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Article

Floristic diversity of a Saharan region in the south east of Algeria

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Abstract : Drylands have less vegetation cover than wetlands due to lack of rainfall. However, the plants in these areas are of economic and environmental importance because they adapt to this special climate and soil, and this feature we benefit from in the adaptation of vegetation .Our work consists of a floristic study of an arid region and seeing its composition and life forms. We used the method of minimal areas. The floristic composition and life form categories of species distribution were analyzed in Tolga region. In total of 63 species belonging to 28 families, half of which are perennial species and half of ephemeral species with biological types dominated by chamaephytes (49%) and then therophytes (25%). The average recovery rate of 28.10% and 24.60%. For the occurrence index, the majority of the species inventoried are accidental species and accessory species, with three species being regular. Specific richness presents 17 and 15.

Keywords : Arid region, flora, floristic wealth, form life, Tolga.

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1. Introduction

Arid regions rich in plant and animal species present deficits for scientific and technical research. The distribution of vegetation is primarily linked to the climate, particularly in arid zones where water remains the main limiting factor [1]. Arid environments offer exceptional opportunities for the evaluation and understanding of the mechanisms involved in the diversification and adaptation of spontaneous plants in relation to the evolution of their environment [2]. However, plant diversity has rapidly disappeared in arid regions due to climatic conditions and human activities. So, plant diversity has been of great interest to mankind since ancient times for several reasons, which include supplies of food, fibers, medicines, as well as plant materials for use in landscape restoration projects [3]. Moreover, allowed us to know the state of the ecosystems to protect them and make a sustainable and balanced development. Our work consists of a floristic study of an arid region and seeing its composition and life forms.

2. Materials and Methods

To facilitate quantitative and qualitative studies, we subdivided the study area into two stations sampled on 20 floristic records of 25 m2 in which we applied a counting of species and individuals, from which were determined. Station 1: is determined by the following coordinates: Latitude: 4°92'-5°52'E Longitude: 34°67'-35°09'N Altitude: 50 to 200 m. Station 2: is determined by the following coordinates: Latitude: 4°92'-5°52'E Longitude: 34°67'-35°09'N Altitude: 60 to 100 m.

2.1. *Phytosociological survey*

The phytosociological survey according to Guinochet (1973), is a floristic inventory. The survey surface must be at least equal to the minimum area, containing almost all the species present [5].

2.2. Minimum area calculation

In a homogeneous sector, a square of 1m2 is delimited by means of 4 stakes and a rope. Count the number of species present in this square. Double its surface (1m x 2m = 2m2) and count the number of new species. We double this square again (2m x 2m = 4 m2) then (4m x 2m = 8m2) and so on. The area/species curve is thus drawn (in abscissa = increasing surface; in ordinate = number of species) [6]. The minimum area is the surface corresponding to the inflection point of the curve. For this work, we have chosen subjective sampling, which is the simplest and most intuitive form of sampling [7]. Positioning of the survey: in a physiognomically homogeneous station from the point of view of flora and plant formations. We say that a group is homogeneous if at any point we can recognize the pattern, that is to say the same plant species in the same order [6].

2.3. Survey size

More or less important depending on the size of the homogeneous zone and the apparent "mesh" of the vegetation. The size of the survey must be greater than the "minimum area", which is specific to each type of association (smaller in a meadow (4m2) than in a forest (100 m2) [6]. The surface of the survey must be at or above the minimum area, containing almost all the species present. In our case, the survey size is 25 m2.

2.4. List of plant species

Performed, using the minimum area method, throughout the study period.

2.5. *Recovery* **rate**

Coverage measurements are carried out for all the individuals of the station, by projecting the aerial organs of the plants vertically on the ground.

2.6. Density

Density measurements are expressed in number of individuals per surface unit (reading of 100 m2).

2.7. Frequency

It is calculated (in %) according to the formula: F(x) = n / N x 100.

n: Number of records of species x, N: Total number of readings taken.

Each species present must be assigned two indices. The first concerns abundance-dominance, the second is sociability.

2.8. Dominance abundance coefficient of Braun Blanquet

Estimated according to the scale of [8]. Among the data collected, the abundance-dominance coefficient is traditionally established during the phytosociological survey. The following scale is the most commonly adopted:

5: overlap greater than 75% of the quadrat
4: recovery between 50 and 75%
3: recovery between 25 and 50%
2: recovery between 5 and 25%
1: coverage less than 5% (not abundant)
+: very sparse

We can add to this notation the acronyms R (very rare species) and i (unique individual).

2.9. Sociability coefficient

The following qualitative scale:

1: elements distributed in a punctual or much diluted way (isolated feet)

2: elements forming open stands, very fragmented into small spots with often diffuse contours (clumps, clumps)

3: elements forming closed stands but fragmented into small islands (tablecloths, groves)

4: elements forming several closed stands, often anastomosed, with clear contours (networks)

5: elements forming a single dense stand

The determination of the taxa was made from the new flora of Algeria and the southern desert regions of [9].

The use of this methodological approach will allow us to develop floristic tables for each station.

2.10. Occurrence index or constancy

The frequency of occurrence Ci of species pi, also called frequency of appearance or consistency index, is the percentage of the ratio of the number of records pi containing species i to the total number of records p [10]. This index is calculated according to the following formula:

C=pi/p×100 (%)

Depending on consistency, species can be divided into the following classes:

Ubiquitous species: C = 100%

Constant species: 75< C < 100%

Regular species: 50< C < 75%

Accessory species: 25< C < 50%

Accidental species: 5< C < 25%

Rare species: C < 5%

2.11. Total species richness

The total richness S corresponds to the total number of species present in a given biotope or station.

The two main variation gradients of specific richness are:

Number of species

Surface on which these species are studied.

Species richness is a measure of the biodiversity of all or part of an ecosystem; it designates the number of species of fauna and/or flora present in the space considered.

2.12. Shannon Diversity Index

Is an index for measuring biodiversity? The names Shannon-Weaver or Shannon-Wiener are incorrect: only Claude Elwood Shannon is at the origin of this index, which is based on the notion of entropy (entropy of Shannon).

$$H' = \sum_{i=1}^{S} pi \ln pi$$

H': Shannon biodiversity index, i: a species from the study environment

pi: Proportion of a species i compared to the total number of species (S) in the study environment (or specific richness of the environment), which is calculated as follows:

$$p(\mathrm{i}) = \frac{\mathrm{ni}}{\mathrm{N}}$$

Where is the number of individuals for species i and N is the total number (individuals of all species). This index makes it possible to quantify the heterogeneity of the biodiversity of a study environment and therefore to observe an evolution over time. This index always varies from 0 to log S this index is one of the best known and most used by specialists.

The higher the value of the index, the lower the rare or scarce species.

2.13. Equirepatition index or equitability

The evenness index E is the ratio between the Shannon diversity index H' and the maximum diversity Hmax which is represented by the logarithm of the specific richness S (Hmax = log S).

$$\mathrm{E} = \frac{\mathrm{H'}}{\mathrm{Hmax}}$$

The analysis and synthesis of ecological data is certainly a first-rate prerequisite for understanding the functioning of ecosystems and for environmental planning. However, this prerequisite, in ecology as for any other study, cannot be an end in itself. It is essentially an instrument of investigation, combination and subsequent use of the information collected for, among other things, a reflection on the development [11, 12, 13].

3. Results and discussions

3.1. Floristic analysis

Station 1: (Table 1)

In this station we notice an important biological diversity dominated by the following species:

Zygophylum album 28.46%
Anabasis articulata 18.49%
Atriplex halimus 15.20%
Astragalus armatus 8.71%
Aristida pungens 8.23%
Arthrophytum scoparium 6.78%

We also note that the tree stratum is only represented by the species *Tamarix africana* and *Ziziphus lotus*. The average recovery rate of 28.10%.

Table 1. Plant survey from station 1

Location	Tolga station 1									
Latitude	4°92′-5°52′									
Longitude	34°67′-35°09′									
Altitude	50 à 200 m									
Substrate	calcareous gypsum, debdeb, saline soil									
Date	March 19									
Recovery rate (%)	38	60	27	28	19	20	21	19	23	26
Survey No	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Spicies										
Anabasis articulata	3.1						+.+	+.+		
Aristida pungens			2.1						+.+	
Arthrophytum scoparium	1.1		+.+		1.1		2.2	1.1	+.+	
Astragalus armatus	1.1							1.1		2.1
Atractylis serratuloides	+.+		+.+							+.+
Atriplex halimus		3.2				3.2				
Chrysanthemum macrocarpum	+.+		+.+					+.+		+.+
Colocynthis vulgaris			r							
Pergularia tomentosa	r							1.+		+.+
Retama retam			+.+						+.+	
Salsola tetragona				1.1						
Solanum nigrum								+.+		
Suaeda fructicosa		+.+				+.+				
Suaeda mollis	r						+.+	+.+		+.+
Tamarix africana					+.+	2.2				
Zygophylum album	2.1		1.1	+.+	+.+			2.2	+.+	1.+

Station 2: (Table 2)

In this station we notice an important biological diversity dominated by the following species:

Zygophylum album 19.31%
Juncus maritima 15.40%
Imperata cylindrica 12.58%

Dactylon cynodon 8.24%
Anabasis articulata 6.51%
Suaeda fructicosa 5.97%

We also note that the tree stratum is only represented by the specie Tamarix africana.

The average recovery rate of 24.60%.

Table 2. Plant survey from station 2

Location	Tolga station 2									
Latitude	4°92′-5°52′									
Longitude	34°67′-35°09′									
Altitude	50 à 100 m									
Substrate	calcareous gypsum, debdeb, saline soil									
Date	March 19									
Recovery rate (%)	37	27	26	25	21	19	22	28	20	21
Survey No	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
Spicies										
Anabasis articulata			1.1	1.1		1.1			1.1	+.+
Chenopodium murale	1.1								+.+	
Chrysanthemum coronarium				+.+			1.1			
Atriplex halimus				+.+	+.+		1.1			
Dactylon cynodon			1.1							2.2
Imperata cylindrica			1.1			1.1		1.1		1.1
Juncus maritima			1.1			1.1		1.1		
Limoniastrum guyonianum		2.2				+.+			1.1	
Peganum harmala	2.2						+.+			
Pergularia tomentosa	1.1								+.+	
Phragmitus communis			1.1							
Suaeda fructicosa				2.1				2.2		
Salsola vermiculata					+.+		+.+		+.+	
Tamarix africana				+.+				1.1		
Zygophylum album	2.2	2.2			1.1		3.2			

Plant species settle in areas according to their edaphic requirements, halophytes like *Atriplex halimus*, *Anabasis articulata*, *Suaeda fructicosa*, psamophytes like *Aristida pungens*, *Limoniastrum guyonianum*, hygrophyte species like *Phragmitus communis*, *Imperata cylindrica*, *Juncus maritima* and species calcifuges like *Zygophylum album*.

3.2. Floristic composition

Through the various floristic surveys carried out, we have identified 63 species belonging to 28 families (Table 3) divided into 30 permanent plants (or perennials) and 33 annuals (ephemeral or acheb).

Table 3. Species inventoried according to the different families, biological type and morphological types

Family	**Species**	**Biological type**	**Morphological type**
Apiaceae	*Daucus carota*	Therophyte	Annual herbaceous
Asclepiadaceae	*Pergularia tomentosa*	Chamaephyte	Perennial herb
Asteraceae	*Atractylis delicatula*	Hemicryptophyte	Annual herbaceous

	Atractylis serratulloides	Chamaephyte	Perennial woody
	Centaurea omphylotricha	Chamaephyte	Annual herbaceous
	Chrysanthemum coronarium	Chamaephyte	Annual herbaceous
	Chrysanthemum macrocarpum	Chamaephyte	Annual herbaceous
	Chrysanthemum segetum	Chamaephyte	Annual herbaceous
	Sonchus arvensis	Chamaephyte	Annual herbaceous
	Sonchus oleraceus	Chamaephyte	Annual herbaceous
Brassicaceae	*Diplotaxis harra*	Therophyte	Annual herbaceous
Chenopodiaceae	*Anabasis articulata*	Chamaephyte	Perennial woody
	Arthrophytum scoparium	Chamaephyte	Perennial woody
	Atriplex halimus	Chamaephyte	Perennial woody
	Chenopodium murale	Chamaephyte	Annual herbaceous
	Hamada cimitiane	Chamaephyte	Perennial woody
	Salsola foetida	Chamaephyte	Perennial woody
	Salsola tetragona	Chamaephyte	Perennial woody
	Salsola vermiculata	Chamaephyte	Perennial woody
	Suaeda fructicosa	Chamaephyte	Perennial woody
	Suaeda mollis	Chamaephyte	Perennial woody
Cistaceae	*Helianthemum kahiricum*	Therophyte	Annual herbaceous
	Helianthemum lipii	Therophyte	Annual herbaceous
Convulvulaceae	*Convolvulus serratuloides*	Chamaephyte	Annual herbaceous
Cucurbitaceae	*Colocynthis vulgaris*	Hemicryptophyte	Annual herbaceous
Ephedraceae	*Ephedra alata*	Chamaephyte	Perennial herb
Euphorbiaceae	*Euphorbia cornuta*	Hemicryptophyte	Annual herbaceous
	Euphorbia guyoniana	Therophyte	Perennial herb
Fabaceae	*Astragalus armatus*	Chamaephyte	Perennial herb
	Genista saharae	Phanerophyte	Perennial woody
	Retama retam	Phanerophyte	Perennial woody
Frankeniaceae	*Frankenia pulverulenta*	Therophyte	Annual herbaceous
Juncaceae	*Juncus maritima*	Chamaephyte	Perennial herb
Labiaceae	*Salvia aegyptiaca*	Chamaephyte	Annual herbaceous
Liliaceae	*Asphodelus tenuifolius*	Geophyte	Perennial herb
Malvaceae	*Malva aegyptiaca*	Therophyte	Annual herbaceous
Orobanchaceae	*Orobanche sp*	Geophyte	Annual herbaceous
Planginaceae	*Plantago ciliata*	Therophyte	Annual herbaceous
	Plantago notata	Therophyte	Annual herbaceous
Plumbaginaceae	*Limonastrirum guynianum*	Chamaephyte	Perennial woody
	Limonium sinuatum	Chamaephyte	Perennial woody
Poaceae	*Aristida pungens*	Hemicryptophyte	Perennial woody
	Avena sterilis	Therophyte	Annual herbaceous
	Bromus rubens	Therophyte	Annual herbaceous
	Cynodon dactylon	Geophyte	Perennial herb
	Hordeum murinum	Therophyte	Annual herbaceous

	Imperata cylindrica	Geophyte	Perennial woody
	Phalaris brachystachys	Therophyte	Annual herbaceous
	Phalaris paradoxa	Therophyte	Annual herbaceous
	Phragmitus communis	Hemicryptophyte	Perennial woody
	Schismus barbatus	Therophyte	Annual herbaceous
	Stipa tenacissia	Geophyte	Perennial woody
Rhamnaceae	*Ziziphus lotus*	Phanerophyte	Perennial woody
Rosaceae	*Poterium sanguisorba*	Chamaephyte	Perennial herb
Rutaceae	*Ruta tuberculata*	Chamaephyte	Annual herbaceous
Solanaceae	*Datura stramonium*	Chamaephyte	Annual herbaceous
	Solanum nigrum	Hemicryptophyte	Annual herbaceous
Tamaricaceae	*Tamarix africana*	Phanerophyte	Perennial woody
	Tamarix gallica	Phanerophyte	Perennial woody
Thymeleaceae	*Thymelea microphylla*	Chamaephyte	Perennial woody
Urticaceae	*Urtica dioica*	Chamaephyte	Annual herbaceous
Zygophyllaceae	*Peganum harmala*	Therophyte	Perennial herb
	Zygophyllum album	Chamaephyte	Perennial herb

It should be noted that of the 28 families listed, 19 are represented by only one species.

3.3. Biological types (Figure 1).

Raunkiaer [14], starts, in fact, from the reasoning that plants, from the biological point of view, are above all organized to cross the critical period of the seasonal cycle, which can be winter because of the cold or the summer because of the drought. The protection of the meristems, which are responsible for ensuring the continuity of the plant, is therefore of great importance.

To this end, Raunkiaer [14] emphasizes the characters and the situation of the buds that house these tissues, and distinguishes the following categories:

Phanerophytes (trees), chamaephytes (shrubs), hemicryptophytes, geophytes and therophytes.

Table 3 shows the distribution of biological types taking into account the presence of species as well as their relative abundance.

The biological forms are composed of 31 chamaephyte species (49%), 16 therophyte species (25%), 6 hemicryptophyte species (10%), 5 geophyte species (8%) and 5 phanerophyte species (5%).

We notice that the chamaephytes occupy half of the space and come the therophytes in second place. This confirms the work of Danin and Orshan [15], the chamaephytes which adapt better to drought and strong light. And also their dominance indicates overgrazing as found [16], overgrazing also globally promotes chamaephytes repelled by herds. Chamephytes are also well represented with 31 species (49%) because they can develop various forms of adaptation to drought, resulting in the reduction of leaf area and the development of a strong root system. So because it is an agricultural area where weeds are abundant. The chamaephytes would be well adapted to the phenomenon of aridization [17, 18]. Grazing thus seems to generally favor chamaephytes with low palatability[19].

For therophytes, [20, 21, 22, 23 and 24] present therophyte as being a form of resistance to drought, as well as to high temperatures of arid environments and an ultimate stage of degradation [25].

[26] point out that the more a system is influenced by humans (overgrazing, cultivation), the more therophytes become important. The most common biological types are chamaephytes and geophytes which characterize desert vegetation with low cover and low height [27]. Chamaephytes are most common in matorrals and are better adapted to aridity [28]. Chamaephytes are better adapted than phanerophytes to drought, because the latter are more

xerophilic [29]. Hemicryptophytes are also absent; this can be explained by the soil's lack of organic matter; phenomenon confirmed by [30].

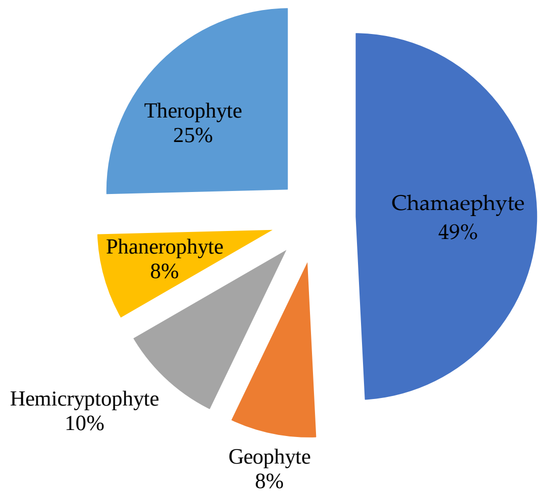

Figure 1. Representation of biological types

3.4. Morphological types (Figure 2).

From our results, we observe that the studied vegetation is divided into equal groups, half annuals and half perennials. The increase in annual herbaceous plants is due to the invasion of therophytes, which are generally annual herbaceous plants.

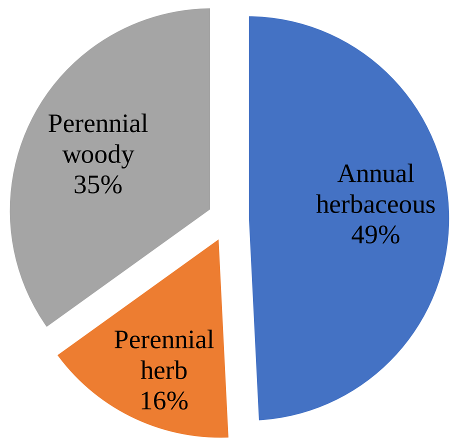

Figure 2. Representation of morphological types

3.5. Abundance dominance (Figure 3)

Among the data collected, the Braun-Blanquet abundance-dominance coefficient is traditionally established during the phytosociological survey.

This coefficient shows, the abundance is an overall estimate of the density or number of individuals and the dominance or coverage rate is a vertical projection of the aerial parts of the plants.

Tamarix africana at statement 5 it is dominant but not abundant. The Atriplex halimus at survey 2 is abundant and dominant.

Our results show that Zygophyllum album is the most abundant in the study area.

3.6. Density (Figure 3).

The highest specific density of 117.6 individuals/100m2 was recorded for Zygophylum album and the lowest density of 0.8.

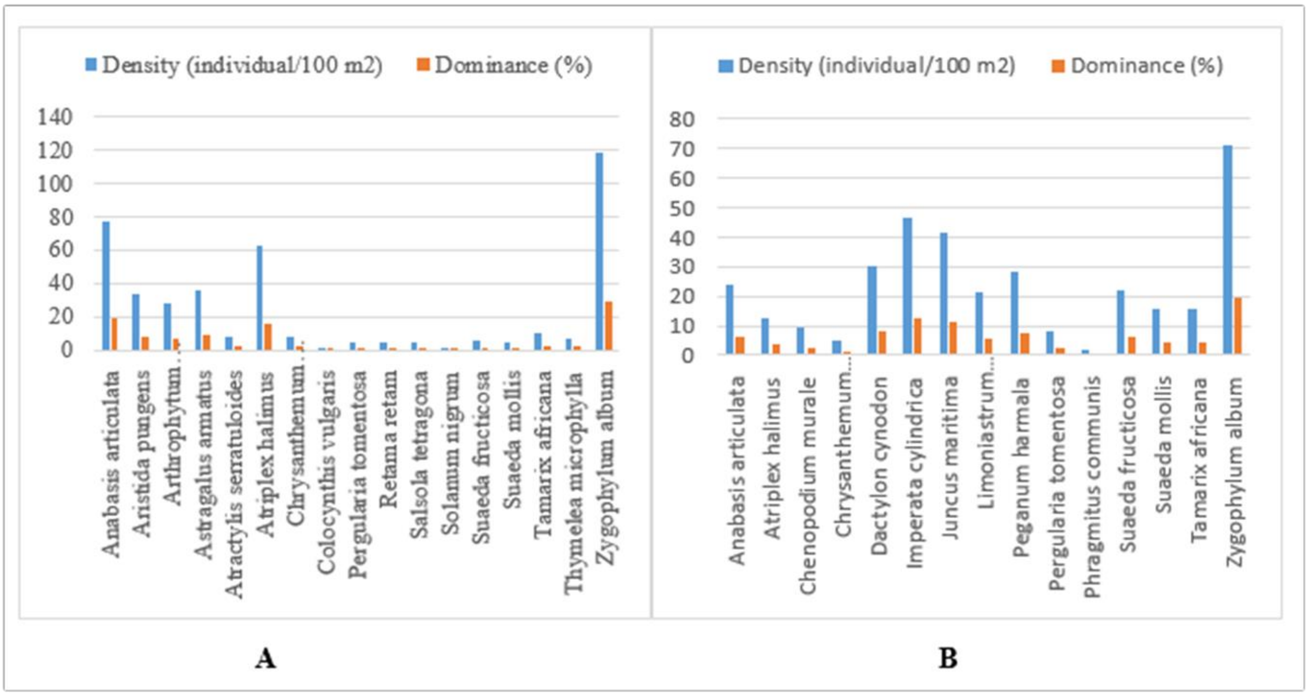

Figure 3. Dominance and density, **A**) for station 1 & **B**) for station 2

3.7. Occurrence index or constancy (table 4)

Table 4 above shows the results of the occurrence index obtained from the floristic surveys.

The majority of the species inventoried are accidental species and accessory species, with 3 species being regular.

Table 4. Occurrence index obtained for each species

	Species	Occurrence index	Remark
	Anabasis articulata	30%	Accessory species
	Aristida pungens	20%	Accidental species
	Arthrophytum scoparium	60%	Regular species
	Astragalus armatus	30%	Accessory species
	Atractylis serratuloides	30%	Accessory species
	Atriplex halimus	20%	Accidental species
	Chrysanthemum macrocarpum	40%	Accessory species
	Colocynthis vulgaris	10%	Accessory species
Station 1	*Pergularia tomentosa*	30%	Accessory species
	Retama retam	20%	Accidental species
	Salsola tetragona	10%	Accidental species
	Solanum nigrum	10%	Accidental species
	Suaeda fructicosa	20%	Accidental species
	Suaeda mollis	40%	Accessory species
	Tamarix africana	20%	Accidental species
	Thymelea microphylla	30%	Accessory species
	Zygophylum album	60%	Regular species

Station 2	*Anabasis articulata*	50%	Regular species
	Atriplex halimus	30%	Accessory species
	Chenopodium murale	20%	Accidental species
	Chrysanthemum coronarium	20%	Accidental species
	Dactylon cynodon	20%	Accidental species
	Imperata cylindrica	40%	Accessory species
	Juncus maritima	30%	Accessory species
	Limoniastrum guyonianum	30%	Accessory species
	Peganum harmala	20%	Accidental species
	Pergularia tomentosa	20%	Accidental species
	Phragmitus communis	10%	Accidental species
	Suaeda fructicosa	20%	Accidental species
	Suaeda mollis	30%	Accessory species
	Tamarix africana	20%	Accidental species
	Zygophylum album	40%	Accessory species

3.8. *Specific richness*

Species richness is an extremely simple diversity index that represents the number of species in a plot. Table 5 below represents a wealth S = 17 for station 1 and S = 15 for station 2.

3.9. *Shannon index*

The Shannon Index assesses both richness and evenness when species have a very regular distribution.

The calculation of this index allowed us to obtain these results H' 2.15 and 2.24 respectively for station 1 and station 2 mentioned in table 5.

3.10. *Equidistribution or equitability index*

The regularity of species distribution is an important element of diversity. A species represented abundantly or by an individual does not make the same contribution to the ecosystem. For an equal number of species, the presence of very dominant species mathematically leads to the rarity of certain others: it is therefore quite intuitively understood that the maximum diversity will be reached when the species have a very regular distribution.

An evenness index is independent of the number of species and therefore of richness. The results of the equity index E are shown in Table 5.

Table 5. Species richness, maximum diversity and Shannon and evenness indices.

	S	Hmax	H’	E
Station 1	17	2.77	2.15	0.75
Station 2	15	2.70	2.24	0.82

4. Conclusion

The floristic analysis allowed us to identify a significant biological diversity of 63 species belonging to 28 families, half of which are perennial species and half of ephemeral species with biological types dominated by chamaephytes and then therophytes. The average recovery rate of 28.10% and 24.60%. For the occurrence index, the majority of the species inventoried are accidental species and accessory species, with three species being regular. Specific richness is below representing a wealth S = 17 and S = 15.

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