all of the inventoried species are found on the ground. Finally, if a certain number of results were released during this study, many points remain to be clarified, in particular the relation between the trophic level and the malacofauna which is listed there.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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