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Botanical Diversity of Arid Steppe in South East of Algeria (Biskra)

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ABSTRACT

In the light of climate change, it is important to acquire the information on the diversity of flora in order to ensure rational use of steppe rangelands. The present study aimed at diagnosing the botanical and the taxonomic diversity of the arid steppe plant communities in South East of Algeria. A total of 216 phytoecological sampling, were collected in three sites and one sample for each month during 2017 and 2018. The vegetation was analyzed using various species diversity parameters (abundance, species richness, life forms, alpha and beta diversity indices and disturbance index). Results show that 985 plant individuals were classified into 27 species, 27 genera and 14 families, with predominance of Chenopodiaceae and Asteraceae in the arid steppe of El-Haouch, and remarkable dominance of Chamaephytic and Therophytic plants in different phytoecological groups. The state of vegetation degradation in a susceptible environment on Algeria's rangeland in the South East which is confirmed by the low values of Shannon, Jaccard indices and the values of disturbance index ranged between 50 and 85.71%. The alpha diversity parameters of the different phytoecological groups have low values, which reflect a more fragile homogeneous ecosystem, unfavorable life conditions and the absence of certain species of high pastoral value.

Keywords: plant diversity, diversity parameters, arid steppe, plant communities.

INTRODUCTION

In arid and semi-arid regions, rangelands are important areas for the conservation of biodiversity in terms of species and habitats [Kideghesho et al., 2013], and are sources of livelihood for the communities; provide food for livestock and fauna, medicinal plants and other diverse ecosystem services [Abule et al., 2007; Selemani, 2020]. Algeria rangelands cover more than 8.4 % of the country's surface area [Neffar et al., 2018]. This transition area is located between the isohyets 400 mm in the North and 100 mm in the South [Aidoud et al., 2006].

In arid steppic rangelands, severe climatic conditions promoted the existence of a specialized plant community [Quezel and Santa, 1963; Slimani et al., 2010; Fatmi et al., 2020; Merdas et al., 2021].

The vegetation in Algerian steppe, occupies an area of 15 M ha. This vegetation is dominated by *Stipa tenacissima*, *Artemisia herba-alba*, *Lygeum spartum* and *Atriplex halimus* [Le Houérou, 2001]. Plant communities including *Aristida pungens*, *Artemisia campestris*, *Arthrophytum scoparium*, *Atractylis serratuloides*, *Noaea mucronata*, *Peganum harmala*, *Retama retam*, *Salsola vermiculata*, and *Thymelaea microphylla* are species that tolerate difficult environmental conditions [Nedjraoui and Bedrani 2008; Boughani et al., 2009; Boughani, 2014; Lahmar-Zemiti and Aidoud, 2016; Belala et al., 2018; Senoussi et al., 2021]. According to Hubert [1994], the specific diversity of steppic vegetation is an opportunity for livestock grazing.

Over the last three decades, steppic rangelands have suffered from rapid degradation [Slimani et al., 2010] by climatic factors [Bensmira et al., 2015] and human activities such as overgrazing. The impact of overgrazing is reflected by the rarefaction and even disappearance of some useful plant species with high forage value, the abundance and even dominance of some less palatable species, and the development of unpalatable species [Ghiloufi et al., 2015]. However, the area of grazing rangeland has decreased at the expense of marginal crops [Demnati et al., 2017].

The steppic rangelands of the region of Biskra have very diverse natural resources and benefits. Indeed, despite its importance, few studies such as Haoumel [2018] and Chaouch Khaoune [2018], have been conducted in this region. In addition, agropastoralism in the region of El-Haouch remains the principal activity at local and regional level, it was noted that the number of sheep has increased from 20 475 heads in 1996 to 52 143 in 2019 [DPAT, 2021].

This study aimed to diagnose the botanic diversity in the region of El-Haouch (Biskra), with establishing phytoecological groups and analyzing plant species composition, in addition to the assessment of botanical diversity by estimating richness (annual and perennial plants), life forms, diversity (alpha and beta-diversity) and disturbance index.

MATERIAL AND METHODS

Study area

The region of El-Haouch (34°33’43” N, 06°03’05” E) is located in the South of Biskra (southeastern Algeria) (Fig. 1). Climate is arid. During the period 1987-2019, precipitation was marked by low amounts (152 mm) and high irregularity (49 mm in 2017 to 343 mm in 1994),

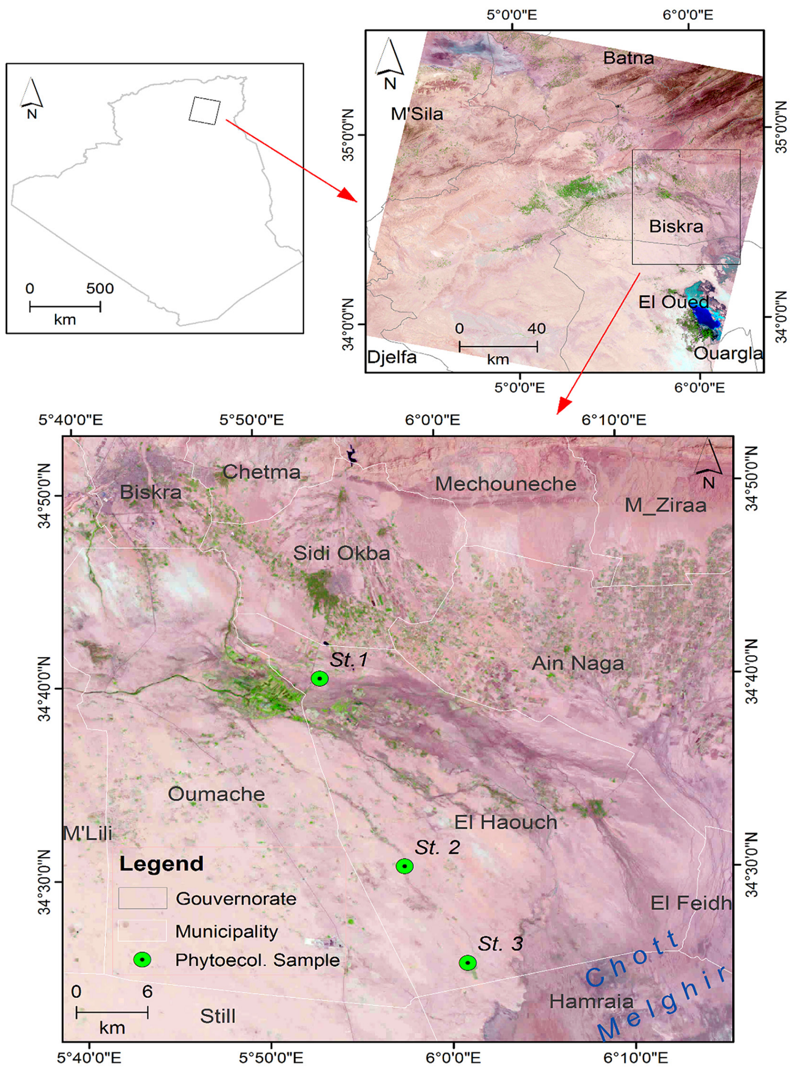


Figure 1. Geo-localization map showing the phytoecological sampling sites in South East of Algeria (Biskra)

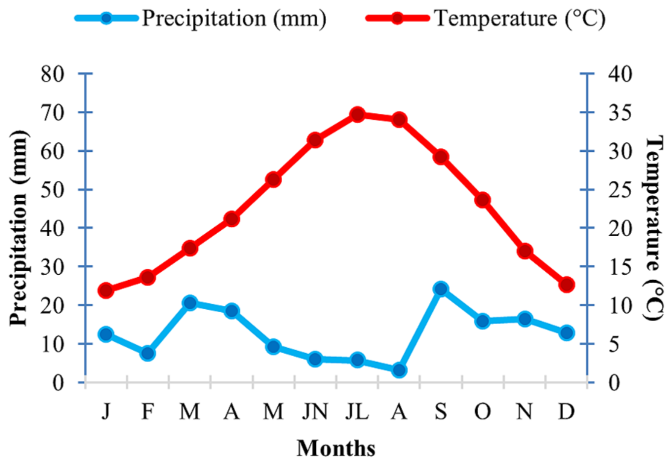


Figure 2. Diagram of Gaussen and Bagnouls applied for the region of Biskra (southeast Algeria), where mean temperature in (°C) and precipitation in (mm) are monthly averages on log-term climatic data from 1987 to 2019

maximum temperatures are higher than 26 °C throughout the year, reaching 40 °C in July and August, minimum temperatures can reach 7 °C in winter and 28 °C in summer, annual relative humidity ranges around 41%, with long dryness period (Fig. 2).

Phytoecological sampling sites were selected according to altitude, geomorphology of the landscape and homogeneity of ecological conditions (Fig. 1).

The soils of the samples sites have poor physicochemical characteristics, in which pedological analyses reveal that sites have highly saline soils (electrical conductivity included = 10.2 dS/m at site 3), which are typically sandy and slightly alkaline (pH = 7.42–8.49), highly deficient in organic matter (0.25–1.76%) and moderately calcareous ($CaCO_3$ content varies from 22.01 to 32.75%).

Data and methods

The conducted study consists in carrying out a short-term monitoring in the arid steppe rangelands in South-East Algeria, three sites (Fig. 1) were selected; site 1 (altitude =17 m), site 2 (altitude = 11 m) and site 3 (altitude = -18 m). Phytoecological sampling was conducted, one sample by month during 2017 and 2018, following a subjective sampling the most simple, 216 samples were collected on floristically homogeneous and representative areas, with a minimum area of 100 m² (10×10 m) according to [Djebaili, 1984; Chalane, 2012; Yahiaoui, 2011; Arabi et al., 2015; Amrani, 2021].

For each sample and specie, its abundance-dominance index was noted from + to 5 according to the scale of Braun-Blanquet et al. [1952]. The identification of existing species was determined referring to several authors Quézel and Santa [1962–1963] and Ozenda [1977], in addition to online resources (www.telabotanica.org).

Individualization of phytoecological groups

On the basis of agglomerative hierarchical clustering (AHC), abundance-dominance data for each plant species surveyed in the 216 samples were used to establish homogeneous phytoecological groups [Bouallala et al., 2020]. The AHC considers similarities between surveys within the same group to discriminate subgroups of very similar surveys [Mecheroum et al., 2021].

Taxonomic structure

The taxonomic structure of each phytoecological group was calculated using the ratios of family richness to species richness (F/S) for each sample. The taxonomic structure of the different phytoecological groups depends on environmental conditions. However, the relationship between taxonomic relationships and ecological variables in this environment were examined using Pearson correlation tests.

Life cycle

The determination of morphological types, annual and perennial species, was based on the work of Quézel and Santa [1962; 1963] and Ozenda [2004].

Life form

According to Raunkiaer's classification [revised by Ellenberg and Mueller-Dombois, 1967], plants can be classified according to their biological form "life form" determined by the phenological state of the species that reflects the expression of its adaptation to its environment, which is related to the protection of the meristem from the soil surface during the unfavorable season. The following main life forms were considered: Chamaephytes, Hemicryptophytes, Phanerophytes and Therophytes.

Alpha diversity

Species richness (S): total number of species present in a given sample site [Magurran, 2004]. Shannon diversity index (H'). S: the specific richness in the sampled site, ni: number of individuals of species i in the sampled site, N = total number of individuals of species S.

$$H' = -\sum_{i=1}^{s}\left(\frac{ni}{N}\log_2\frac{ni}{N}\right) \quad (1)$$

The evenness index "E", was calculated as the ratio between the Shannon diversity index, where S is the specific richness in the sampled site and the theoretical maximum diversity.

$$E = H' / \log_2 s \quad (2)$$

$$H'_{max} = \log_2 s \quad (3)$$

Beta diversity

Spatial similarity between different phytoecological groups was assessed by Vann's diagram and qualitatively by Jaccard (J) and Sørensen indices (S).

$$J = \frac{a}{a+b+c} \quad (4)$$

where: a – the total number of species present in both sites;
b – the number of species present only in the first site;
c – the number of species present only in the second site. [Benkhettou et al., 2022].

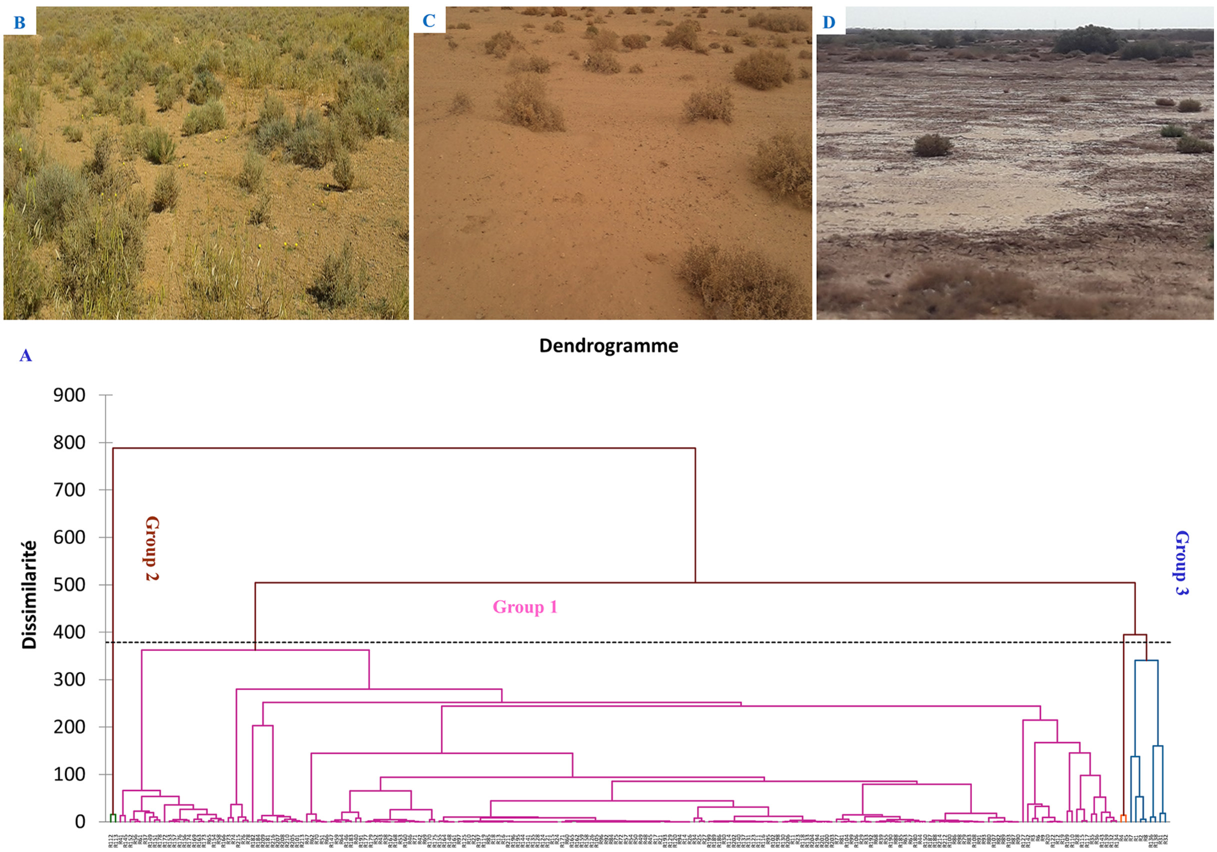


Figure 3. Agglomerative hierarchical clustering showing the phytoecological groups of plant in arid steppe of southeast Algeria (Biskra) (A). B: steppe of *Atriplex halimus* and *Tamarix gallica* (Group 1), C: steppe of *Retama retam* and *Thymelaea microphylla* (Group 2), D: steppe of *Atriplex halimus* and *Suaeda vermiculata* (Group 3)

$$S = \frac{2c}{2c + a + b} \quad (5)$$

where: a – the number of species unique in site 2, c – the number of species unique in site 1, b – the number of species common to site 1 and 2 [Sorensen, 1948; Wolda, 1981; Rahman et al., 2019].

Disturbance index

The disturbance index was calculated to measure the rate of therophytization in the different phytoecological groups [Loisel and Gamila, 1993].

$$Id(\%) = \frac{Th + Ch}{S} \quad (6)$$

where: Th – the number of therophytes; Ch – the number of chamaephytes; S – the species richness.

RESULTS

Phytoecological groups

The agglomerative hierarchical clustering (Fig. 3) allowed individualizing three different groups during two years; group (G1),represents a rangeland established on wadi beds, it included (15; 17) species belonging to 10 families where *Atriplex halimus* and *Tamarix gallica* dominate (56%; 2017, 63%; 2018); group (G2), is a sandy soil, the number of species recorded is (6; 8) species in year 2017, 2018 respectively, belonging to (4; 6) families with *Retama retam* and *Thymelaea microphylla* as characteristic species of the vegetation, these are psammophytes on aeolian formations; group (G3), near to chott Melghir characterized by salty accumulations dominated by *Atriplex halimus* and *Suaeda vermiculata* where (7 ; 9) species and 4 families were reported.

Floristic composition

During the study period, a total of 985 individuals belonging to 27 species, 27 genera and 14 families were recorded in the arid steppe rangelands of the El-Haouch region (Table 1). The plant communities are particularly dominated by the Chenopodiaceae (29.03%) of which six species *Anabasis articulata*, *Atriplex halimus*, *Salsola tetrandra*, *Spinacia oleracea*, *Suaeda vermiculata*, *Traganum nudatum*, followed by Asteraceae (15%) represented by five species *Artemisia campestris*, *Atractylis aristata*, *Centaura pungens*, *Echinops spinosus*, *Rhantherium suaveolens*, Fabaceae (15%) and Poaceaes (10%) by three species. Amaranthaceae, Boraginaceae, Euphorbiaceae, Globulariaceae, Lamiaceae, Malvaceae, Rhamnaceae, Tamaricaceae, Thymeliaceae, Zygophyllaceae were represented by one species (2%) (Table 2).

Moreover, based on the relative frequencies of botanical families, in the three phytoecological groupings, there are three dominant families in these arid rangelands, where Chenopodiaceae have the highest frequency (57.14%; 2017 and 56%; 2018) in the rangelands of salt accumulation (G3). The plant communities of the rangelands established on the wadi bed (G1) are dominated particularly by Chenopodiaceae and Asteraceaes 20% (2017) and 24% in year 2018. The rangelands of the aeolian formations (G2) dominated by Fabaceae 33.33% (2017) and Chenopodiaceae 25% (2018).

In terms of relative abundances, the plant species with the highest relative abundances (RA) are: 1) *Atriplex halimus* (38%; 2017 and 46.49%; 2018) and *Tamarix gallica* (30.14%; 2017 and 36%; 2018) at the level of wadi bed rangelands, while *Thymelaea microphylla* (40%, 34%), *Retama retam* (30%, 31.01%) *Aristida pungens* (5%, 27.27%) in 2017 and 2018, respectively, are the most abundant in the rangelands of aeolian formations, and in the rangelands of saline accumulations, *Suaeda vermiculata* (44%; 2017) and *Atriplex halimus* (26.04%; 2017 and 41% ; 2018) remains the most common.

Taxonomic structure and effect of ecological processes

The ratio (F/S) is 0.76 ± 0.35 (2017) and 0.91 ± 0.22 (2018). Pearson's correlation test showed significantly positive correlations ($r_{G1\text{-}G2} = 0.240$; $p_{G1\text{-}G2} = 0.002$ (<0.05)) between the phytoecological groups; G1 (Wadi beds) and G2 (aeolian formations); this indicated that variations in the F/S (Family/Species) ratio are related to local environmental conditions (Table 3).

Table 1. Systematic list of families, genre, lifecycle forms and plant species identified in arid steppe of southeast Algeria (Biskra) (P: Perennial, A: Annual, +: Presence, -: Absence)

Family	Genre	Species	2017				2018		
			Lifecycle forms	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
Amaranthaceae	Arthrocnemum	*Arthrocnemum glaucum* (Moric.) K. Koch	P	-	-	+	-	-	+
Asteraceae	Artemisia	*Artemisia campestris* L.	P	+	-	-	+	-	-
	Atractylis	*Atractylis aristata* Batt.	P	+	-	-	+	-	-
	Centaurea	*Centaura pungens* Pomel.	A	-	-	-	+	-	-
	Echinops	*Echinops spinosus* L.	A	-	+	-	-	+	-
	Rhanterium	*Rhantherium suaveolens* Desf.	P	+	-	-	+	-	-
Boraginaceae	Echium	*Echium vulgare* L.	A	-	-	-	+	-	-
Chenopodiaceae	Anabasis	*Anabasis articulata* Forssk.	P	+	+	+	+	++	+
	Atriplex	*Atriplex halimus* L.	P	+++	-	+	+++	+	++
	Salsola	*Salsola tetrandra* Forssk.	P	-	-	+	-	-	+
	Spinacia	*Spinacia oleracea* L.	A	+	-	-	+	-	-
	Suaeda	*Suaeda vermiculata* Forssk.	P	-	-	++	-	-	+
	Traganum	*Traganum nudatum* Delile.	P	-	-	-	-	-	+
Euphorbiaceae	Euphorbia	*Euphorbia cornuta* Forssk.	A	+	-	-	-	-	-
Fabaceae	Astragalus	*Astragalus armatus* Willd.	P	+	+	-	+	+	+
	Cassia	*Cassia italica* Mill.	P	-	-	-	+	-	-
	Retama	*Retama retam* (Forssk.) Webb	P	-	++	-	-	+	+
Globulariaceae	Globularia	*Globularia alypum* L.	A	+	-	-	+	-	-
Lamiaceae	Ballota	*Ballota hirsuta* (Willd).	A	+	-	-	-	-	-
Malvaceae	Malva	*Malva aegyptiaca L.*	A	+	-	-	+	-	-
Poaceae	Aristida	*Aristida pungens* Desf.	P	-	+	-	-	+	-
	Cynodon	*Cynodon dactylon* L.Pers.	A	+	-	-	+	-	-
	Lolium	*Lolium multiflorum* Lam.	A	+	-	-	+	-	-
Rhamnaceae	Ziziphus	*Zizyphys lotus* (L). Lam.	P	-	-	-	+	-	-
Tamaricaceae	Tamarix	*Tamarix gallica L.*	P	++	-	+	+++	+	+
Thymeliaceae	Thymelaea	*Thymelaea microphylla* Coss. & Durieu ex Meisn.	P	-	++	-	-	++	-
Zygophyllaceae	Peganum	*Peganum harmala* L.	P	+	-	+	+	-	-

Life cycle

On the basis of abundance, perennial species are dominated in the different phytoecological groups; group 1 (89%; 89%), group 2 (92.07; 99.46%), and group 3 (98; 100%) in 2017 and 2018, respectively. The life cycle forms with the highest frequency of occurrence in the surveys were the perennials in group 1 (37.30%; 25%), group 2 (29%; 33.33%), and group 3 (29.17%; 30%) in 2017 and 2018, respectively (Fig. 4).

Life forms

Except for the rangelands established on wadi beds, chamaephytes species have the highest values in the biological spectra of life forms in the rangelands of aeolian formations (G2) and saline accumulation rangelands (G3) with (50 ± 0; 74.60 ± 4.49), respectively (Table 4). Therophytes (34.71±7.49) are dominant in wadi beds rangelands (G1), geophytes are observed only in these rangelands with 13.33% and 17.65% in year

Table 2. Frequencies of plant families (%) in arid steppe of southeast Algeria (Biskra). Overall value is given as means with standard deviation

Family	Wadi beds (%)			Aeolian formations -Dunes (%)			Salty accumulations -Depression (%)		
	2017	2018	Overall	2017	2018	Overall	2017	2018	Overall
Amaranthaceae	0.00	0.00	0.00 ± 0.00	0.00	0.00	0.00 ± 0.00	14.29	11.11	12.70 ± 2.24
Asteraceae	20.00	23.53	21.76 ± 2.50	16.67	12.50	14.58 ± 2.95	0.00	0.00	0.00 ± 0.00
Boraginaceae	0.00	5.88	2.94 ± 4.16	0.00	0.00	0.00 ± 0.00	0.00	0.00	0.00 ± 0.00
Chénopodiaceae	20.00	17.65	18.82 ± 1.66	16.67	25.00	20.83 ± 5.89	57.14	55.56	56.35 ± 1.12
Euphorbiaceae	6.67	0.00	3.33 ± 4.71	0.00	0.00	0.00 ± 0.00	0.00	0.00	0.00 ± 0.00
Fabaceae	6.67	11.76	9.22 ± 3.60	33.33	25.00	29.17 ± 5.89	0.00	22.22	11.11 ± 15.71
Globulariaceae	6.67	5.88	6.27 ± 0.55	0.00	0.00	0.00 ± 0.00	0.00	0.00	0.00 ± 0.00
Lamiaceae	6.67	0.00	3.33 ± 4.71	0.00	0.00	0.00 ± 0.00	0.00	0.00	0.00 ± 0.00
Malvaceae	6.67	5.88	6.27 ± 0.55	0.00	0.00	0.00 ± 0.00	0.00	0.00	0.00 ± 0.00
Poaceae	13.33	11.76	12.55 ± 1.11	16.67	12.50	14.58 ± 2.95	0.00	0.00	0.00 ± 0.00
Rhamnaceae	0.00	5.88	2.94 ± 4.16	0.00	0.00	0.00 ± 0.00	0.00	0.00	0.00 ± 0.00
Tamaricaceae	6.67	5.88	6.27 ± 0.55	0.00	12.50	6.25 ± 8.84	14.29	11.11	12.70 ± 2.24
Thymeliaceae	0.00	0.00	0.00 ± 0.00	16.67	12.50	14.58 ± 2.95	0.00	0.00	0.00 ± 0.00
Zygophyllaceae	6.67	5.88	6.27 ± 0.55	0.00	0.00	0.00 ± 0.00	14.29	0.00	7.14 ± 10.10

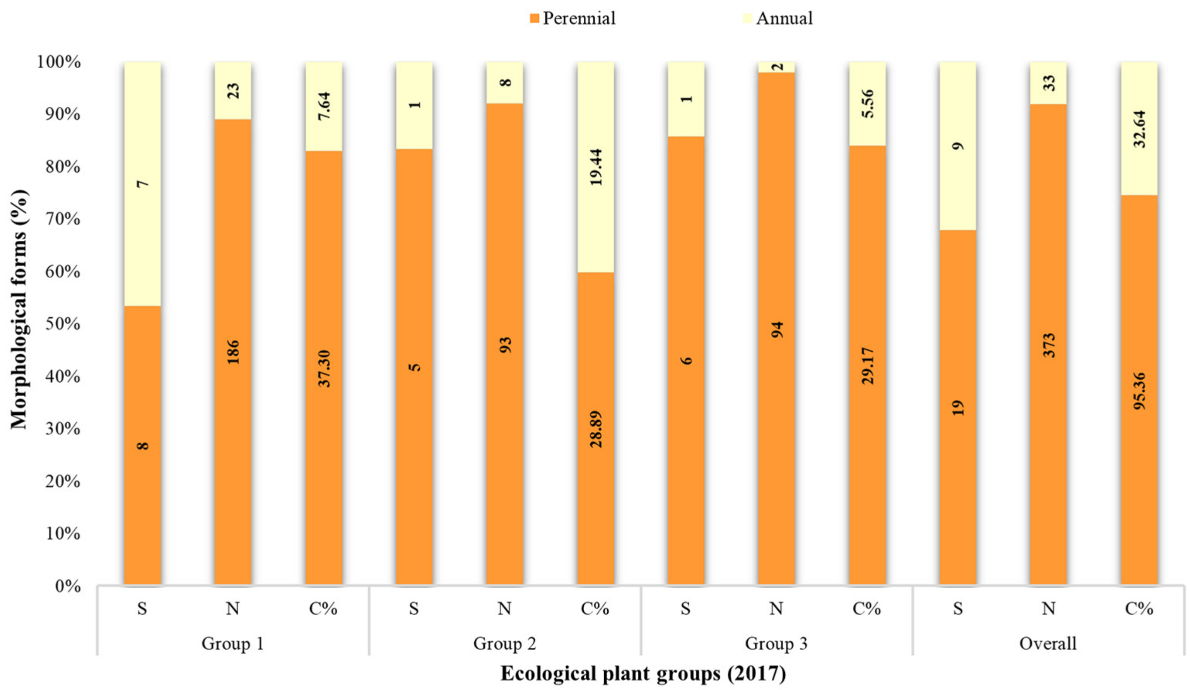
Table 3. Descriptive statistics of ration of family richness to species richness (F/S) and Pearson correlation tests (r: correlation coefficient, *P*: *P*-value) between the taxonomic ration (F/S) and phytoecological groups in arid steppe of southeast Algeria (Biskra)

Variables		Family/Species (F/S) ration (2017)				Family/Species (F/S) ration (2018)			
		Group 1	Group 2	Group 3	Overall	Group 1	Group 2	Group 3	Overall
Mean		0.856	0.784	0.635	0.758	0.952	0.896	0.873	0.907
Standard deviation		0.287	0.500	0.555	0.447	0.184	0.311	0.190	0.228
Quartile		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Minimum		0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.167
Maximum		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Pearson correlation tests									
Group 1	*r*	1	0.012	0.001	0.338	1	0.240	0.009	0.416
	p	0	0.522	0.830	0.451	0	0.002	0.589	0.197
Group 2	*r*	0.012	1	0.047	0.353	0.240	1	0.031	0.424
	p	0.522	0	0.203	0.242	0.002	0	0.308	0.103
Group 3	*r*	0.001	0.047	1	0.350	0.009	0.031	1	0.346
	p	0.830	0.203	0	0.344	0.589	0.308	0	0.299

2017, 2018, respectively. Phanerophytes are represented by (*Tamarix gallica*, *Zizyphys lotus* and *Retama retam*), occurring in different phytoecological groups. Hemicryptophytes are 6.27 ± 0.55 at the courses of wadi beds (G1) and 29.17 ± 5.89 in the rangelands of aeolian formation (G2).

Alpha diversity

For the whole study area, the species richness was 3.11 ± 0.99 (G1; 2017), 1.30 ± 1.61 (G2; 2017) and 1.5 ± 1.59 (G3; 2017) and for the year 2018 (2.77 ± 2.37), (2.13 ± 1.45) and (2.61 ± 1.29) for G1, G2 and G3, respectively. The number of individuals, in descending order, recorded values of 6.33 ± 5.41; 5.80 ± 5.32; 5.19 ± 4.04; 4.55 ± 2.15; 2.80 ± 2.94 and 2.66 ± 2.49 for (G1; 2018), (G1; 2017), (G2; 2018), (G3; 2018), (G2; 2017) and (G3; 2017), respectively. The Shannon index is 1.25 ± 0.87; 1.11 ± 0.73 for group 1 in 2017;2018. Group 2 in 2017;2018 with varied values of 0.61 ± 0.74;1.02 ± 0.69 and 0.67 ± 0.73 (G3; 2017); 1.22 ± 0.58 (G3; 2018). Shannon index values in 2017, differed significantly between phytoecological groups, with H’ showing higher values in G1 and G3



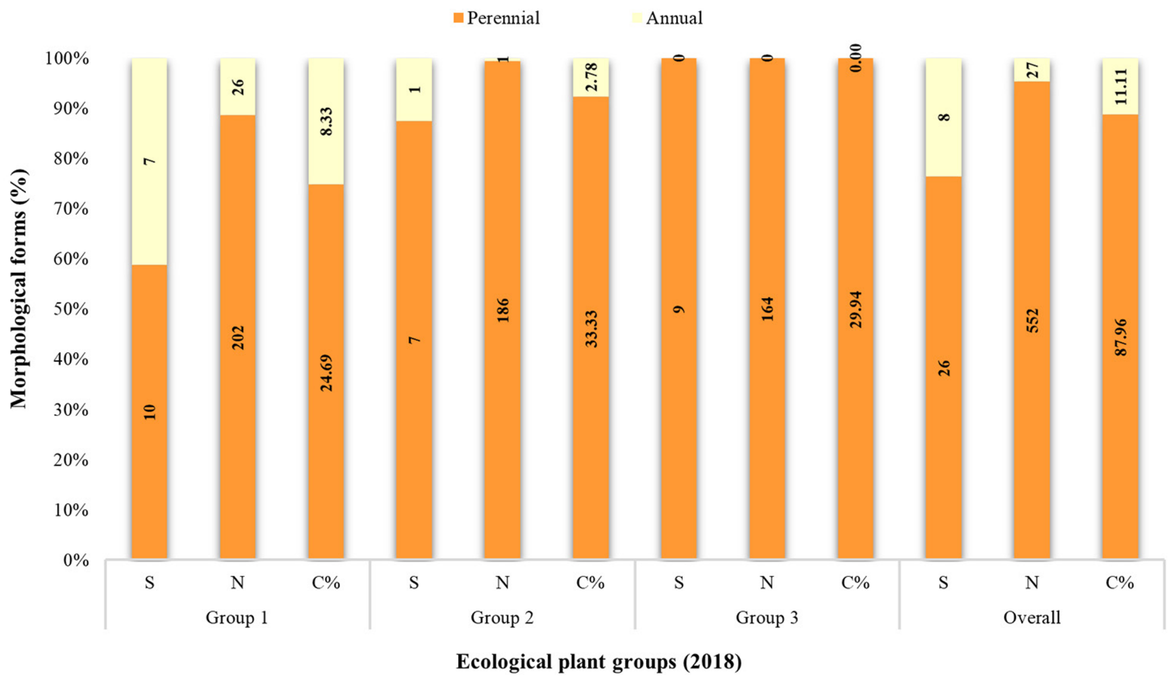


Figure 4. Species richness (S), Number of individuals (N) and occurrence frequency (C%) of different lifecycle types for phytoecological groups of vegetation recorder in arid steppe of southeast Algeria (Biskra)

Table 4. Value of life forms (%) of plant in arid steppe of southeast Algeria (Biskra). Overall value is given as means with standard deviation

Plant	Wadi beds (%)			Aeolian formations -Dunes- (%)			Salty accumulations -Depression- (%)		
	2017	2018	Overall	2017	2018	Overall	2017	2018	Overall
Chamaephytes	33.33	35.29	34.31 ± 1.39	50	50	50 ± 0	71.43	77.78	74.60 ± 4.49
Phanerophytes	6.67	11.76	9.22 ± 3.60	16.67	25	20.83 ± 5.89	14.29	22.22	18.25 ± 5.61
Therophyte	40	29.41	34.71 ± 7.49	0	0	0.00 ± 0.00	14.29	0	7.14 ± 10.10
Geophytes	13.33	17.65	15.49 ± 3.05	0	0	0.00 ± 0.00	0	0	0.00 ± 0.00
Hemicryptophyte	6.67	5.88	6.27 ± 0.55	33.33	25	29.17 ± 5.89	0	0	0.00 ± 0.00

compared to G2 (one-factor ANOVA: F = 7.148, P < 0.001), while H' values in 2018, were non-significant (one-factor ANOVA: F = 0.840, P = 0.434 (>0.001)). For all phytoecological groups, the H'; 2017 and H'; 2018 relationships were significant and showing higher values in 2018 (one-factor ANOVA: F = 7.516, P < 0.001).

The highest values of maximum diversity were noted in G1; 2017 (1.41 ± 0.99) and G3; 2018 (1.31 ± 0.59), while it averaged (0.64 ± 0.78) and (0.74 ± 0.76) in the (G2, G3; 2017). The evenness showed high values ranging from 0.79 ± 0.32 (G1; 2018) and 0.85 ± 0.29 (G3; 2018) (Fig. 5).

Similarity analysis between phytoecological groups

The Venn diagram showed that (1; 4) plant species were common to all phytoecological groups in year 2017; 2018, respectively, including four species common between groups G1 and G2 in 2018, and five species common to groups G2 and G3 in 2018. Of the 27 plant species recorded in the conducted study, 4 species were exclusively present in group 2 in 2017, 10 species in group 1 in 2017, and 4 species in G3 in 2018 (Fig. 6).

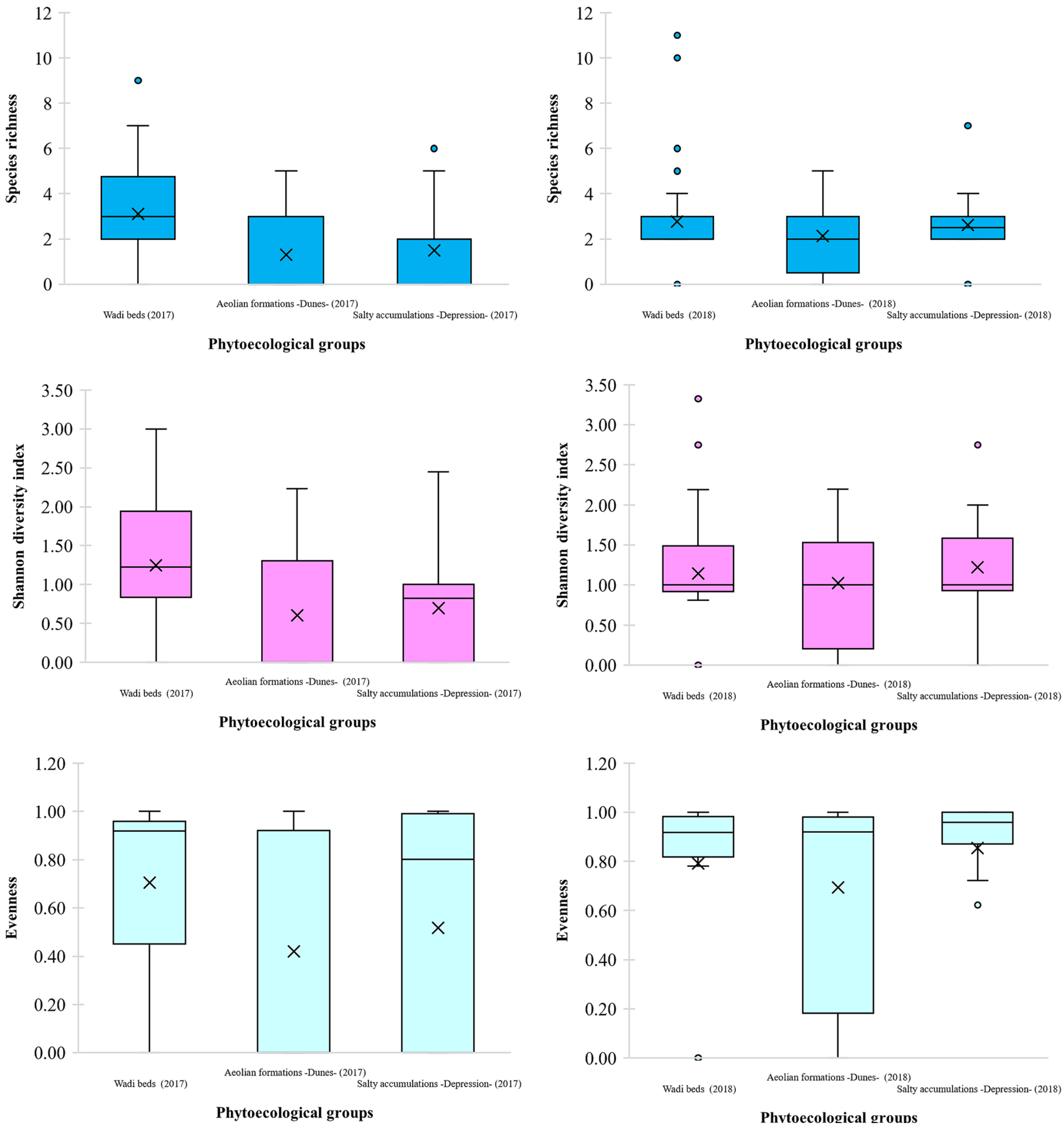


Figure 5. Diversity alpha traits for phytoecological groups of the vegetation in arid steppe of southeast Algeria (Biskra)

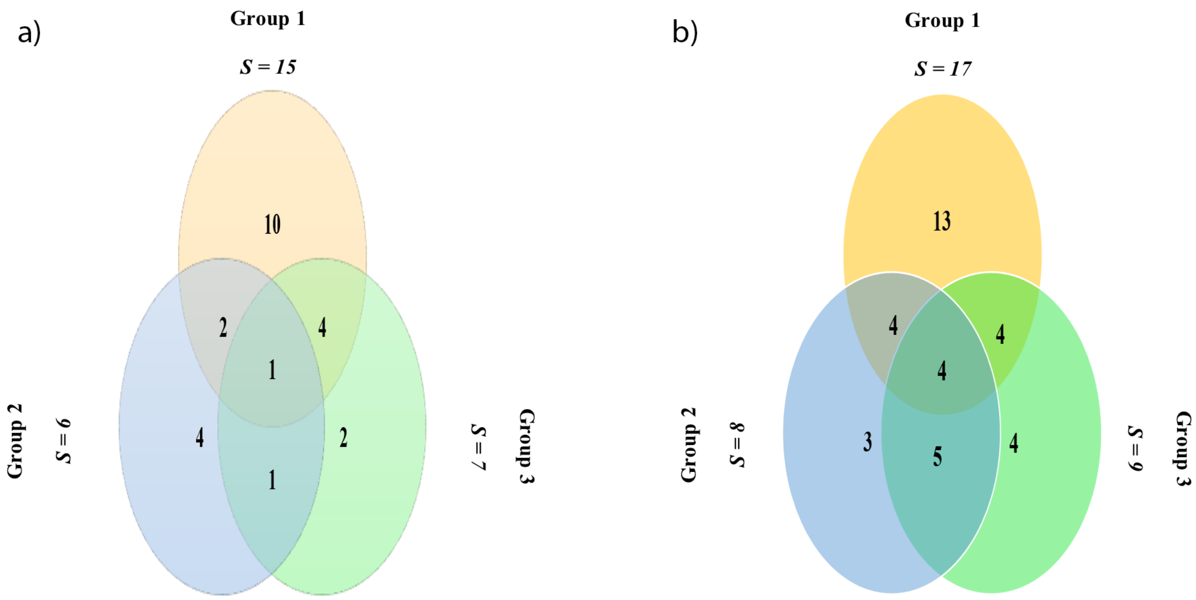


Figure 6. Venn diagram displaying plant species richness (S) recorded at various ecological groups of the vegetation associated to arid steppe of southeast Algeria (Biskra) (A): 2017, (B): 2018

Beta diversity

The similarity analysis showed the presence of only one common species between the three phytoecological groups in 2017 (*Anabasis articulata*), and four species *Anabasis articulata*, *Atriplex halimus*, *Astragalus armatus* and *Tamarix gallica*, in 2018 in the three phytoecological groups.

Of the 27 species reported in the arid steppe rangelands of the El-Haouch region, thirteen were exclusive to G1 (*Artemisia campestris*, *Atractylis aristata*, *Rhantherium suaveolens*, *Echium vulgare*, *Spinacia oleracea*, *Euphorbia cornuta*, *Cassia italica*, *Globularia alypum*, *Ballota hirsuta*, *Malva aegyptiaca*, *Cynodon dactylon*, *Lolium multiflorum* and *Zizyphys lotus*), Three for G2 (*Echinops spinosus*, *Aristida pungens* and *Thymelaea microphylla*) and four species for G3 (*Arthrocnemum glaucum*, *Salsola tetrandra*, *Suaeda vermiculata* and *Traganum nudatum*).

The similarity analysis (beta biodiversity) between the three phytoecological groups taken two by two showed Jaccard index values ranging from 0.08 to 0.42. The low similarity observed between the different phytoecological groups is explained by a low specific richness in the different phytoecological groups. Therefore, the species are totally different indicating that the different local environmental conditions determine a turn-over of important species. The Sørensen index values ranged from 0.40 to 0.81 between G2 and G3 in 2018, G1 and G2 in 2017, respectively (Table 5).

Disturbance index

The disturbance index becomes important when the area is increasingly degraded. Indeed, during both years, i.e. 2017 and 2018, this index

Table 5. Similarity indices between phytoecological groups in arid steppe of southeast Algeria (Biskra)

Pair comparisons	Group 1 Group 2		Group 1 Group 3		Group 2 Group 3	
	2017	2018	2017	2018	2017	2018
Jaccard index	0.11	0.19	0.22	0.18	0.08	0.42
Sørensen index	0.81	0.76	0.76	0.74	0.59	0.40

Table 6. Value of disturbance index (%) evaluated in arid steppe of southeast Algeria (Biskra). Overall value is given as means with standard deviation

Parameter	Wadi beds			Aeolian formations -Dunes-			Salty accumulations -Depression-		
	2017	2018	Overall	2017	2018	Overall	2017	2018	Overall
Distrubance index (%)	73.33	64.71	69.02 ± 6.10	50	50	50 ± 0	85.71	77.78	81.75 ± 5.61

values are 64.02% in Wadi beds rangelands (2018) and 50% in aeolian formation rangelands which are moderately degraded and 73.33% in Wadi bed rangelands (2017) and (85.71%; 2017) (77.78 %; 2018) in salty accumulation rangelands that are severely degraded (Table 6).

DISCUSSION

On the basis of the results obtained from the analysis of 216 floristic samples and following the individualization of three phytoecological groups, the flora is dominated by the families of Chenopodiaceae, Asteraceae, Fabaceae and Poaceaes. Nevertheless, the number of 27 species remains relatively reduced in comparison with the results found by Mechroum et al. [2021] in the semi-arid steppe rangelands in northeastern Algeria, while Bouallala et al. [2022] identified 19 plant species classified in 18 genera and 13 families, the Asteraceae and Poaceae being the most important families in the Saharan rangelands of Ghardaia.

Fatmi et al., 2020 found that extensive rangelands mainly represented by *Atriplex halimus* and other species of Chenopodiaceae exist on saline soils in the Tebessa region. In this study, among the 14 families, 10 (32.25%) were represented by only one species per family, the high values of this coefficient reflect the essential characteristics of a low diversity desert flora. However, it is an indicator of strong species adaptation to xeric conditions [Chenchouni, 2012; Abd El-Khalik et al., 2017; Azizi et al., 2021; Mechroum et al., 2021; Bouallala et al., 2022].

In arid regions, most plant families are represented by only one or two genera and most genera by only one or two species [Boughani, 2014; Kouba et al., 2021; Mechroum et al., 2021; Azizi et al., 2021]. Correlation tests show that the differences in taxonomic structure can significantly remit from one plant community to another depending on its environmental conditions [Fan et al., 2017]. For example, the obtained results demonstrate that F/S taxonomic ratios increase in steppes of good ecological conditions (wadi beds rangelands and aeolian formations rangelands).

Perennial plants are characterized by morphological and anatomical adaptive strategies that consist mainly in an increase of the absorbing system and a reduction of the evaporating surface, allowing them to survive more or less long periods, depending on the degree of disturbance [Ozenda, 1991]. In the arid rangelands of southern Tunisia, perennial species are the essential component of these rangelands [Gamoun et al., 2010]. A strong and chronic anthropogenic disturbance can decrease the floristic richness and induce the replacement of woody species by perennial species whose floristic composition remains strongly linked to the effect of this disturbance on the soil properties [Mcintyre et al., 1995; Rodriguez et al., 2005; Salemkour et al., 2017]. Grazing promotes the development of annual species [Pfeiffer et al., 2019; Senoussi et al., 2021]. According to [Le Floc'h, 2000], annual species germinate only immediately after rainfall, they are opportunistic and ephemeral species, able to grow and flower rapidly. Their absence during the sampling period is due to drought [Gamoun et al., 2010]. Ghiloufi et al., [2015] proved that the overgrazing has been the main cause of this serious degradation by reducing perennial vegetation cover and consequently increasing erosion, and decreasing the number of palatable species, which can be replaced by unpalatable plant units resulting from a dynamic degradation with low functional performance as *Atractylis serratuloides* and *Astragalus armatus.*

The life forms based on species richness show a high level of chamaephytes in aeolian formation and salt accumulation rangelands, indicating their adaptation to the aridity of the Saharan climate [Chenchouni, 2012; Bouallala, 2013; Bradai et al., 2015; Gamoun et al., 2012; 2018]. The predominance of therophytes in the first phytoecological group is generally a critical indicator of hot and dry climate, human and animal interference [Abdel Khalil et al., 2017]. In arid and semiarid areas, champhytization and therophytization are strategies of adaptation of degraded steppe plant formations vis-à-vis anthropic and climatic pressures [Taibaoui et al.,2020].

Hemicryptophytes are represented by one species of the family Poaceae, one species of Euphorbiaceae, one species of Asteraceae and one species of Boraginaceae. Bouallala [2013] confirmed that the presence of hemicryptophytes in sandy soils and dunes is represented by psammophytes. The absence of geophytes in eolian formation and salt accumulation courses, confirming their regression in grasslands and steppe areas [Barbero et al., 1989; Henni et al.,2012]. The absence of this biological type in aeolian formation and saline accumulation rangelands is related to the climatic gradient favoring the development of short-lived species [Aidoud, 1983; Hachemi et al., 2015]. Phanerophytes are located in mesic habitats receiving irrigation water, such as wadi beds and irrigation channels [Bouallala, 2013; Bradai et al., 2015; Bouallala et al., 2020].

These very low values of alpha diversity alter the capacity of ecosystems to react to disturbances, thus reflecting a rarefaction or even disappearance of certain species, especially those of good pastoral value [Gamoun et al., 2010]. Similarly, Aïdoud [1989] measured an index of Shannon diversity of 2.69 and equitability of 0.5 in the Southern Oran steppes. This reduction is explained by a homogeneous system that is more fragile in its ecological contributions [N'zala, 1997]. According to [Dajoz, 1982], a low alpha diversity index reflects unfavorable living conditions. Low Jaccard index values indicate high dissimilarity in the floristic composition of different phytoecological groups [Neffar et al., 2018]. The recorded disturbance index rates show high anthropozoological pressure [Bekkouche et al., 2019; Zemmar et al., 2020].

CONCLUSIONS

The diagnostic of the botanic diversity can further explain the relationships between the species distribution and the environmental factors. This study showed that the plant composition is principally marked by the dominance of Chenopodiaceae and Asteraceae families, and the codominance of Chamaephytes and Therophytes, in different phytoecological groups; this particular situation favors the installation of Chamaephytization and the phenomena of Therophytization.

The alpha diversity parameters of the different phytoecological groups have low values, which reflect a more fragile homogeneous ecosystem, unfavorable life conditions and the absence of certain species of high pastoral value. The high dissimilarity observed between phytoecological groups reflects a state of degradation in this arid steppic rangeland. Biodiversity studies provide a more complete understanding of vegetation in arid steppe and its functioning in the ecosystem, by analyzing plant components and patterns at multiple spatial and temporal scales. The region of El Haouch remains a strong link in the agropastoral economy of Algeria, to preserve this fragile ecosystem, it is necessary to consider rational management programs to restore and improve the steppe vegetation cover.

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