

A TAXONOMICAL, MORPHOLOGICAL AND CYTOLOGICAL REVISION OF THE GENUS FORMERLY TREATED AS NARDURUS REICHENB. (POEAE, POACEAE) IN IRAN

S. Zoughi, H. Saeidi & M. R. Rahiminejad

Received 22.02.2011. Accepted for publication 16.11.2011.

Zoughi, S., Saeidi, H. & Rahiminejad, M. R. 2011 12 31: A taxonomical, morphological and cytological revision of the genus *Nardurus* Reichenb. (*Poeae*, *Poaceae*) in Iran. -*Iran. J. Bot.* 17 (2): 189-199. Tehran.

The taxonomic status of the two species previously treated as *Nardurus subulatus* (now *Lolium subulatum*) and *Nardurus maritimus* (now *Vulpia unilateralis*) are reviewed and improved according to the latest classifications for these taxa. A critical study of 30 herbarium specimens and 490 plant individuals collected all around Iran were studied based on the morphological and cytological characters. Cytological analysis showed that $2n = 2x = 14$ and all karyotype symmetry indices indicated symmetric karyotypes for both species with metacentric chromosomes. This is the first report on chromosome number of *Lolium subulatum*. Two species were clearly separated by morphological data and a close relationship between both species and two species of *Vulpia* (*V. persica* and *V. hirtiglomis*), used as controls, was observed. Regarding high similarity between *Lolium subulatum* and the species of *Vulpia* we propose to transfer this species to the genus *Vulpia*.

Somayeh Zoughi, Hojjatollah Saeidi, (correspondence) <ho.saeidi@sci.ui.ac.ir> and Mohammad Reza Rahiminejad, Department of Biology, Faculty of Science, University of Isfahan, Isfahan, Iran.

Key words. Cytology, Iran, *Lolium*, *Nardurus*, *Poeae*, Taxonomy, *Vulpia*.

مطالعه تاکسونومی، ریخت‌شناسی و سلولی جنس معرفی شده با نام قبلی *Nardurus Reichenb.* (Poeae, Poaceae) در ایران

سمیه ذوقی، دانشجوی کارشناسی ارشد گروه زیست‌شناسی دانشگاه اصفهان.

حجت‌الله سعیدی، استادیار گروه زیست‌شناسی دانشگاه اصفهان.

محمد رضا رحیمی‌نژاد، استاد گروه زیست‌شناسی دانشگاه اصفهان.

موقعیت تاکسونومی دو گونه *Nardurus subulatus* و *N. maritimus* (اکنون با نام جنس *Vulpia*) بررسی و بر اساس آخرین طبقه‌بندی‌ها معین می‌گردد. این مطالعه بر روی تعداد ۳۰ نمونه هرباریومی و ۴۹۰ گیاه جمع‌آوری شده از سطح ایران بر اساس ویژگیهای ریخت‌شناسی و سلول‌شناسی انجام شده است. مطالعات سلول‌شناسی $2n=2x=14$ را با کاریوتیپ متقارن و کروموزومهای متاستریک برای هر دو گونه نشان داد. گزارش کروموزومهای گونه *Lolium subulatum* برای اولین بار است. مشاهدات نشان می‌دهد که دو گونه به آسانی از همدیگر تفکیک می‌شوند و از طرف دیگر شباهت گونه *Lolium subulatum* با گونه‌های جنس *Vulpia* موجب پیشنهاد انتقال این گونه به جنس *Vulpia* می‌گردد.

INTRODUCTION

Taxonomic complexities are common features of many genera within the tribe *Festuceae*. The genus *Nardurus* was referred to a combination of small, racemose annual species that were previously placed in the genera *Brachypodium*, *Triticum* and *Festuca*, by Reichenbach (1844). Because of high taxonomic complexities, the genus has undergone many taxonomic innovations since its first establishing in 1844. As reviewed by Stace (1978), 10 species (*N.*

salzmannii Boiss., *N. subulatus* (Banks & Solander) Bor, *N. persicus* Boiss. & Buhse, *N. patens* (Brot.) Hackel, *N. cynosuroides*, (Desf.) Trabut, *N. demnatensis* (Murb.) Maire, *N. tuberculosus* (Moris) Hayek, *N. mamoraeus* Maire, *N. maritimus* (L.) Murb. and *N. maririmus*) were placed in this genus by different authors. Stace (1978) believed that the genus *Nardurus* s.l. is very heterogenous and all of the species in this genus could be placed in separate genera (*Castelia* Tineo, *Narduroides* Rouy, *Lolium* Krecz. &

Table 1. Population codes, locations and other details regarding the populations of *Nardurus maritimus* and *N. subulatus* used in this study.

| Population Code | Location | Date | Collected by | Herbarium number |
|-----------------|--|-----------|----------------|------------------|
| NS16 | C: Isfahan toward Kashan, 25 km to Abyaneh | 30/4/2009 | | HUI16926 |
| NS13 | C: Karaj, Botanical Garden | 8/5/2009 | Zoghi & Naderi | HUI16923 |
| NS 12 | C: Qom toward Isfahan, 116 km to Salafchegan | 9/5/2009 | Zoghi | HUI16922 |
| NS 9 | C: Isfahan, University of Isfahan campus | 19/5/2009 | Zoghi | HUI16919 |
| NS 14 | W: Kamyaran, 20 km to Sanandaj (N: 35° 05.655', E: 46° 56.070'), 1370 m | 25/5/2009 | Zoghi | HUI16924 |
| NS 5 | W: Road of Sanandaj to Hamedan (N: 35° 17.343', E: 47° 5.614'), 1690 m | 26/5/2009 | Zoghi | HUI16915 |
| NS 10 | W: Hamedan, 20 km to Malayer (N: 34° 21.625', E: 48° 0.775'), 1790 m | 27/5/2009 | Zoghi | HUI16920 |
| NS 1 | C: Arak, northern mountains slopes (N: 34° 4.201', E: 49° 44.807'), 1743 m | 28/5/2009 | Zoghi | HUI16910 |
| NS 2 | C: Arak toward Khomein , 22 km to Khomein (N: 49° 54.36', E: 33° 51.873'), 1982 m | 28/5/2009 | Zoghi | HUI16912 |
| NS 4 | C: Arak toward Khomein , 20 km to Khomein (N: 33° 36.869', E: 50° 120.492'), 1940 m | 28/5/2009 | Zoghi | HUI16914 |
| NS 3 | C: Saveh to Salafchegan (N: 34° 33.931', E: 50° 240.702'), 1365 m | 29/5/2009 | Zoghi | HUI16913 |
| NS 8 | W: Around of Uromieh Lake (N: 38° 0.476', E: 45° 5.956'), 1288 m | 25/6/2009 | Zoghi | - |
| NS 11 | W: Uromieh toward Salmas, 4 th km (N: 38° 2.649', E: 45° 7.807'), 1496 m | 25/6/2009 | Zoghi | HUINS 11 |
| NS 7 | C: Saveh toward Tehran, 60 km to Tehran, 1150 m | 1/7/2009 | Zoghi | HUI16917 |
| NS 6 | NE: Mashhad, Golmakan | 31/6/2009 | Zoghi | HUI16916 |
| NS 15 | C: Isfahan, Mouteh Protected Area | 25/6/2009 | Naderi | HUI16925 |
| NS 17 | C: Isfahan, Kolah Ghazi Protected Area | 8/4/2009 | Zoghi | HUI16927 |
| NS 19 | SW: Chaharmahal-o-Bakhtiahri, Sarkhon toward Dehdez | 10/4/2009 | Zoghi | HUI16929 |
| NS 18 | C: Isfahan, University of Isfahan | 21/4/2009 | Naderi | HUI16928 |
| NS 20 | C: Karaj | 29/4/2009 | Zoghi | HUI16930 |
| NS 24 | S: Fars, Shiraz, Shahrak Sadra | 23/5/2009 | Zoghi | HUI16934 |
| NS 25 | S: Fars, Shiraz, 10 km to Shahrak Sadra | 23/5/2009 | Zoghi | HUI16935 |
| NS 27 | C: Yazd toward Tabas, 50 km to Deyhok (N: 33°, 23.255', E: 57°, 9.562'), 1028 m | 25/5/2010 | Naderi | HUI16937 |
| NS 28 | C: Yazd toward Tabas, Deyhok, 20 km to Chirok (N: 33° 22.812', E: 57° 15.395'), 1435 m | 25/5/2010 | Naderi | HUI16938 |
| NS 29 | C: Yaz toward Tabas, Deyhok, 10 km to Critlam (N: 33° 24.392', E: 57° 15.144'), 1772 m | 25/5/2010 | Naderi | - |
| NS 30 | W: Mashhad toward Neyshabour, 10 km to Neyshabour (N: 35° 20.155', E: 58° 28.072'), 1341 m | 26/5/2010 | Naderi | HUI16940 |
| NS 23 | E: Kerman, Dehe Bakri toward Bam (N: 29° 32.76', E: 57° 54.18'), 2134 m | 28/5/2010 | Zoghi | HUI16933 |
| NS 22 | E: Kerman, Chahe Chaghok, 65 km to Hajiabad (N: 28° 46.52', E: 55° 49.50'), 1868 m | 28/5/2010 | Zoghi | HUI16932 |
| NS 21 | S: Bande Sivand, Chah Siah Mountain (N: 30° 64.39', E: 52° 55.37'), 1723 m | 6/6/2010 | Zoghi | HUI16931 |
| NS 26 | S: Fars, Marvdasht toward Sivand (N: 29° 57.24', E: 52° 54.1'), 1625 m | 6/6/2010 | Zoghi | HUI16936 |
| NS 32 | W: Mashhad, 130 km to Torbat e Heydarieh | 21/6/2010 | Zoghi | HUI16942 |
| NS 34 | C: Semnan to Shahrod, Nekarman Village | 21/6/2010 | Zoghi | HUI16944 |
| NS 31 | E: Khorasan, 10 km to Gonabad | 23/6/2010 | Zoghi | HUI16941 |
| NS 33 | C: Damghan toward Shahroud, 20 km to Shahroud | 23/6/2010 | Zoghi | HUI16943 |
| NM11 | W: Sanandaj, 15 km to Kamyaran (N: 34° 12.458', E: 47° 48.02'), 1415 m | 24/6/2010 | Zoghi | HUI16954 |

Table 1. Continued

| Population Code | Location | Date | Collected by | Herbarium number |
|-----------------|---|-----------|--------------|------------------|
| NM 10 | W: Kamyaran toward Sanandaj, 45 km to Sanandaj (N: 34° 56.326', E: 46° 57.254'), 1611 m | 24/6/2010 | Zoghi | HUI16953 |
| NM 8 | W: Kamyaran toward Sanandaj, 20 km to Sanandaj (N: 35° 5.655', E: 46° 56.07'), 1370 m | 24/6/2010 | Zoghi | HUI16951 |
| NM 6 | W: Sanandaj toward Saghez, 165 km to Saghez (N: 36° 52.965', E: 49° 21.193'), 1619 m | 24/6/2010 | Zoghi | HUI16949 |
| NM 4 | W: Sanandaj toward Divandarreh, 45 km to Divandarreh (N: 33° 11.843', E: 50° 02.543'), 1645 m | 24/6/2010 | Zoghi | HUI16947 |
| NM 2 | W: Piranshahr, 15 km toward Mirabad (N: 35° 33.989', E: 47° 8.430'), 1355 m | 24/6/2010 | Zoghi | HUI16945 |
| NM 9 | W: Sardasht (N: 35° 33.989', E: 47° 8.403'), 1360 m | 24/6/2010 | Zoghi | HUI16952 |
| NM 7 | W: Sanandaj toward Divandarreh (N: 35° 33.991' E: 47° 8.43'), 1700 m | 24/6/2010 | Zoghi | HUI16950 |
| NM 1 | W: Oshnavieh toward Uromieh, 20 th km (N: 36° 56.43', E: 45° 10.443'), 1650 m | 24/6/2010 | Zoghi | HUI16944 |
| NM 3 | W: Around of Uromieh lake (N: 38° 0.476', E: 45° 5.956'), 1288 m | 25/6/2010 | Zoghi | HUI16946 |
| NM 5 | C: Damavand city, Islamic Azad University campus, 1900 m | 27/6/2010 | Naderi | HUI16948 |
| NM 15 | W: Fars, Shiraz, Sadra town | 24/4/2010 | Zoghi | HUI16958 |
| NM 12 | E: Kerman, Dehbakri toward Bam (N: 29° 32.76', E: 57° 54.189'), 2134 m | 25/4/2010 | Zoghi | HUI16955 |
| NM 14 | S: Fars, Shiraz toward Kazeron, 45 km to Kazeron (N: 29° 31.4', E: 51° 58.175'), 1651 m | 24/4/2010 | Zoghi | HUI16957 |
| NM 13 | S: Bande Sivand, Chahe Siah Mountain (N: 30° 64.39', E: 52° 55.37'), 1723 m | 24/6/2010 | Zoghi | HUI16956 |

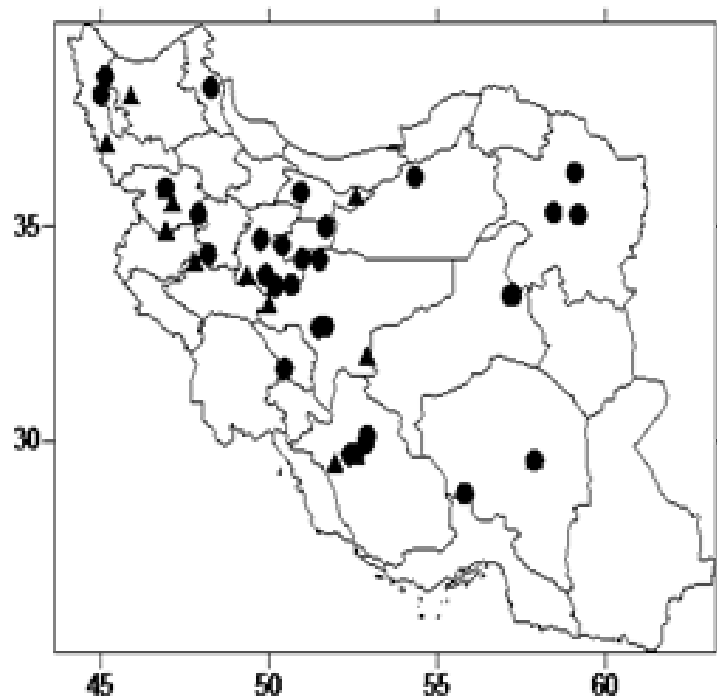


Fig. 1. Distribution of species previously treated as *Nardurus* in Iran. *Loliolum subulatum* (□) and *Vulpia unilateralis* (▲) analyzed in this study.

Table 2. The evaluated qualitative and quantitative morphological characters and their character states observed in species studied. The quantitative characters were multistate.

| No | Character | Character states | No | Character | Character states |
|-------------------------------|-----------------------------|------------------------------|----|---------------------------------------|------------------------------|
| <i>Qualitative characters</i> | | | | | |
| 1 | Adaxial blade surface hairs | absent present | 23 | Lower floret lemma tip | obtuse acute acuminate |
| 2 | Abaxial blade surface hairs | absent present | 24 | Lower floret lemma margins | glabrous pubescence |
| 3 | Adaxial leaf | smooth nerved ridged | 25 | Lower floret palea hairs | glabrous pubescence |
| 4 | Abaxial leaf | smooth nerved ridged | 26 | Hair on palea veins | absent present |
| 5 | Blade marginal | glabrous pubescence | 27 | Lower floret palea veins number | 0, 1, 3 |
| 6 | Blade tip shape | obtuse acute acuminate | 28 | Lower floret palea tip shape | obtuse acute truncate |
| 7 | Leaf ligule shape | lacinate bidentate | 29 | Lower floret palea margins | glabrous pubescence |
| 8 | Ligule hairs | absent, present | 30 | Upper floret lemma hairs | absent present |
| 9 | Pedicle hairs | absent, present | 31 | Hair status on lemma veins | absent present |
| 10 | Upper glume hairs | absent present | 32 | Number of upper floret lemma veins | 1, 2, 3, 5 |
| 11 | Hair status on glume veins | absent present | 33 | Tip shape of upper floret lemma | obtuse acute acuminate |
| 12 | Upper glume veins number | 1, 2, 3 | 34 | Upper floret lemma margins | glabrous pubescence |
| 13 | Upper glume tip shape | obtuse acute acuminate | 35 | Upper floret palea hairs | absent present |
| 14 | Upper glume margins | glabrous pubescent | 36 | Hair status of palea veins | absent present |
| 15 | Lower glume hairs | absent present | 37 | Upper floret palea veins number | 0, 1, 3 |
| 16 | Lower glume veins number | 0, 1, 2, 3 | 38 | Upper floret palea tip shape | obtuse acute truncate |
| 17 | Lower glume tip shape | obtuse acute acuminate | 39 | Upper floret palea margins | glabrous pubescence |
| 18 | Lower glume margins | glabrous pubescence | 40 | Caryopsis shape | ovate oblong elliptic |
| 19 | Rachilla | glabrous pubescence | 41 | Node status | smooth sulcate |
| 20 | Lower lemma hairs | glabrous pubescence | 42 | Angle of two glumes related to rachis | close open |

Table 2. Continued

| No | Character | Character states | No | Character | Character states |
|--|---------------------------------------|------------------------|----|----------------------------------|-------------------|
| 21 | Hair status on lemmas veins | glabrous pubescence | 43 | Pedicel | absent present |
| 22 | Number of lower lemma veins | 0, 1, 2, 3, 5 | | | |
| <i>Quantitative characters; characters were multistate</i> | | | | | |
| 44 | Leaf length | mm | 57 | Lower glume width | mm |
| 45 | Leaf width | mm | 58 | Lower floret lemma length | mm |
| 46 | Inflorescence length | mm | 59 | Lower floret lemma width | mm |
| 47 | Plant height | cm | 60 | Awn long of lower floret lemma | mm |
| 48 | Inflorescence width | mm | 61 | Lower floret palea length | mm |
| 49 | Number of nodes | mm | 62 | Lower floret palea width | mm |
| 50 | Number of spikelets per inflorescence | mm | 63 | Upper floret lemma length | mm |
| 51 | Spikelet length | mm | 64 | Awn length of upper floret lemma | mm |
| 52 | Spikelet width | mm | 65 | Second palea length | mm |
| 53 | Number of florets per spikelet | mm | 66 | Upper floret palea width | mm |
| 54 | Upper glume length | mm | 67 | Caryopsis length | mm |
| 55 | Upper glume width | mm | 68 | Caryopsis width | mm |
| 56 | Lower glume length | mm | | | |

Borbov, *Wangenheimia* Moench, *Micropyrum* Link and *Nardurus* s.s. Reichenb.). This classification was commonly accepted and followed by taxonomists in subsequent literatures. The *Nardurus* s.s. contains only one species *N. maritimus*. All the diagnostic characters of this species were applicable to the genus *Vulpia*, therefore, Stace (1978) has transferred this species to the genus *Vulpia*, under section *Nardurus* as *Vulpia unilateralis* (L.) Stace.

Parsa (1950) recognized 3 species *N. tenoiflorus* Boiss., *N. orientalis* Boiss. and *N. persicus* from Iran. All of these taxonomic names are synonym of *Nardurus maritimus* or *N. subulatus* which are growing in Iran (Bor 1970). As mentioned above, *N. maritimus* is now a synonym of *V. unilateralis* (L.) Stace and *N. subulatus* is now transferred to the monotypic genus *Lolium* as *L. subulatum* (Bank & Soland) Eig. (Stace, 1985).

The populations of *Nardurus* species are growing in different regions of Iran with a wide range of ecological conditions. The information on taxonomy and diversity of *Nardurus* species are meager and the taxonomic literatures are not modified according to the latest classifications. The monotypic genus *Lolium* grows in Iran and some neighboring countries and relationships between this genus and its relative genera such as *Vulpia* is not well documented.

In this study we aimed to revise the taxonomic status of species previously treated as *Nardurus* in Iran, evaluate the morphological and cytological variation of the species and their relationships with closely related

genus *Vulpia* and to improve the literatures according to the latest accepted classifications.

MATERIAL AND METHODS

A total of 490 plant individuals belonging to 34 populations of *N. subulatus* and 15 populations of *N. maritimus* were collected from various regions of Iran (Fig. 1, Table 1). The samples were collected from different regions with wide range of ecological conditions to sample all possible adaptation dependent/independent variations. These were identified according to Bor (1970). Thirty herbarium specimens were also analyzed. Two species of closely related genus, *Vulpia* (*V. persica* and *V. hirtiglomis*), were also included in the analysis as controls. 68 qualitative and quantitative morphological characters were measured with special focus on the characters that are taxonomically important in the tribe *Poeae* (Table 2). The multistate quantitative characters were converted to binary states using frequency distribution

and standardizing method $[X_s = (x - \frac{\min}{\max - \min})n]$; in

which X_s is standardized data, X is raw data, n is number of observations and \max and \min are maximum and minimum amount of data].

Morphological data were analyzed using NTSYS pc ver. 2.2 (Rohlf 1997). Morphological similarities among populations were calculated using different similarity coefficients. The morphological data and calculated similarity matrices were then used for

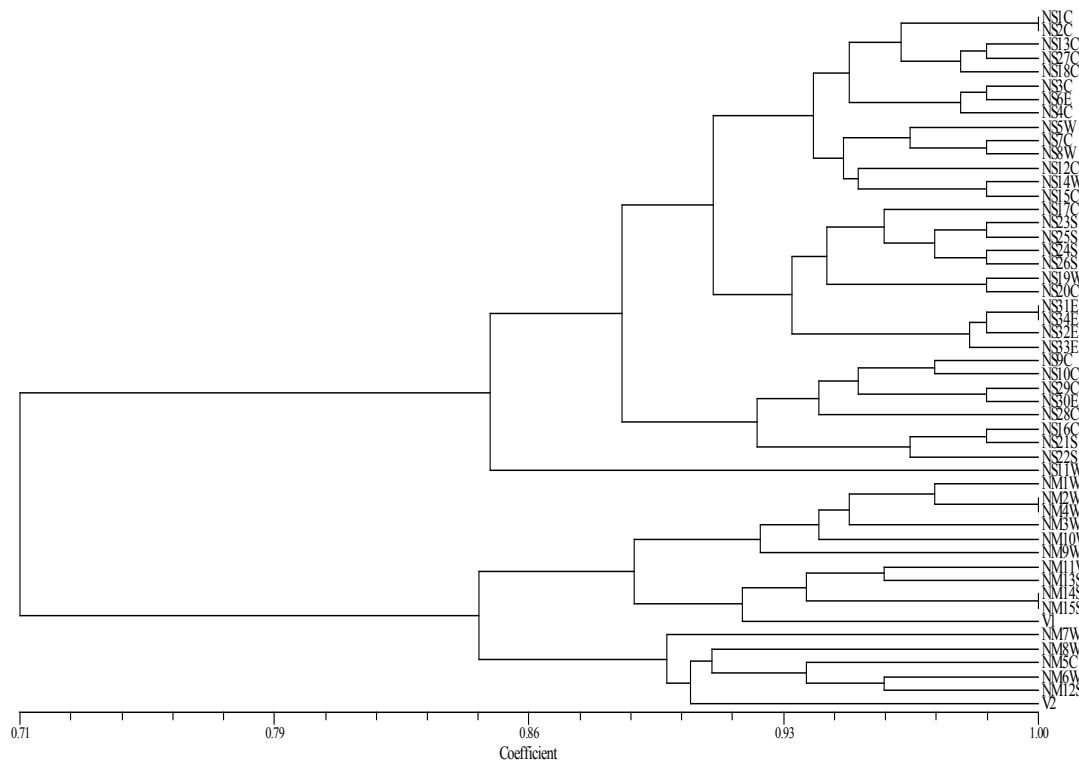


Fig. 2. A morphological similarity based UPGMA dendrogram showing relationships among 49 populations of two species previously treated as *Nardurus subulatus* (now, *Lolium subulatum*) and *N. maritimus* (now, *Vulpia unilateralis*). The population codes are provided with species names (*N. maritimus* = NM and *N. subulatus* = NS) and geographic regions (C = Center, E = East, W = West, S = South). V1 = *Vulpia persica*, V2 = *V. hirtiglomis*.

generating dendrogram showing relationships between populations and species.

In order to evaluate cytological features of the species, 7 populations belonging to two species were analyzed. Seeds were germinated in petri dish and chromosome slides were prepared from root meristems according to Aghayev (1996) method. Briefly, the 1.5-2 cm roots were placed in 1% α -bromonafthalin for 4-6 h. Then the roots were transferred in fixative of Levitsky (Sharma and Sharma 1999) in fridge. Roots were washed under running water for 3 h and transferred in 70% ethanol. Root were placed for 10 min. in 1N NaOH at 60°C, stained by Hematoxylin for 24 h in 30°C and squashed on microscopic slides after 10 min. in Cellulase-Pectinase enzyme solution and visualized under light microscope.

Chromosomes were categorized according to Levan et al. (1965). Several parameters regarding the karyotypes symmetry/asymmetry such as total form percent ($TF\% = \frac{\sum(Total\ lengths\ of\ short\ arms\ of\ chromosomes)}{\sum(Total\ chromosome\ lengths)}$), Stebbins Coefficient (Stebins 1971; $S\% = \frac{(shortest\ chromosome\ length)}{(biggest\ chromosome\ length)}$)

Mean Chromosome Length \pm Standard Error (MCL \pm SE) and Coefficient of Variation ($CV = SE / (Average\ of\ total\ chromosome\ lengths\ in\ all\ populations)$) were calculated for each species. Details regarding karyotypes are summarized in Table 3.

RESULTS AND DISCUSSION

Based on reviewed literatures, the genus *Nardurus* comprised no accepted taxa for the time being. The *Nardurus maritimus* is synonym of *Vulpia unilateralis* and *N. subulatus* is synonym of *Lolium subulatum*. Based on the studied specimens, *Vulpia unilateralis* grows mainly along Zagros Mountains and *Lolium subulatum* can be found in different regions of Iran with a wide range of ecological conditions. As it is observed in dendrogram (Fig. 2), the results of morphological data showed clearly separation within two species. The two species *Vulpia persica* and *V. hirtiglomis* were placed in the *V. unilateralis* (*N. maritimus*) cluster supporting the transferring of *Nardurus maritimus* to the genus *Vulpia*, subgenus *Nardurus*. Regarding high similarity between *V. unilateralis* and other species of *Vulpia* (from sect. *Vulpia*), relationships between sections *Nardurus* and

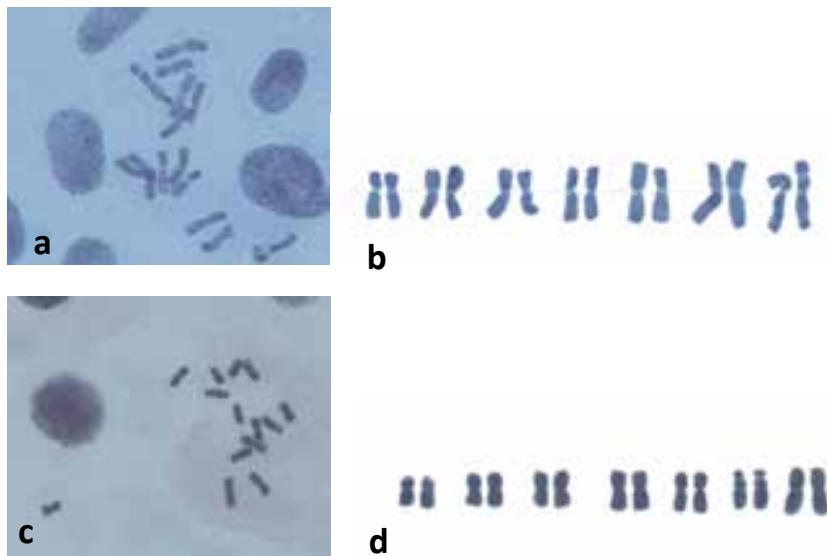


Fig. 3. Chromosome spread and Karyotype of *Vulpia unilateralis* (a, b) and *Lolium subulatum* (c, d).

Vulpia in the genus *Vulpia* needs to be revised. The populations of *V. unilateralis* were divided into two groups in the dendrogram, suggesting the presence of two different genotypes within Iranian populations of this species.

The results of morphological data distinguished all populations and there was no clear groupings related to the geographic regions, but some local groupings among geographically closely distributed populations were evident (Fig 2).

Cytotaxonomy

Both species were diploid with $2n = 2x = 14$. No B chromosome was observed. Two satellites at the end of the short arm of one homolog chromosome pairs in both species were observed. All of the karyotype symmetry indices showed that the karyotypes of two studied species are symmetric with big and metacentric chromosomes. Only one chromosome of *Lolium subulatum* was sub-metacentric. There were no significant differences in measured karyotype parameters for both species indicating high cytological similarities between two species (Table 3 and Fig. 3).

Morphological Characters

In this study, the following characters were taxonomically valuable: glumes sizes ratio, lemmas texture, lemmas tip (attenuate or owned), adherence of the caryopsis to the palea, hilum shape and size, presence of protruded nodes, unilateral or bilateral inflorescence, inflorescent length, spikelet length,

glume length and width, own length of first and second florets, paleas length of first and second florets, lemma and palea margins status.

Taxonomic discussion

Based on this study, the following discussion and conclusions concerning the taxonomic status of the species formerly recognized as *Nardurus* species (*Vulpia unilateralis* and *Lolium subulatum*) in Iran can be made:

Vulpia unilateralis (L.) Stace in Bot. J. Linn. Soc. 76:350 (1978). Fig. 4.

Syn: *Triticum unilaterale* L., Mant. 35 (1767); *Nardurus maritimus* (L.) Murb. in Lunds Univ. Arsskr. 2(1) 25 (1900). Ic: Proc. Bot. Soc. Brit. Is. 4:248 (1961); Hubbard Grasses ed. 2: 164 (1968). This species was treated as *Nardurus maritimus* (L.) Murb. in Flora Iranica (Bor 1970).

Annual, herbaceous. Stems 3-45 cm high, usually single, erect or rarely ascendant. Leaf sheaths glabrous to pubescent; ligules membranous, truncate to jagged, 0.5-1 mm long; blade partly conduplicate, 1-5 cm long and 0.5 wide. Inflorescent simple or second spike-like raceme, 1-16 cm long. Rachis straight to curved; spikelets arranged at one side (unilateral), condensed, with one spikelet at each node. Spikelets pedicellate, 4-8 mm long, with 4-5 fertile florets and aborted florets at the tip, laterally condensed, separated at maturity; rachilla geniculated at the base of each floret; pedicels 0.7-1.6 mm long. Glumes unequal, shorter than

Table 3. Details regarding karyotyps of *Vulpia unilateralis* and *Lolium subulatum*. Values are provided as average. All of the chromosomes were metacentric except one chromosome of *L. subulatum* (chromosome no. 1 in Table) was sub-metacentric.

| Chromosome number | TL (μ) | L (μ) | S (μ) | L/S | | | |
|----------------------------|--------|-----------|-------|--------|--------|----------|----------|
| <i>Vulpia unilateralis</i> | | | | | | | |
| 1 | 5.88 | 3.337 | 2.540 | 1.32 | | | |
| 2 | 5.98 | 3.589 | 2.381 | 1.51 | | | |
| 3 | 6.2 | 3.254 | 2.937 | 1.11 | | | |
| 4 | 6.37 | 3.348 | 3.016 | 1.12 | | | |
| 5 | 7.5 | 4.016 | 3.492 | 1.15 | | | |
| 6 | 7.15 | 3.734 | 3.409 | 1.10 | | | |
| 7 | 8.8 | 4.442 | 4.312 | 1.04 | | | |
| <i>Lolium subulatum</i> | | | | | | | |
| 1 | 3.4 | 2.193 | 1.172 | 1.87 | | | |
| 2 | 3.4 | 1.875 | 1.484 | 1.27 | | | |
| 3 | 4 | 2.109 | 1.875 | 1.12 | | | |
| 4 | 4.3 | 2.422 | 1.875 | 1.30 | | | |
| 5 | 4.3 | 2.656 | 1.641 | 1.60 | | | |
| 6 | 4.2 | 2.344 | 1.875 | 1.25 | | | |
| 7 | 5.006 | 2.975 | 2.109 | 1.40 | | | |
| Species | 2n | MCL±SE | C.V | max TL | min TL | L | S |
| <i>V. unilateralis</i> | 14 | 7.4±2.05 | 0.3 | 8.95 | 6.4 | 4.1 | 3.22 |
| <i>L. subulatum</i> | 14 | 5.25±1.65 | 0.32 | 6.4 | 4.09 | 2.96 | 2.28 |

spikelet; upper glume lanceolate, 3-5 mm long, 1.25 – 2 times longer than the lower glume, acute, as long as adjacent lemma, coriaceous, killed, nerves 1-3; lower glume lanceolate, 1.5-3.5 mm long, coriaceous, killed, 3 nerved. Lemma 3-5 mm long, with awn as long as or longer than lemma, sometimes ± unawned, glabrous to pubescent.

Distribution. Mediterranean region, Europe, Caucasus, Southwest and Central Asia.

Distribution in Iran. Southeast, West, Northwest and Center (see Table 1 and Fig. 1).

Lolium subulatum (Banks & Soland) Eig, J. Bot. (London) 75:189 (1937). Fig. 5.

Syn: *Triticum subulatum* Banks & Sol. In Russell & Aleppo ed. 2 :2:244(1794); *N. subulatus* (Banks & Sol.) Bor in Danks Biol. Skr. 14(4); 67 (1965). Ic; Fl. Iraq 9; t. 34 (1968). This species was treated as *N. subulatus* in Flora Iranica (Bor 1970).

Herbaceous, annual. Stems 10-20 cm high, erect. Leaf sheaths inflated; ligules hyaline, 0.5-1 mm, fimbriate to jagged or lacinate; blades partly conduplicate, 1-3 cm long, 0.5 mm wide. Inflorescence simple, unilateral,

straight or rigidly curved. Spikelets 3-6.2 mm long, partly overlapping the next higher spikelet at the same side, arranged on two sides of the rachis, fertile or sterile; fertile spikelets with 3-7 fertile florets and reduced florets at the end; rachilla brittle between fertile florets; pedicel absent or to 0.4 mm long.

Glumes similar, persistent; lower glume lanceolate-attenuate, 2.6-5.1 mm long, about ¼ shorter than upper glume, displaced from side of spikelet to lie parallel to rachilla; upper glume lanceolate, 3-6.2 mm long, as long as adjacent lemma, not keeled, with 1-3 nerves. Lemma elliptic, 2-3 mm long, coriaceous, with 5 nerves, lateral nerves are not well visible, glabrous to scabrid, awnless or with awn to 1.5 mm long. Anthers 0.5-1 mm long, slightly exerted at anthesis. Caryopsis 1.5-2 mm long.

Distribution. Middle East, Iran, Afghanistan and Pakistan.

Distribution in Iran. This species can be found almost in all regions of Iran (see Table 1 and Fig. 1)



Fig. 4. *Vulpia unilateralis*. p,q: plant habit, a1,2: node, b1,2: ligule, c1,2: adaxial surface of palea, d1-3: lemma and palea, f1,2: seed, g: lodicule, h: anthers and pistil, i1,2 : rachilla, j1-3 : lower glume, k1-3: upper glume, l1,2: florete, m1-3: spikelet.

Stace (1978) transferred this species from genus *Nardurus* s. l. to the monotypic genus *Loliulum*. He has noted that this genus is superficially resemblance to *Nardurus maritimus* but with subequal glumes; obtuse to shortly acuminate, rather coriaceous lemmas; a caryopsis slightly adherent to the palea and with a short, linear hilum; and an abaxial leaf epidermis with straight-walled long-cells which are not parallel sided.

In this study, many of these characters without remarkable differences were observed in the *Vulpia* species. The abaxial leaf epidermis of *L. unilateralis* and the studied species of *Vulpia* had similar semiparallel-sided undulate-walled long-cells (Fig 6). Therefore, we propose to transfer this species to the genus *Vulpia* in a new subgenus.

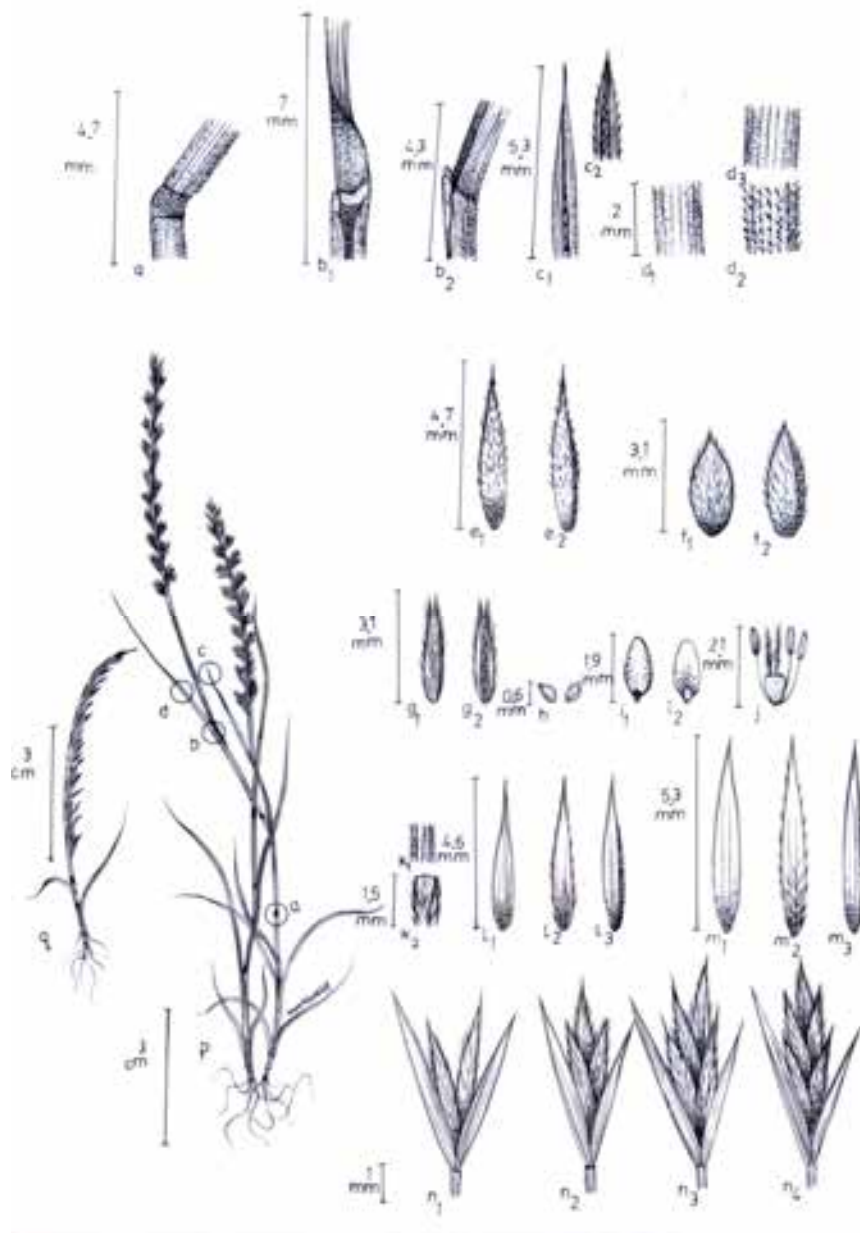
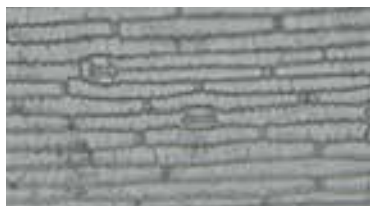


Fig 5. *Lolium subulatum*. p,q: plant habit, a: node, b1,2: ligule, c1,2: adaxial surface of lemma, d1-3: stem, e1,2: abaxial surface of lemma, f1,2: abaxial surface of lemma, g1,2: palea, h: lodicule, i1,2: seed, j: anthers and pistil, k1,2: spikelet stalk, l1-3: lower glume, m1-3: upper glume, n1-4: spikelet.



Vulpia persica



Vulpia unilateralis



Lolium subulatum

Fig 6. Abaxial leaf epidermis with long, semiparallel-sided and undulate-walled cells.

REFERENCES

- Agayev, M. 1996: Advanced squash method for investigation of plant chromosomes. -Institute of Genetics and Selection. Baku 370106. Azarbaijan Republic. 1-20.
- Bor, N. L. 1970: *Nardurus* (Bluff, Nees & Schauber) Reichenb. in Gordon in K. H. Rechinger *Flora Iranica*, no. 70: 50-51. -Akademische Druck-u. Verlagsanstalt, Graz.
- Stace, C. A. 1985: *Vulpia* C. C. Gmelin and *Lolium* V. Krecz. & Bobrov in P. H. Davis *Flora of Turkey and the East Aegean Islands*, vol. 9: 451-461. -Edinburgh University Press, Edinburgh.
- Parsa, A. 1950: *Nardurus* in *Flore de L'Iran*, vol. 5: 750-752. -Publication du Ministere de L' Education Museum d' Histoire Naturelle de L' Tehran, Tehran.
- Rohlf, F. J. 1997: NTSYS-pc version 2.2. Numerical Taxonomy and Multivariate. Analysis System Exter Publ. New York.
- Sharma, A. & Sharma, A. 1999: *Plant chromosome*. - Harwood Academic Publishers. Australia. 17-19.
- Stace, C. A. 1978: Changing concepts of the genus *Nardurus* Reichenb. (Gramineae). *Flora Europaeae. Notulae systematicae* (ed. Heywood, V. H.). 20: 344-350.
- Stebbins, G. L. 1971: *Chromosomal evolution, higher plants*. -Edvard Arnold Publishers. London.