

Numerical Taxonomic Study on Some *Centaurea* L. Species

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Abstract

In this study; numerical taxonomic study was carried out by using 23 morphological characters on 10 taxa (3 endemic) in *Centaurea*. Two methods used for numerical analysis; Clustering (UPGMA) and Principal Component Analysis (PCA). According to UPGMA Analysis, *C. calcitrapa* subsp. *calcitrapa* with *C. iberica* and *C. antiochia* var. *antiochia* with *C. urvillei* subsp. *armata* are the most related taxa. According to results of PCA analysis, minimum and maximum value of appendage broad and minimum value of appendage length are important characters for the classification of *Centaurea*.

Keywords: *Centaurea*, Numerical Taxonomy, UPGMA, PCA, Clustering

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Introduction

Turkey is one of the main centers of diversity for the genus *Centaurea* (Wagenitz 1986). There are 191 taxa in 34 sections and endemism value is about 60% in Turkey (Wagenitz 1975; Davis 1988; Güner 2000; Duran and Duman 2002; Turkoğlu et al. 2003; Uzunhisarcıklı et al. 2005; Uysal et al. 2007). Clustering (UPGMA) analysis results in a hierarchic dendrogram, produced by a sequence of fusions between taxa or group of taxa. Principal Component Analysis (PCA) results reduce numerous characters to less than components and give relationship between characters (Cole 1968; Nogrady 1998; Rohlf 1998; Karamura 1999; Coşkunçelebi 2001; Lawrey 2001; Süslü 2001).

Material and Methods

In this study, numerical analysis practiced using 23 morphological characters on *C. cassia* Boiss. (ISTF: 40033, 40042, 40043, 40044, 40045), *C. lycopifolia* Boiss. & Kotschy (ISTF: 40030, 40039, 40040, 40041), *C.*

cheirollopha (Fenzl) Wagenitz (ISTF: 40032, 40046, 40047, 40048, 40049), *C. spicata* Boiss. (ISTF: 40029, 40050, 40051, 40052), *C. ptosimopappa* Hayek (ISTF: 40028, 40063, 40064, 40065), *C. solstitialis* L. subsp. *solstitialis* (ISTF: 40035, 40057, 40058, 40059, 40060, 40061, 40062), *C. iberica* Trev. (ISTF: 40037, 40053, 40054, 40055, 40056), *C. calcitrapa* L. subsp. *calcitrapa* (ISTF: 40036, 40038), *C. urvillei* DC. subsp. *armata* Wagenitz (ISTF: 40034, 40066, 40067), *C. antiochia* Boiss. var. *antiochia* (ISTF: 40031, 40068, 40069, 40070, 40071, 40072). *C. lycopifolia* Boiss. & Kotschy, *C. ptosimopappa* Hayek, *C. antiochia* Boiss. var. *antiochia* taxa are endemic. Study material were collected in the year of 2003, 2004, 2005 from Hatay in Turkey. They were compared with specimen taxa deposited in ISTF, ANK, GAZI, and HUB. Two numerical analysis methods were used; clustering (UPGMA) and Principal Coordinate Analysis (PCA). NTSYSpc version 2.1 was used for these analysis.

Results

Key to studying taxa

1. Phyllaries without a distinct appendage *C. ptosimopappa*
1. Phyllaries with a distinct appendage
 2. Stem winged *C. solstitialis*
 2. Stem not winged
 3. Leaves decurrent (at least ones)
 4. Flowers pink-purple *C. spicata*
 4. Flowers yellow *C. cheirolopha*
 3. Leaves not decurrent
 5. Appendage ending in a mucro (shorter than 0.5 mm)
 6. Appendages decurrent *C. cassia*
 6. Appendage not decurrent *C. lycopifolia*
 5. Appendage ending in a spine (longer than 5mm)
 7. Annual, biannual, cilia of appendage less than 10
 8. Achens with pappus *C. iberica*
 8. Achens without pappus *C. calcitrapa*
 7. Perennial, cilia of appendage more than 10
 9. Appendage not concealing basal part of phyllaries..... *C. antiochia*
 9. Appendage concealing basal part of phyllaries..... *C. urvillei*

Centaurea cassia Boiss.

Perennial, stem erect 20-80 cm, branched near base or in upper part. Leaves 3–75 x 0.5–26 mm, glandular-punctate, slightly scabrous and sessile with 3-14 lateral segments; upper leaves undivided. Involucres 7.24–11.07 x 6.19–11.19 mm, ovoid to subglobose. Appendages large, concealing basal part of phyllaries, brown (darker in central part), ovate to nearly orbicular, decurrent, 2.79–5.58 x 3.22–6.80 mm. Appendages ciliate with 14–30 cilia, 0.12–2.09 mm, all ending in a very short 0.14–2.09 mm mucro. Flowers pink–purple. Achens 2.54–3.82 x 1.25–1.71 mm. Pappus 0.14–1.36 mm.

Centaurea lycopifolia Boiss. & Kotschy

Perennial, stem erect to ascending or decumbent, 20–40 cm. Leaves scabrous, basal with 3–12 segment, 4.35–16.6 x 0.1–3.2 cm, toothed; Lower similar to basal sessile and 3.9–8.6 x 0.15–2.8 cm; Upper sessile, nearly simple, toothed and 2.9–7.55 x 0.3–2.65 cm. Involucres 11.44-19.25 x 8.21-13.57 mm, ovate. Appendage 3.49–8.65 x 2.89–8.89 mm, concealing most of basal part of phyllaries, brown, triangular, ciliate with 4-20 cilia, 0.134–0.365 mm, all ending in an 1.99–6.49 mm spinule. Flowers yellow. Achens 3.08–5.48 x 1.69–2.61 mm. Pappus 0.7–2.16 mm. Endemic (Fig. 1).



Figure 1. *Centaurea lycopifolia* Boiss. & Kotschy.

Centaurea cheirolopha (Fenzl) Wagenitz

Perennial, stem erect, simple or with a few branches, 20–80 cm. Leaves sessile, decurrent, green and glabrescent above, grey-tomentose below, 22–260 x 1–41 mm, basal and lower usually lyrate with 4–7 segments, upper simple. Involucres 8.04–17.41 x 9.21–13.65 mm, ovate. Appendages brown, triangular, 2.31–5.47 x 3.44–9.8 mm ciliate with 5–9 cilia, 0.78–4.25 mm, all ending in a 1.63–4.88 mm spinule. Flowers yellow. Achens 3.57–5.04 x 1.69–2.34 mm. Pappus 0.15–1.47 mm.

Centaurea spicata Boiss.

Biannual or short lived perennial, stem erect, 40–150 cm. Leaves papery when dry, with short scattered hairs, basal lyrate with 5–12 segments, 16–40 x 6–17.5 cm, toothed; lower lyrate with 3–9 segments, 12–24 x 3.5–10.5 cm, toothed, decurrent; upper 7.8–13.2 x 2–6.1 cm, lanceolate and ending in a distinct mucro,

toothed, decurrent. Involucres 18.5–26.5 x 18.5–26 mm, ovate. Appendages triangular, brown, 4–24 x 6.57–13.79 mm, ciliate with 10–27 cilia, 1–4.81 mm, all ending in a 6.79–18.64 mm spine. Flowers pink–purple. Achens 4.14–4.86 x 2.15–2.89 mm. Pappus 7.12–8.92 mm, purple.

Centaurea ptosimopappa Hayek

Perennial, with ascending glabrous branches, 1–1.80 m. Leaves firm, lathery, glabrous, woolly at margin, lanceolate–spatulate, sessile, ending in a mucro; Leaves of sterile shoots crowded at top of branches, 12–15 x 2.5–3 cm; leaves of flowering shoots much smaller, 13.2–1.4 x 0.1–1.8 cm. Involucres 13–19 x 8.5–11.5 mm, ovate, contracted towards apex. Appendage absent or a very deciduous spinule. Flowers yellow. Achens 2.57–5.13 x 1.47–2.82 mm. Pappus 0.48–5.66 mm, deciduous, sometimes purple. Endemic.

Centaurea solstitialis* L. subsp. *solstitialis

Annual, stem winged, 15–60 cm. Leaves decurrent, tomentose, 16–217 x 1.5–30.5 mm, basal and lower usually with 4–6 segments, lyrate, upper simple. Involucre 9–14 x 7.5–11.5 mm, ovate. Appendages straw-coloured, triangular, 3.57–22.99 x 2.41–13.87 mm, ciliate with 2–6 distinct spinule (cilia), 0.49–8.11 mm, all ending in a 2.94–21.63 mm spine. Flowers yellow. Achens 1.93–2.62 x 1–1.43 mm, marginal blackish and without pappus. Central with 0.22–3.93 mm pappus.

***Centaurea iberica* Trev.**

Annual or biannual, repeatedly branched from near base 20–90 cm. Branches overtopping their relative main-axis. Leaves sparsely hairy, sessile, toothed, with 5–23 segments, 15–248 x 2–24 mm, all ending in a mucro. Involucre 6–12 x 6–10.5 mm, ovate to cup-shaped. Appendage triangular, straw-coloured, 5–25 x 2.58–9.24 mm, ciliate with 2–8 cilia, 1.31–3.89 mm, all ending 2.14–19.37 mm spine. Flowers pink-purple. Achens 2.17–3.66 x 1.25–2.03 mm. Pappus 0.22–2.03 mm.

Centaurea calcitrapa* L. subsp. *calcitrapa

Annual or biannual, 20–90 cm, very similar to *C. iberica*. Leaves 5–91 x 0.5–2.7 mm, with 3–10 segments, sessile, sparsely hairy. Involucre 8.5–12.5 x 6–8.5 mm, narrowly cylindrical to fusiform. Appendages straw-coloured, triangular, 5–21.5 x 1.28–8.98 mm, ciliate with 2–10 cilia, 1.28–4.56 mm, all ending in a 3.55–18.87 mm spine. Flowers pink-purple. Achens 1.94–3.02 x 1–1.86 mm, without pappus. Rarely some achen with 0.28–1.52 mm pappus.

***Centaurea urvillei* DC subsp. *armata* Wagenitz**

Short lived perennial, stem 20–30 cm, simple or branched from near base. Leaves arachnoid to tomentose, sessile, 13–150 x 1–40 mm, lyrate, with 2–26 segments, upper rarely simple. Involucre 15–23 x 16.5–25.5 mm, ovate to spherical. Appendage mostly concealing basal part of phyllaries, brown, triangular, 6.83–27.63 x 4.33–13.61 mm, ciliate

with 9–30 cilia, 0.59–4.93 mm, all ending 2.6–23.78 mm spine. Flowers blackish-purple. Achens 4.31–5.83 x 2.02–2.56 mm. Pappus 0.15–6.7 mm, purple.

Centaurea antiochia* Boiss. var. *antiochia

Perennial, stem erect with a few long branched, 30–80 cm. Leaves sparsely hairy, 9–221.5 x 1–44 mm, sessile, basal and lower pinnatisect to pinnatilobed, with 7–15 segments, upper with 3–5 segments lyrate to simple. Involucre 16–25.5 x 15–30 mm, spherical to ovate. Appendage brown, triangular, 7.34–26.46 x 5.21–11.88 mm, ciliate with 15–30 cilia, 0.2–5.7 mm; all ending in a 5–21.49 mm spine. Flowers blackish-purple. Achens 3.87–5.53 x 2.31–3.03 mm. Pappus 0.13–7.37 mm sometimes purple.

Numerical Results

10 OTU (taxa) which numerical analysis were made are shown in Table 1. 23 characters which were used in numerical analysis were shown in Table 2. Dendrogram which achieved UPGMA analysis was shown in Fig. 2. 23 characters were converted to less number components with PCA analysis. Eigen value and eigen value percentage of these components were shown in Table 3. Eigen vectors of these components were shown in Table 4. Configuration of 23 character's on first two component were shown in Fig. 3.

Table 1. OTU List

OTU1	<i>Centaurea cassia</i> Boiss.
OTU2	<i>Centaurea lycopifolia</i> Boiss. & Kotschy
OTU3	<i>Centaurea cheirolapha</i> (Fenzl) Wagenitz
OTU4	<i>Centaurea spicata</i> Boiss.
OTU5	<i>Centaurea ptosimopappa</i>
OTU6	<i>Centaurea solstitialis</i> L. subsp. <i>solstitialis</i>
OTU7	<i>Centaurea iberica</i> Trev.
OTU8	<i>Centaurea calcitrapa</i> L. subsp. <i>calcitrapa</i>
OTU9	<i>Centaurea urvillei</i> DC subsp. <i>armata</i> Wagenitz
OTU10	<i>Centaurea antiochia</i> Boiss. var. <i>antiochia</i>

Table 2. Characters list

K1	Appendage broad min.	mm
K2	Appendage broad max.	mm
K3	Appendage length min.	mm
K4	Appendage length max.	mm
K5	Spine length min.	mm
K6	Spine length max.	mm
K7	Cilia length mean	mm
K8	Cilia number mean	number
K9	Achen broad mean	mm
K10	Achen length mean	mm
K11	Involucre broad mean	mm
K12	Involucre length mean	mm
K13	Pappus length min.	mm
K14	Pappus length max.	mm
K15	Leaf broad mean	mm
K16	Leaf length mean	mm
K17	Segment number of folia mean	number
K18	Annual-biannual plant, perennial plant	0,1
K19	Decurrent folia present, absent	0,1
K20	Leaves glabrous, surface glabrous, not glabrous	0,1,2
K21	Stem winged, or not	0,1
K22	flower pink-purple, yellow, blackish purple	0,1,2
K23	Stem less than 50 cm, upper 50 cm, upper 100 cm.	0,1,2

Table 3. Eigen value and Eigen % of components

Components	Eigen value	Eigen (%)	Total Eigen (%)
1	9,0521	39,36	39,36
2	5,397	23,46	62,82
3	3,4647	15,06	77,88
4	2,0761	9,03	86,91
5	1,3007	5,66	92,57
6	0,9944	4,32	96,89
7	0,3969	1,73	98,62
8	0,207	0,9	99,51

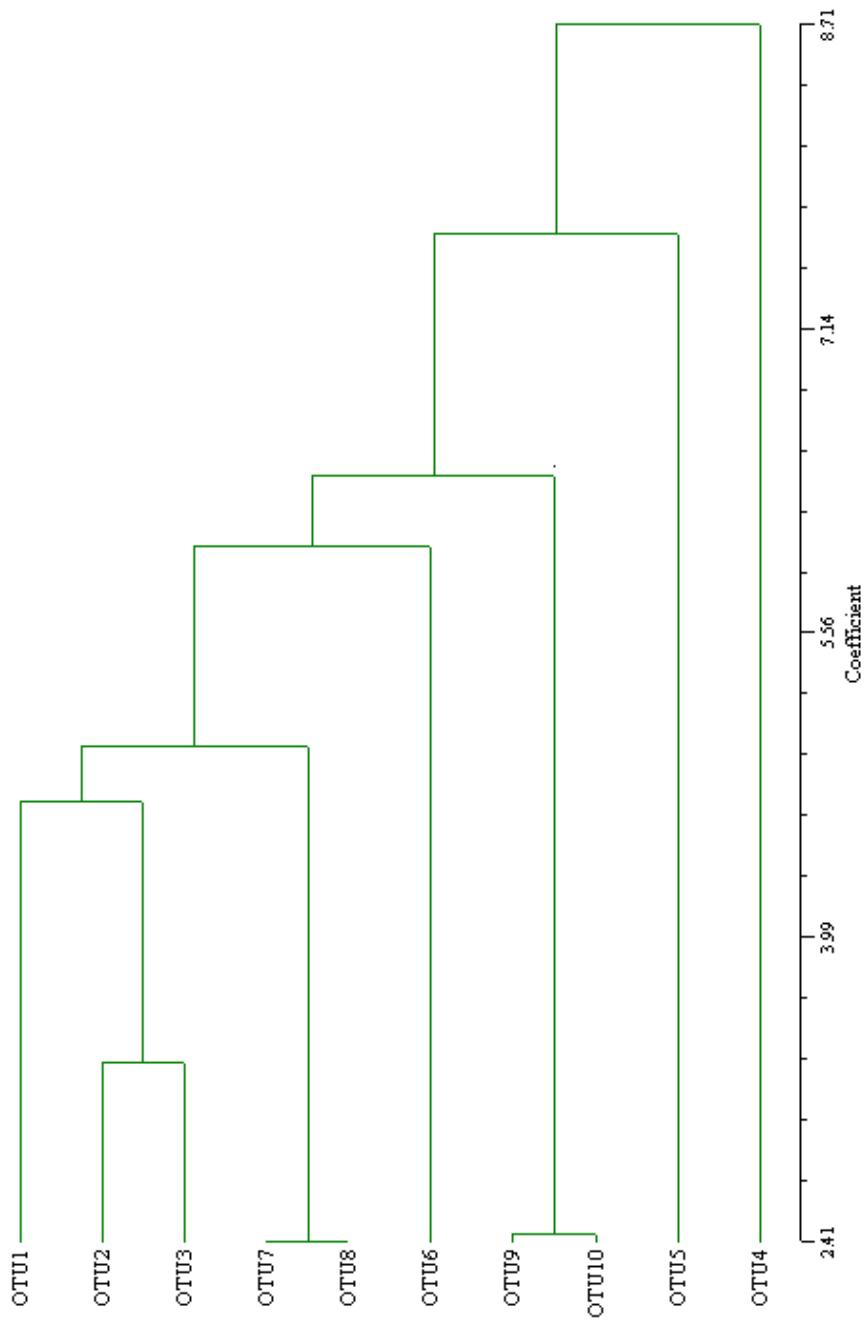


Figure 2. UPGMA Dendrogram

Table 4. Eigen Vector value of components

	C1	C2	C3	C4
K1	9,2002	4,0859	1,0256	2,2624
K2	7,7304	-5,718	7,3187	-8,6068
K3	7,654	-5,2983	-1,986	-1,4136
K4	6,8153	-6,1024	1,4205	-1,771
K5	9,2829	-1,2682	-2,1541	1,0304
K6	6,3748	-6,2579	9,5747	-1,7481
K7	5,1311	-6,556	1,5863	-2,603
K8	4,8233	1,1965	4,7075	4,5745
K9	7,227	6,1559	2,194	-1,3554
K10	5,5209	6,8103	4,1391	-1,2195
K11	8,8183	3,4785	2,0322	-1,2742
K12	7,2	6,1305	2,0857	-2,6075
K13	6,8452	2,4211	-5,8975	2,7302
K14	7,592	4,0056	-4,5655	-2,7465
K15	7,1689	1,849	-5,7474	2,9257
K16	6,7292	1,5114	-4,7684	1,1288
K17	3,9895	-4,7664	4,8301	5,0415
K18	2,6592	8,4779	3,0082	3,6354
K19	-3,6666	1,0597	6,6369	3,1961
K20	4,7159	-6,9337	2,6994	3,7616
K21	3,0818	5,7487	3,0911	5,9964
K22	2,6613	2,1077	6,3314	-6,9091
K23	1,3072	3,672	-7,6451	7,6318

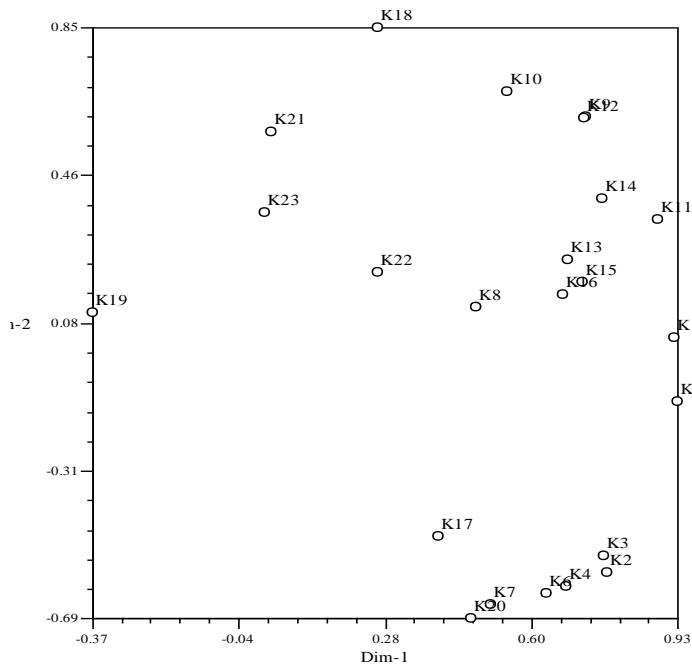


Figure 3. Characters on first two components

Discussion

Numerical taxonomic results are coherent with cladistic taxonomic results. *C. calcitrapa* L. subsp. *calcitrapa* (OTU8) and *C. iberica* Trev. (OTU7) which belong section *Calcitrapa* are the most related taxa and they are clustered in a group. *C. antiochia* Boiss. var. *antiochia* (OTU10) and *C. urvillei* DC subsp. *armata* Wagenitz (OTU9) which belong section *Acrocentron* are secondly the most related taxa and they are clustered in a group too. *C. cheirolopha* (Fenzl) Wagenitz (OTU3) ile *C. lycopifolia* Boiss. & Kotschy (OTU2) which belong section *Pseudoseria* are thirdly the most related taxa and they are clustered in a group too. *C. cassia* Boiss. (OTU1) wicb belong section *jacea* and *C. spicata* Boiss. (OTU4) which belong section *Cynaroides* and *C. ptosimopappa* Hayek (OTU5) which belong section *Ptosimopappus* and *C. solstitialis* L. subsp. *solstitialis* (OTU6) which belong section *Mesocentron* are not clustered in a group. *C. cassia* Boiss. (OTU1) and *C. spicata* Boiss. (OTU4) are the farthest taxa.

23 characters which were used for separated taxa from each other were reduced less than numerous components. First two components are explained % 62.82 of total variation. Vector values of first four components are given Table 4. According to Table 4; first component is represented by K5 (Spine length min.), K1 (Appendage broad min.), K11 (Involucre broad), K2 (Appendage broad max.) and K3 (Appendage length min.). Second component is represented by K18 (Annual-biannual plant, perennial plant), K20 (Leaves glabrous, surface glabrous, not glabrous), K10 (Achen length), K7 (Cilia length mean) and K6 (Spine length max.).

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