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Article

Study of plant biodiversity and spatial distribution of spontaneous vegetation in semi-arid region (Tebessa Province. Northeast Algeria)

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Abstract: The semi-arid is a climate characterized by precipitation that is. insufficient to maintain crops and where evaporation often exceeds rainfall. Vegetation is one of the most sensitive indicators of environmental changes understanding the patterns of biodiversity distribution and what influences them is a fundamental pre-requisite for effective conservation and sustainable utilization of biodiversity. In this study. our focus was on examining the vegetation diversity in the semi-arid region of Tebessa. which falls within the Eastern Saharan Atlas domain in North Africa's semi-arid zone. Plants were sampled at 15 sites distributed across the study area. The quadrat method was used to conduct floral surveys. The sampling area of each sample was 100 square meters 10 m × 10 m (quadrat). Each quadrat was measured for species richness (number of species). abundance (number of individuals). and Richness generic (plant cover). Based on the floristic research. 48 species were found. classified into 21 families. with Asteraceae accounting for 34.69% of the species and Poaceae accounting for 14.28%.

Keywords: plant biodiversity; flora inventory; semi-arid; Northeast Algeria

1. Introduction

Plant biodiversity has long been a topic of interest in ecological research. with researchers attempting to comprehend the evolution of Plant biodiversity over time and the factors that influence its spatial distribution [1]. Abiotic environmental factors have a significant impact on the distribution and performance of plant species [2–4]. Abiotic variables regulate plant population dynamics and community features in dry or semi-arid habitats [5]. Adaptations to abiotic conditions and resources. as well as interactions with established rivals. have all contributed to the evolution of plant biodiversity over time [6]. In recent decades. there has been a lot of interest in the impact of environmental conditions on vegetation. and numerous researchers have looked at the relationship between edaphic and floristic elements [7–10].

Global climate change is the main factor contributing to abiotic and biotic stresses that have irreversible detrimental effects on agricultural productivity. Consequently. imperiling the foundation of sustainable agriculture and menacing the potential for enhanced productivity [11,12]. In semi-arid regions. annual fluctuations in precipitation and grazing activity have a significant impact on grassland renewal and restoration because they can change the type. density. richness. and variety of plants in the soil [13–15]. Numerous models have been developed by ecologists to predict how climate change would affect rangeland vegetation. but it is uncertain how useful these predictions of future changes will be for land management planning [16].

Semi-arid zones cover about 15% of the Earth's geographical surface [17]. Seasonal climate defines the mediterranean climate. with mild winters that enable fuel storage and scorching. dry summers [18]. Semi-arid regions all around the world have low rainfall and high evapotranspiration rates [19]. Semi-arid climates are thought to represent a halfway point between desert and humid climates. They comprise locations with an average annual temperature of less than 18 degrees Celsius [20]. Because plants are the principal producers in every ecosystem. a study of floristic composition in semi-arid regions is important for environmental planning. We were interested in studying the diversity of vegetation in the semi-arid region of Northeast Algeria.

2. Materials and methods

2.1. Study area

The study area is located at (35°44′N to 35°45′N. 08°09′E to 08°10′E) Algeria's far east in Tebessa. at the desert's entrance. roughly 230 kilometers south of the Mediterranean coast (**Figure 1**). The total site area covers ~12.000 km^2 at altitudes between 700 and 1000 meters above sea level. The region is limited to the South by the city of El Oued. to the West of Souk Ahras. Khenchela. Oum El Bouaghi. and to the East of Tunisia.

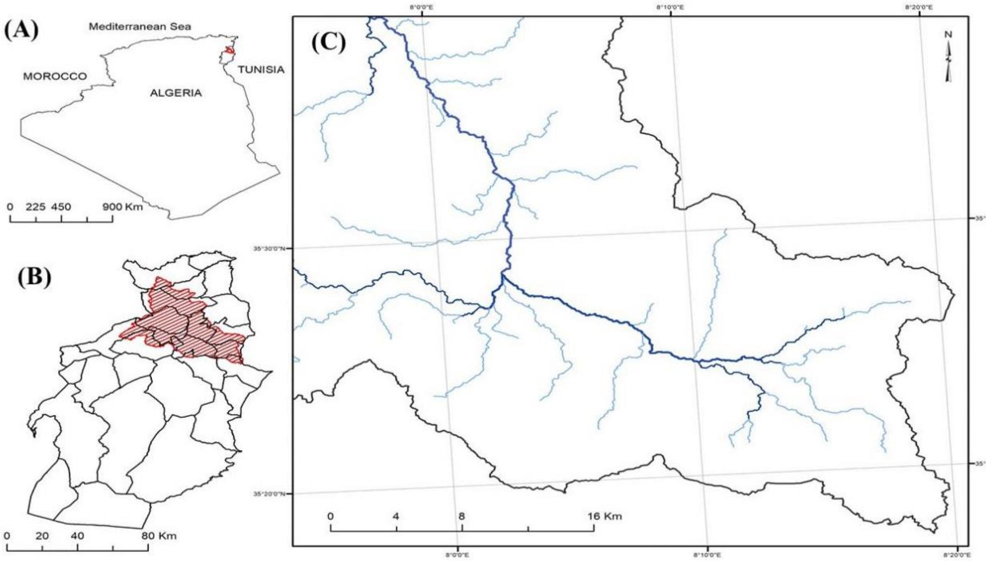

Figure 1. Geographic location of the study area.

The analysis of climate data isprovided by climatsetvoyages. It features all-weather data series. including temperature and precipitation. In Tébessa. the summers are hot. dry. and mostly clear and the winters are long. cold. windy. and partly cloudy. Over the course of the year. the temperature typically varies from 1.6 °C to 34.4 °C and is rarely below −2.2 °C or above 38.8 °C. The chance of wet days in Tébessa varies throughout the year. The wetter season lasts 9.9 months. from August 18 to June 14 (**Figure 2**).

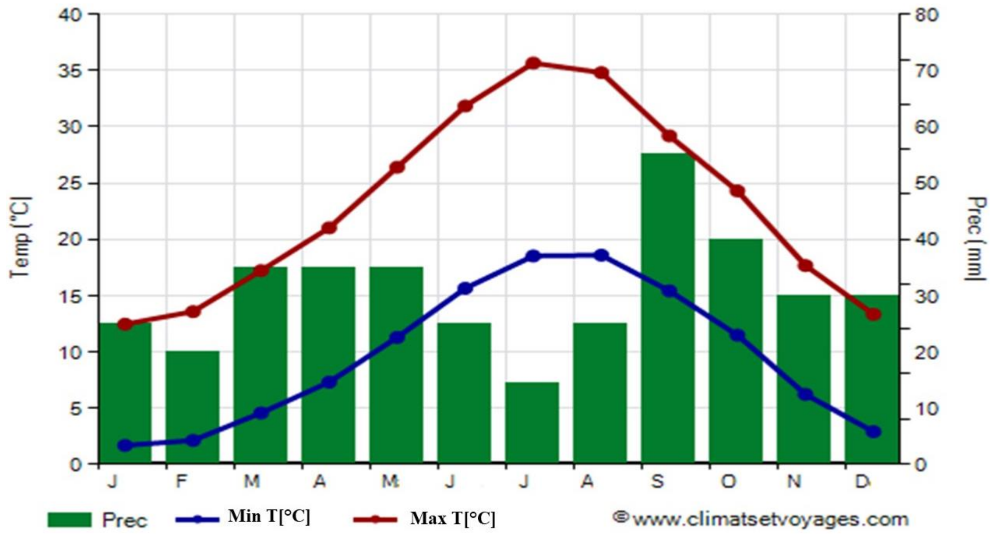

Figure 2. The climate in the study area. Where the minimum temperature (Min T [°C]). maximum temperature (Min T [°C]). and precipitation (Prec) are the monthly means for the period 1991–2020.

2.2. Plant sampling and data collection

The vegetation samples were taken from fifteen sites distributed along the Oued Chabro (Each region is represented by the letter R followed by the site number) during of February–June 2021. in a season that has transitional climate characteristics between the cold-wet season and the hot-dry season. The sampling area of each sample was 100 square meters 10 m × 10 m (quadrat). We chose 15 quadrats of 100 m^2 with repetitions monthly for each region.

A floristic survey is defined to be the inventory of plant species by the set of operations that allow the survey carried out in quadrats present in a given situation; is a qualitative study of the vegetation. which aims to study the species richness. It is carried out in a minimal area. which is defined as the smallest surface necessary for the majority of the species to be met. the minimum area adopted in our case is quadrat 100 m^2 or (10 m × 10 m) plots considering this size to be able to capture the diversity [21]. Along the line transect in each quadrat. the observations were recorded at regular intervals of 10 cm (100 points). often known as quadrat points are a type of quantitative measurement (Linear surveys). All plants that intercepted transects were identified and registered. Each quadrat was measured for species richness (number of species). abundance (number of individuals). and species cover [22].

Concerning the floristic characterization of the different stations. the study was carried out by the realization of floristic surveys. The number of quadrats per transect was determined by the repetitive landscape of the vegetation. The minimum area was determined by the diversity of species encountered. The identification of plant species was carried out with the help of several plant guides and determined according to the flora of Algeria of Quezel and Santa [23].

The richness generic (RG) is the proportion of the soil surface covered by the vertical projection of the aerial organs of this species. expressed in percentage (%). as an indicator of the state of the vegetation. The global cover which is. according to

Gounot 1961 [22]. an indicator of the state of the vegetation. is calculated by the following formula:

$$RG(\%) = \frac{Nv}{N} \times 100$$

(N. the total number of observations).

(Nv. the number of plants).

3. Results

3.1. Floristic composition

The plant composition and species richness inventory were investigated in this study. In general. 49 species were found. belonging to 7 life forms and 21 families. Asteraceae. with 17 species. is the largest of these families. representing 34.69% of all species. The Poaceae family comes in second with 7 species (14.28%). Amaranthaceae and Brassicaceae accounting for 6.12% (each with 3 species). Only one species represents each of the twenty-four families (**Table 1**, **Figure 3**).

Table 1. Plant species and life forms in the study regions. Each region is represented by the letter R followed by the region number. (+): expresses the presence of the Plant specie in the region. and (-) expresses the absence of the Plant specie in the region.

Family	Plant species	Life form	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15
Asteraceae	*Anacyclus radiatus Lois.*	Therophyte	+	+	-	-	-	+	-	-	-	+	-	-	-	-	-
	Atractylis caespitosa L.	Hemicryptophyte	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-
	Atractylis delicatula L.	Hemicryptophyte	+	+	+	+	+	+	+	-	+	-	+	-	+	+	-
	Bellis sylvestris Cirillo	Hemicryptophyte	-	-	+	+	+	+	+	+	+	+	+	-	-	-	+
	Bombycilaena discolor (Pers.) Laínz	Hemicryptophyte	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-
	Calendula arvensis L.	Therophyte	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-
	Carduncellus pinnatus Desf.	Hemicryptophyte	+	+	+	-	-	-	-	+	-	-	-	+	-	-	-
	Carduus pycnocephalus L.	Therophyte	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	Carthamus lanatus L.	Therophyte	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	Echinops spinosus L.	chamaephyte	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	Hedypnois cretica L.	Therophyte	-	-	-	-	-	-	+	+	+	+	-	-	+	-	-
	Hertia cheirifolia L.	Hemicryptophyte	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Matthiola lunata DC.	Therophyte	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Onopordum acanthium L.	Hemicryptophyte	-	-	-	+	+	+	+	+	+	-	-	-	-	-	-
	Reichardia picroides L.	Therophyte	+	+	+	-	+	+	-	-	-	-	-	-	-	-	-
	Scolymus hispanicus L.	Hemicryptophyte	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+
	Xanthium spinosum L.	Therophyte	-	-	+	-	-	-	+	+	+	-	-	-	-	-	-
	Atractylis humilis L.	Hemicryptophyte	-	-	-	+	+	+	+	+	+	-	-	-	-	-	-
Poaceae	*Arundo donax L.*	Geophytes	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
	Avena fatua L.	Hemicryptophyte	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
	Hordeum maritimum With	Therophyte	-	-	-	+	+	+	+	-	+	-	-	-	-	+	-
	lagurus ovatus L.	Therophyte	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+
	Lolium perenne L.	Hemicryptophyte	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Oryzopsis miliacea L.	Hemicryptophyte	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-

Table 1. (*Continued*).

Family	Plant species	Life form	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15
	Stipa tenacissima L.	Hemicryptophyte	+	-	+	+	-	-	+	+	+	-	-	-	-	-	-
	Arthrocnemum glaucum Moric	Chamaephyte	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Amaranthaceae	*Beta vulgaris Thell.*	Therophyte	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
	Salsola vermiculata L.	Chamaephyte	+	-	+	+	+	+	+	-	-	-	-	-	-	-	-
	Eruca vesicaria L. Car.	Therophyte	+	+	+	+	+	+	+	-	+	-	-	-	-	-	-
Brassicaceae	*Moricandia arvensis L.*	Hemicryptophyte	+	+	+	+	+	+	+	-	+	-	-	-	-	-	-
	Sisymbrium irio L.	Therophyte	-	+	-	+	+	+	+	-	+	-	-	-	-	-	-
Chenopodiaceae	*Arthrocnemum indicum Willd.*	Hemicryptophyte	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	Atriplex halimus L.	Chamaephyte	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Lamiaceae	*Marrubium vulgare L.*	Hemicryptophyte	+	+	-	-	+	-	+	+	+	+	-	+	-	-	-
	Rosmarinus officinalis L.	Chamaephyte	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-
Apiaceae	*Scandix pecten-veneris L.*	Therophyte	+	+	+	+	+	-	-	+	-	-	-	-	-	-	-
Arecaceae	*Phoenix dactylifera L.*	Mesophanérophytes	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-
Boraginaceae	*Echium italicum L.*	Therophyte	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Cupressaceae	*Juniperus oxycedrus L.*	Phanerophyte	-	-	-	-	-	-	+	+	+	-	-	+	-	-	-
Ephedraceae	*Ephedra alata Def.*	Nanophanerophytes	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-
Euphorbiaceae	*Euphorbia helioscopia L.*	Therophyte	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Fabaceae	*Retama raetam Forssk.*	Phanerophyte	-	+	-	-	-	-	+	+	+	+	-	+	+	+	+
Frankeniaceae	*Frankenia Thymifolia Desf.*	Chamaephyte	+	-	-	+	-	+	+	-	-	-	-	-	-	-	-
Geraniaceae	*Erodium cicutarium L.*	Therophyte	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-
Malvaceae	*Malva sylvestris L.*	Hemicryptophyte	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Pinaceae	*Pinus halepensis Mill.*	Phanerophyte	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-
Plantaginaceae	*Plantago lanceolata L.*	Hemicryptophyte	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhamnaceae	*Ziziphus lotus L.*	Chamaephyte	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tamaricaceae	*Tamarix balansae J.Gay*	Phanerophyte	-	+	+	-	-	-	-	-	-	-	+	-	-	-	-

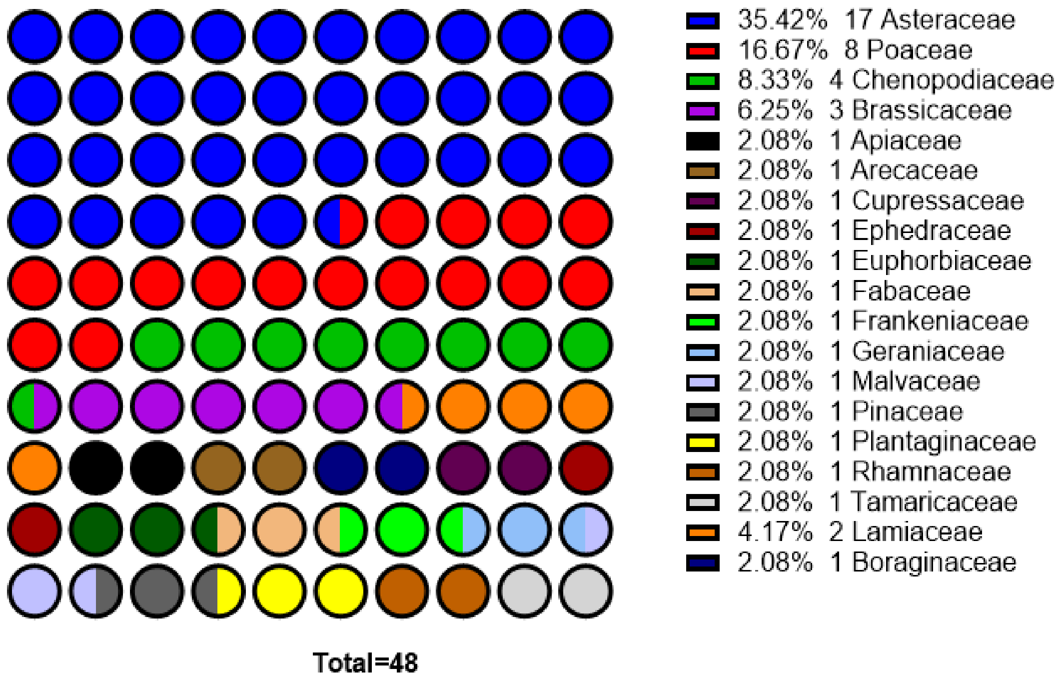

Figure 3. Overall distribution of species richness by family.

Table 2 shows the relative abundance of plants located in the sampling area. especially species *Lolium perenne L. Atractylis humilis L. Onopordum acanthium L. lagurus ovatus L. and Erodium cicutarium L.* These species. exhibited a great ability to cope with the soils disturbances. could be useful for offering their possible use in phytoremediation perspectives and use in the restoration of vegetation.

Table 2. The diversity of species in relation to vegetation types and soil layers. Ratio descriptive statistics of Taxa (S). richness generic (RG%). Individuals. Dominance (D). Plant litter %. Coarse materials. Bare soil %. textural of soil %. Recorded in different regions of the watershed (Each region is represented by the letter R followed by the region number).

	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**
Taxa_S	22	21	18	17	18	17	28	22	26	11	9	10	9	6	7
Individuals	109	148	99	135	125	129	247	224	261	110	111	90	70	127	67
Dominance_D	0.0844	0.088	0.1091	0.1019	0.1155	0.135	0.0755	0.087	0.09	0.138	0.191	0.164	0.247	0.361	0.22
Simpson_1-D	0.9156	0.912	0.8909	0.8981	0.8845	0.865	0.9245	0.914	0.91	0.862	0.809	0.836	0.753	0.639	0.78
Shannon_H	2.704	2.695	2.502	2.542	2.46	2.339	2.909	2.655	2.72	2.144	1.831	1.974	1.678	1.278	1.68
Evenness_e^H/S	0.6788	0.705	0.6781	0.7473	0.65	0.61	0.6546	0.647	0.58	0.776	0.694	0.72	0.595	0.598	0.76
Brillouin	2.423	2.472	2.244	2.336	2.244	2.141	2.718	2.494	2.55	1.98	1.703	1.807	1.504	1.203	1.52
Menhinick	2.107	1.726	1.809	1.463	1.61	1.497	1.782	1.47	1.61	1.049	0.854	1.054	1.076	0.532	0.86
Margalef	4.476	4.002	3.7	3.262	3.521	3.292	4.901	3.881	4.49	2.127	1.699	2	1.883	1.032	1.43
Equitability_J	0.8747	0.885	0.8656	0.8972	0.851	0.826	0.8729	0.859	0.83	0.894	0.834	0.857	0.764	0.713	0.86
Fisher_alpha	8.31	6.684	6.438	5.144	5.767	5.242	8.123	6.046	7.18	3.043	2.313	2.878	2.747	1.308	1.97
Berger-Parker	0.1376	0.189	0.2121	0.2148	0.216	0.264	0.1498	0.147	0.15	0.227	0.261	0.244	0.343	0.535	0.36
Chao-1	25	21	21	17	21	18.5	28	24.5	31	11	9	11	9	6	7
Plant litter %	18	20	16	18	17	24	12	18	15	7	14	11	11	8	18
Coarse materials	12	19	20	9	16	20	19	21	16	28	19	14	23	14	17
Bare soil %	9	17	18	13	5	16	34	27	25	12	16	8	15	13	13
RG%	82	75	79	71	68	79	45	56	53	87	79	75	82	71	67
Gravel%	72.84	74.56	85.86	35.04	82.04	72	62.76	63.6	61.2	91.96	75.1	62.45	63.53	49.58	31.9
Coarse sand %	18.84	17.94	10.6	9.73	5.8	8.81	12.07	16	16	1.96	3.77	6.2	19.93	20.56	24.7
Medium sand %	5.28	3.88	1.98	2.97	2.88	6.6	5.01	6.33	7.46	2.36	7.28	11.6	4.19	3.34	5.08
Fine sand %	2.18	1.6	1	7.38	3.83	2.59	15.64	9.02	4.16	1.2	5.35	11.36	9.58	16.72	27.4
Silt%	0.14	0.14	1.18	31.24	2.4	3.7	1.91	3.9	6.16	1.56	5.04	4.78	1.95	8.21	7.94
Clay %	0.72	1.88	0.38	13.64	3.05	6.3	2.61	1.1	5.01	0.91	3.49	3.58	0.79	1.57	2.9

3.2. Richness generic estimation

Ratio descriptive statistics of richness generic (RG%) differed across all of the sites studied are presented in **Table 3**. The sites R1. R10. and R13 were the most diverse in richness generic with 82%. 87%. and 82% respectively. R7 was the least richness site by 45%. Conversely. the highest levels of bare soil were found in R7 with 34%. The lowest Bare soil values were recorded in sites R5 and R12 with respectively 5% and 8%. Overall. species Dominance was higher in R7. R8 and R9 Recording 247. 224. and 261 individuals. respectively. Compared to the R3. R13. and R15 sites. which had significantly. lower results of 99. 70. and 67 individuals. respectively. The higher Shannon index values indicate a rich and evenly distributed plant diversity along the watershed. The basis for Simpson's index is the likelihood that any two people chosen at random from an arbitrarily vast group will belong to the same species. One of the suitable habitats for the development of unbounded plant biodiversity throughout the watershed is indicated by the value reaching 1.

Table 3. The most representative plant species along a watershed in the semi-arid lands of Northeast Algeria.

	IndVal	***p* value**	**Feq**
Lolium perenne L.	0.67	0.001	38
Atractylis humilis L.	0.40	0.001	6
Onopordum acanthium L.	0.40	0.001	6
Lagurus ovatus L.	0.33	0.001	5
Erodium cicutarium L.	0.17	0.029	5

4. Discussion

Plants are exposed to a variety of environmental challenges during their lives. including heat. cold. drought. salinity. and so on. This has a significant impact on the plant's performance and is one of the most important elements in the distribution of plant species [24]. Plant biodiversity and its factors must be studied in order to have a better knowledge of semi-arid ecosystems and later aid rehabilitation efforts. The identification of correlations between the distribution of biological Species and environmental conditions can be aided by determining the vegetation. The plant composition and diversity of the semi-arid regions of Algeria are very variable.

Since the climate is basically an average of the weather over a long period of time. vegetation is important to the climate. In fact. the process of photosynthesis is responsible for building up atmospheric oxygen to the level we enjoy today (21% concentration). Plants also help keep our climate stable over time by offsetting temperature and moisture fluctuations through transpiration. Plants also use carbon dioxide during photosynthesis. which slightly offsets the amount of greenhouse gas released into the atmosphere through the burning of fossil fuels. Vegetation is necessary for normal weather and climate [25]. The physiological and physical properties of the vegetation affect the weather and climate by influencing the transfer of heat and by affecting the level of stored soil moisture. moisture that is available to the vegetation during a later period may influence the level of convective activity within a region during a subsequent season [26].

As in our study. the composition and the taxonomic and phylogenetic diversity of the plant communities of the semi-arid steppes in the rangelands of northeastern Algeria. The rarefaction and extrapolation curves applied to the whole steppe vegetation showed the predominance of species of the families *Asteraceae. Fabaceae.* and *Brassicaceae* [27,28]. This study gave a general overview of the aromatic profile of plants of semi-arid pastures in Algeria. The analysis of the botanical composition revealed the presence of species *(Atractylis humilis. Calendula arvensis. Filago pygmaea. Globularia alypum. Hordeum vulgare. Malva sylvestris. Plantago* sp. *Scolymus hispanicus. Sonchus asper* and *Thymus algeriensis*) with the dominance of the *Asteraceae* family [29]. The richness and plant diversity existed in semi-arid lands. The families *Asteraceae. Poaceae. Brassicaceae. Amaranthaceae.* and *Chenopodiaceae* were the most representative [30]. Since 1960. the steppe regions of North Africa have been subject to increasing desertification. including the degradation of traditional pastures. The initially dominant species (*Artemisia herbaalb*a. *Lygeum spartum* and *Stipa tenacissima*) have declined and have been progressively replaced by other species (*Atractylis serratuloides* and *Salsola vermiculata*) that are more tolerant of the new conditions. It is unclear whether these changes are due to anthropogenic reasons or climatic determinism [31].

5. Conclusion

The studies in semi-arid lands exhibit high diversity. as affirmed by multiple studies. This floristic diversity is closely tied to the region's soil and climatic conditions. Consequently. identifying the links between the distribution of biological kinds and environmental conditions can be aided by determining the vegetation. The results of inventory of the species obtained in the site of study. allowed to identify 49 species were found. classified into 21 families. with Asteraceae accounting for 34.69% of the species and Poaceae accounting for 14.28%. The other families are scantily represented. The vegetation cover adapts well to the semi-arid climate. demonstrating tolerance to semi-arid soil and thriving in challenging conditions. Consequently. we can utilize it for soil fertilization and prevention of erosion.

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