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ECOLOGICAL CHARACTERIZATION OF NATURAL HABITATS OF SOME *VICIA* L. SPECIES (*FABACEAE*) IN NORTHEASTERN ALGERIA

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Abstract

Within the framework of the evaluation and development of plant genetic resources of fodder and pastoral interest in Algeria, a study was conducted on the characterization of the natural habitats corresponding to some *Vicia* species (*Fabaceae*). Following a prospecting and collection mission carried out across north-eastern Algeria (Blida, Boumerdes, Bouira, Tizi ouzou, Béjaia, Sétif), seven species were identified (*Vicia sativa, Vicia disperma, Vicia monardi, Vicia narbonensis, Vicia ochroleuca, Vicia onobrychoides* and *Vicia lutea*). Fifty (50) sites and five species were selected. For each site, three soil samples were randomly chosen. Sixteen (16) physico-chemical parameters were analysed (soil pH, conductivity, total limestone, total nitrogen, potassium, phosphorus, carbon, organic matter, C/N ratio, soil texture composition). Two (02) factors related to the topography (altitude) and climate (rainfall) of the natural habitats of the various vetches were also considered. The results of the variance analysis (anova and manova), applied to the physical and chemical characteristics of soils, indicated very highly significant variability in the majority of cases. Vetch species are adapted to soils of various textures, however, they are more frequently encountered on soils of balanced textures. Vetches are often found on soils of basic pH, less frequently on acidic or neutral soils. Many significant relationships have also been highlighted, particularly between most of the physico-chemical characteristics of the soils and some climatic and topographical factors (altitude, rainfall). The hierarchical analysis highlighted several groups of sites which confirming the observed variation. The work highlighted the wide capacity of *Vicia* species to adapt to different ecological conditions, particularly *Vicia sativa* and *Vicia disperma*. This work is a contribution to the conservation and enhancement of fodder legumes in Algeria, especially the endemic and rare ones, which would be threatened and endangered.

Key words: Adaptation, Ecological factors, Fodder legumes, Plant genetic resources, Soils, *Vicia* L.

Introduction

The legume family (*Fabaceae*) is widely represented throughout the world. Grain legumes provide food and feed and facilitate soil nutrient management while herbaceous can restore soil fertility and prevent land degradation which improves crop and livestock productivity on a more sustainable basis (Desalegn & Hassen, 2015). Legumes have also real nutritional value (Anon., 2016).

Within this family, the genus *Vicia* (*Fabaceae*) includes about 200 species concentrated particularly in temperate regions of the northern hemisphere (Fridlender, 2009). The Mediterranean region is its main centre of diversity (Naranjo *et al*., 1998).

In Algeria, the flora contains 3139 species (Quezel & Santa, 1962). More recently, 4449 taxa have been reported (Dobignard & Chatelain, 2013). Fodder legumes (*Fabaceae*) are represented by 33 genera comprising about 293 species (Issolah & Beloued, 2013; Issolah *et al*., 2011), among which, the genus *Vicia* L. contains twenty-six (26) species (Quezel & Santa, 1962). Dobignard & Chatelain (2012) reported thirty-nine (39) taxa in the genus *Vicia* including two (02) endemics (*V. ochroleuca* Ten. subsp. *atlantica* (Pomel) Greuter & Burdet and subsp. *baborensis* (Batt. & Trab.) Greuter & Burdet).

Annual species of the genus *Vicia* can be used as hay or grain for livestock feed (Mebarkia & Abdelguerfi, 2007). Several species belonging to the genus *Vicia* L. have demonstrated economic importance (El-Bok, 2014; Abozeid *et al*., 2017; Martin *et al*., 2018). In addition, some taxa are also grown as ornamental plants in parks and gardens (Martin *et al*., 2018). More than that, *Vicia* plants have been considered for treating many chronic diseases (Salehi *et al*., 2020).

Despite the large number of described taxa and the numerous interests established in this genus (*Vicia* L.), very little work has been done on Algerian spontaneous vetches (Bechkri *et al*., 2017a, 2017b), the majority of the species thus remaining unknown.

This study is part of the evaluation and valorization of plant genetic resources of fodder and pastoral interest in Algeria. The objective of this work is to characterize the natural habitats of species belonging to the *Vicia* genus in order to know the adaptation conditions of the different species and to be able to use them, in the medium and long term, in similar agro-edapho-climatic regions throughout the country. It is also a contribution to preserve and conserve the spontaneous vetches, particularly the rare and endemic ones, with a view to valorizing them and developing a strategy for the enhancement and development of fodder and livestock in Algeria.

This work follows and completes the previous studies conducted on fodder legumes in Algeria (Korichi & Issolah, 2013; Issolah *et al*., 2016; Bouziane *et al*., 2019; Chabouni *et al*., 2019), particularly the ecological ones that have been carried out on the genera *Hedysarum* L. (Issolah *et al*., 2012) and *Trifolium* L. (Issolah *et al*., 2015).

Material and Methods

Sites of study: A prospecting and collection mission of several populations belonging to various species of vetches (*Vicia* L.) was carried out by INRAA (Institut National de la Recherche Agronomique d'Algérie), in 2016, across north-eastern Algeria (Blida, Boumerdès, Bouira, Tizi ouzou, Béjaia, Sétif) (Fig. 1).

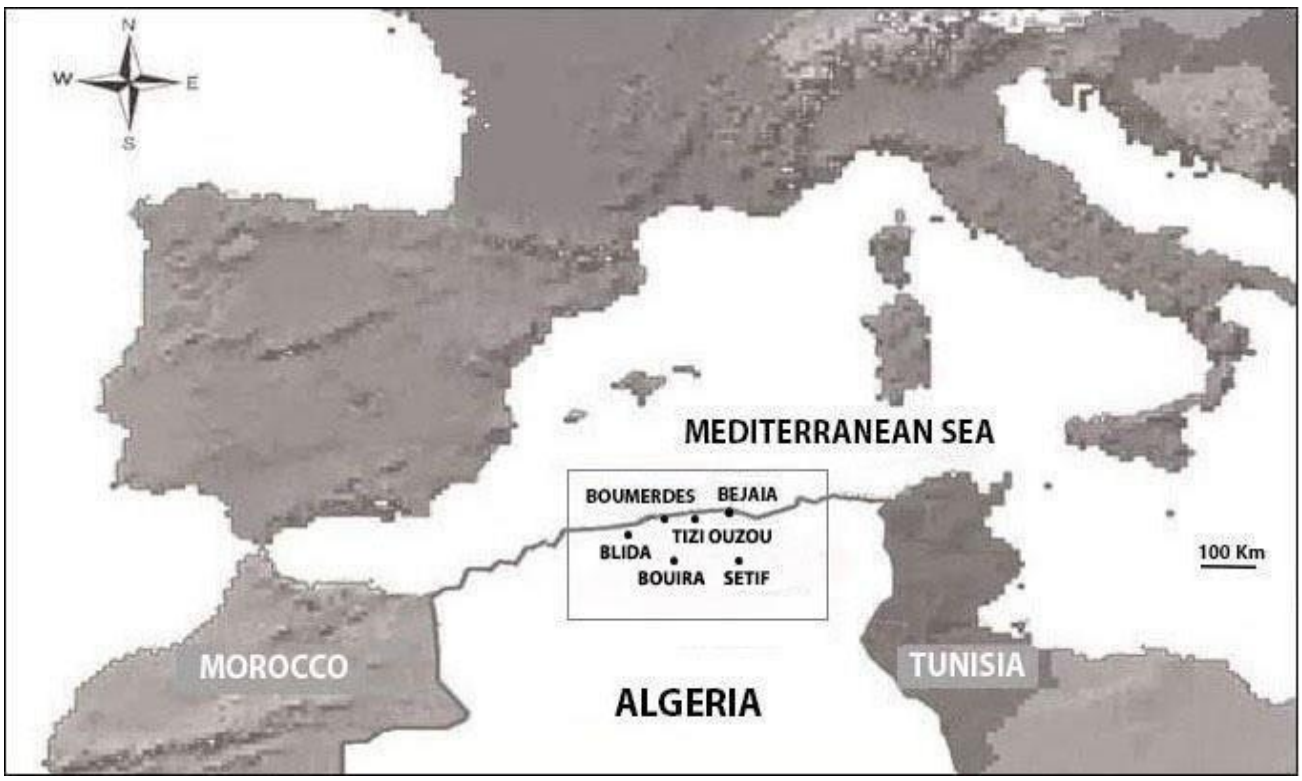

Fig. 1. Locations of natural populations of various *Vicia* L. species throughout the Northeastern Algeria.

The bioclimatic and topographic parameters: Two ecological factors related to the topography (altitude) and climate (rainfall) (ANRH, 1993) of the natural habitats, of the various *Vicia* L. species (Table 1), were considered.

The *Vicia* L. species and the associated species: The identification of vetch species has been carried out, in particular, on the basis of the new flora of Algeria and southern desert regions (Quezel & Santa, 1962) and the synonymic index of the flora of North Africa (Dobignard & Chatelain, 2012). We also used the herbarium of the INA (Institut National Agronomique / currently ENSA / El Harrach-Alger / Algeria). Other forage legumes (*Fabaceae*), encountered in association with vetches, were also reported.

The edaphic parameters: Fifty (50) sites, with at least one vetch population, have been identified. For each site, three soil samples were randomly collected, at a depth of 30 cm from the soil. A total of 150 soil samples were collected.

Each soil sample was subjected to a physico-chemical study based on various methods (Anon., 1986; Anon., 1993; Anon., 1990; Mathieu & Pieltain, 1998; Mathieu & Pieltain, 2003). Sixteen parameters were considered:

pHwater: Its determination was carried out on a soil suspension (soil / solution ratio = 1/2.5). Electrical conductivity (EC) (mmhos /cm): The measurements were carried out on a soil suspension (soil / solution ratio = 1 / 10).

Total limestone (T CaCO3) (%): The determination was carried out by Bernard's calcimeter method (gasometric method).

Total nitrogen (N) (%): This determination was made by the Kjedahl method.

Phosphorus (P_2O_5) (ppm): The determination of assimilable phosphorus was carried out by the Olsen method.

Potassium (K_2O) (ppm): The potassium determination was carried out by flame photometry. Extraction was carried out using ammonium acetate (1N).

Carbon (C) (%): Carbon was determined by the Anne's method.

Granulometry: This was carried out using the Robinson pipette according to the international method (Soltner, 1988). Soil texture was determined on the basis of its composition of Clay (A) (%), fine silt (FSi) (%), coarse silt (CSi) (%), total silt (TSi) (%), fine sand (FSd) (%), coarse sand (CSd) (%) and total sand (TSd) (%).

Following this analysis, two parameters were deduced:

Organic matter (OM): The organic matter rate was deduced by the formula: Organic carbon X 1.724.

C/N: This ratio gives an idea of the decomposition of organic matter.

Analyses of the data: The data (16 physico-chemical parameters analysed for each soil sample / total: 2400 data) were statistically processed (Anova one way, Manova). Additional analyses (correlation matrix, hierarchical analysis) were carried out on the site means, taking into account all the analysed edaphic parameters (soil pH, conductivity, total limestone, total nitrogen, potassium, phosphorus, carbon, organic matter, C / N ratio, composition of soil texture) as well as climatic and topographical factors (rainfall, altitude) characterizing the natural habitats of the different identified vetch sites. Statistical processing was carried out using MINITAB (2003) and EXCEL (2007).

Table 1. Ecological characteristics of the natural habitats of some *Vicia* L. species in Northeastern Algeria.

N of site	Origin	Altitude (m)	Rainfall (mm)	Species
5/16	Blida	1080	850	*Vicia disperma* DC.
6/16	Blida	1240	850	*Vicia disperma* DC.
7/16	Blida	1310	850	*Vicia sativa* L., *Vicia disperma* DC.
8/16	Blida	1200	850	*Vicia diperma* DC.
9/16	Blida	960	850	*Vicia disperma* DC.
11/16	Boumerdès	25	850	*Vicia sativa* L.
12/16	Boumerdès	35	850	*Vicia sativa* L.
13/16	Boumerdès	35	850	*Vicia narbonensis* L.
14/16	Boumerdès	50	850	*Vicia sativa* L.
15/16	Boumerdès	60	850	*Vicia sativa* L., *Vicia disperma* DC.
17/16	Boumerdès	65	850	*Vicia sativa* L.
18/16	Médéa	935	650	*Vicia sativa* L.
19/16	Médéa	940	650	*Vicia sativa* L.
20/16	Médéa	940	650	*Vicia sativa* L.
22/16	Médéa	1150	650	*Vicia sativa* L.
23/16	Médéa	1210	650	***Vicia sativa* L.**
24/16	Tizi Ouzou	110	950	*Vicia sativa* L.
26/16	Tizi Ouzou	120	950	*Vicia disperma* DC.
27/16	Tizi Ouzou	190	950	*Vicia sativa* L.
32/16	Tizi Ouzou	600	950	*Vicia sativa* L.
34/16	Tizi Ouzou	490	950	*Vicia disperma* DC.
35/16	Tizi Ouzou	490	950	*Vicia disperma* DC.
37/16	Bouira	580	500	*Vicia sativa* L.
38/16	Bouira	585	500	*Vicia narbonensis* L., *Vicia sativa* L.
39/16	Bouira	570	500	*Vicia narbonensis* L.
40/16	Bouira	800	500	*Vicia monardi* Boiss.
41/16	Bouira	940	500	*Vicia disperma* DC.
42/16	Sétif	890	650	*Vicia sativa* L.
43/16	Sétif	840	650	*Vicia sativa* L.
44/16	Sétif	720	650	*Vicia sativa* L.
45/16	Sétif	1110	650	*Vicia sativa* L.
46/16	Béjaia	855	700	*Vicia sativa* L.
47/16	Béjaia	880	700	*Vicia sativa* L., *Vicia disperma* DC.
48/16	Béjaia	560	700	*Vicia monardi* Boiss., *Vicia sativa* L.
49/16	Béjaia	550	700	*Vicia disperma* DC.
50/16	Béjaia	560	700	*Vicia sativa* L.
51/16	Béjaia	595	700	*Vicia monardi* Boiss.
52/16	Béjaia	1140	1100	*Vicia sativa* L., *Vicia ochroleuca* Spreng. *Trifolium stellatum* L., *Medicago* sp.
53/16	Béjaia	1160	1100	*Vicia sativa* L.
54/16	Béjaia	1170	1100	*Vicia sativa* L.
55/16	Béjaia	1250	1100	*Vicia ochroleuca* Spreng., *Vicia sativa* L. *Trifolium* sp., *Medicago* sp.
56/16	Béjaia	25	950	*Vicia sativa* L.
57/16	Béjaia	25	950	*Vicia disperma* DC.
58/16	Béjaia	60	950	*Vicia sativa* L.
59/16	Béjaia	60	950	*Vicia sativa* L.
60/16	Béjaia	130	950	*Vicia sativa* L., *Vicia disperma* DC.
61/16	Béjaia	85	950	*Vicia disperma* DC.
63/16	Béjaia	160	950	*Vicia sativa* L.
64/16	Béjaia	420	950	*Vicia sativa* L.
65/16	Béjaia	450	950	*Vicia sativa* L., *Medicago* sp., *Trifolium* sp.

Results and Discussion

Prospecting and collection: Prospecting carried out across north-eastern Algeria (Fig. 1) identified seven (07) species belonging to the genus *Vicia* L. (*Vicia sativa* L., *Vicia disperma* DC., *Vicia monardi* Boiss., *Vicia narbonensis* L., *Vicia ochroleuca* Spreng., *Vicia onobrychoides* L.and *Vicia lutea* L.) (Table 1). Although Quezel & Santa (1962) reported the existence of twenty-six (26) species of vetches in Algeria, the number of species encountered through our prospecting and collection proved to be much lower (07), equivalent to about a quarter of the species previously reported through the Algerian flora. This reveals the rarity or probable disappearance of certain species not encountered throughout all the prospected regions (Blida, Boumerdès, Bouira, Tizi Ouzou, Béjaia, Sétif).

Nevertheless, it is important to point out that our prospecting revealed two populations corresponding to *Vicia ochroleuca* subsp. *atlantica*. According to Dobignard & Chatelain (2012), *Vicia ochroleuca* is represented by two endemic subspecies (*V. ochroleuca* Ten. subsp. *Atlantica* (Pomel) Greuter & Burdet and subsp. *Baborensis* (Batt. & Trab.) Greuter & Burdet), both located in Algeria.

The present study was the subject of an ecological characterization of natural habitats concerning fifty (50) sites related to five species of vetches (Table 1). The number of species varies from one site to another. The most frequently encountered species are, respectively, *Vicia sativa* L. (35 populations) and *Vicia disperma* L. (15 populations). Other species, relatively less frequent, even rare, were also encountered: *Vicia monardi* (03 populations), *Vicia narbonensis* (03 populations) and *Vicia ochroleuca* (02 populations).

In some cases, vetch species are encountered, in association with other species of the same family (*Fabaceae*), such as the species corresponding to the genera *Trifolium* L. and *Medicago* L. (Table 1).

The results of the prospection also indicated that Algerian vetch populations are encountered on sites of varying altitudes, ranging from 25m to 1310 m and rainfall varying between 500 mm and 1100 mm (Table 1).

In Tunisia, vetches are relatively rare, in particular *Vicia lutea*, *V. tetrasperma* and *V. sativa* var. amphicarpa; *V. villosa* and *V. sativa* var. nigra are frequent in humid zones while *Vicia narbonensis* is rather frequent in sub-humid zones; *Vicia monantha* exists in arid and semi-arid zones (Zoghlami & Hassen, 2004). A previous study carried out on the geographical distribution of vetches in Tunisia indicated that the upper altitude limit is around 1000 m; this is lower than the 1300 m limit found in Sardinia (Piano *et al*., 1982 In Hassen *et al*., 1996).

In the genus *Vicia* L., Fridlender (2009) reported that the original distribution of many taxa remains unknown and the area regressions currently observed should be interpreted with caution. The author also indicates that new species or subspecies of vetches in the north-western Mediterranean are still described (Foggi & Ricceri, 1989 *In* Fridlender, 2009).

Analysis of variance: The univariate analysis (ANOVA), applied to the different soil parameters (16), indicated very highly significant results in the majority of cases (Table 2).

Soil pH varies between 5.86 (34/16) and 8.47 (58/16). Overall, vetch sites are characterized by slightly to medium alkaline soils in the majority of cases. However, moderately to slightly acidic or neutral soils are also encountered.

The results obtained at this level showed that all reported species (*Vicia sativa*, *Vicia disperma*, *Vicia monardi*, *Vicia ochroleuca*) were found in soils with a low acidic or basic pH, with the exception of the species *Vicia narbonensis* which was only found in soils with an exclusively basic pH.

Table 2. Results of the variance analysis (ANOVA) of soil physico-chemical characteristics of the natural habitats (50 sites) within various species of *Vicia* L. in Algeria.

Characteristics	MIN	MAX	MEAN	Fobs	P
pH	5.86	8.47	7.45 ABCDEFGHIJKL	15.44	0,000***
EC (mmhos/cm)	0.01	0.28	0.12 ABCDE	2.96	0,000***
T $CaCO_3$ (%)	0.77	37.67	10.01 ABCDEFGHIJ	19.93	0,000***
N (%)	0.06	0.16	0.11 ABCD	4.26	0,000***
K_2O (ppm)	28.25	586.56	198.3 ABCDEFGHI	10.53	0,000***
P_2O_5 (ppm)	0.16	22.42	11.45 ABCDEFGH	16.04	0,000***
C %	0.45	7.13	2.61 ABCDEFGHIJKLM	13.65	0,000***
OM (%)	0.77	12.29	4.49 ABCDEFGHIJKLM	13.65	0,000***
C/N	5.33	64.93	25.08 ABCDEFG	7.39	0,000***
A (%)	3.78	44.00	18.82 ABCDE	4.74	0,000***
FSi (%)	3.11	30.08	18.13 A	1.58	0,028*
CSi (%)	2.29	56.61	22.08 AB	2.00	0,002**
TSi (%)	13.83	66.04	40.21 ABC	2.47	0,000***
FSd (%)	4.11	41.30	15.11 ABC	2.55	0,000***
CSd (%)	3.73	67.67	27.01 ABCDEFGHIJ	7.38	0,000***
TSd (%)	14.52	81.46	42.13 ABCDEFG	4.28	0,000***

MIN: Mean of site, MAX: Mean of site, MEAN: Mean of all sites

The indicated letters at the level of the mean (MEAN) correspond to the homogeneous groups

*$p\leq0.05$; **$p\leq0.01$ and *** $p\leq0.001$

In addition, the conductivity varies between 0.01 (5/16) and 0.28 (11/16) mmhos / cm. The soils were found to be non-saline. Total limestone varies between 0.77% (5/16) and 37.67% (42/16). The different sites show non-calcareous, calcareous to frankly calcareous soils. Potassium varies between 28.25 ppm (26/16) and 586.56 ppm (11/16). The potassium content is highly variable and all all soils were found to be rich in potassium. The phosphorus varies between 0.16 ppm (65/16) and 22.42 ppm (44/16). The phosphorus content is variable and the soils were found to be very poor to poor in phosphorus.

Total nitrogen varies between 0.06% (15/16) and 0.16% (6/16). Carbon varies between 0.45% (26/16) and 7.13% (7/16). On the basis of these two elements (N and C), two parameters were also deduced:

The organic matter varies from 0.77% (26/16) to 12.29% (7/16) and the C / N ratio varies from 5.33 (14/16) to 64.93 (9/16). Our results indicated ten sites (14/16; 24/16; 25/16; 26/16; 34/16; 39/16; 45/16; 48/16; 61/16; 63/16) with a low level (< 9). For cultivated soils, this ratio is generally between 9 and 12 (Anon., 1986); well-decomposed organic matter, i.e. stable soil humus, has a C/N ratio close to 10; this value indicates a healthy soil where microbial life is active; in general, grassland soils have higher organic matter levels and C/N ratios than cultivated soils (Anon., 1986).

Physical analyses of the soil samples identified different types of texture. Overall, the results of the soil analyses indicated that, out of a total of 50 sites, 25 sites (49.02%) were characterized by a predominance of sand, 23 sites (45.10%) were characterized by a predominance of silt, and only 03 sites (5.88%) were characterized by a predominance of clay.

In addition, eight texture types were identified: loam, clay, silty-clay, clay loam, silt loam, silty-clay loam, Sandy loam, Sandy-clay loam.

The most frequent types of soils are the loam ones (balanced), reflecting an optimal texture in the majority of cases. Indeed, 27 sites (54% of the totality) are characterized by this type of texture (5/16, 6/16, 9/16, 11/16, 12/16, 15/16, 20/16, 22/16, 23/16, 24/16, 26/16, 27/16, 32/16, 34/16, 35/16, 38/16, 40/16, 41/16, 42/16, 44/16, 46/16, 47/16, 53/16, 56/16, 58/16, 61/16, 63/16). In second place, 10 sites presented silt loam soils (7/16, 8/16, 18/16, 39/16, 49/16, 50/16, 55/16, 57/16, 60/16, 67/16). In third place, 08 sites presented clay loam soils (13/16, 19/16, 37/16, 43/16, 45/16, 51/16, 52/16, 65/16) and in last place, the rarest textures appear, each represented by only one site: clay soil (48/16), silty-clay (17/16), sandy loam (59/16), sandy-clay loam (14/16) and silty-clay loam (54/16).

The analysis of variance allowed the constitution of homogeneous groups for all the physico-chemical parameters, with a very highly significant difference (probability ≤ 0.001) in the majority of cases. The descending ranking of the parameters, according to the number of homogeneous groups, is as follows (Table 2): C (13) > OM (13) > pH (12) > T CACO3 (10) > CSd (10) > K (9) > P (8) > C/N (7) > TSd (7) > A (5) > EC (5) > N (4) > TSi (3) > FSd (3) > CSi (2) > FSi (1).

The variation between the different sites thus seems to be more accentuated, respectively, in the case of carbon, organic matter, pH, limestone, potassium and finally phosphorus. Relatively less variation was found in the case of electrical conductivity and nitrogen. Overall, the results indicate the wide adaptive capacity of the vetches, particularly from the point of view of chemical edaphic parameters of soils.

The multivariate analysis (MANOVA) highlighted the existence of very highly significant differences between the soils of different sites for all considered parameters (Table 3).

Matrix of correlation: Globally, the matrix of relations highlighted many significant (nitrogen, phosphorus, potassium, fine sand, coarse sand), highly significant (pH, limestone) to very highly significant (carbon, organic matter and C/N) relations between the chemical and physical edaphic parameters, on the one hand, and, on the other hand, some climatic (rainfall) and topographical (altitude) factors, characterizing the natural habitats of vetch species in Algeria (Table 4).

The chemical edaphic parameters are more exposed to the influence of climatic and topographical factors (rainfall, altitude) than the physical edaphic parameters.

Ten edaphic parameters are influenced by at least one ecological factor (altitude or rainfall).

The effect of altitude is preponderant on carbon, organic matter and C/N ratio through a very highly significant positive correlation. On the other hand, a highly significant negative correlation is observed between altitude and pH.

Only one parameter (phosphorus) is simultaneously influenced by both ecological factors (altitude and rainfall).

Within the same family (*Fabaceae*), previous ecological studies have been carried out, in Algeria, respectively, in the genera *Medicago* L. (Abdelguerfi *et al*., 1988), *Hedysarum* (Abdelguerfi-Berrekia *et al*., 1991; Issolah *et al*., 2012), *Trifolium* L. (Abdelguerfi *et al*., 2006; Issolah *et al*., 2015), *Scorpiurus* (Bensalem *et al*., 1988) and *Onobrychis* (Abdelguerfi *et al.*, 2006).

In the genus *Medicago* L., rainfall, altitude, texture, pH and salinity seem to be the most important factors in the distribution of annual lucerne species (Abdelguerfi *et al.*, 1988).

Table 3. Physico-chemical characteristics of soils in the natural habitats of various *Vicia* species in Algeria: Results of statistical tests (MANOVA).

Sites	Statistical tests	Observed valueof test	F_{obs}	P
50 sites (samples)	Wilk's	0.00000	3.80	0.000***
	Lawley-Hotelling	57.36571	6.009	0.000***
	Pillai's	8.96922	2.577	0.000***

*$p \leq 0.05$; **$p \leq 0.01$ and *** $p \leq 0.001$

Table 4. Relations between different ecological factors of the natural habitats of various *Vicia* species in Algeria.

Ecological factors	Altitude		Rainfall	
Chemical edaphic parameters	**R**	**P**	**R**	**P**
pH	-0.413	0.003**	-0.276	0.053
CE	0.068	0.639	-0.181	0.208
$CaCO_3$	-0.196	0.174	-0.377	0.007**
N	0.207	0.149	-0.318	0.025*
P	0.351	0.012*	-0.323	0.022*
K	0.139	0.336	-0.306	0.031*
C	0.522	0.000***	-0.048	0.739
OM	0.522	0.000***	-0.048	0.740
C/N	0.449	0.001***	-0.015	0.916
Physical edaphic parameters	**R**	**P**	**R**	**P**
Clay	0.031	0.833	-0.171	0.236
FSi	0.016	0.913	0.063	0.663
CSi	0.241	0.092	-0.044	0.762
TSi	0.210	0.144	-0.001	0.996
FSd	0.140	0.333	-0.311	0.028*
CSd	-0.267	0.061	0.296	0.037*
TSd	-0.187	0.199	0.122	0.398

r: Correlations of Pearson; P: Probability. *$p \leq 0.05$; **$p \leq 0.01$ and *** $p \leq 0.001$

In the genus *Hedysarum* L., altitude and especially rainfall remain the most important factors in the distribution of the studied species (Abdelguerfi-Berrekia *et al.*, 1991). Sulla (*Hedysarum coronarium*) is present on soils with alkaline pH varying between 8.1 and 8.94 (Issolah *et al*., 2012); this species far prefers clay soils, however it adapts to other types of texture and seems to tolerate silty texture; Sulla has not been found on sandy textured soils (Issolah *et al*., 2012). The distribution of *Sulla coronaria*(syn. *Hedysarum coronarium*) is conditioned by the variation and interaction of three ecological factors (edaphic, climatic, topographic); altitude and rainfall influence the physico-chemical properties of the different soils on which the Sulla was encountered, with a more pronounced effect of the first factor (altitude), especially on the physical parameters (Issolah *et al*., 2012).

In the genus *Trifolium* L., rainfall is the most determining factor on the presence-absence of species; pH, altitude, texture and total limestone also intervene (Abdelguerfi *et al.*, 2006). Subterranean clover (*Trifolium subterraneum*) seems to be adapted to non-saline, frankly calcareous soils, characterized by quite diverse textures (clay, clay loam, sandy loam, sandy clay loam, loam) and a variable pH (slightly acidic, neutral, slightly alkaline, alkaline) ranging from 6.46 to 8.64 (Issolah *et al*., 2015). Overall, altitude affects four physico-chemical parameters of the soils (clay, N, pH, C/N) while rainfall influences three parameters (K, P, fine silt) (Issolah *et al*., 2015).

In the genus *Scorpiurus* L., the distribution of species appears to be strongly determined by rainfall and altitude (Bensalem *et al*., 1988).

In *Onobrychis* L., altitude and rainfall appear to be the most discriminating factors betweenspecies (Abdelguerfi *et al*., 2006).

In Tunisia, a study conducted on 92 ecotypes of vetches showed that the geographical distribution of spontaneous vetches is dependent on the altitude of the sites and climatic factors (except maximum temperature). With the exception of nitrogen, chemical components of the soil do not seem to influence this distribution (Hassen *et al*., 1996). Furthermore, a weak action of chemical elements on the distribution of spontaneous species of fodder and pastoral legumes, particularly vetches, was noted by many authors (Hassen *et al*., 1996).

Hierarchical classification: The grouping of the fifty (50) sites was carried out on the basis of all the considered ecological characteristics (physico-chemical parameters of the soils, altitude, rainfall). The dendrogram was obtained following the application of the simple linkage method and the Pearson square distance for a similarity of 70% (Fig. 2).

This analysis highlighted the existence of seventeen (17) groups of sites (Table 5). Three (03) groups encompass the majority of sites characterized by some ecological similarities (Group D: 30 sites; Group I: 03 sites; Group K: 03 sites). Group D is the only one that includes all the encountred vetch species. The rest of the groups, fourteen (14) in numbers, each have one (01) unique site.

Overall, the species *Vicia sativa* appears, very frequently, at the majority of sites, followed by *Vicia disperma*. These are the only species that can be distinguished, alone, at the level of several groups of sites. The rest of the species seems much less frequent, even rare (Table 5).

The results obtained through this analysis confirmed the existence of a significant ecological variation (edaphic, topographic, climatic parameters) recorded within the natural habitats of vetches, denoting the wide adaptation of these forage resources, observed particularly, in *Vicia sativa* and *Vicia disperma*.

Kaplan *et al*., (2021) signalized that several previous studies (morphological, anatomy, ecological and karyological) were done to try and resolve the great confusion about the taxonomy and nomenclature of *Vicia* species. From a molecular taxonomic viewpoint, *Vicia sativa* is an aggregate that comprises several polymorphic annual autogamous taxa in a dynamic evolution (Mikic *et al*., 2013). Recently, Kaplan *et al*., (2021) indicated that the developed species-specific markers are useful for early detection of targeted *Vicia* taxa and can act as a guide to the basic data required for the evolution of systematic breeding and conservation strategies, as well as for germplasm resources.

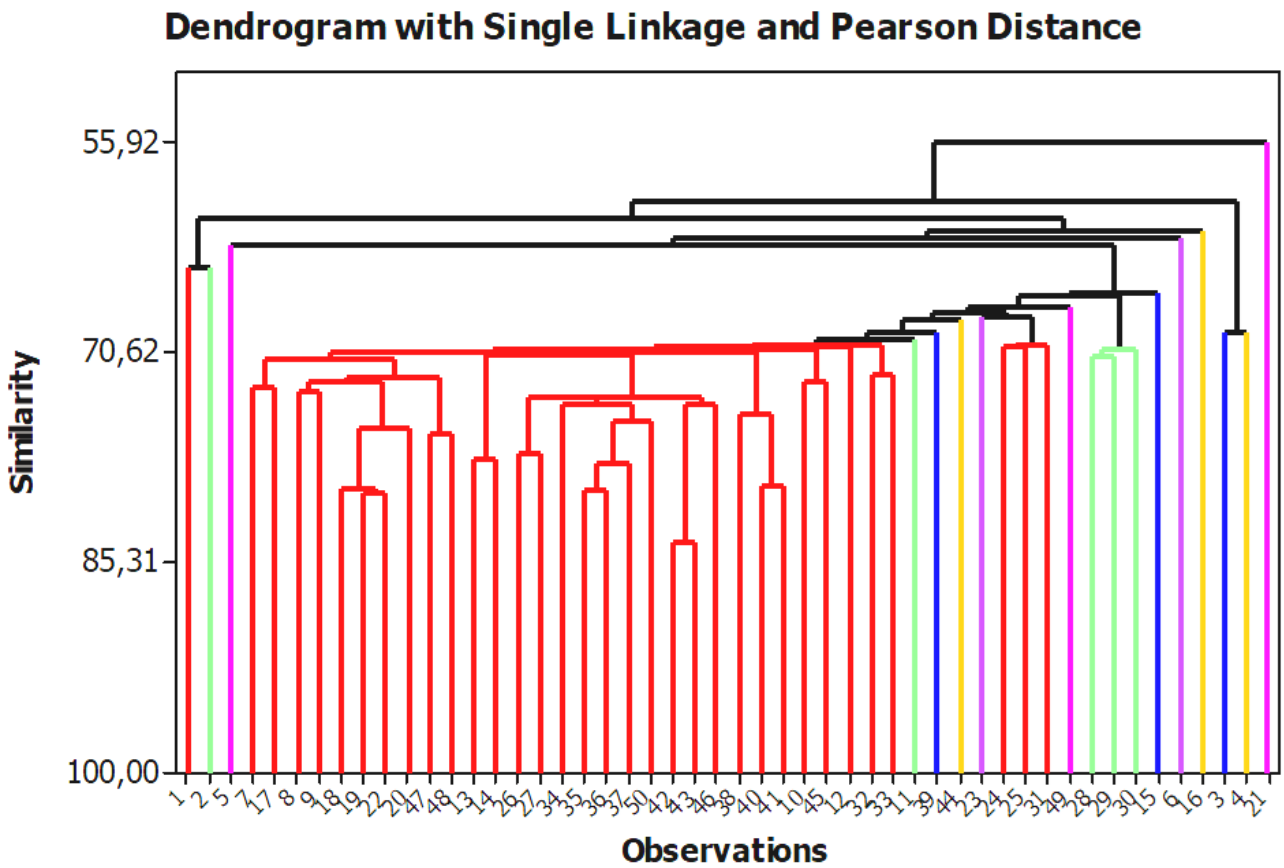

Fig. 2. Dendrogram derived from the combination of fifty (50) sites based on the ecological characteristics (soils, altitude, rainfall) of the natural habitats of *Vicia* species in Algeria.

Table 5. Groups of sites derived from the hierarchical classification based on the ecological characteristics (soils, altitude, and rainfall) of the natural habitats *of Vicia L. species* in Algeria.

Groups	Corresponding sites	Corresponding species
A	5/16	*V. disperma*
B	6/16	*V. disperma*
C	9/16	*V. disperma*
D	12/16; 13/16; 14/16; 15/16; 18/16; 19/16; 20/16; 24/16; 26/16; 27/16; 32/16; 35/16; 40/16; 41/16; 46/16; 47/16; 48/16; 49/16; 50/16; 51/16; 52/16; 54/16; 55/16; 56/16; 57/16; 59/16; 60/16; 61/16; 63/16; 65/16	*V. sativa (21 sites)/ V. disperma (09 sites) / V. monardi (03 sites) / V. ochroleuca (02)/ V. narbonensis (01) / Medicago sp.(03 sites) Trifolium stellatum (01 site)/ Trifolium sp.(02 sites)*
E	17/16	*V. sativa*
F	53/16	*V. sativa*
G	58/16	*V. sativa*
H	37/16	*V. sativa*
I	38/16; 39/16; 45/16	*V. sativa* and *V. narbonensis / V. narbonensis / V. sativa*
J	64/16	*V. sativa*
K	42/16; 43/16; 44/16	*V. sativa / V. sativa / V. sativa*
L	22/16	*V. sativa*
M	11/16	*V. sativa*
N	23/16	*V. sativa*
O	7/16	*V. sativa / V. disperma*
P	8/16	*V. disperma*
Q	34/16	*V. disperma*

Conclusion

The study of the natural habitats of some *Vicia* species in Algeria highlighted the wide adaptation of these fodder legumes to the various edaphic (physico-chemical parameters), topographic (altitude) and climatic (rainfall) parameters, characterizing the North-East of the country.

The prospecting carried out, showed the frequency of *Vicia sativa*, followed by *Vicia disperma* and the rarity recorded in some encountred species such as *Vicia monardi*, *Vicia narbonensis* and *Vicia ochroleuca* (subsp. *atlantica*). The vetches were encountred on various texture soils with a predominance of loam (balanced) texture. Although the vetches go well on variable pH soils, the alkaline soils are predominant. The variation between the different sites seems to be more accentuated, respectively, in the case of carbon, organic matter, pH, limestone, potassium and phosphorus.

Numerous significant relationships were recorded between the chemical and physical edaphic parameters and some climatic (rainfall) and topographic (altitude) factors characterizing the natural habitats of the species. The chemical edaphic parameters are more exposed to the influence of some climatic and topographic (rainfall, altitude) factors, comparatively to physical edaphic ones.

Several edaphic parameters are influenced by, at least, one ecological factor (altitude or rainfall).

The effect of the altitude is preponderant on carbon, organic matter and C/N ratio.

This study permitted to characterize the natural habitats of some *Vicia* species in Algeria.

A significant variation was detected. The species seem to be adapted to diverse ecological conditions of the natural habitats. This work is a contribution to the preservation, conservation and valorization of fodder resources, especially the endemic or rare taxa, which are probably threatened by extinction, with a view to developing a strategy for the enhancement and development of fodder and livestock in Algeria.

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