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A PHENETIC ANALYSIS OF THE SPECIES OF IRANIAN *OXYTROPIS* (*FABACEAE*) BASED ON MORPHOLOGICAL DATA

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Abstract

A phenetic analysis is presented using SAHN clustering (UPGMA, simple matching coefficient). The resulting phenetic analysis is compared with the classification of *Oxytropis* as suggested by Bunge [2] and Vassilczenko [11]. The results partly correspond with Bungean classification and suggest that there are basically four sections (*Mesogaea, Oxytropis, Janthina, Eumorpha*) which can be grouped under two subgenera, namely *Oxytropis* and *Euoxytropis*. The subgenus *Oxytropis* including section *Mesogaea* and the subgenus *Euoxytropis* including sections *Oxytropis*, *Janthina* and *Ortholema* are upheld by this analysis. It is concluded that section *Ortholema* should be united with section *Eumorpha* or *O. masanderanensis*, *O. Kuchanensis* and *O. suavis* moved to section *Eumorpha*. The results of cluster analyses were compared with the classification obtained by conventional methods and the relations among the taxa have been discussed.

Introduction

Oxytropis is a large genus of small herbs, mainly present in high pastures and rocky places. It is separated from *Astragalus* largely by tradition and for convenience; the main difference is in the shape of the keel [4].

According to the most recent morphological classification of the papilionoid tribe *Galegeae* [5], the closest relatives of *Oxytropis* include *Meristotropis*., *Astragalus* L., *Caragana* Fabr., *Chesneya* Lindl.ex Endl., and all members of the subtribe *Astragalinae*.

In this study, a phenetic analysis based on the morphology of flowers, fruits and vegetative parts of 24 species of *Oxytropis* is presented. It enables us to reconsider Bunges classification in particular the uncertain position of some species.

The genus *Oxytropis* is one of the most complex genera of *Fabaceae*. For the most part, this genus was introduced as a sister group of the genus *Astragalus*. Boissier [1] in Flora Orientalis placed 8 species under two sections, namely *Phacoxytropis* and *Euoxytropis* while Vassilczenko [11] in Flora Iranica placed 40 species under two subgenera, namely *Oxytropis* and *Euoxytropis*. These species and records were introduced only by one specimen and differential characters between them were very artificial. Recent taxonomic studies carried out by Ranjbar [7], considered some of the species as synonymous and excluded some of the records for Flora of Iran. Now *Oxytropis* is represented by 32 species in Iran. The identification of the species of the genus is very complex, difficult and often confusing. However, the work on plants of the genus *Oxytropis* done by Vassilczenko [11] in Flora Iranica still

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Table 1. Taxa studied and acronyms

1-*Oxytropis aucheri* Boiss	auch
2-*Oxytropis bicornis* Vass	bico
3-*Oxytropis binaludensis* Vass	bina
4-*Oxytropis chrysocarpa* Boiss	chry
5-*Oxytropis cinerea* Vass	cine
6-*Oxytropis heratensis* Bge	hera
7-*Oxytropis hypsophila* Bge. ex Boiss	hyps
8-*Oxytropis iranica* Vass	iran
9-*Oxytropis kermanica* Freyn & Bornm	kerm
10-*Oxytropis kotschyana* Boiss & Hohen	kots
11-*Oxytropis kuchanensis* Vass	kuch
12-*Oxytropis masanderanensis* Vass	masa
13-*Oxytropis neo-rechingeriana* Vass	neor
14-*Oxytropis persica* Boiss	pers
15-*Oxytropis pusilloides* Vass	pusi
16-*Oxytropis rechingeri* Vass	rech
17-*Oxytropis rhodontha* Vass	rhod
18-*Oxytropis rudbariensis* Vass	rudb
19-*Oxytropis savellanica* Bge	save
20-*Oxytropis sojakii* Vass	soja
21-*Oxytropis suavis* Boriss	suav
22-*Oxytropis szovitsii* Boiss & Buhse	szov
23-*Oxytropis takhti-soleimanii* Vass	takh
24-*Oxytropis zangolehensis* Vass	zang

demands a new revision for the genus in Iran . Obviously, complete revision of the genus requires more specialized investigations, which would also include species outside Iran.

Material and Methods

The study of morphological variation in the genus was done from fresh or preserved material collected during field trips and herbarium collections of TARI, IRAN, HUH. Extensive field trips were undertaken to study the taxa in their natural habitats. Specimens from 24 species of the genus *Oxytropis*, available (Table 1), were examined and scored for 24 different characters (Table 2). All the specimens were collected from the Flora of Iran.

The NTSYSpc Version 2.02j program package written for IBM PC by Rohlf [8] for clustering and ordination analysis was used. First of all, a raw matrix for 24 OTUs was made and 24 two or multistate qualitative and quantitative characters using (Table 3) then, the simple matching coefficient between pairs of OTUs to measure taxonomic resemblance using the standardized scores was computed. Having measured more than one specimen, arithmetical averages were used. UPGMA clustering of similarity matrices based on a simple matching coefficient was yielded [4], and a majority rule consensus tree (MAJRUL CONSEN of NTSYSpc ver. 2) was constructed as a summary of the more than 70 tied trees resulting from the present UPGMA clustering of *Oxytropis*. Also, a principal coordinates analysis was computed was by performing the following operations: the raw matrix was standardized by variables (characters), a similarity matrix between the OTUs was computed by using the simple matching coefficient. This matrix was transformed to scalar product form by double-center program, so that its eigenvalues and eigenvectors could be computed. Then a plot was made showing the OTUs in a 2-dimensional space (Fig. 2).

Results and Discussion

The MAJRUL CONSEN tree based on similarity matrix is presented in Figure 1. A line across the phenogram at 0.75 similarity level results in two subgroups corresponding to the two subgenera of *Oxytropis*, *Euoxytropis* and *Oxytropis* described earlier by Bunge [2] and Vassilczenko [10]. The results of the principle component analysis on the matrix of correlations are given in Figure 2. It is possible to distinguish the two subgenera, *Oxytropis* and *Euoxytropis* as two distinct clusters when plotted on the first two eigenvectors. The subgenus *Euoxytropis* is more problematical than the subgenus *Oxytropis*. In the works of Bunge [2] and Vassilczenko [11], two sections from the subgenera *Euoxytropis*, *Eumorpha* and *Ortholema* were recognized.

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

1- Stem: stem scapiform (0), stem leafy (1)
2- Stipule: chartaceous (0), herbaceous (1)
3- Stipule length: 2-3 mm (0), 3-5 mm (1), 5-8 mm (2), 8-10 mm (3), 10-15 mm (4)
4- Stipule width: 0.5-1 mm (0), 1-3 mm (1), 3-10 mm (2)
5- Hair density on stipule: dense (0), lax (1), glaber (2)
6- Petiole length: 4-6 mm (0), 3-4 mm (1), 1.5-3 mm (2), 0.5-1.5 (3)
7- Leaflet number: 12-16 pairs (0), 6-12 pairs (1), 4-6 pairs (2)
8- Leaflet length: 2-6 mm (0), 6-11 (1), 11-15 mm (2), 15-30 mm (3)
9- Leaflet shape: elliptic (0), lanceolate (1)
10- Leaflet hair: both surfaces sericeous (0), both surfaces pubescent (1)
11- Hair density on peduncle: dense (0), more or less dense (1), sparse (2)
12- Inflorescence: terminale (0), axillary (1)
13- Inflorescence: lax (0), more or less dense (1), dense (2)
14- Calyx: campanula (0), campanula-tubular (1), tubular (2)
15- Hair colour of calyx: white and black hair (0), white hair (1)
16- Calyx teeth length: 1-2 mm (0), 2-4 mm (1), 4-6 mm (2)
17- Gynophor length: 0-1 mm (0), 1-2 mm (1), 2-5 mm (2)
18- Pod shape: oblong (0), oval (1), oval-orbicular (2)
19- Pod position: erect (0), erect-horizontal (1), deflxed (2)
20- Pod stipe: 0-1 mm (0), 1-3 mm (1), 2-7 mm (2)
21- Pod beak: 0-1 mm (0), 2-5 mm (1)
22- Hair position on pod: erect (0), prostrate (1)
23- Pod: non-inflate (0), inflate (1)
24- Type of hair: villose (0), shortly pubescent (1), long pubescent (2)

Table 3. Morphological character state matrix for the species included in this study

Pers	iran	cina	save	kerm	takh	suav	bico	hyps	szov	kuch	masa	chry	auch	zang	hera	kots	bina	neor	rhod	rech	soja	pusi	rudb
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0
0	1	1	1	0	1	3	2	1	3	2	3	1	3	4	0	4	1	3	2	2	2	1	2
1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
3	3	3	3	3	3	2	1	3	2	2	2	2	2	0	3	3	3	0	2	2	0	3	2
2	1	2	2	2	1	1	1	1	1	1	2	1	1	1	1	0	1	1	1	1	1	2	1
0	0	1	0	0	0	1	1	0	1	0	1	0	1	1	1	3	0	2	2	2	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0
0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0
2	1	0	0	0	0	1	0	2	0	2	2	2	0	0	1	0	1	1	0	0	0	0	1
2	1	0	2	0	2	0	0	2	1	0	0	0	0	2	2	2	2	0	0	2	2	2	0
0	1	1	0	1	1	1	1	1	0	1	1	1	0	1	0	0	0	1	1	0	0	0	1
0	0	1	1	1	1	2	2	1	1	2	2	1	2	1	0	2	1	2	2	1	1	1	1
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	2	2	0	1
0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	1	0	0	0
0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0
1	0	0	1	0	1	0	1	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0

Bunge [2] placed four species namely *O. szovitsii, O. aucheri, O. chrysocarpa* and *O. hypsophila* under section *Eumorpha* and Vassilczenko [11] placed four species namely *O. aellenii, O. suavis, O. kuchanensis* and *O. masanderanensis* under section *Ortholema*. The results of the present study do not support the findings of Bunge [2] and Vassilczenko [11] in these two sections. Sectional delimitations in the subgenus *Euoxytropis* given by Bunge [2] and Vassilczenko [11] seem very much artificial. The phenon line at 0.52 similarity level creates three sections in the subgenus *Euoxytropis*, namely section *Janthina*, section *Eumorpha* and section *Oxytropis*. The present analysis suggests that *O. iranica, O. suavis, O. rudbarensis, O. kuchanensis, O. rhodontha, O. masanderanensis, O. neo-rechingeriana, O. szovitsii, O. aucheri, O. chrysocarpa, O. cinerea and O. kermanensis* must be included in section *Eumorpha* with the exception of *O. persica* from section *janthina* that is well supported by this analysis and should be maintained. But the systematic position of this section should be replaced in the subgenus *Euoxytropis* from the subgenus *Oxytropis*. The species placed in this section diagnosed by characters such as scapiform stem, fruit inflate, unilocular and covered with appressed hairs. In MAJRUL consensus tree *O. hypsophila* and *O. binaludensis* are placed at section *Oxytropis* artificially in contrast of Ranjbar grouping (submitted), which these species put in section *Eumorpha*. It is concluded that section *Ortholema* should be united with section *Eumorpha* or *O. masanderanensis, O. kuchanensis* and *O. suavis* moved to section *Eumorpha*. Another section from the subgenus *Oxytropis* which is placed within the subgenus *Euoxytropis* by this analysis is section *Oxytropis*. This section represented here by *O. takhti-soleimanii, O. pusilloides, O. zangolehensis, O. savellanica* diagnosed by character fruit covered with appressed hairs. The species *O. heratensis, O. rechingeri, O. kopetdaghensis* and *O. sojakii* of section. *Mesogaea* can be found in Figure 1 in a strong phenone. Bunge [2] and Vassilczenko [11] both placed these species in this section by having characters such as stem leafy, appressed hairy fruit (exception *O. sojakii*) and calyx tubular. The results of the present study support the findings and only partly correspond with the genera and sections according to Bunge [2] and Vassilczenko [11].

However, the classification obtained by MAJRUL

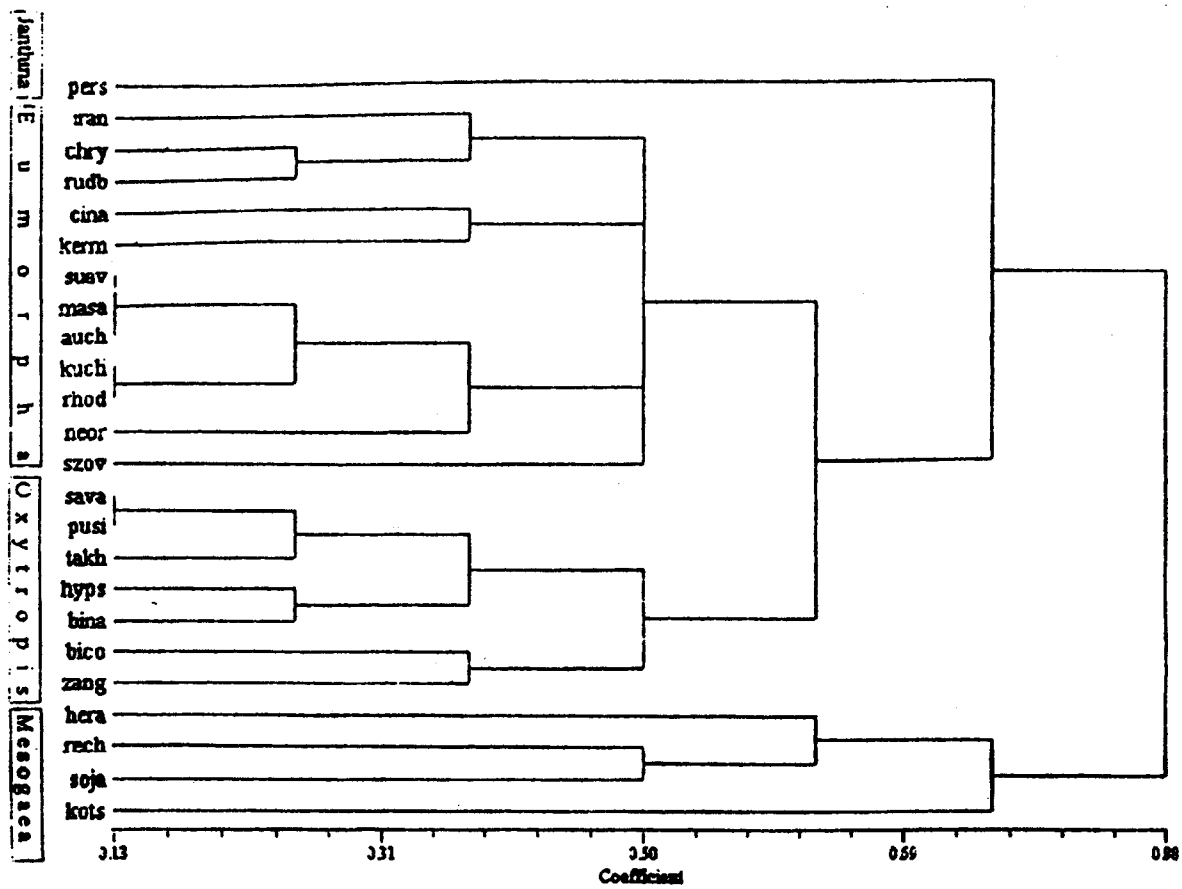

Figure 1. MARUL CONSENS tree of the genus Oxytropis in Iran

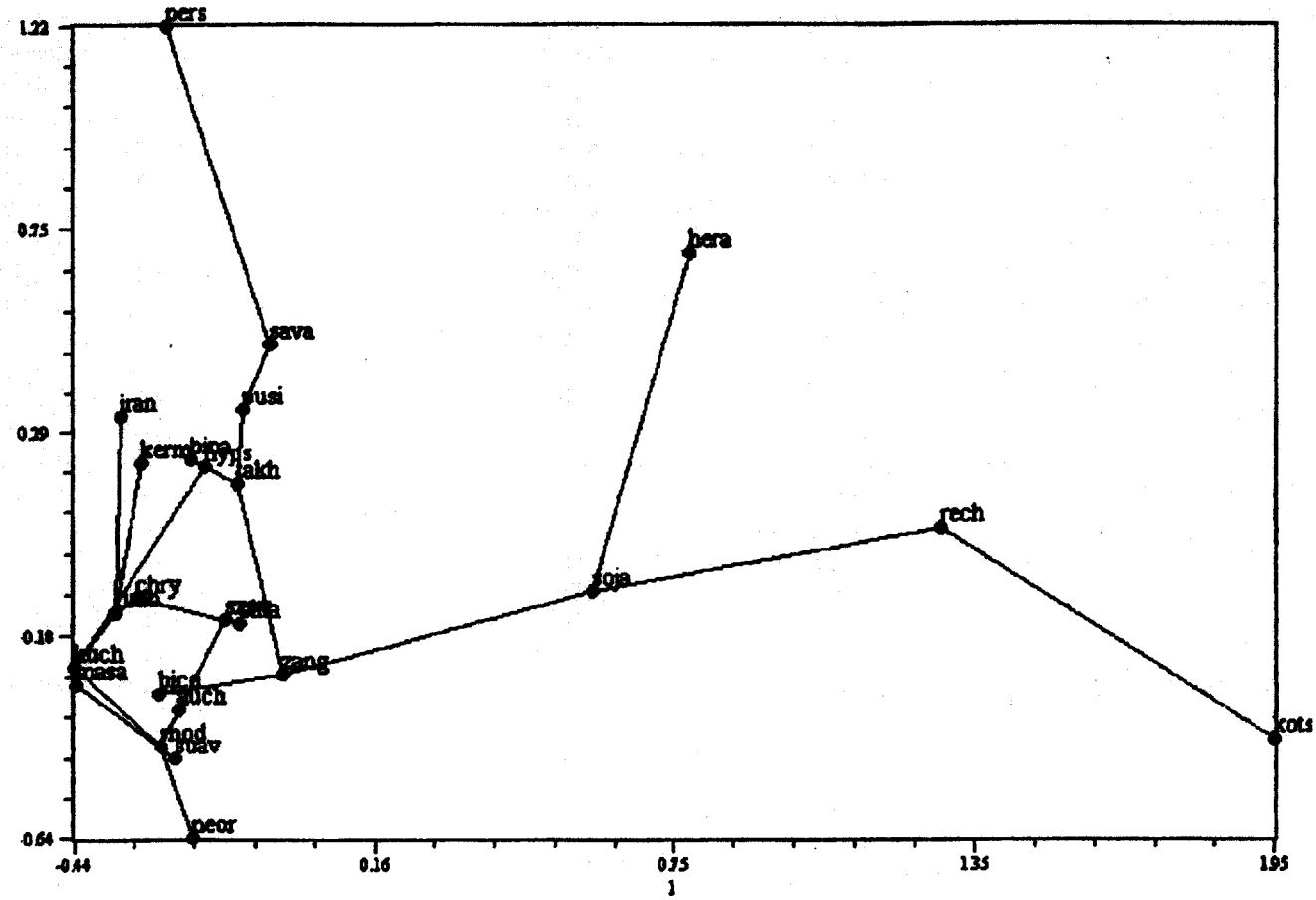

Figure 2. PCA with MST of the genus Oxytropis in Iran

methods appears to give more information than those of conventional methods on the relationship between OTUs used in this study. Therefore, the classification obtained in this study would be expected to approximate natural groupings better than the previous studies. Nevertheless, this study does not reveal all relationships in *Oxytropis* beyond any doubts, notwithstanding the least homoplasy of morphological characters were used.

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