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A morphometric study on *Scorzonera* L. taxa (Asteraceae) from northeast Anatolia

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Phenetic traits of 39 populations belonging to 19 taxa of *Scorzonera* L. (Asteraceae) from north Anatolia were analyzed with the use of numerical methods. Principal component analysis (PCA) showed that pubescence and length of achenes, the shape of outer phyllaries, and average length of flowering capitula, plant pubescence, root shape and state of the plant stem are the best variables to distinguish the examined taxa. In addition, it was also found that binary are more important than quantitative characters in discriminating the examined *Scorzonera* taxa. Numerical results based on 25 morphological characters were discussed and compared with traditional taxonomic treatments.

Key words: Phenetics, *Scorzonera*, systematics, Turkey

Introduction

The genus *Scorzonera* L. (Asteraceae) numbers about 160 species, ancient Mediterranean by origin, belonging to the subtribe Scorzonerinae Dumort. (Lactuceae Cass., Cichorioideae) is widely spread in the arid regions of Eurasia and Africa (NAZAROVA 1997, BREMER and ANDERBERG 1994). The genus includes up to 47 species in Turkey, some of which are endemic (DURAN 2008). This genus appears simple at first sight. However, it is a taxonomically difficult genus with several complexes of closely related species (CHAMBERLAIN 1975). The difficulties of identifying *Scorzonera* derive from the genus not having been sufficiently well investigated by taxonomists, many questions thus remaining controversial (NAZAROVA 1997). In recent years *Scorzonera* has been the subject of caryological (NAZAROVA 1997, GUARDIA and BLANCA 1987), ethnobotanical (RIVERA et al. 2006, ERTUĞ 2000), chemical (ZIDORN et al. 2003, MAGIATIS et al. 2001) and phenetic (MAVRODIEV et al. 2004) studies that have improved our understanding of the systematics of this genus.

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Nevertheless, there are still systematic problems. To date, no comprehensive numerical taxonomic study has been conducted on *Scorzonera* species, which are often difficult to distinguish from each other and whose infrageneric classification is only preliminary. The numerical approach is indeed a powerful tool in resolving the relationships and taxonomy of closely related species with complex variation patterns. The purpose of this study is to evaluate the extent of the variations in morphological characters and determine the taxonomic value of phenetic traits in classifying *Scorzonera* taxa as represented by 39 populations distributed in NE Anatolia.

Materials and methods

Thirty-nine populations of nineteen *Scorzonera* taxa were collected from NE Anatolia and used as operational taxonomic units (OTUs) in this study. Locality information and a distribution map of the OTUs are given in table 1 and figure 1. Vouchers are deposited in the Herbarium of Karadeniz Technical University, Department of Biology (KTUB). Twenty-five morphological characters were assessed: 11 related to vegetative structure, and 14 to floral structures (Tab. 2). Trait selection was based on floras and our own observations. A total of 234 individuals with flowers were scored for all these characters and the averages of all the individuals from each species were combined to yield the basic data matrix. The raw data matrix of 25 variables as columns and 39 objects (populations) as rows were used for numerical analysis (Tab. 3).

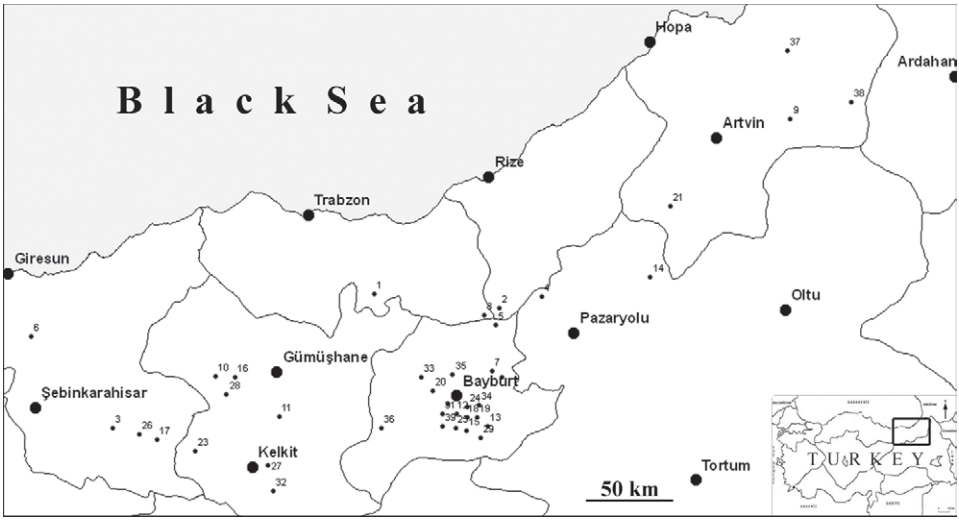

Fig. 1. Distribution map of the investigated taxa in NE Anatolia. Population numbers are specified in table 1.

Identifications were made according to Flora of Turkey (CHAMBERLAIN 1975), Flora of Europe (CHATER 1976), Flora Iranica (RECHINGER 1977) and Flora of USSR (LIPSCHIZ 1964) and assigned to nineteen taxa as follows: *Scorzonera cana* var. *jacquiniana* , *S. cana*

Tab. 1. Collection data of the examined specimens.

No	Taxa	Locality	Altitude (m)	Collection Numbers
1	*Scorzonera cana* (C.A. Mey.) Hoffm. var. *jacquiniana* (W. Koch) Chamb.	Trabzon: Araklı-Dağbaşı	1850	Makbul 054
2		Rize: Ovit	2400	Makbul 028
3		Giresun: Alucra	1490	Makbul 078
4	*S. cana* (C.A. Meyer) Hoffm. var. *cana*	Rize: Cimil	2300	Makbul 057
5		Rize: Ovit	2400	Makbul 030
6		Giresun: Eğribel Geçidi	2350	Makbul 095
7		Erzurum: İspir-Moryayla	2450	Makbul 093
8	*S. cana* (C.A. Meyer) Hoffm. var. *alpina* (Boiss.) Chamb.	Rize: Ovit	2400	Makbul 029
9		Artvin: Ardanuç	640	Makbul 076
10	*S. eriophora* DC.	Gümüşhane: Tersun Dağı	2040	Makbul 050
11		Gümüşhne: Mogoldas Dağı	1650	Makbul 044
12	*S. armeniaca* (Boiss. et Huet.) Boiss.	Bayburt: Bayburt Kalesi	1650	Makbul 059
13		Erzurum: Aşkale	2000	Makbul 048
14		Artvin: Yusufeli-İspir road 40. km	815	Makbul 073
15	*S. parviflora* Jacq.	Erzurum: Aşkale	1630	Makbul 088
16	*S. mollis* Bieb. ssp. *mollis*	Gümüşhane: Tersun Dağı	2040	Makbul 051
17		Giresun: Findikbeli Geçidi	1730	Makbul 080
18	*S. insica* DC.	Bayburt: Kop Dağı	2150	Makbul 085
19	*S. laciniata* L. ssp. *laciniata*	Bayburt: Kop Dağı	2100	Makbul 045
20		Bayburt: Çerçi Köyü	1700	Makbul 070
21		Artvin: Yusufeli-Yokuşlu Köyü	815	Makbul 074
22	*S. inaequiscapa* Boiss.	Bayburt	1500	Makbul 068
23		Giresun: Alucra-Şiran, 15. km	1670	Makbul 079
24	*S. sericea* DC.	Bayburt: Kop Dağı	2450	Makbul 089
25	*S. tomentosa* L.	Bayburt: Kop Dağı	2160	Makbul 010
26		Giresun: Alucra	1400	Makbul 012
27	*S. mollis* Bieb. ssp. *szowitzii* (DC) Chamb.	Gümüşhane: Kelkit	1635	Makbul 039
28		Gümüşhane: Tersun Dağı	2000	Makbul 064
29		Erzurum. Aşkale	1640	Makbul 090
30	*S. sosnowskyi* Lipschitz.	Erzurum: İspir-Moryayla	2400	Makbul 091
31		Bayburt: Kop Dağı	2150	Makbul 086
32	*S. suberosa* C. Koch	Erzincan: Erzincan-Kelkit 20. km	1750	Makbul 041
33		Bayburt: Çerçi Köyü	1700	Makbul 069
34	*S. cinerea* Boiss.	Bayburt: Kop Dağı	2150	Makbul 087
35	*S. pseudolanata* Grossh.	Bayburt	1500	Makbul 072
36		Bayburt: Köse	1650	Makbul 040
37	*S. seidlitzii* Boiss.	Artvin: Şavşat, Sahara Mezrası	2150	Makbul 022
38		Artvin: Yalnizçam Dağları	2200	Makbul 025
39	*S. latifolia* (Fish. et Mey.) DC.	Bayburt: Kop Dağı	2160	Makbul 094

Tab. 2. List of characters used in this study.

Symbol	Characters
X_1	Total plant high (cm)
X_2	State of the plant stem; 0: scape, 1: caulescent
X_3	Root; 0: cylindrical, 1: tuberose
X_4	Residue leaves at the base of the stem; 0: absent, 1: present
X_5	Stem; 0: not branched, 1: branched
X_6	Leaf; 0: entire, 1: pinnatisect or pinnatifit
X_7	Width of leaf (mm)
X_8	Length of leaf (mm)
X_9	Lamina; 0: linear, lanceolat, 1: ovat, eliptic
X_{10}	Leaf margin; 0: smooth, 1: undulate
X_{11}	Plant; 0: densely hairy (tomentose, pallose, villous), 1: slightly hairy (pubescent and sericea)
X_{12}	Number of capitula
X_{13}	Average length of flowering capitula (mm)
X_{14}	Average length of outer phyllaries (mm)
X_{15}	Average length of inner phyllaries (mm)
X_{16}	Shape of outer phyllaries; 0: linear, lanceolat, 1: ovat, eliptic
X_{17}	Ligulae color; 0: yellow, 1: purple
X_{18}	Length of achenes (mm)
X_{19}	Pappus color; 0: white or cream, black or brownish
X_{20}	Pappus; 0: completely plumose or barbellat, 1: plumose together with barbellat
X_{21}	Lower surface of inner phyllaries; 0: hairless, 1: hairy
X_{22}	Average row number of phyllaries
X_{23}	Apex of outer phyllaries; 0: unforked, 1: forked
X_{24}	Surface of achenes; 0: smooth, 1: rough
X_{25}	Achenes; 0: glabrous, 1: hairy

var. *cana*, *S. cana* var. *alpina*, *S. eriophora*, *S. armeniaca*, *S. parviflora*, *S. mollis* ssp. *mollis*, *S. insica*, *S. laciniata* ssp. *laciniata*, *S. inaequiscapa*, *S. sericea*, *S. tomentosa*, *S. mollis* ssp. *szowitzii*, *S. sosnowskyi*, *S. suberosa*, *S. cinerea*, *S. pseudolanata*, *S. latifolia*, *S. seidlitzii*.

Two multivariate analyses were performed using SYN-TAX PC 5.0 (PODANI, 1993): cluster analysis (CA) and principal components analysis (PCA). For the CA, a pair-wise matrix of resemblance values was calculated from the standardized data matrix, using Gower's coefficient as the coefficient of resemblance that is designed for mixed data sets (SNEATH and SOKAL 1973). A dendrogram was generated by the unweighted pair-group method using arithmetic averages (UPGMA). For PCA, the standardized data were used to create a covariance matrix, and three eigenvectors were extracted.

Results

Dendrogram of 25 phenetic variables corresponds to 19 taxa (Fig. 2). All taxa fall into two main clusters. The first group is labeled »a« and consists of 30 populations belonging to 15 taxa. The second cluster is labeled »b« and consists of the rest of the examined populations belonging to 4 taxa (*Scorzonera mollis* subsp. mollis, *S. inaequiscapa*, *S. mollis* subsp. *szowitzii*, *S. suberosa*). The cluster »a« is divided into small subclusters labeled »c« and »d«.

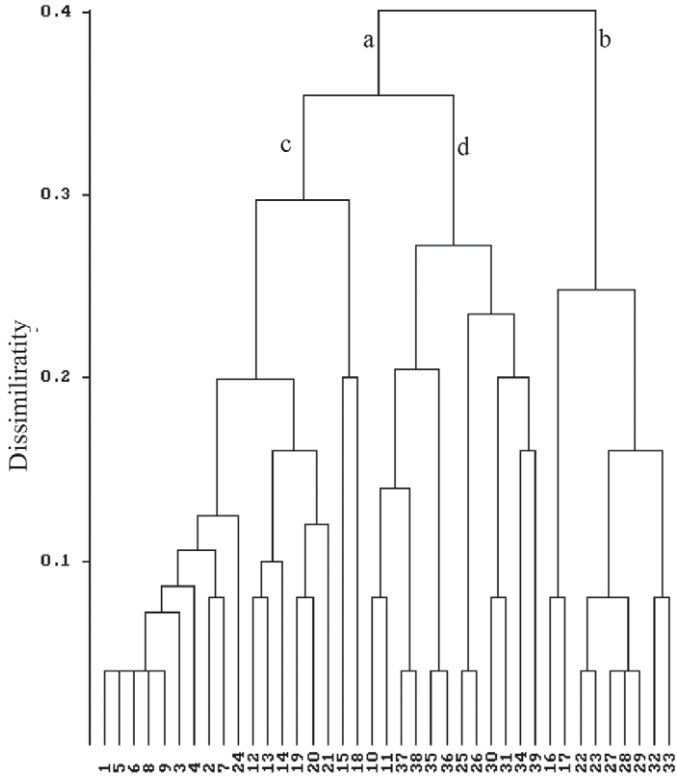

Fig. 2. Cluster analysis – UPGMA. The clusters discussed in the text are marked with letters. Population numbers are given in table 1.

PCA results using 25 characters are given in figures 3 and 4, showing the distribution of OTUs and variables on the first two components (axis). The results of principal component analysis show eigenvalues as percentages of explained variance, and cumulative percentages (Tab. 4). PC-1 and PC-2 had the highest score for the eighteen of the twenty five traits (Tab. 4). These variables are X3, X10, X13, X14, X15, X16, X17, X18, X25 for PC-1 and X4, X6, X9, X11, X12, X19, X20, X23, X24 for PC-2. PC-3 received the highest score only for the remaining seven variables used in this study. Eleven of the twenty-five traits analyzed in the present study explained more than 50% of the total variation. The highest variation rates observed among the twenty-five characters and accounting for the first three

Tab. 3. Raw Data Matrix using Numerical Analysis (Raw: Character, Column: Taxa).

25.83	0	0	1	0	1	3.13	10.51	0	0	1	3.33	21.60	7.50	20.16	0	1	9.33	0	0	1	1	3	1	0
25	0	0	1	1	1	2.98	12.16	0	0	1	5.16	22.50	8	22.16	0	1	10	0	0	1	1	3	1	0
24.83	0	0	1	0	1	2.42	13.33	0	0	1	1.33	24.66	6	17	0	1	9.66	0	0	1	1	3	0	0
20.83	0	0	1	0	1	1.88	8.83	0	0	1	3.16	22.16	6.83	19.16	0	1	8.50	0	0	1	0	3	1	0
11.33	0	0	1	0	1	1.80	11.33	0	0	1	2.83	22.50	5.58	16.66	0	1	9.66	0	0	1	1	3	1	0
18.66	0	0	1	0	1	2.61	12.50	0	0	1	3.83	22.16	8	23.83	0	1	11.60	0	0	1	1	3	1	0
18.66	0	0	1	1	1	2.15	10	0	0	1	6	19.16	6	18.16	0	1	9.50	0	0	1	1	3	0	0
6	0	0	1	0	1	1.10	7.25	0	0	1	1.66	16.25	5.83	14.16	0	1	8.16	0	0	1	1	3	1	0
9.33	0	0	1	0	1	1.80	7	0	0	1	3.50	13.83	6.50	18	0	1	9	0	0	1	1	3	1	0
24	1	0	0	0	0	1.33	16.60	0	0	0	3.83	22.66	13	24	0	1	11	1	1	1	1	2	0	0
33.16	1	0	0	1	0	1.85	15.33	0	0	0	2.50	26.50	12.50	31.50	0	1	6.33	1	1	1	1	2	0	0
20	1	0	1	1	1	2.56	15.66	0	0	1	5.16	15.83	4.83	16.83	0	1	8.66	1	0	1	1	3	1	0
34.16	1	0	1	1	1	3.18	13.83	0	0	1	3.16	15.66	5	21.83	0	1	10.33	1	0	0	1	3	1	0
31.16	1	1	1	1	1	2.60	13.83	0	0	1	8	18.83	4.83	16.66	0	1	8.50	1	0	1	1	3	1	0
54.66	1	0	0	0	0	11.16	27.66	0	0	1	1	24.66	7.83	23.33	1	1	7.66	0	0	1	0	3	1	0
27.33	1	1	1	1	0	0.66	13.33	0	1	1	2.66	32.16	10.16	29.50	1	1	16.66	0	0	0	0	2	0	1
21.50	1	1	1	1	0	0.45	13.66	0	1	1	4	32.50	11.16	30.66	1	1	14	0	0	1	0	2	0	1
33.50	1	0	1	0	0	3.45	17.66	1	0	1	3.16	31.33	9.83	28.33	1	1	20.16	0	0	1	0	3	0	1
51.66	1	0	1	1	1	4.50	20	0	0	1	3.33	18.16	5.16	22.33	0	1	9.16	0	0	0	1	3	1	0
48.83	1	0	1	1	1	3.50	19.16	0	0	1	3	13.50	5.33	21.16	0	1	11.33	0	0	0	1	3	0	0
49	1	0	0	1	1	3.73	10.50	0	0	1	3.66	22.33	6.16	21.16	0	1	11.33	0	0	0	0	3	1	0
12	0	1	1	0	0	0.90	8.83	0	1	1	1	26.66	7.50	27.83	1	1	15.50	0	1	1	1	3	0	1
13.33	0	1	1	0	0	0.96	9	0	1	1	1	26.66	8.83	34.50	1	1	16	0	1	1	1	3	0	1
4	0	0	1	0	0	2.66	3	0	0	1	1	14.66	5	10.83	0	1	7.33	0	0	1	1	3	0	0
49	1	0	0	1	0	2.13	8.25	1	1	0	12.66	19.66	9	16.50	0	1	10.33	0	1	0	1	2	0	0
32.16	1	0	0	1	0	1.83	8.83	1	1	0	6.16	16.83	7.16	17.16	0	1	8.66	0	1	0	1	2	0	0
13.83	0	1	1	0	0	0.48	10.50	0	1	1	3	27.66	8.83	26.33	1	1	15.83	0	1	1	1	2	0	1
12.16	0	1	1	0	0	2.41	11.50	0	1	1	1.66	24.16	9.83	24.33	1	1	16.50	0	1	1	1	2	0	1
23.66	0	1	1	0	0	2.33	13.66	0	1	1	6.50	27.50	8.16	29.33	1	1	14.16	0	1	1	1	2	0	1
66	1	0	1	1	0	2.18	10.33	1	0	1	10.66	16.83	5.16	15.66	0	1	11	1	0	1	1	2	0	0
65.33	1	0	1	1	0	1.96	11.83	1	1	1	18	15	5.83	16.83	0	1	11.16	1	0	1	1	2	0	0
10.16	0	1	1	0	0	0.58	8.66	0	1	1	1.66	22	7.50	17.16	1	0	15.66	0	1	0	1	3	0	1
8.83	0	1	1	0	0	0.96	8.33	0	1	1	2.50	25	9	20.33	1	0	16	0	1	0	0	3	0	1
52.16	1	0	0	1	0	1.41	11.83	1	0	1	5.33	19.16	6.16	13	0	1	8.66	0	0	1	1	3	0	0
8.16	0	1	0	0	0	0.81	7.25	0	1	0	3.16	12.66	4.50	11.83	0	1	6.33	1	0	1	1	2	0	0
7.50	0	1	0	0	0	0.86	6.83	0	1	0	3.33	13.33	3.50	12	0	1	5.41	1	0	1	1	2	0	0
11.83	0	0	0	0	0	2.08	7.83	0	0	0	1.83	17.66	8	14.83	0	1	5.91	0	1	1	1	2	0	0
10.16	0	0	0	0	0	1.33	5.50	0	0	0	2.50	14.16	5.50	14.16	0	1	5.66	0	1	1	1	2	0	0
75	1	0	0	1	0	2.18	11.83	1	0	0	44.16	18.16	7.50	15.50	0	1	9.50	1	1	1	1	3	0	0

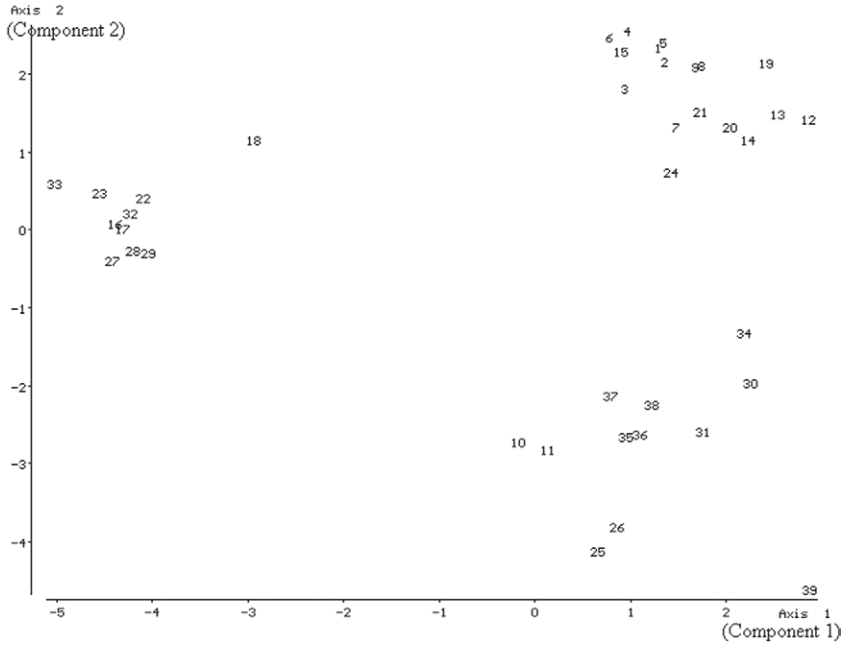

Fig. 3. Principal component analysis of 39 populations projected onto the first two axes. For population number explanations see table 1.

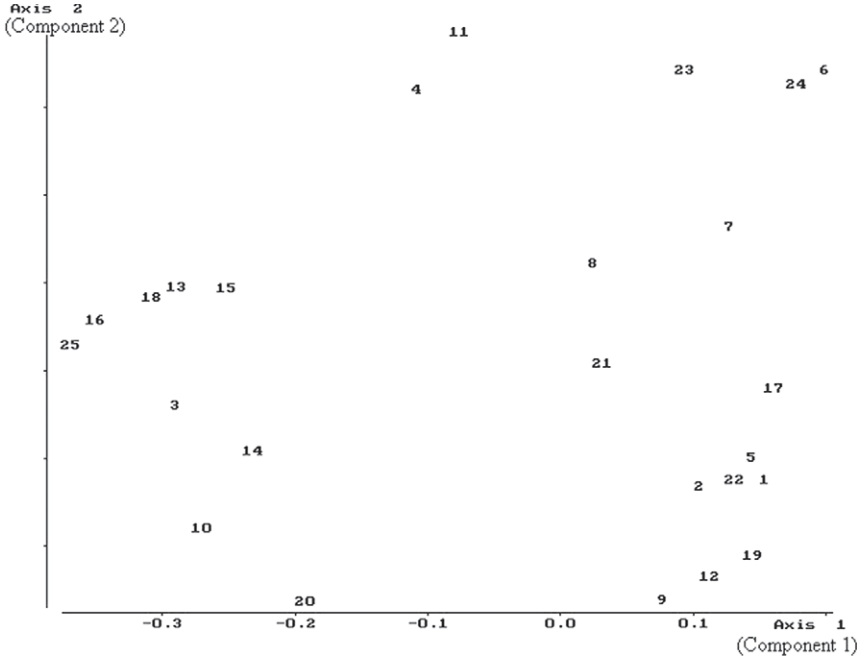

Fig. 4. Principal component analysis of 25 variables projected onto the first two axes. For variables number explanations see table 2.

Tab. 4. Percentage of variance of variables accounted for by first three components.

Names of variables	PC-1	PC-2	PC-3
X_1	15.981	7.052	61.736
X_2	7.373	7.770	69.471
X_3	57.119	0.730	4.527
X_4	8.108	45.162	0.147
X_5	13.995	4.502	34.571
X_6	26.887	51.816	0.339
X_7	10.890	11.774	25.331
X_8	0.385	6.451	59.081
X_9	3.948	30.556	17.282
X_{10}	49.736	14.570	1.507
X_{11}	3.927	65.503	3.842
X_{12}	8.451	24.685	9.668
X_{13}	56.878	3.881	16.841
X_{14}	36.768	3.774	12.378
X_{15}	43.064	3.743	21.436
X_{16}	83.705	1.424	4.333
X_{17}	17.493	0.209	2.170
X_{18}	64.405	3.017	10.716
X_{19}	14.161	20.058	0.687
X_{20}	25.361	30.846	1.906
X_{21}	0.655	0.023	8.316
X_{22}	11.527	7.026	21.506
X_{23}	5.888	51.826	0.362
X_{24}	21.179	47.062	0.389
X_{25}	92.789	0.340	0.715
Percentage of variance explained	27.23	17.75	15.57
Cumulative percentages of variance explained	27.23	44.98	60.55

components are 92.25% (X25), 83.705% (X16) and 69.471% (X2). These characters are among the binary traits examined in this study. Only the first three components were taken into account because of their eigenvalues. The three components account together for 60.55% variation (Tab.4). The first component accounts for 27.23% variation. The second component accounts for 17.75%, the third component accounts for 15.57% and together they account for 60.55 %.

Discussion

There are many clustering methods and similarity coefficients in the literature as can be seen in SNEATH and SOKAL (1973). In this study, UPGMA along with Gower's coefficient has been used for clustering the 39 OTUs (Fig. 2). In order to determine how well this dendrogram represents the underlying matrix of resemblances, the cophenetic correlation

coefficient (rcs) was also calculated. It has generally been found to vary from 0.6 to 0.95, depending on the methods producing the dendrogram and the nature of the differences among the specimens classified (SNEATH and SOKAL 1973). Our dendrogram had a cophenetic correlation of 0.72. This means that the dendrogram provides a fairly accurate representation of the resemblances among OTUs.

All the examined OTUs fall into two major clusters at 88.2% dissimilarity levels (Fig. 2). One, labeled »a«, consists of populations that belong to scapigerous and caulescent taxa, the other, labeled »b«, includes all the remaining OTUs representing entirely scapigerous taxa. When the dendrogram is carefully examined, it can be seen that cluster »a« consisting of most of the examined OTUs belongs to fifteen taxa, but cluster »b« consisting only of nine OTUs belongs to four taxa. There are no significant differences in the anatomical peculiarities among the taxa in group »b« (LIPSCHIZ 1964, KAMELIN and TAGEV 1986).

Cluster »a« splits into two small clusters (c, d). Cluster »c« consists of OTUs corresponding to scapigerous, subscapigerous and caulescent taxa. They are morphologically and anatomically related to each other. All OTUs in this group have a typically cylindrical root system, but the representatives of S. parviflora (OTU 15) and *S. insica* (OTU 18) form a small group because of the unforked stem and the pubescence. The representatives of S. armeniaca (OTUs 12–14) and *S. laciniata* ssp. *laciniata* (OTUs 19–21) are close to each other because of the similar morphological traits as indicated by CHAMBERLAIN (1975). These views are correlated with our results obtained from UPGMA. Additionally, our findings also support the results based on caryological data as indicated by NAZAROVA (1997). Although OTU 24 (*S. sericea*) display some different morphologic properties and grow in different habitats from the other examined populations in cluster »c«, it occurs in cluster »c«, together with the other OTUs because of the shared characters such as cylindrical root, pinnatisect leaf, similar achene and flower peculiarities. Although all representatives of *S. cana* (OTUs 1–7) are uniform at the specific level, they are not separated at the subspecific level. *S. cana* is said to be close to *S. laciniata* ssp. *laciniata* (CHAMBERLAIN 1975), but our results from UPGMA do not support this view and show that S. cana is more closely related to *S. armeniaca* (Fig. 2). This situation might be explained as follows; *S. laciniata* prefers dry habitats and is characterized by an entire leaf and *S. cana* prefers humid habitats and is characterized by a compound leaf.

Cluster »d« includes OTUs characterized by densely hairy, generally caulescent and a few lanate scapigerous taxa (*S. pseudolanata*, *S. seidlitzii*). Although the representatives of *S. pseudolanata* (OTUs 35–36) and *S. seidlitzii* (OTUs 37–38) are morphologically similar to the representatives of cluster »b«, these scapigerous OTUs that are densely lanate and hairy occur in cluster »d«. The major group of the cluster »d« includes only caulescent tomentose taxa. But *S. latifolia* (OTU 39) characterized by numerous capitula (more than 20) and *S. cinerea* (OTU 34) characterized by globrous achenes form a small group in cluster »d«. *S. tomentosa* is closed to *S. latifolia* (CHAMBERLAIN 1975). Our results do not support this idea; those from UPGMA show that *S. latifolia* is more closely related to *S. cinerea* and *S. sosnowskyi* than *S. tomentosa*.

OTUs characterized by scapigerous or semi-caulescent, tuberose-root, glabrous or pubescent and entire linear lamina with undulate margins were clustered in group »b«. It seems that the representative of *S. mollis* ssp. *mollis* forms a small sub-group in cluster »b«.

The reason for this can be explained with the different phenetic traits such as the forked and semi-caulescent stem. The other OTUs in cluster »b« have very similar morphological characters. The representatives of *S. suberosa* (OTUs 32–33) with lilac to purple flowers are separated from the other OTUs (Fig. 2). This delimitation is coincided with the caryological and ITS results of MAVRODIEV (2004). The ranks of subgenus and section have been used in *Scorzonera* by several scientists (LIPSCHIZ 1964, KAMELIN and TAGEV 1986, NAZAROVA 1997). *Scorzonera cana*, *S. armeniaca* and *S. laciniata* ssp. *laciniata* treated in subg. *Podospermum* (DC.) Lipschiz, *S. suberosa* in subg. *Pseudupodospermum* (Lipschiz et Krash) Lipschiz, *S. seidlitzii* in subgen. *Scorzonera* sect. *Pulvinares* Lipschiz and *S. latifolia* in subg. *Scorzonera* sect. *Nervosae* Lipschiz (LIPSCHIZ 1964). All the OTUs of these listed taxa are grouped as indicated by LIPSCHIZ (1964) and our results from UPGMA support the use of such ranks within the genus (Fig. 2).

The position of the 39 examined populations on the first two components of the PCA (Fig. 3) shows that all populations examined in this study are split into three distinct clusters. These clusters are almost associated with the results from UPGMA except for the representatives of *S. insica*. This situation could be explained by the differences in the root systems and the shapes of lamina, which are the most important characters, explaining most of the variation among the examined taxa. This might be caused by the insufficient specimens or population examined in this study. There is no other contradiction between PCA and UPGMA with respect to the distribution of OTUs.

The first two extracted components explain 44.98% of the total variation among the examined populations (Fig. 3). The three components account together for 60.55% of the variation among populations (Tab. 4). The first component emphasizes pubescence and length of achenes, shape of outer phyllaries, average length of flowering capitula, root shape and leaf margin and the second component with apex of outer phyllaries, hair types of plant and shape of lamina. The third component emphasizes length of the leaf, total plant height and state of the plant stem. However, weights are all under 50% and almost equal. In summary, the state of residue leaves at the base of the stem, pubescence and length of achenes, shape of outer phyllaries, average length of flowering capitula, root shape and leaf margin are the most important characters separating the *Scorzonera* species. These characters are the basic ones used in most floras for separating these species (CHATER 1976, CHAMBERLAIN 1975).

The present study is a preliminary step in the analysis of morphological characters by means of numerical analysis. The results basically agree with the traditional taxonomic treatments of *Scorzonera*. Although qualitative variables such as shape of outer phyllaries, achenes and root shape explain most of the total variation, binary characters seem to be more important than quantitative ones in separating *Scorzonera* taxa.

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References

BREMER, K., ANDERBERG, A. A., 1994: Asteraceae: Cladistics and classification. Timbers Press, Portland.

CHAMBERLAIN, D. F., 1975: *Scorzonera* L. In: DAVIS, P. H. (ed), Flora of Turkey and the east Aegean islands. Edinburgh University Press, Edinburgh.

CHATER, A. O., 1976: *Scorzonera*. In: TUTIN, T. G, HEYWOOD, V. H, BURGES, N. A, VALENTINE, D. H, WALTERS, S. M, WEBB, D. A. (eds.), Flora Europaea. Cambridge University Press, Cambridge.

DURAN, A., 2008: Rediscovery of the poorly known *Scorzonera argyria* and its relationships in Turkey. Biologia 63, 1078–1084.

ERTUĞ, F., 2000: An ethnobotanical study of Central Anatolia (Turkey). Economic Botany 54, 155–182.

GUARDIA, C. D., BLANCA, G., 1987: Karyology of the *Scorzonera* (Compositae) species from the Iberian Peninsula. Plant Systematic and Evolution 156, 29–42.

KAMELIN, R. V., TAGEV, I. U., 1986: Survey of the species of the genus *Scorzonera* (Asteraceae). Botanical Journal 71, 1972–1982.

LIPSCHIZ, S. J., 1964: *Scorzonera*. In: SHISHIN, B. K. (ed.), Flora of the USSR, 29 (in Russian). Academy of Science of the USSR, Moscow, Leningrad.

MAGIATIS, P., MITAKU, S., SKALTSOUNIS, A., TILLEQUIN, F., 2001: 1-Oxo-2-hydroxy-1,2--dihydroacronycine: a useful synthon in the acronycine series for the introduction of amino substituents at 6-position and for the conversion into isopropylfuroacridones. Chemical and Pharmological Bulletin 49, 1304–1307.

MAVRODIEV, E. V., EDWARDS, C. E., ALBACH, D. C., GITZENDANNER, A., SOLTIS, P. S., SOLTIS, D. E., 2004: Phylogenetic relationships in subtribe Scorzonerinae (Asteraceae: Cichorioideae: Cichorieae) based on ITS seguence data. Taxon 53, 699–712.

NAZAROVA, E. A., 1997: Karyosystematic investigation of the genus *Scorzonera* L. s.l. (Lactuceae, Asteraceae). Caryologia 50, 239–261.

SNEATH, P. H. A., SOKAL, R. R., 1973: Numerical taxonomy: The principles and practice of numerical classification. W. H. Freeman and Company, San Francisco.

PODANI, J., 1993: Multivariate data analysis in ecology and systematic, A methodological guide to Syn-Tax 5.0 Package. SPB Academic Publishing, Netherlands.

RECHINGER, K. H., 1977: *Scorzonera* L. In: Rechinger, K. H. (ed.), Flora Iranica, 122, 16–79. Graz Akademische Druck und Verlagsanstalt.

RIVERA, D., OBÓN, C., HEINRICH, M., INOCENCIO, C., VERDE, A., FAJARDO, J., 2006: Gathered Mediterranean food plants–ethnobotanical investigations and historical development. Forum of Nutrition 59, 18–74.

ZIDORN, C., ELLMERER, E. P., STURM, S. STUPPNER, H., 2003: Trylobibenzyls E and F from *Scorzonera humilis* and distribution of caffeic acid derivatives, lignans and tyrolobibenzyls in European taxa of the subtribe Scorzonerinae (Lactuceae, Asteraceae). Phytochemistry 63, 61–67.