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CHARACTERIZATION OF 7 *VICIA* L. TAXA FROM ALGERIA BASED ON EVIDENCE FROM MORPHOLOGY AND ECOGEOGRAPHY

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Abstract

Description of the subject: The genetic diversity of a vetch collection collected in Algeria was assessed by the variation of 78 plant morphological characters and 5ecogeographic parameters of the collection stations. 37 accessions belonging to 7 taxa of the genus *Vicia* L. were the subject of this study
Objective: Characterize the accessions using two different markers and then correlate their results. In parallel, the results are used in the taxonomy and phylogeny of the populations studied
Methods: the hierarchical classification in clusters using a Euclidean distance matrix based on a UPGMA - principal component analysis - the Mantel test used to correlate the matrices of ecogeography and morphology
Results: Cluster analysis showed clear separation among accessions from their plant morphology but significant differences at subspecies level were observed regarding the results of investigated morphological traits. Important diversity in leaflet consistence, calyx hairness, stem form, leaflet abaxial hair density, leaflet hair elevation, seed colour, spongy inside legume and peduncle length was found in most accessions of the collection. The dendrogram obtained with ecogeographic parameters did not indicate clear division among accessions. A distribution map of each taxa was produced and data obtained can be used as a guide for future collecting missions.
Conclusion: inter and intraspecific differences were obtained by the morphological descriptors. The collected eco-geographic data can be used as a guide for future collection missions. Other markers should be used for the phylogeny of the collection.
Keywords: Algeria; diversity; ecogeography; morphology;*Vicia* L.

CARACTERISATION DE 7 TAXA DE *VICIA* L. COLLECTÉS EN ALGÉRIE, SUR LA BASE DE LA MORPHOLOGIE ET DE L'ÉCOGÉOGRAPHIE

Résumé

Description du sujet : La diversité génétique d'une collection de vesce collectée en Algérie a été évaluée par la variation de78 caractères morphologiques et 5 paramètres écogéographiques des stations de collecte. 37 accessions appartenant à 7 taxa du genre *Vicia* L. ont fait l'objet de la présente étude
Objectifs : Caractériser les accessions en utilisant deux marqueurs différents puis corréler leurs résultats. En parallèle, les résultats sont exploités dans la taxonomie et la phylogénie des populations étudiées
Méthodes : la classification hiérarchique en clusters en utilisant une matrice de distances Euclidiennes basée sur une UPGMA - une analyse en composantes principales - le test de Mantel pour corréler les matrices de l'écogéographie et la morphologie
Résultats : L'analyse en clusters a montré une nette séparation entre les accessions sur la base de leur morphologie mais des différences significatives entre les sous-espèces ont été observées. Une diversité importante dans la consistance des folioles, la pilosité du calice, la forme de la tige, la densité des poils abaxiaux des folioles, l'élévation des poils des folioles, la couleur des graines, la spongiosité à l'intérieur des gousses et la longueur du pédoncule a été observée dans la plupart des accessions de la collection. Le dendrogramme obtenu avec les paramètres écogéographiques n'a pas indiqué de séparation claire entre les accessions. Une carte de distribution de chaque taxon a été produite
Conclusion : Des différences inter et intraspécifiques ont été obtenues par les descripteurs morphologiques. Les données écogéographiques collectées peuvent être utilisées comme guide pour les futures missions de collecte. D'autres marqueurs doivent être exploités pour la phylogénie de la collection.
Mots clés: Algérie; diversité; écogéographie; morphologie; *Vicia* L.

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INTRODUCTION

The taxonomy and nomenclature of *Vicia* species are very confused. The number of species recognized in the genus has varied significantly from about 150 accepted by [1] up to about 210 used by [2], which indicates differences in species delimitation and ranking in the genus, depending on the species concept and the criteria used for their delimitation. [3] pointed out that there had been 20 major classifications of the group since Linnaeus. These problems have, at least partially, resulted from the publication of national or regional floristic accounts, but also because of the conflicting results produced by morphological, cytological and molecular investigations [2]; [4]. Many characters vary considerably within the genus, but few prove useful for infrageneric grouping like characters of the morphology of the inflorescence, the flower, the leaf, the pod and the seed. Several not greatly different classifications were proposed for the genus on the basis of the above-mentioned character differentiations [2]. The genus has been subdivided into four sections (Ervum, Cracca, Vicia, Faba) by [5]. [1] has subdivided the genus into two subgenera (*Vicilla*, *Vicia*)which can be distinguished using stipule nectary, peduncle length, style type, keel shape, legume and canavanine. Subgenera *Vicilla* and *Vicia*have been further subdivided into 17 and 5 sections, respectively. The subgenus *Vicia*sensu [3] contains 9 sections including section Hypechusa composed of 14 species (incl. *V. lutea*) and section Narbonensis which comprises 7 species (incl. *V. narbonensis*). [6] indicated that *Narbonensis* should be considered a well-separated section which may be related to section *Vicia*. Moreover, [7] showed that *V. faba* clustered in the *Narbonensis* group with good support and treated the group as section Narbonensis. Section Hypechusa (subgenus*Vicia*) is based on the genus Hypechusa created by [8] who separated into it six *Vicia* species. Hypechusa is also treated as section by [1] and [3]. *V. lutea* was treated in a separate series Luteae B. Fedtch. by [9] and [10]. The isozyme evidence provides further support to this treatment, even suggesting sectional status for Luteae. According to [11], *V. lutea* differs distinctly from the other Hypechusa species by showing no cross-hybridization of genomic DNAs. [12] placed *V. lutea* separately from a clade of series Hypechusa. The subgenus name Cracca (Dum.) Gams was rejected by [1] because it was published later than the subgenera proposed by [13]: Vicilla, Ervoidea and Pseudoervoidea. [14] has applied Cracca Peterm. as a correct name of the subgenus (published in 1847: Deutchl. Fl., 152). Section Cracca sensu [1] belongs to Subgenus Vicilla and is composed of 40 species including *V. monantha, V. tenuifolia, V. leucantha.*

In the case of the *Vicia* species, only a relatively minor proportion of the genepool is currently conserved and therefore available for utilization. There is a clear requirement for further study of the genepool, accurately targeted conservation (particularly seed collection), along with characterization and evaluation of the currently unavailable elements of the gene pool. The first step towards more efficient conservation is to undertake an ecogeographic study [15] The distribution maps will be used to formulate conservation policy and specifically in the planning of future *ex situ* collecting missions.

In Algeria, the genus *Vicia* L. comprises 26 species according to the key used by [16] in the unique flora covering the entire country. Using the relative length of the flower, the presence or the absence of the peduncle and the number of flowers by inflorescence, the authors divided the genus into three series where *V. narbonensis* and *V. lutea* belong to the serie 1, *V. monantha* and *V. tenuifolia* are grouped in the serie 2 and *V. leucantha* belong to the serie 3. Since [16], no work has been undertaken to study the genus in Algeria. As the characterization of plant genetic resources is the first step towards improving their use and as effective exploitation of any crop germplasm must be preceded by efficient and comprehensive conservation of the gene pool, whether *ex situ* or *in situ*, the purpose of the present work was to study the diversity of *Vicia* L. taxa from Algeria on both an inter and intraspecific levels and evaluate species groupings and relationships in the genus. The paper describes variation of 78 morphological traits and 5 ecogeographic parameters among 7 *Vicia* taxa belonging to sections Hypechusa, Narbonensis and Cracca to improve the resolution of phylogenetic relationships and to assess the usefulness of plant morphology as diagnostic characters to discriminate vetch species and sections.

MATERIAL AND METHODS

1. Plant material and taxa identification

Thirty-seven populations of *Vicia* L. collected from their natural habitats in various bioclimatic conditions of north Algeria are used in the current study. Origins and field information are given in Table I. Localities of the studies taxa were shown in Figure I. Individual plants were randomly collected in each sampling site. Pods were shelled and the dry seeds were poured in to separate paper bags at room temperature and the bags sealed tightly until their utilization. As the only taxonomic study of the whole genus *Vicia* in Algeria was undertaken by [16], the present study relies on their taxonomy. Taxonomic identification of accessions was verified by the morphology of plants grown from seeds. Germination and growing were carried out according to the same approach adopted in our previous study [17].

Table 1.Passport information and taxonomic identification of accessions investigated

Species	Subspecies	Code	Date of collection	Province /Locality/Origin	Latitude	Longitude	Altitude (m)
V. lutea L.		1	28.5.14	Skikda Ramdane Djamel	N36°45.977'	E006°53.432'	42
		4	22.5.14	Constantine University	N36°20.387'	E006°37.177'	604
		58	27.5.14	Constantine Didouche Mourad	N36°30.025'	E006°40.058'	448
		82	28.5.14	Guelma	N36°28.361'	E007°21.280'	223
		62	1st.6.14	Skikda Azzaba	N36°43.531'	E007°04.708'	110
		63	1st.6.14	Skikda Ain Cherchar	N36°44.366'	E007°14.176'	52
		79	1st.6.14	El Tarf Ben M'hidi	N36°46.402'	E007°53.600'	11
		87	30.5.14	Jijel El Milia	N36°46.668'	E006°13.551'	28
		90	1st.6.14	Annaba	N36°49.980'	E007°34.092'	24
		3	2.6.14	Oum El BouaghiSigus	N36°04.485'	E006°48.867'	822
		12	5.6.14	Relizane	N35°43.689'	E000°24.265'	105
		26	28.5.15	Guelma	N36°14.816'	E007°03.045'	757
		27	2.6.14	Oum El Bouaghi	N35°51.459'	E007°06.377'	887
		40	28.5.14	Guelma	N36°16.276'	E007°05.751'	711
		44	6.6.14	Tlemcen	N34°52.088'	W001°11.698'	843
		45	3.6.14	Bordj Bou Areridj	N36°04.070'	E004°41.899'	923
		49	28.5.14	Constantine Ain Abid	N36°13.543'	E006°55.782'	847
		60	2.6.14	Khenchla	N35°33.685'	E007°02.177'	860
		74	14.6.14	Tébessa	N35°15.936'	E007°30.306'	1078
		77	26.5.14	Batna Ain Touta	N35°17.632'	E005°49.035'	683
		78	20.5.14	Constantine El Coudiat	N36°21.787'	E006°36.418'	633
		84	10.6.14	Constantine INATAA	N36°19.002'	E006°34.626'	586
		98	14.6.14	Tébessa Chria	N35°16.328'	E007°44.359'	1087
		29	2.6.14	Oum El BouaghiSigus	N36°04.485'	E006°48.867'	822
		18	3.6.14	Bordj Bou Areridj Ain taghrout	N36°07.741'	E005°03.364'	934
	***V. monanthas*sp*cinerea* (M.B.) Maire**	46	3.6.14	Bordj Bou Areridj El Achir	N36°04.017'	E004°40.525'	944
		91	14.6.14	Khenchla	N35°15.704'	E007°20.957'	1222
		101	14.6.14	Khenchla	N35°15.807'	E007°28.934'	1077
***V. narbonensis*L.**	-	23	30.5.14	Constantine HammaBouziane (Chaabet El Medhbouh)	N36°26.391'	E006°33.282'	425
		30	30.5.14	Mila Messaoud Boudjriou	N36°29.748'	E006°25.530'	325
		34	27.4.14	Constantine Didouche Mourad	N36°29.216'	E006°38.731'	434
		55	27.5.14	Constantine Didouche Mourad	N36°30.023'	E006°40.051'	443
		81	22.5.14	Constantine University	N36°20.387'	E006°37.177'	604
	-	56	6.6.14	Ain Temouchent	N35°16.476'	W001°13.800'	276
		89	6.6.14	Sidi Bel Abbes Sidi Khaled	N35°06.59'	W000°44.238'	543
		97	6.6.14	Ain Temouchent Ain Tolba	N35°14.721'	W001°17.054'	222
***V. leucantha*Biv.**	-	100	10.6.14	Constantine INATAA	N36°19.002'	E006°34.626'	586

Figure1.Geographical origin of the 37 Algerian populations studied

2. Morphological analyses

The variation of 78 morphological characters with two to five states was analyzed (Table 2) on 111 individuals using the same approach explained by [17].

Table 2. Morphological characters used for cladistic analysis

	Symbol	Character name	Character state
Stem	S.B	Stem branching	0- unbranched 1 - in the upper part 2 - from the base
	S.H	Stem height	0 - small (up to 40cm) 1 - high (over 40cm)
	S.F	Stem Form	0- slender 1 - rigid
	SEC	Stem edgescolor	0- green 1 - purple
	SP	Stem pubescence	0- glabrous 1 - sparse 2 - dense
	SHE	Stem hairelevation	0- ascending 1 - adpressed 2 - curled
	SHL	Stem hairlength	0- short 1 - long
	SNC	Stem nodecolour	0 - green 1 - purple
Leaflets	LPL	Leaflets pairs per leaf	0- 1-3 pairs 1 - more than 3 pairs
	LRSh	Leaflets relative shape	0- all of same shape 1 - different shapes
	LRS	Leaflets relative size	0- all of same size 1 - larger at leaf base
	LC	Leafletconsistence	0- thin 1 - normal 2 - fleshy
	LAC	Leafletabaxialcolour	0- pale 1 - same as adaxial
	LLP	Lowerleaflets position	0- at base of rachis 1 - higher
	LS	Leafletshape	0- lineal 1 - elliptical 2 - obovate 3 - ovate
	LBP	Leafletbroadest point	0- at apex 1 - in middle 2 - at base
	LAS	Leaflet apex shape	0- acute 1 - obtuse 2 - truncate 3 - emarginate
	LAD	Leaflet apex dentate	0 - not 1 - two teeth 2 - more than two
	LB	Leaflet base	0- rounded 1 - acute
	LM	Leafletmargin	0 - entire 1 - dentate 2 - undulate
	LMH	Leafletmarginhairness	0- glabrous 1 - ciliate
	LHE	Leaflethairelevation	0 - ascending 1 - adpressed
	LAHD	Leafletabaxialhairdensity	0 - glabrous 1 - sparse 2 - dense
Stipules	SS	Stipule size	0- small (shorter than 6 mm) 1 - large (longer than 6 mm)
	SSh	Stipule shape	0- lanceolate 1 - semi-hastatte 2 - semi-sagitatte 3 - ovate
	SNS	Stipule nectariferous spot	0 - absent 1 - dark 2 - pale
	SE	Stipule edge	0- entire 1 - dentate 2 - 2 - 3-partite
	Spa	Stipules of the pair	0 - identical 1 - different
Tendril	TP	Tendrilpresence	0- absent 1 - present 2 - in some leaves
	TB	Tendrilbranching	0- not branched 1 - branched
	TL	Tendrillength	0- short 1 - long
	THD	Tendrilhairdensity	0- glabrous 1 - sparse 2 - dense
Flower	NFI	Number of flowers per inflorescence	0- one 1 - 1 - 4 2 - 5 or more
	FL	Flower length	0 - up to 0.8(0.9) cm 1 - 2.5 cm 2 - over 2.5 cm
	PcL	Pedicellength	0- shorter than calyx 1 - equal or longer than calyx
	PL	Pedunclelength	0- absent 1 - very short 2 - up to as long as leaf 3 - longer than leaf
	SCP	Standard colour pattern	0 - absent 1 - differently coloured spot 2 - differently coloured veins 3 - differently coloured back 4 – darker
	SC	Standard colour	0 - white 1 - yellow 2 - purple (bluish)
	SP	Standard pubescence	0- glabrous 1 - pubescent at back
	SASh	Standard apex shape	0- stronglyemarginate 1 - slightlyemarginate
	WCP	Wing colour pattern	0- absent 1 - tip differently coloured 2 - differently coloured veins
	WC	Wing colour	0- white 1 - yellow 2 - purple
	WL	Wing length	0- ¼ shorter than standard 1 - little shorter than standard 2 - longer than standard
	KC	Keelcolour	0- white 1 - yellow 2 - purple
	KCP	Keelcolour pattern	0- absent 1 - dark tip 2 - much darker
	KL	Keellength	0- shorter than wings 1 - equal or longer than wings
	CBSh	Calyx base shape	0 - not gibbous 1 - slightly gibbous 2 - strongly gibbous
	CMSh	Calyxmouthshape	0- straight 1 - slightly oblique 2 - strongly oblique
	CH	Calyxhairness	0- glabrous 1 - clayx teeth only 2 - general coverage
	CHD	Calyxhairdensity	0- sparse 1 – dense
	CC	Calyxcolour	0- green 1 - purple at base 2 - teeth purple 3 - purple 4 - dark at base
	CTL	Calyxteethlength	0- equal 1 – unequal
	CUTL	Calyxupperteethlength	0- longer than tube 1 - shorter than tube
	CLTL	Calyxlowerteethlength	0- longer than tube 1 - shorter than tube
	CUTSh	Calyxupperteethshape	0- triangular 1 - lanceolate 2 – subulate
	CLTSh	Calyxlowerteethshape	0- triangular 1 - lanceolate 2 - subulate

	Symbol	Character name	Character state
Legume	LSh	Legumeshape	0 - linear 1 - lanceolate 2 - rhomboid 3 – oblong
	LCS	Legume cross-section	0- rounded 1 - slightlycompressed 2 – compressed
	LP	Legume position	0- erect 1 - horizontal 2 – hanging
	LSt	Legumestipitate	0 - not 1 – stipitate
	Lpu	Legume pubescence	0- glabrous 1 - entire coverage 2 - only on sutures
	LSf	Legume surface	0- smooth 1 - slightly ridged with veins 2 - strongly ridged with veins
	LT	Legumetorulose	0 - not 1 – torulose
	LC	Legumecolour	0- black 1 - brown 2 - yellowish brown 3 – yellow
	LSC	Legume suture curvature	0- suture parallel 1 - sutures unparallel
	LSH	Legume suture hairness	0- glabrous 1 - hairy 2 – ciliate
	LBe	Legumebeak	0- absent 1 - short 2 – long
	LBSh	Legumebeakshape	0- straight 1 - curved up 2 - curved down
Seed	SNL	Seednumber per legume	0 - 2 1 - 3 - 4 2 - over 5
	Ssha	Seedshape	0- spherical 1 - cubical 2 – elliptical
	SCS	Seed cross-section	0- uncompressed 1 – compressed
	Ssu	Seed surface	0- smooth 1 - wrinkled
	Sco	Seedcolour	0- black 1 - brown 2 - red-brown 3 - yellowish
	SCM	Seedcolourmottling	0- absent 1 - present
	HL	Hilumlength	0 – long(70 - 80%) 1 – intermediate(20 - 40%) 2 – short(less than 20%)
	HC	Hilumcolour	0 - pale 1 - seedcolour 2 - dark
	LSI	Legumespongyinside	0 - not 1 - spongy
	SSz	Seed Size	0 - 3-5(6) mm 1 - over 6 mm

3. Ecogeographic parameters and climatic data corrections

A Global Positioning Systems (GPSGARMIN eTrex® model 30) was used to collect coordinates of sites investigated. Each sampling site was characterized by the five ecological factors (table 3) of Mediterranean climate as described in [17]. Data of reference stations did not reflect the point of view ecogeographical actual bioclimatic conditions. For this reason, we have made correction of climate data based on extrapolations for different altitudinal point as reported by [17].

Table 3 Climatic characteristics of reference stations (2004-2014)

Reference station	Latitude	Longitude	Alt. (m)	P (mm)	m (°C)	M (°C)
Jijel (airport)	36°48 N	05°53 E	8	1066.1	6.8	31.5
Skikda	36°53 N	06°54 E	2	829	8.8	29
Annaba	36°50 N	07°48 E	3	684.4	6.7	31.5
Relizane	35°44 N	00°32E	95	352,5	5,3	38,6
Constantine	36°17 N	06°37 E	693	486.6	2.2	35.2
Bordj Bou Arerridj	36°04 N	04°46 E	928	392,9	1,7	36,4
Khenchla	35°28 N	07°05 E	983	520,8	1,8	34,9
Oum El Bouaghi	35°52 N	07°07 E	889	410.4	1.1	35
Tlemcen (Zenata)	35°01 N	01°28 W	246	359.8	6.2	33.9
Tébessa	35°25 N	08°07 E	821	382,6	1,7	35,6
Batna	35°45 N	06°19 E	822	346,8	0,1	36,4
Guelma	36°28 N	07°28 E	227	622.3	4.5	36.4
Mila*	36°27 N	06°16 E	437	742	4.4	31.5
Ain Temouchent*	35°17 N	01°08 W	235	485	6.8	30.2
El Tarf Ben M'hidi*	36°46 N	07°54 E	6	707	7,1	31,2

Alt altitude, P annual rainfall, M and m are the of the average maximum temperature of the hottest month and the average of the minimum of the coldest month, respectively * Data from "Climate data org"

4. Calculation of the bioclimatic coefficient of Emberger (1955) and definition of the bioclimate

The pluviothermic Emberger quotient (Q2) is determined by the combination of three major climate factors. This quotient easy to interpret: the more Q2 values are larger and more stations are wet. Calculation details are reported in [17].

5. Data analyses

Cluster analysis of morphological characters and ecogeographic parameters were performed with Euclidean Distances Matrix based on the UPGMA. In the other side, a PCA was undertaken to clarify correlation between morphological characters and to identify characters which contribute the most in accessions distinction.

These analyses were carried out with Data analysis software (STATISTICA version 6.1 program). Finally, to display a possible correlation between morphological characters and ecogeographic parameters, a Mantel test [18] based on Pearson's correlation was used (XLSTAT Pearson edition, version 2014.5.03). The p-value was calculated from the distribution of r(AB) using 10000 permutations.

RESULTS

1. Cluster analysis based on morphological characters

The dendrogram illustrated in Figure 2 shows the relationships between taxa, based on the variation in morphological characters. At a distance of 7.71, the dendrogram can be divided into 2 major clusters (I and II).

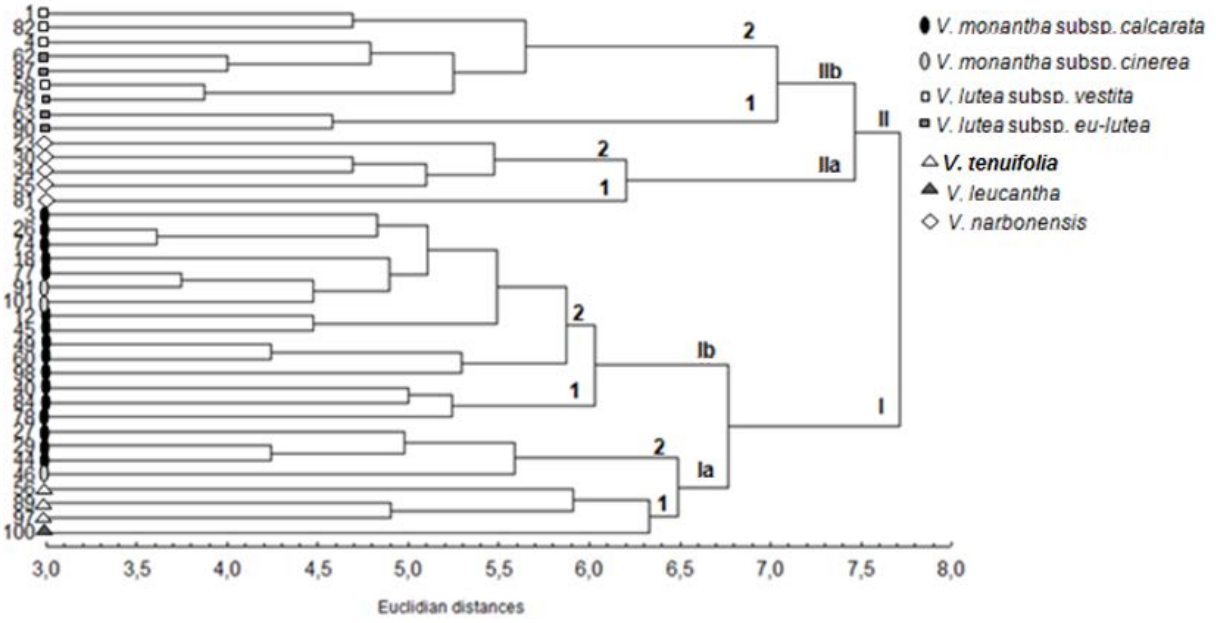


Figure 2.Dendrogram generated using UPGMA cluster analysis based on morphological diversity of 37 *Vicia* L. accessions

1.1. Interspecific polymorphism

The similarity matrix of all pairs of studied populations (Fig. 3) shows variability within and between accessions. The low distance value indicates high level of homology in the variation pattern of the morphological characters. Accessions 26 and 74 appears to be a sister taxa of *V. monantha* subsp. *calcarata*. This clade is strongly supported by the lowest distance (d=3.61). Differences between the two accessions concern only 13 characters on 78 used (SP-SHL-LB-LHE-TP-TL-THD-NFI-SCP-WCP-CBSh-CMSh-SNL). The higher distance (d=9.59) is observed between 97 (*V. tenuifolia*) and 34 (*V. narbonensis*) which are different by 41 characters (SB-SEC-SP-LPL-LRSh-LRS-LC-LLP-LS-LAS-LB-LM-LHE-LAHD-SS-NFI-PL-WCP-WC-KC-CBSh-CMSh-CH-CC-CTL-CLTSh-LCS-LP-Lpu-LT-LC-LSH-LB-LBSh-SNL-Ssha-SCS-Ssu-SCM-HL-SSz).

1.2. Intraspecific variability

For each species, a distance matrix is obtained and used to construct the dendrogram between accessions of the same species (data not shown). The results of the dendrograms are used in the discussion.

2. Principal Component Analysis based on morphological data

Six characters (LAC-LBP-LAD-TB-WL-LBSh) were excluded from PCA as they are homologous between all accessions. The remaining 72 characters were used for the analysis. Two-dimensional (2D) plot was obtained using the first two PCs. The morphological characters which strongly contributed to the formation of PC1 are LC, CH, SF, LAHD, LHE, Sco, LSI and PL. Those which most contribute to the formation of PC2 are LSf, SCM, HL, LPL, LLP and LRSh. In the other side, characters which have a low loading in accessions distinction are SNL, NFI, FL, SB for PC1 and LSI, CC, PcL, SP and LC for PC2.

The strongest positive correlation (r = 1.00) was found between SP and PcLand also between SCM and LPL. The strongest negative one (r = -0.89) was obtained between LPL and LRSh, SCM and LRSH ($p < 0.05$).

In parallel, the projection of individuals (accessions) was done using the observation with the sum of the squared cosinus ≥0.00. The results are shown in figure 5.

	1	3	4	12	18	23	26	27	29	30	34	40	44	45	46	49	55	56	58	60	62	63	74	77	78	79	81	82	84	87	89	90	91	97	98	100	101
1	0,00																																				
3	6,78	0,00																																			
4	5,48	6,78	0,00																																		
12	7,48	5,10	6,48	0,00																																	
18	6,48	5,10	6,48	4,69	0,00																																
23	7,21	6,78	7,07	7,21	6,16	0,00																															
26	6,71	4,36	6,71	4,58	4,58	6,86	0,00																														
27	7,62	5,10	8,12	5,83	5,29	7,75	5,74	0,00																													
29	8,00	5,29	7,48	5,83	6,00	7,75	5,74	4,47	0,00																												
30	6,16	7,62	7,48	8,00	6,63	5,66	7,42	8,00	8,37	0,00																											
34	7,21	7,75	8,00	8,60	7,62	5,10	8,06	8,83	8,60	4,69	0,00																										
40	7,35	6,16	7,48	6,48	6,32	7,48	5,57	7,07	7,62	7,21	7,62	0,00																									
44	8,00	6,32	7,35	6,32	6,93	8,25	5,74	5,48	4,24	8,37	9,17	6,78	0,00																								
45	7,48	5,83	5,83	4,47	6,00	7,07	5,00	7,21	6,48	7,75	8,25	6,78	6,16	0,00																							
46	7,35	6,00	7,21	6,93	6,63	7,75	6,24	5,48	5,29	8,49	8,49	8,00	6,00	7,48	0,00																						
49	7,48	5,83	7,35	5,66	5,10	8,00	5,20	5,83	6,93	8,25	9,27	5,29	6,48	6,16	7,21	0,00																					
55	7,21	7,07	7,35	8,25	7,75	5,66	7,94	8,60	8,12	5,29	4,90	7,35	8,25	7,75	8,25	8,83	0,00																				
56	6,93	6,32	6,78	5,83	6,16	6,32	5,74	7,07	6,93	7,48	7,75	6,93	6,93	6,63	6,63	7,75	7,62	0,00																			
58	5,57	6,40	4,36	6,56	5,32	7,00	6,48	7,42	7,68	7,14	8,19	6,71	7,14	6,24	7,55	6,40	7,14	7,42	0,00																		
60	7,35	5,29	7,07	6,00	5,48	7,87	5,92	5,66	6,63	8,37	9,27	6,48	6,78	6,93	6,63	4,24	8,49	7,07	6,71	0,00																	
62	5,92	7,00	4,58	7,28	6,56	6,56	6,78	8,43	7,94	6,86	7,00	7,00	7,94	6,56	7,81	7,55	6,24	7,28	4,90	7,55	0,00																
63	7,42	8,31	7,68	8,43	7,55	8,31	8,37	7,42	7,42	7,14	7,94	7,55	7,42	8,19	7,42	7,55	7,94	8,43	7,35	7,68	6,93	0,00															
74	6,93	5,29	6,63	5,29	5,10	7,07	3,61	6,48	6,00	7,75	8,25	6,16	5,83	5,66	6,78	6,16	7,87	5,48	6,86	6,63	6,56	8,66	0,00														
77	6,71	5,57	6,86	5,00	4,58	7,42	3,74	6,24	7,00	7,81	8,77	5,74	7,00	5,74	7,00	4,58	8,89	6,56	6,00	5,92	7,07	8,00	5,39	0,00													
78	7,75	6,63	8,49	7,07	6,16	8,00	5,39	5,48	6,32	7,75	8,49	5,10	5,83	7,62	6,78	4,69	8,72	7,75	7,68	6,32	8,06	6,86	6,32	5,57	0,00												
79	5,83	7,07	5,66	7,48	6,93	7,21	7,00	8,25	8,37	6,93	8,00	7,48	8,12	6,93	8,37	7,21	7,48	8,00	3,87	7,48	5,20	7,42	7,35	6,08	8,00	0,00											
81	8,31	8,54	8,54	9,00	8,31	6,08	8,25	7,94	7,14	6,56	6,24	8,43	7,28	8,54	7,55	9,43	5,92	7,81	8,72	9,00	7,62	7,07	8,54	9,17	7,81	8,89	0,00										
82	4,69	6,16	4,90	6,32	6,16	6,78	6,08	7,35	7,07	6,16	6,33	7,21	6,93	6,32	6,63	7,07	6,32	6,00	5,57	6,32	5,74	6,71	6,32	6,56	7,75	6,00	7,81	0,00									
84	7,42	5,74	7,42	6,40	6,24	7,55	4,90	6,56	7,42	7,14	7,81	5,00	6,40	6,40	7,55	5,32	7,28	6,24	7,35	6,71	7,07	8,00	5,39	6,16	5,39	8,06	8,25	6,56	0,00								
87	6,08	7,55	5,00	7,55	7,28	7,55	7,35	8,54	8,43	6,56	7,42	7,42	8,43	7,14	8,19	7,81	7,14	7,81	6,00	7,42	4,00	6,48	7,42	7,48	8,19	5,39	8,25	5,39	7,35	0,00							
89	7,21	6,93	7,07	6,93	7,07	7,62	6,08	6,63	5,83	8,25	8,60	7,35	5,83	7,07	6,63	7,35	8,72	5,66	7,94	6,93	7,42	7,42	6,16	6,71	6,48	7,87	7,42	6,78	6,86	7,14	0,00						
90	7,07	3,17	7,21	9,38	8,49	8,83	9,11	8,49	8,12	7,87	8,49	8,37	8,25	8,94	8,00	8,37	8,37	9,38	7,42	8,60	6,08	4,58	9,27	8,66	7,62	7,21	7,68	7,35	8,89	6,24	7,62	0,00					
91	6,71	6,08	6,71	5,74	5,20	7,55	4,90	6,56	7,55	7,81	8,66	5,92	7,28	6,08	6,86	4,80	9,00	6,56	6,16	5,92	7,35	7,62	5,74	3,74	5,74	6,71	9,49	6,56	6,16	7,48	7,00	8,43	0,00				
97	8,12	6,48	7,62	6,48	7,35	8,25	6,86	6,16	5,48	8,94	9,59	7,87	5,66	7,48	6,63	7,87	8,83	6,16	8,06	7,07	8,31	7,81	6,93	7,14	7,62	8,25	8,31	7,21	7,55	8,31	4,90	8,83	7,94	0,00			
98	7,48	6,32	8,25	6,78	5,83	8,00	6,08	5,48	6,48	8,49	9,27	6,78	6,78	7,62	6,78	5,29	9,43	7,48	7,28	5,29	8,31	7,42	7,21	4,80	5,29	7,48	8,43	7,48	7,28	8,54	6,78	8,12	5,74	7,35	0,00		
100	7,55	7,81	7,42	7,68	7,94	8,31	6,78	7,55	7,00	8,54	9,00	8,06	6,24	7,42	6,56	7,81	9,00	6,24	8,00	7,81	7,87	7,62	7,14	7,48	7,00	8,54	7,87	6,86	7,21	7,87	5,20	7,81	7,35	7,55	7,55	0,00	
101	6,78	5,83	7,62	5,66	4,90	7,48	4,12	6,00	7,07	7,62	8,49	5,10	6,63	6,48	7,07	4,90	8,94	5,83	7,00	6,00	7,81	8,31	5,10	4,36	4,90	7,62	8,89	6,78	5,20	8,19	6,63	9,17	4,58	7,62	5,66	6,86	0,00

Figure 3. Similarity matrix of morphological characters

Figure 4.Principal Component Analysis of 72 morphological characters

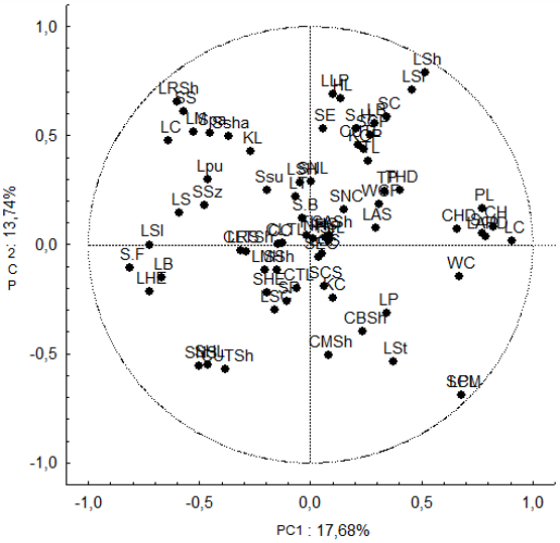
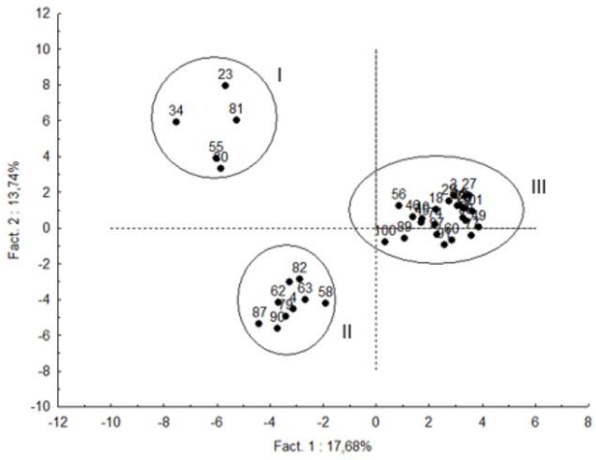


Figure 5. Principal Component Analysis of studied populations



3. Ecogeographic parameters

3.1. Data correction and bioclimate definition

The results of correction of the pluviometric and temperature data and calculation of Q2 were used to define the bioclimate of each site using Emberger climagramm. All results are shown in table 4. The large difference between taxa in the range of GPS coordinates from which they were collected is reported in table 1.

Table 4. Corrected data of climatic characteristics and calculation of Emberger quotient of sampling sites investigated

Code	Alt. (m)	K	P (mm)	m (°C)	M (°C)	Q2	Bioclimate
1	42	1,0386	860,99	8,64	28,72	147,07	LH - warm winter
4	604	0,9268	450,98	2,55	35,82	46,49	HSA - cool winter
58	448	0,7986	388,59	3,18	36,91	39,52	MSA -temperate winter
82	223	1,0025	611,62	4,51	36,52	65,54	SH - mild winter
62	110	1,1042	701,16	8,36	28,24	120,97	SH - warm winter
63	52	1,0482	868,95	8,6	28,65	148,65	LH - warm winter
79	11	1,0056	710,93	7,08	31,16	101,27	SH - warm winter
87	28	1,0150	1082,09	6,72	31,36	150,63	LH - mild winter
90	24	1,0245	701,16	6,61	31,35	97,21	SH - mild winter
3	822	0,9346	383,56	1,36	35,46	38,58	MSA - cool winter
12	105	1,0113	356,48	5,26	38,53	36,75	LSA - mild winter
26	755	1,3393	833,44	2,38	32,80	93,97	SH - cool winter
27	887	0,9980	409,57	1,108	35,014	41,43	MSA -cool winter
40	711	1,3111	815,89	2,56	32,80	92,54	SH - cool winter
44	843	2,3274	837,39	3,81	29,72	110,85	LH - temperatewinter
45	923	0,9949	390,89	1,72	36,43	38,63	MSA -cool winter
49	847	1,1265	548,15	1,58	34,12	57,78	HSA- cool winter
60	860	0,9055	471,58	2,29	35,76	48,33	HSA- cool winter
74	1078	1,2686	485,36	0,67	33,80	50,25	HSA -cold winter
77	683	0,8396	291,17	0,65	37,37	27,20	HA -cold winter
78	633	0,9506	462,56	2,44	35,62	47,82	HSA - cool winter
84	586	0,9120	466,85	2,62	35,94	48,06	HSA- cool winter
98	1087	1,2780	488,96	0,63	33,73	50,67	HSA- cold winter
29	822	0,9346	383,56	1,36	35,46	38,58	MSA - cool winter
18	934	1,0061	395,29	1,67	36,35	39,10	MSA - cool winter
46	944	1,0162	399,26	1,63	36,28	39,52	MSA - cool winter
91	1222	1,1835	616,36	0,84	33,22	65,29	SH - cold winter
101	1077	1,0721	558,35	1,42	34,24	58,35	HSA- cool winter
23	425	0,7796	379,35	2,62	35,94	39,05	MSA - cool winter
30	325	0.9396	697.18	4.84	32.28	87,15	SH - mild winter
34	434	0,7870	382,95	3,23	37,01	38,88	MSA- temperate winter
55	443	0,7944	386,55	3,2	36,95	39,28	MSA- temperate winter
81	604	0.9268	450.98	2.55	35.82	46,49	HSA- cool winter
56	276	1,0338	501,38	6,63	29,91	73,87	SH - mild winter
89	543	1,0725	402,29	2,52	35,52	41,81	MSA - cool winter
97	222	1,0107	490,13	6,85	30,29	71,72	SH - mild winter
100	586	0,912	466,85	2,62	35,94	48,06	HSA- cool winter

K correction factor, Alt altitude, P annual rainfall, M and m the average maximum temperature of the hottest month and the average of the minimum of the coldest month, respectively, Q2 Emberger coefficient, SH subhumid, LH Less Humid, HSA Higher Semiarid, HA Higher arid, MSA Means semiarid, LSA Less semiarid

3.2. Cluster analysis based on ecogeographic data

The dendrogram illustrated in Figure 6 shows the relationships between taxa, based on the variation in ecogeographic parameters. At the distance of 754.84, the dendrogram can be divided into two major clusters (I and II). The distances matrix of all pairs of studied accessions (Figure 7) shows that the higher distance (d=1284) is obtained between 91 (*V. monantha* subsp. *cinerea*, Khenchla) and 87 (*V. lutea*subsp. *eu-lutea*, Jijel-El Milia) when the lower distance (d=5) is observed between samples 55 (*V. narbonensis*, Constantine-DidoucheMourad) and 58 (*V. lutea* subsp. *vestita*, Jijel-El Milia).

4. Correlation between morphology and ecogeography

This test showed that the two matrices are not correlated (r = -0.022, p =0.576=57.61%, α=0.05=5%).

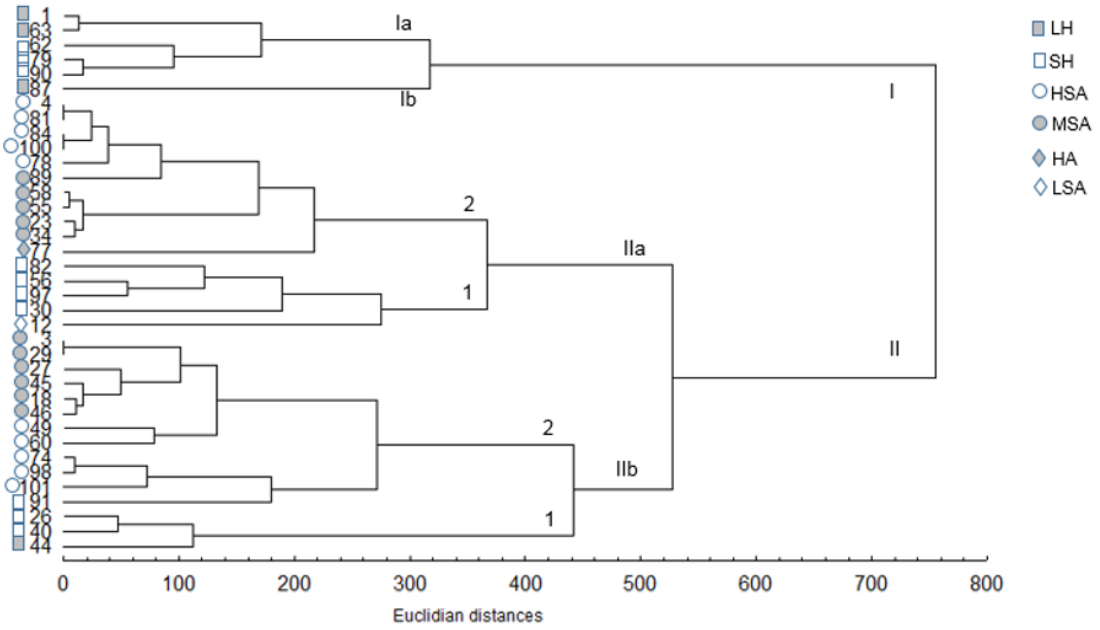


Figure6.Dendrogram generated using UPGMA cluster analysis based on ecogeographic diversity of 37 *Vicia.* L. accessions

	1	4	58	82	62	63	79	87	90	3	12	26	27	40	44	45	49	60	74	77	78	84	98	29	18	46	91	101	23	30	34	55	81	56	89	97	100
1	0																																				
4	703	0																																			
58	632	168	0																																		
82	319	414	316	0																																	
62	176	559	468	155	0																																
63	13	700	632	320	180	0																															
79	160	650	547	237	101	170	0																														
87	222	861	818	516	391	215	375	0																													
90	168	634	530	221	89	178	17	385	0																												
3	921	228	374	642	784	917	877	1063	861	0																											
12	520	508	345	283	355	527	372	739	359	718	0																										
26	716	414	543	577	659	706	754	770	743	458	808	0																									
27	964	286	440	694	834	959	928	1096	913	70	784	447	0																								
40	673	383	505	530	613	664	708	735	697	450	763	47	446	0																							
44	802	459	602	661	746	793	842	852	830	460	884	90	436	135	0																						
45	1005	325	475	734	874	1000	969	1136	953	101	819	477	41	478	459	0																					
49	868	262	430	627	755	862	853	982	838	168	767	302	145	302	294	176	0																				
60	911	257	420	652	788	906	884	1037	868	96	764	380	68	378	372	103	78	0																			
74	1106	475	637	864	994	1100	1092	1212	1077	276	982	477	206	496	428	182	240	218	0																		
77	866	179	255	562	711	864	796	1034	779	167	582	551	236	530	575	260	306	254	441	0																	
78	720	31	199	437	580	716	672	872	656	205	539	393	260	365	434	299	231	227	446	180	0																
84	679	24	159	391	536	676	627	837	611	250	494	406	306	373	455	346	274	274	432	202	47	0															
98	1113	485	647	873	1002	1107	1100	1218	1085	285	991	480	215	500	430	191	247	228	10	450	455	502	0														
29	921	228	374	642	784	917	877	1063	861	0	718	458	70	450	460	101	168	36	276	167	205	250	285	0													
18	1012	335	486	744	883	1007	977	1142	962	113	830	476	43	479	457	12	177	107	170	272	309	355	180	113	0												
46	1019	344	496	752	891	1014	986	1148	970	123	840	477	58	480	455	23	179	111	160	283	317	364	169	123	11	0											
91	1208	640	807	999	1117	1200	1215	1284	1201	464	1147	516	394	549	441	375	381	390	195	631	609	654	186	464	364	354	0									
101	1082	485	652	856	980	1075	1078	1176	1063	310	993	425	242	449	368	228	230	234	73	477	454	500	71	310	218	208	156	0								
23	625	193	25	309	458	625	534	815	517	397	321	564	463	525	624	438	455	445	662	273	224	183	671	397	509	519	832	676	0								
30	332	374	336	135	218	328	315	490	301	590	409	451	633	404	537	674	544	582	783	545	389	350	791	590	681	689	901	765	337	0							
34	628	183	15	312	462	628	539	816	522	388	330	556	454	517	616	489	445	435	652	266	215	174	662	388	500	510	822	667	10	336	0						
55	631	174	5	316	465	631	544	818	527	379	339	548	445	509	607	480	436	426	643	259	205	164	652	379	491	501	813	657	19	336	10	0					
81	703	0	168	414	559	700	650	861	634	228	508	414	286	383	459	325	262	257	475	179	31	24	485	228	335	344	640	485	193	374	183	174	0				
56	435	333	209	123	264	437	339	636	322	560	227	583	619	537	660	657	573	585	803	461	360	313	811	560	667	677	953	803	196	202	201	206	333	0			
89	687	78	96	383	532	686	618	860	601	280	440	483	344	449	533	380	338	325	541	179	108	78	551	280	391	401	712	557	120	370	111	101	78	287	0		
97	419	385	250	122	244	422	307	628	290	610	181	634	671	588	713	709	628	639	856	504	413	366	865	610	719	728	1008	858	234	232	240	246	385	55	334	0	
100	679	24	159	391	536	676	627	837	611	250	494	406	306	373	455	346	274	274	432	202	47	0	502	250	355	364	654	500	183	350	174	164	24	313	78	366	0

Figure 7. Similarity matrix of ecogeographic parameters

DISCUSSION

Morphological characters

Majority of the morphological characters used in different cladistic studies are binary, usually only some characters included have three or more states. In our morphological multistate matrix, 33 out of 78 characters used have two states and 45 of remaining many state characters are polymorphic. When the multistate characters were coded into presence/absence form, the need to code polymorphic states as new characters disappeared [19].

Our results have demonstrated that using morphological traits alone produce a stable grouping. The morphological resemblances which led [16] to place populations in the same species are correlated with the data of the 78 morphological traits used in our study. Indeed, accessions of the same taxon present a high homology level in morphological characters demonstrated by a low distance in the similarity matrix and by the dendrogram which places them in the same group.

Cluster analysis of morphological traits revealed two basic monophyletic groups, differing only in the relative position of some accessions in subclusters: 1) populations of *V. monantha* in one subcluster linked to two other species (*V. tenuifolia and V. leucantha*) belonging to section Cracca of the subgenus Vicilla (sensu Kupicha) together with four accessions of *V. monantha*; II) all accessions of *V. narbonensis* (section Narbonensis) in one subcluster linked with samples of *V. lutea* (section Hypechusa) in a second subcluster. These results concord with those of [20] which found that species of section Hypechusa were unexpectedly nested within the NSC (subgenus *Vicia*) and section Cracca (subgenus *Vicilla*), respectively.

Sections Narbonensis and Hypechusa (cluster II)

All populations of *V. narbonensis* belong to the same subcluster (IIa). [16] have use 6 characters to rank samples in this species. Also, the utilization of the 78 characters of current study places them in the same subcluster. This observation shows that there are accessions which appear to belong to the same species on the basis of few characters while they have a lot of common characteristics. In parallel, a high distance can be obtained between accessions in this species as in the case of 30 and 81 showing morphological differences between accessions of *V. narbonensis*. This result can be explained by the fact that the key used by [16] did not consider the infraspecific level for this species while several others keys distinguished five or seven varieties. However, the distinction of each variety is based on characters that are difficult to discern in the field [21]. The subcluster IIb is composed of all accessions of *V. lute*a. These observations show that there is an overlap between accessions of *V. lute*a subspecies. Indeed, [16] used the color of flower to distinguish the two subspecies, but the utilization of characters of the present study shows a close relationship between the taxa when it is difficult to determine distinct groups which could be individually identified as *eu-lutea* or as *vestita*. [22] reported that subspecies have been established within species showing significant intra-specific variation. This is consistent with our results where differences at subspecies level can be observed between samples of *V. lutea* subsp. *eu-lutea* as in the case of 62 and 87.

The two populations differ by 8 flower and 5 legume traits, when the remaining characters were identical.

According to [16], *V. narbonensis* belongs to the same serie of *V. lutea* (serie 1). Also, in the present study, they are grouped in the same cluster and have a lot of common characteristics. In the other side, these two species, belonging to subgenus Vicia, section Narbonensis (*V. narbonensis*) and section Hypechusa (*V. lutea*) differ significantly from each other. Morphological differences are reflected in their placement in different subsections. The UPGMA results join the classifications of [1] and [3] who place *V. narbonensis*and *V. lutea*in the same sub-genus (*Vicia*). The apparition of the two sub-clusters (IIa and IIb) also joins these two authors who place the two species in different sections and series (*V. lutea*in the section Hypechusa, serie Hypechusa and *V. narbonensis* in the section Faba by Kupicha and section Narbonensis, serie Narbonensis by Maxted). Our results concord with those of [11] which showed the species of sections Hypechusa as sister to the clade of section Narbonensis. Moreover, in our study, the seed morphology confirms this division, since samples belonging to the two species can have identical seed characters: compressed seed cross-section, smooth seed surface, brown seed color, seed presenting color mottling, hilum length (20-40%), pale hilum, spongy legume inside and seed size 3-6mm. The section Hypechusa reported to be monophyletic based on several works [6]. A closer relationship between the NSC and section Hypechusa has been deduced by [20]. Our data revealed that subgenus *Vicia* is a well-separated subgenus and agreed with the traditional results based on morphology reported by [23] and with results on phylogenetic analyses [6]; [7]

Section Cracca (cluster I)

The results of the analysis of the section Cracca indicate that the species fall into two distinct groups. However, the division between these two groups is not as distinct as between section Hypechusa and section Narbonensis.

Species of section Cracca sensu Kupicha belong all to one group. Fifteen accessions of *V. monantha* are classified in the same subcluster (Ib). But, there are no clear groups defined as *cinerea* or as *calcarata* showing an overlap between the morphology of these subspecies.

An example can be given for samples 77 (*calcarata*) and 91(*cinerea*) distant by 3.74 which have 64 common characters when the key of [16] distinguish between the two subspecies by only two characters (flower size and legume size). Accessions belonging to the same subspecies present also differences. Samples 26 and 74 belonging to *V. monantha* subsp. *calcarata* are a good example in this case. In another side, the cluster II regroup samples of *V. monantha* (subsp. *calcarata* and subsp. *cinerea*) belonging to the series 2 together with the three accessions of *V. tenuifolia* (serie 2) and the unique accession of *V. leucantha* (serie 3). The subcluster Ia comprises populations of *V. tenuifolia*, *V. leucantha* and four populations of *V. monantha* showing also an overlap in morphological traits between these four accessions and the samples of *V. leucantha* and *V. tenuifolia*. The key of [16] classifies *V. tenuifolia* and *V. monantha* in the same series. They also have a lot of common characters according to the results of the present study. The unique accession of *V. leucantha* is classified by [16] in the series 3, when it has a lot of common characteristics with the samples of the serie 2. The species belonging to the cluster I are classified by [1] in the sub-genus *Vicilla*, section Cracca. Thus, the three species attributed to the section Cracca appear in a well-supported monophyletic group in the present work. *V. tenuifolia* and *V. leucantha*, form a subgroup of closely related species that revealed extensive homologous polymorphism with shared characters without any differentiation by species-specific traits. Seed morphology confirmed this division because both *V. tenuifolia* and *V. leucantha* can have similar characteristics, such as SB, SH, SF, SP, SHE, SHL; LPL, LRSh, LC, LAC, LS, LBP, LAS, LAD, LM, LMH, LHE, LAHD, SS, SSh, SNS, Spa, TP, TB, TL, THD, PcL, PL, SP, SASh, WC, WL, KC, KCP, KL, CH, CHD, CTL, LSh, LCS, LP, LSt, LSf, LT, LC, LSC, LBe, LBSh, SNL and all seed characters. However, both species also have different characteristics, such as SEC, SNC, LRS, LLP, SE, NFI, FL, SC, WCP, CBSh, CMSh, CC, CUTL, CLTL, CUTSh, CLTSh, Lpu, LSH. The largest section in the subgenus *Vicilla*, section Cracca (as interpreted by Kupicha), appears paraphyletic. In the present analysis, *V. leucantha*, the species transferred by [5] to his section Ervum, is in the same clade with the remaining Craccaspecies.

In spite of this, our analysis of the morphological characters supports Kupicha's placement of *V. leucantha* in section Cracca as was also done by [24]. These results join those of [7] in his study of phylogenetics of *Vicia* based on morphological data.

Principal Component Analysis

Among morphological characters which contribute the most in accessions separation, three are quantitative (PL, HL, LPL) and the majority is qualitative (LC-CHD-SF-LAHD-LHE-SC-LSI-LS-SCM…). Those which contribute least to samples separation are both qualitative (SB-CC-LSI-SP) and quantitative (SNL-NFI-FL-PL). As quantitative characters are essential at this taxonomic level, several quantitative characters were included in the present study according to recommendations of [25]. In the other side, there are many qualitative characters like color of seeds and hilum color, which usually are not used for taxonomy, but are important for cultivar identification. Information on the variability of these hereditary characteristic in populations from different geographical regions can also be useful for curators and collectors. Our data show that the qualitative variables allowed a clear separation of *Vicia* taxa and are good diagnostic taxonomic characters for the accessions. The same findings were reported by [26] in their study on several *Vicia* taxa in Southern Brazil where they underline a clear samples separation by corolla color, pod and seed color and pod constriction. Concerning characters that strongly contribute to the separation of the accessions, the range of variation does show overlap at subspecies level. PCA shows that morphological characters which strongly contribute in accessions distinction concern characters of leaflets, flower, stem, pod and seed showing the importance of each part of the plant in accession distinction. According to [24], *Vicia* species present considerable variations in almost every trait, but particularly in leaflet morphology. Our results show that, effectively, among characters which strongly contribute to samples distinction, six (LC, LAHD, LHE, LPL, LLP, LRSh) concern leaflets traits. In the present study, leaf and stem characters were measured at the first productive node. Leaflets were also measured at the lower part of the stems, so that heterophylly, an indicator of the difference in leaf shape at the bottom and the top of the plant, which has been used by [27].

The results of PCA show that there is a strong positive correlation between characters of the same part of the plant like standard pubescence and pedicel length or between characters which belong to different parts like seed color mottling and leaflets per leaf. In parallel, traits of the same plant part can have a strong negative correlation as in the case of leaflets relative shape and leaflets per leaf. In our results, no differences were observed for leaflet abaxial color, leaflet broadest point, leaflet apex dentate, tendril branching, wing length and legume beak shape. These characters are identical between the 37 *Vicia* populations and cannot be used for taxa identification. Morphological characters used in the present work allow good separation among accessions at species levels as shown by the use of the observation with the sum of the squared cosines (Figure 4) which determines three distinct groups which could be individually identified when no groups at subspecies level were generated. The first group includes all accessions of *V. narbonensis*. The second one contains samples of *V. lutea*. The third group includes all accessions of subgenus *Vicilla* section *Cracca* (*V. monantha, V. tenuifolia and V. leucantha*) showing even an overlap among these three taxa.

Ecogeographic diversity

The results of the ecogeographic survey elucidate each taxon geographic and ecological location, and thus which areas could most profitably be targeted for future collecting missions. The use of GPS in the present study is supported by the recommendations of [28]. According to [29], in the Mediterranean region, there is a need for more collection in Algeria, Egypt and Yemen.

The wide geographic ranges found in the present work should be taken into account both in conservation programs and in the genetic improvement of this economically important wild *Vicia* species as suggested by [30]. The UPGMA results show that accessions with high morphology differences and belonging to different taxa can have an identical bioclimate and close altitudes. On the other hand, the groups may comprise accessions from similar latitudes and climates. The same findings were reported by [31]. The dendrogram obtained with ecogeographic parameters did not indicate clear division among accessions based on their geographical locations, indicating that the association between genetic similarity and geographical distance was less significant as it was reported by [32]

Considering all stations of the current work, the studied samples of *Vicia* L. occur from 11 to 1222m. Algeria has all the Mediterranean bioclimates from the perhumid in the north to the perarid in the south for the bioclimatic levels and from the cold to the hot for their temperature variants. Sites investigated belong to 6 different bioclimates (SH, SAS, SAM, SA, AS, SAI) and are characterized by cool, wild, warm or temperate winter with a minimum average temperature ranged from 0.63 to8.64°C.

Samples of *V. narbonensis* were collected from sites receiving between 382.95 and 697.18 mm of precipitations and belonging to bioclimates characterized by cool or mild winter. This is consistent with findings of [28] who reported that taxa belonging to the *V. narbonensis* complex occur over a wide range of altitudes, from sea level to 3200m. According to [33], *V. narbonensis* shows adaptation in areas receiving 250–300 mm annual rainfall with low winter temperatures. Accessions belonging to *V. monanatha* occur until 1222m and at these altitudes they require some frost tolerance as the temperatures can drop to 0.63°C. It is interesting to mention that it is from m = 1 and not m = 0, as the risk of frost become important. The patterns described above are not necessarily a true indication of the preferred altitude of each taxon but may reflect the number of collections that occurred at each altitude.

CONCLUSION

The present study is the first attempt to analyze phonetic relationships among some Algerian species of genus *Vicia* using cladistic analysis of 78 morphological characters and 5 ecogeographic parameters. Sections *Narbonensi*s (*V. narbonensis*) and Hypechusa (*V. lutea*) were considered a separate group, while section *Cracca* was the most heterogeneous section. Significant differences at subspecies level were observed regarding the results of investigated morphological traits. Several studies have mapped the distributions of the *Vicia* species. Their results must be used in conjunction with those described in this study to provide further information on the ecogeography of *Vicia* species. To clarify the position of species, collections need to be made in Algeria and grown for further identification in the same location.

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