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PHENETIC ANALYSIS OF THE IRANIAN SPECIES OF THE *BROMUS* SECTIONS *GENEA*, *NEOBROMUS* AND *NEVSKIELLA*

A. Aryavand*

Department of Biology, Faculty of Sciences, University of Isfahan, Isfahan, Islamic Republic of Iran

Abstract

A phenetic analysis of the 12 taxa or operational taxonomic units (OTUs) belonging to the three sections; *Genea, Neobromus,* and *Nevskiella* of the genus *Bromus* was performed. Unweighted pair-group method using arithmetic averages (UPGMA) and weighted pair-group method using arithmetic averages (WPGMA) clustering and factoriel method analyses were used to set the taxa apart. Forty-four characters including 4 vegetative and 38 reproductive characters, the chromosome number and the geographical distribution were considered in this study. The outcomes of multivariate analyses were compared with different conventional classifications. The results show that four major phenetically well-defined groups existed which confirmed the Sale's concept. This finding, however, is in odd with that expressed in Flora of U.S.S.R. The relations between the taxa were discussed, and a key to identify them was presented.

Keywords: *Bromus*; *Genea*; *Neobromus*; *Nevskiella*; Phenetic analysis; Iran

Introduction

The genus *Bromus* L. consists of *ca*. 130 species and many subspecies and varieties in the temperate areas of Eurasia and America [14]. Due to morphological variations within the taxa, several taxonomists studied this genus and divided this genus into 6 or 7 subgenera and sections. Dumortier (1823) (cited by Sales [11]) for the first time divided *Bromus s.l.* into four sections; sect. *Genea*, sect. *Bromopsis*, sect. *Pnigma* and sect. *Bromium*. Stebbins [18], following the Smith's nomenclature [14], recognized seven subgenera for the genus *Bromus s.l.: Neobromus* Shear, *Ceratochloa* P. Beauv., *Festucaria* L., *Stenobromus* Griseb., *Nevskiella* V. Krecz and Vved., *Bromus* and *Boissiera* Hochst. In Flora of the U.S.S.R. [9] the genus *Bromus* was divided into four subgenera namely *Zerna* (Panzer) Asch., *Stenobromus* Griseb., *Nevskiella* V. Krecz. and Vved., and *Zeobromus* Griseb. *Bromus danthoniae* Trin. which is considered in the "Flora Iranica" [3] as the only member of the sect. *Neobromus*, is treated in the Flora of the U.S.S.R. [9], as a member of the subgen. *Zeobromus.*

According to Smith [14], Bor [2,3], Smith [15], and Sales [11], there are six sections in the genus *Bromus* named: *Bromus, Genea* Dumort., *Nevskiella* (V. Krecz.

* *E-mail: aaryavand@yahoo.com*

and Vved.) Bor, *Neobromus* (Shear) Hitch., *Ceratochloa* (P. Beauv.) Griseb. *ex* Ledeb., and *Pnigma* Dumort.

In Flora Iranica, Bor [3] reported 44 species in the genus *Bromus*; from these taxa, 29 species, belonging to the five sections, have been reported from Iran. The sect. *Genea* includes about 7 or 8 annuals and sometimes biennial species. This section is widely distributed in Mediterranean countries, south-west Asia and also in northern Europe; some taxa specially *B. rubens* L. and *B. tectorum* L. are imported as weed to other regions of the world, mainly within a Mediterranean-type of climate specially in North America and Australia [5,7]. The sections *Neobromus* and *Nevskiella* are monotypic including *B. danthoniae* and *B. gracillimus* Bunge, respectively.

Bor [3] reported 7 species from sect. *Genea* in Flora Iranica and 6 species in Iran. According to him *B. diandrus* Roth was the only unreported species within the borders of Iran until 1970. This species is native to the Kurdistan of Iraq and Mediterranean region. Stebbins [18] by correlating karyological data with morphology and distribution of the genus *Bromus*, suggested an Eurasia origin for this genus, presumably in the Tertiary period. Scholz [13], on the basis of new morphological characters, retained *Bromus fasciculatus* Presl subsp. *delilei* (Boiss.) H. Scholz as an eastern marginal segregate of the south- Mediterranean species *B. fasciculatus* var. *alexandrinus* Thell. Sales [11,12] by conducting a multidisciplinary investigation of sect. *Genea*, brought new ideas to the taxonomy, nomenclature and evolutionary trends. She suggested that these taxa are still actively in the process of speciation, and presented a list of ancestral and derived characters for this group.

In this article, a phenetic analysis of the Iranian species of the *Bromus* sect. G*enea*, *Neobromus*, and *Nevskiella* is presented. In addition to 9 taxa belonging to six species of the section *Genea*, 3 taxa of the sect. *Neobromus* (*B. danthoniae* var. *danthoniae*, and *B. danthoniae* var. *lanuginosus* Rostev.) and *Nevskiella* (*B. gracillimus*) were examined. The main objectives of this study are:

(1) Surveying of the members of these sections in Iran with more detailed numerical data

(2) Demonstrate the relations between these taxa and to acquire the main aggregate species into these sections

(3) Presentation of a key on the basis of surveying Iranian specimens to identify them.

Material and Methods

The plant specimens were obtained from collections, which have been performed during the years 2000-2001, and main herbaria in Iran. These included University of Isfahan Herbarium (IUH), Herbarium of the Institute of Forests and Rangelands in Tehran (TARI), the Herbarium of the Research Institute of Agricultural Ministry (Iran) (PPDRIE), and the Central Herbarium of the University of Tehran (TUH) and other local herbaria. The specimens selected for phenetic analysis cover approximately the whole area of the geographical distribution of the taxa in Iran. The phenetic characters used in this research were those found in mature plants, unless stated otherwise. Spikelet measurements exclude the awns.

Data Accumulation

12 taxa constituted the operational taxonomic units (OTUs) (Table 1), and more than 150 specimens were studied. The 12 OTUs were compared using a total of 44 characters. These characters included 38 reproductive and 4 vegetative ones. The chromosome number and geographical distribution of the OTUs were also considered. Each morphological character was measured at least 10 times in any specimen, and the mean was used as a single character. Characters and character states are shown in Table 2. Information for chromosome number and geographic distribution were extracted from the literature [1,3].

Data Processing

The data matrix (Table 3) for 12 OTUs by 44 characters was analyzed by cluster and factoriel analyses.

Table 1. Taxa studied and acronyms

1- *Bromus danthoniae* Trin. var. *danthoniae*	dd
2- *Bromus danthoniae* Trin. var. *lanuginosus* Rozhev.	dl
3- *Bromus fasciculatus* Presl var. *alexandrinus* Thell.	fa
4- *Bromus gracillimus* Bunge	gr
5- *Bromus madritensis* L. var. *ciliatus* Guss.	mc
6- *Bromus madritensis* L. var. *madritensis*	mm
7- *Bromus rubens* L. var. *glabriglumis* Maire	rg
8- *Bromus rubens* L. var. *rubens*	rr
9- *Bromus sericeus* Dorobov	se
10- *Bromus sterilis* L.	st
11- *Bromus tectorum* L. var. *hirsutus* Regel	th
12- *Bromus tectorum* L. var. *tectorum*	tt

Table 2. Characters and character states used in the phenetic analysis

1- Stem height: long (1), short (2), very short (3)
2- Stem position: erect (1), erect and ascending (2), erect and geniculate at the base (3)
3- Indumentum of leaf sheaths: pubescent (1), pilose (2)
4- Indumentum of blade leaf: pubescent (1), softly pilose (2)
5- Position of the panicle: erect or somewhat erect (1), nodding (2)
6- Panicle condensation: lax or open (1), dense (2), very dense (3)
7- Size of panicle branches: very long, more than 30 mm (1), long, 10 to 30 mm (2), short, up to 10 mm (3)
8- Number of panicle branches per node: non or few ramifications up to 2-3 (1), many, more than 4 (2)
9- Ramification of the panicle: not unilateral (1), unilateral (2)
10- Ramification of the panicle: erect or little flexuosus (1), flexuosus (2), nodding (3)
11- Texture of the ramification: thick (1), slender (2)
12- Length of pedicel comparing to spikelets (excluding awn): much longer than spikelets (1), shorter than spikelet or somewhat equal (2), shortly pedicellate or subsessile (3)
13- Number of spikelets on the ramification of the panicle: 1, 2 or rarely 3 (1), more than 3 (2)
14- Shape of spikelets: ovate lanceolate (1), lanceolate to oblong (2), cuneate (3)
15- Presence of hairs in spikelets: glabrous (1), glabrous or hairy (2), pubescent (3), pilose (4)
16- Number of florets in spikelets: up to 9 florets (1), more than 9 florets (2)
17- Number of sterile florets in spikelets: up to 3 (-5) sterile florets (1), more than 5 sterile florets (2)
18- Articulation at the floret base: articulated (1), not articulated (2)
19- Shape of lower glume: lanceolate (1), narrowly lanceolate or subulate (2)
20- Length of lower glume: short up to 5 mm long (1), 6-9 mm long (2), more than 10 mm long (3)
21- Width of lower glume: wide, more than 1 mm width (1), narrow, less than 1 mm width (2)
22- Shape of upper glume: elliptic (1), lanceolate (2), linear lanceolate (3)
23- Length of upper glume: up to 9 mm long (1), 10 to 18 mm long (2)
24- Width of upper glume: wide, more than 3 mm width (1), narrow, less than 3 mm width (2)
25- Texture of glumes: more like leaves (herbaceous) (1), with little developed hyaline area (2), with well developed hyaline area (3)
26- Number of nerves in lower glume: one nerve (1), 3 nerves (2), 3-5 nerves (3)
27- Number of nerves in upper glume: 3 nerves (1), 3-5 nerves (2), 7-9 nerves (3)
28- Shape of lemma: broadly elliptic or oblong (1), narrowed-lanceolate (2), narrowed-subulate (3)
29- Number of nerves in lemma: up to 5 nerves (1), 7-9 nerves (2), 9-11 nerves (3)
30- Texture of lemma: more like leaves (herbaceous) (1), with wel developed hyaline area (2)
31- Indumentum of lemma: glabrous (1), glabrous or hairy (2), pubescent, pilose or hirsute (3)
32- Margin of lemma: straight (1), somewhat inrolled at maturity (2)
33- Lemma and palea morphology: similar (1), dimorphic (2)
34- Length of palea comparing to lemma: shorter than lemma (1), more or less equaling to lemma (2)
35- Shape of palea: broadly elliptic (1), narrowed lanceolate (2)
36- Length of palea: short, up to 8 mm long (1), long, more than 9 mm long (2)
37- Width of palea: narrow less than 1.5 mm width (1), wide, more than 1.5 mm width (2)
38- Indumentum of awn: glabre or smooth (1), rough or scabrid (2), pubescent or hairy (3)
39- Length of awn comparing to lemma: somewhat equal (1), longer (2)
40- Number of awns in lemma: one awn (1), more than one awn (2)
41- Number of stamens: 3 stamens (1), 2 stamens (2)
42- Length of anthers: up to 1 mm long (1), more than 1 mm long (2)
43- Chromosome number: 2n=14 (1), 2n=28 (2)
44- Phytogeography: Euro-Siberian (1), Euro-Siberian and Irano-Turanian (2), Irano-Turanian and Saharo-Sindian (3)

Table 3. Raw data matrix of 12 OTUs and 44 multistate characters

	dd	**dl**	**fa**	**gr**	**mc**	**mm**	**rg**	**rr**	**se**	**st**	**th**	**tt**
1	2	2	3	2	2	2	2	2	2	1	2	2
2	2	2	3	1	2	2	2	2	3	2	1	1
3	1	1	2	1	2	2	2	2	2	1	2	2
4	1	1	2	1	1	1	1	1	2	2	1	1
5	1	1	1	1	1	1	1	1	2	2	2	2
6	2	2	3	1	2	2	3	3	2	1	2	2
7	3	3	3	2	3	3	2	2	2	1	2	2
8	1	1	1	2	1	1	2	2	2	1	2	2
9	1	1	1	1	1	1	1	1	2	1	2	2
10	1	1	1	1	1	1	1	1	2	3	2	2
11	1	1	2	2	2	2	2	2	2	2	2	2
12	3	3	3	1	3	3	3	3	2	1	1	1
13	1	1	1	1	1	1	1	1	1	1	2	2
14	2	2	3	1	3	3	3	3	3	3	3	3
15	1	4	2	3	4	1	1	4	4	2	4	1
16	2	2	1	1	1	1	1	1	1	1	2	2
17	1	1	1	1	1	1	2	2	1	1	2	2
18	2	2	1	2	1	1	2	2	2	1	2	2
19	1	1	2	1	2	2	2	2	1	2	1	1
20	2	2	2	1	2	2	2	2	3	3	2	2
21	1	1	2	1	2	2	2	2	1	2	1	1
22	1	1	3	2	3	3	3	3	2	3	2	2
23	1	1	2	1	2	2	2	2	2	2	2	2
24	1	1	2	2	2	2	2	2	2	2	2	2
25	1	1	2	1	2	2	3	3	2	2	3	3
26	3	3	1	1	1	1	1	1	2	1	1	1
27	3	3	1	1	1	1	1	1	2	1	1	1
28	1	1	3	1	3	3	3	3	2	2	2	2
29	3	3	1	1	2	2	1	1	2	2	1	1
30	2	2	2	1	1	1	2	2	1	1	2	2
31	1	3	2	3	3	1	1	3	3	2	3	1
32	1	1	2	1	2	2	2	2	1	1	1	1
33	1	1	1	1	1	1	2	2	1	1	2	2
34	1	1	1	2	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	2	2	1	1	2	2
34	1	1	1	2	1	1	1	1	1	1	1	1
35	1	1	2	1	2	2	2	2	2	2	2	2
36	1	1	2	1	2	2	2	2	2	2	2	2
37	2	2	1	1	1	1	1	1	1	1	1	1
38	1	1	2	1	2	2	2	2	2	2	2	2
39	1	1	1	2	1	1	1	1	1	2	1	1
40	2	2	1	1	1	1	1	1	1	1	1	1
41	1	1	1	1	2	2	1	1	1	1	1	1
42	2	2	1	1	2	2	2	2	2	1	2	2
43	1	1	1	1	2	2	2	2	1	1	1	1
44	1	1	2	3	2	1	2	2	3	1	1	1

Cluster Analysis

The percent disagreement and city block (Manhattan) distance coefficients were used for computing dissimilarity matrices. The resulting OUT × OTU correlation matrices served as input for illustrating the correlation of a phenogram by the unweighted pair-group method using arithmetic averages (UPGMA) and the weighted pair-group method using arithmetic averages (WPGMA) methods [16] with aid of software "Statistica" [17]. The phenograms of UPGMA and WPGMA clustering analysis are similar, thus only the first one is presented here (Figs. 1 and 2).

Factoriel Analysis

Factoriel analysis was performed on the 44 × 44 morphological characters correlation matrix obtained from raw data matrix by calculating the percent disagreement coefficients between each pair of the 44 characters [16]. After computing eigenvalues and variances of the first three principal components (Tables 4 and 5), factors and taxa loading on the first three axes are shown in Figures 3 and 4. As, the presentation of the OTUs in the three dimensional diagram is not sufficiently clear, in addition of the above mentioned phenograms, a presentation of the OTUs in the two dimensional phenogram (Fig. 5) is also demonstrated. The computational work was done by using the softwares "Statistica" [17] and "NTSYS-PC" [8].

Results

Cluster Analysis

Four major well-defined phenetic clusters were obtained from these analyses. These clusters retained their integrity regardless of the two clustering techniques utilized (UPGMA and WPGMA).

Factoriel Analysis

The position of the OTUs in the factor axes (Figs. 4 and 5) is in agreement with the results of the UPGMA clustering method (Figs. 1 and 2).

Factor 1 was the best discriminator between the main groups. The most important characters in this factor were leaf sheath indumentum; texture of the ramification of the panicle; shape, size and texture of the glumes, lemma and palea; number of nerves in the glumes; awn indumentum and finally number of awns in lemma.

In factor 2, the most important characters were position and ramification of the panicle and number of spikelets on the ramification of the panicle.

Finally, in factor 3, the most important characters were texture of lemma and length of awn. All important characters are asterisked in Table 5.

Discussion

The cluster and ordination analyses showed four phenetically significant groups as follow:

1) *Bromus tectorum* var. *tectorum*, *B. tectorum* var. *hirsutus* and *B. sericeus*.

2) *B. fasciculatus* var. *alexandrinus*, *B. madritensis* var. *madritensis*, *B. madritensis* var.*ciliatus*, *B. rubens* var. *rubens* and. *B. rubens* var. *glabriglumis*.

3) *B. sterilis*.

4) *B. gracillimus*, *B. danthoniae* var. *danthoniae* and *B. danthoniae* var. *lanuginosus*.

The groups which emerged from multivariate analyses, confirm the concept of Sales [11], while, it does not concur with the classification of Roshovites and Shishkin [9].

In fact, in the Flora of U.S.S.R. [9], the subgen. *Stenobromus* (=sect. *Genea*) is divided into four series namely ser. *Sterile* (including *B. sterilis* and *B. madritensis*); ser. *Rigentes* (*B. rigens*), ser. *Rubentes* (*B. rubens* and *B. tectorum*), and finally ser. *Sericeae* (*B. sericeus*). According to this Flora, *B. gracillimus* belongs to the subgen. *Nevskiella* and *B. danthoniae* is included in the subgen. *Zeobromus*.

Taxonomic position of the genus *Bromus* has been discussed by various authors like Smith [14], Stebbins [18], Macfarlane , Watson [6], Sales [11,12] and Scholz [13]. Based on karyological data, Stebbins (1981) suggested an origin in the Tertiary in Eurasia for the genus *Bromus*. He considered that the most primitive, now extinct, *Bromus* species probably differentiated in south-west Asia during the Miocene. Sales [11] suggested that the center of origin for sect. *Genea* is south-west Asia. She believed that this was also the center of genetic diversity, center of greatest ecological range, center of frequency and presence of close relatives. Sales [12] conclusions were based on a multivariate approach in *Bromus madritensis* complex, and she tried to clarify the taxonomic problems posed by this group. According to her idea, this complex contains 4 species namely *B. madritensis*, *B. rubens*, *B.haussknechtii*, and *B. flabellatus* Boiss. She concluded that the entire range of variation falls in one species with two subspecies: *B. madritensis* subsp. *madritensis* and *B. madritensis* subsp. *rubens*. Present results confirm her conclusions, except that the specific ranks for these taxa were preserved. Such conclusions were based on major differences between these taxa alluded to in the taxonomic key presented here.

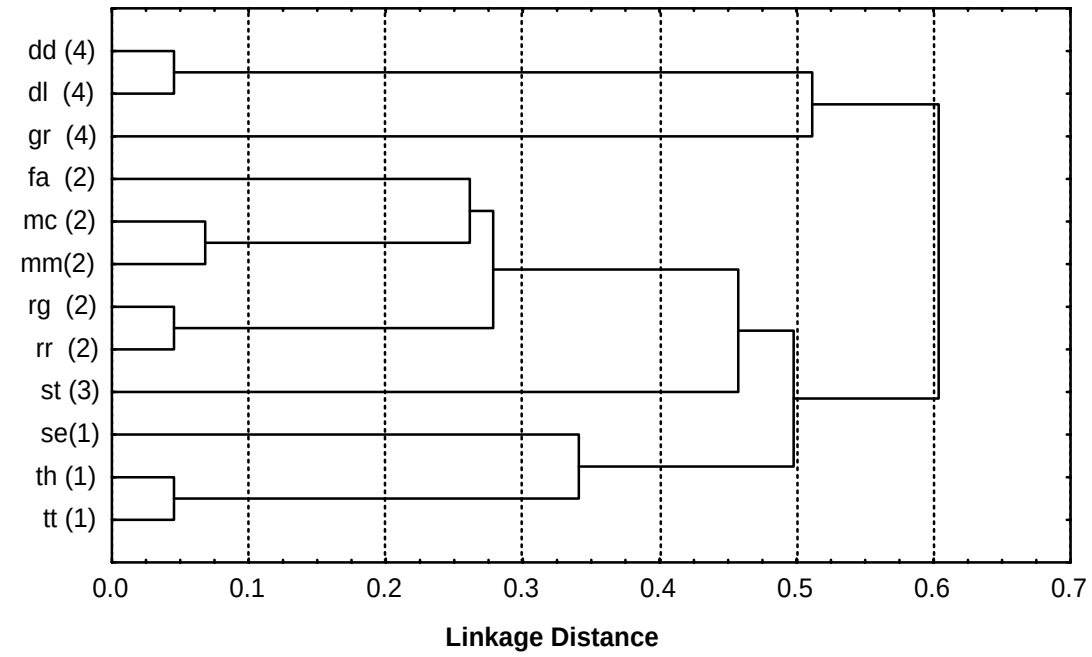

Figure 1. Phenogram of UPGMA clustering analysis of the taxa studied by using percent disagreement coefficient. The number of the phenons is demonstrated into parenthesis.

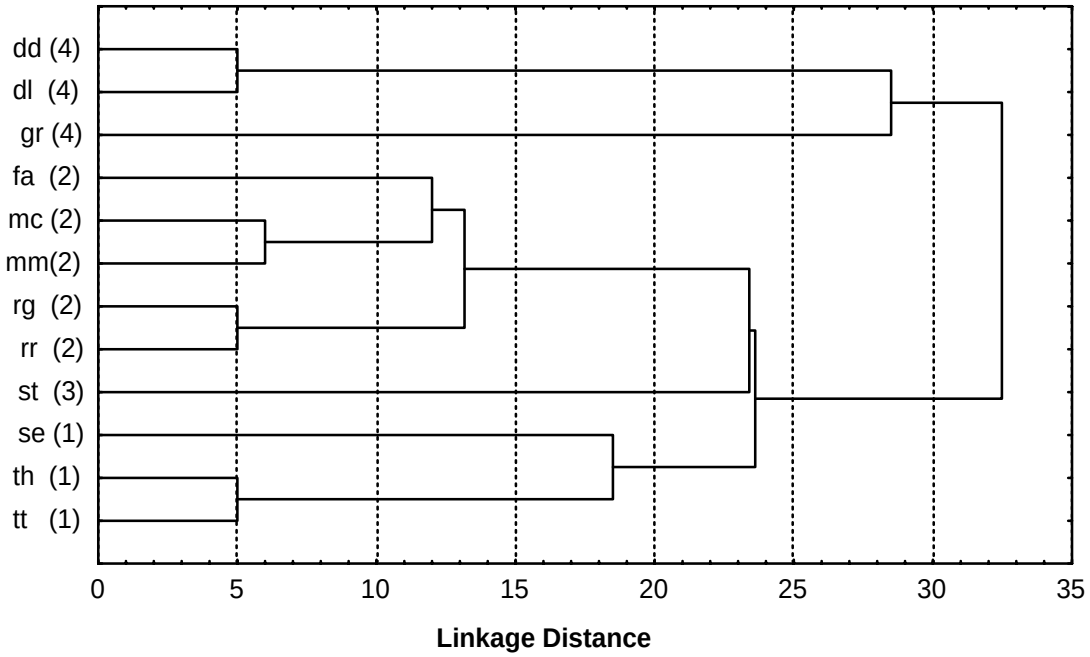

Figure 2. Phenogram of UPGMA method clustering analysis of the taxa studied by using Manhattan distances coefficient. The number of phenons is demonstrated into parenthesis.

Table 4. Principal component analysis (PCA); Eignvalues and variances of the first three principal components

	Eigenvalue	Variance	% Cumulative Eigenvalue	% Total Cumulative variance
1	15.54431	35.32797	15.54431	35.32797
2	8.41945	19.13512	23.96376	54.46309
3	6.7741	15.39588	30.73795	69.85897

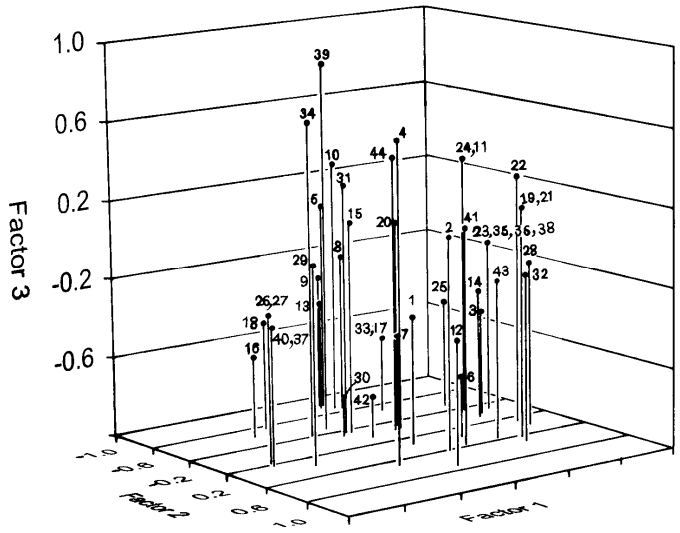

Figure 3. Factoriel analysis of the characters on the first three factors by calculating the percent disagreement coefficient (characters loadings).

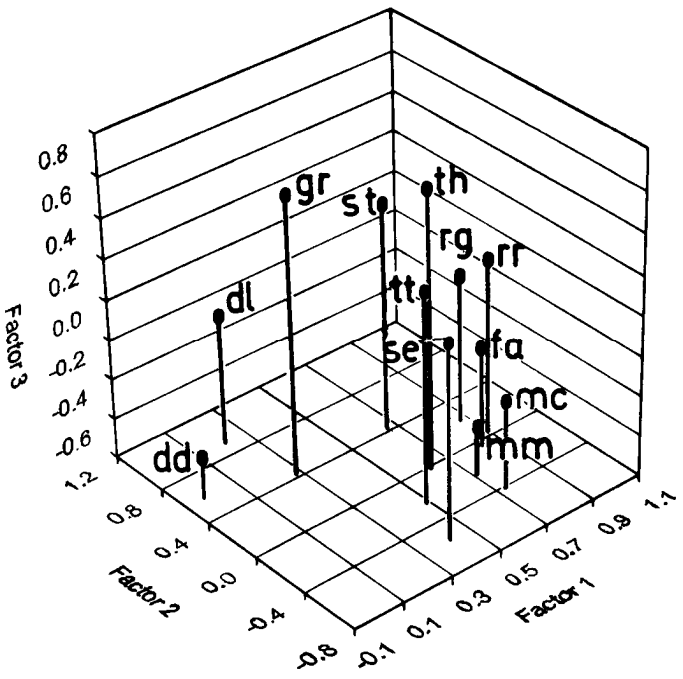

Figure 4. Factoriel analysis of the taxa studied on the first three factors by calculating the percent disagreement coefficient (taxa loading).

Table 5. Principal components analysis (PCA): loading value of each character on the first three principal factors

	Factor 1	Factor 2	Factor 3
1	-.05431	.346566	-.352362
2	-.13406	.597158	.073272
3	*-.80129	.050543	-.448746
4	-.23028	-.018150	.478079
5	-.22244	* -.806696	.053145
6	-.38453	.407219	-.682803
7	.32708	.696408	-.355375
8	-.27723	-.675049	-.199545
9	-.16669	*-.766488	-.313249
10	-.21487	.669683	.290186
11	* -.88989	-.233324	.305066
12	.04327	*.901068	-.378381
13	-.16098	*-.749486	-.443061
14	-.78443	.060686	-.345384
15	.05523	-.128693	.079399
16	.57626	-.408061	-.591446
17	-.43528	-.472084	-.623220
18	.40948	-.531538	-.452825
19	-.67646	.614688	.169588
20	-.25077	-.078221	.051994
21	-.67646	.614688	.169588
22	*-.89873	.295683	.266297
23	* .94780	-.056708	-.117426
24	*-.88989	-.233324	.305066
25	*-.81086	-.325470	-.453944
26	*.85761	.159809	-.260675
27	*.85761	.159809	-.260675
28	*-.89573	.414322	-.158571
29	.68815	.374040	-.001723
30	.14523	-.086172	* -.792357
31	.08016	-.155943	.266014
32	-.61977	.721542	-.153953
33	-.43528	-.472084	-.623220
34	.28499	.225771	.595322
35	*-.94780	-.056708	-.117426
36	*-.94780	-.056708	-.117426
37	* .88989	.233324	-.305066
38	*-.94780	-.056708	-.117426
39	.12367	-.297256	*.872690
40	* .88989	.233324	-.305066
41	* .88989	.552344	.096403
42	.02023	.040823	-.789988
43	-.53183	.557103	-.196736
44	-.16019	.026629	.405540
Expl. Var	15.54431	8.419454	6.774185
Prp. Totl	.35328	.191351	.153959

*Important characters

Scholz [13] considered that *B. fasciculatus* must be principally a south Mediterranean grass, annual and diploid. Morphologically, it occupies a rather isolated position with narrow-linear lemma of only 1.5-2 mm width. He concluded also that the inclusion of the latter in *B. rubens* as a subspecies is based only on a superficial similarity of inflorescence structure (compact panicle) and is otherwise not actually justified. Based on the number of flower on the spikelet, lemma callus, indumentum of the lower leaf sheaths and so on, Scholz recognised two subsp. named *B. fasciculatus* subsp. *fasciculatus* (including *B. fasciculatus* var. *alexandrinus* Thell.) and *B. fasciculatus* subsp. *delilei* (Boiss.) H. Scholz. The first taxon only exists in Iran. Our results demonstrate that *B. fasciculatus* is very close to *B. madritensis* aggregate.

Bromus sterilis occurs as isolated in the cluster analyses. In fact, as stated by Sales [10], this species is a very distinct annual brome-grass, easily recognized by the very open panicle with few long spikelets at the top long, slender branches. In all features, *B. sterilis* seems to be the least specialized plant in the sect. *Genea*, and its main distribution in the Euro-Siberian territory supp-orts its basic evolutionary position within the section.

B. tectorum group (including *B. tectorum* var. *tectorum*, *B. tectorum* var. *hirsutus* and *B. sericeus*) is the most widespread, extending from the Canary Islands, north west Africa, throughout Europe and south west Asia to Pakistan [3,4], and one of the most evolved line in this section.

Although, *B. danthoniae* has been placed in the same cluster that *B. gracillimus* placed, these two species are separated from each other at the more than 50% level of dissimilarity index. This act confirm that, these species belong to the different sections.

As one can see, sect. *Genea* contains several critical groups of species where the inherently high variation includes components arising from probable occasional hybridization and from developmental plasticity. Morphology of panicles and to a lesser extent, of spikelets can be greatly affected by the water and soil nutrient supply. Many important characters (both qualitative and quantitative) vary considerably between juvenile and mature states.

In conclusion, it is suggested that the south-west Asia, specially Irano-Turanian region has been the center of diversity of the sect. *Genea*, and all variation of these taxa occur in this area. The most primitive taxa like *B. sterilis* is basically a Euro-Siberian species, *B. tectorum* group mainly Euro-Siberian, Mediterranean and Irano-Turanian and others like *B. madritensis* group are Mediterranean extending to western Iran and some localities in Afghanistan [3]. Finally, to reveal these

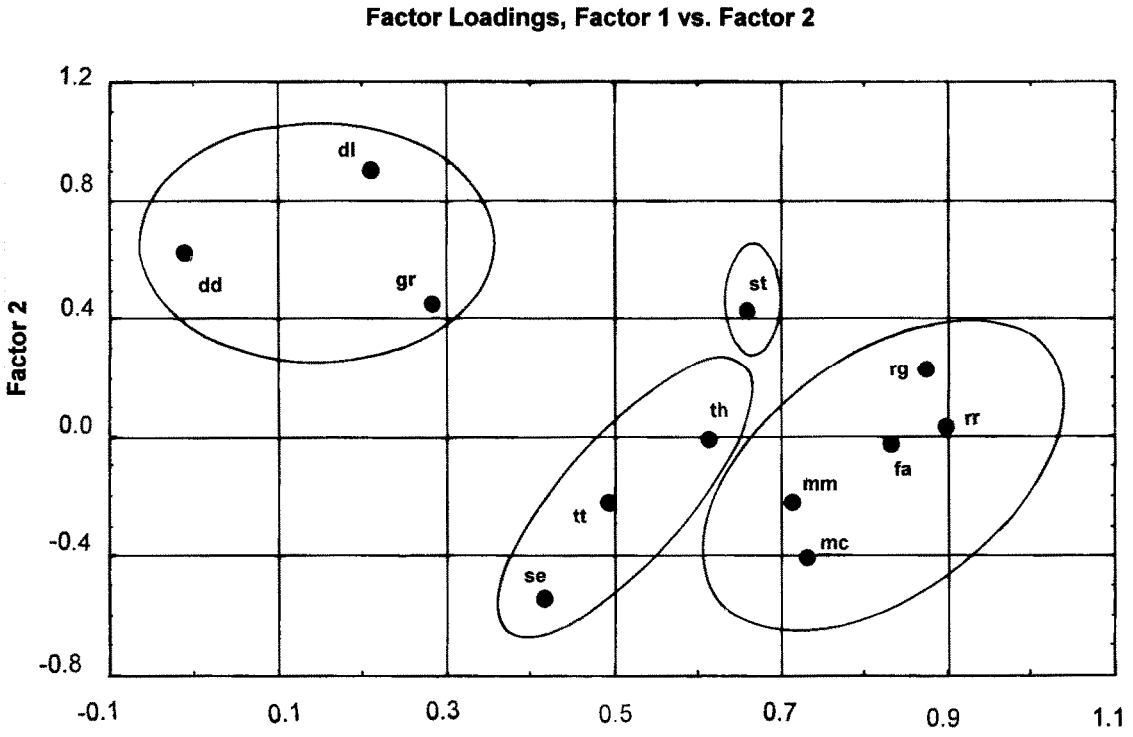

Figure 5. Factoriel analysis of the taxa studied on the first two factors by calculating the percent disagreement coefficient (taxa loading).

taxa better, a key of identifying of them on the basis of surveying more than 150 Iranian specimens is presented below.

Key of the Different Sections of the Genus *Bromus*

1a. Plant mostly perennial sect. *Pnigma*
b. Plant mostly annual or biennial 2

2a. Awns geniculate, recurved at maturity; and teeth of lemma aristate; lemma, at least the upper, with three awns; side-awns shorter
sect. *Neobromus* = (B. *danthoniae*)

b. Awns straight or divaricate, not geniculate; each lemma has only one awn
3

3a. Lemma oblanceolate in side view; awn slender, terete, 3-5 times longer than lemma
sect. *Nevskiella* = (B. *gracillimus*)

b. Lemma elliptic or lanceolate in side view; awn at maximum 1-2 times longer than lemma
4

4a. Lower glume 1-nerved (3-nerved in *B. sericeus*); upper glume 3-nerved (5-nerved in *B. sericeus*); lemma narrow, elongate; spikelets oblong or wedge-shaped, not elliptic nor lanceolate, wider at top and not tapering towards the tip; awn usually longer than lemma
sect. *Genea*

b. Lower glume 3-7 nerved; upper glume 5-9 nerved; back of lemma rounded; lemma wide, short; spikelets ovate to lanceolate; awn about as long as or shorter than lemma
sect. *Bromus*

In this article, the sections *Neobromus*, *Nevskiella* and *Genea*, have been studied, and the key for the determination of their taxa in Iran has been presented. The sections *Bromus* and *Pnigma* will be reported in the future.

Section Neobromus

This section has only one species namely *B. danthoniae* with two varieties in Iran as follow:

Spikelets glabrous; lateral awn conspicuous var. *danthoniae*

Spikelets hairy var. *lanuginosus* Rozhev.

Section Nevskiella

This section has only one species in Iran, namely *B. gracillimus* Bunge.

Section Genea

1a. Panicle nodding, open, with branches drooping or secund; most panicle branches as long as or longer than their spikelets 2

b.Panicle ± erect, often dense or nearly so; most panicle branches shorter than their spikelets, or spikelets sub sessile 4

2a. Panicle loose, usually simple; branches widely spreading, up to 10 cm long, carrying 1-3 spikelets including the awns up to 60 mm long; anthers 3, 1-1.8 mm long

B. sterilis

b. Panicle usually compound, contracted or somewhat loose; the longer panicle branches bearing 4 or more spikelets; spikelets parallel or roughly parallel, erect or turned to one side; lemma with silvery margins 3

3a. Lower glume 1-nerved; upper glume 3-nerved; lemma 10-12 (-16) mm long

B. tectorum

b. Lower glume 3-nerved; upper glume 5-nerved; lemma 20-25 mm long

B. sericeus

4a. Panicle branches 1-3 ramifications with 1-2 spikelets on each panicle branches; Spikelets 4-9 flowered, 1.5-2.5 cm long; lemma (without awn) 9-16 × 1.5-2 mm; lemma in fruit with involutes edges and ± slightly bent outwards; awn inserted 0.8-3.5 mm below the bifid tip; awns often curved outwards at maturity; anthers 3, 0.3-0.4 mm long

B. fasciculatus subsp. *Fasciculatus* = *B. fasciculatus* var. *alexandrinus*

b. Panicle branches with more than 3 ramification; more than three spikelets on each branches; glumes and lemma wider; lemma 2-3 mm wide or more; awn straight; anthers 2 rarely 3 and more than 0.5 mm long 5

5a. Panicle branches often longer than spikelets, sometimes shorter; shortest branch on lowest panicle node 6- 24 mm long; little ramified (longest branch on lowest node 0-1-ramified); sterile florets up to 3; panicle internodes gradually shorter towards the top; florets clearly distichous at maturity; lemma at least 3 mm broad; spikelets not densely crowded; Panicle branches 10 mm or more

B. madritensis

b. Panicle branches always much shorter than spikelet (shortest branch on lowest panicle node up to 6 mm long); panicle much ramified (longest branch on lowest node 2-5-ramified); sterile florets 3 or more; panicle internodes dramatically shorter towards the top especially after the second node; florets ± imbricate at maturity; lemma 2-3 mm broad; spikelet densely crowded; panicle branches 1-10 mm long

B. rubens

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