Identification of Two Morphologically Similar Charophytes using Morphometric Characteristics: *Chara vulgaris* and *Chara gymnophylla*

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Abstract

The study of morphometric measurements of two morphologically similar charophytes, *Chara vulgaris* L. and *Chara gymnophylla* A. Braun from freshwater habitats can distinguish them from each other. Although both species differ in some characters but morphological differences are problematic when they co-occur in the same lakes, rivers or springs. Morphological differences given in identification keys couldn't distinguish species and subspecies in the field. Therefore, additional characteristics were measured and suggested as useful features in differences of both species and their subspecies. Individuals of both species were collected in the vegetation seasons (2009) and (2013). Morphometric measurements and Statistical tests were done on 19 different quantitative and qualitative characters, number of branchlet corticated segments revealed the most significant difference. Branchlet/internode length ratio, characteristics of end segment: number of cells, number of corticated segments, end segment length,were differed in *Chara vulgaris* and *C. gymnophylla* varieties. We applied these features as a useful morphometry characters for differentiation, particularly under conditions where both species co-occur.

Keywords: *Chara vulgaris*, Charophytes, *Chara gymnophylla*, Identification, PCA, Morphometric Analysis.

Introduction

The genus *Chara* (Charophyta, Charophyceae) is widely distributed throughout the world in all continents (Wood and Imahori, 1964). Taxonomic studies based on the morphology of charophytes started at the end of the 19th century. Authors such as Braun and Nordstedt (1882), Groves and Bullock-Webster (1924), Zaneveld (1940), Olsen (1944) and Krause (1997) characterized the morphological variation in charophytes and find features that could distinguish every single species. Separation of the species in this genus Charais primarily based on morphological characters and the wide range of morphological variations commonly occurring in this genus makes it difficult to quantify (Wood, 1965; Wood and Imahori, 1964). Also members of family Characeae are often affected by ecological environment (Urbaniak, 2010).

C. gymnophylla is characterized by slender axes, 3-30cm high, upper parts much compacted ("foxtails"), aulacanthous or some times isostichous cortex, globular spine cells that are

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shorter than axis diameter and two rows of short stipulodes. *C. vulgaris* is highly polymorphic species, much branched, axes slender or moderately stout, moderately to heavily encrusted and characterized by aulacanthous cortex that primary rows of cortex equal or narrower than secondary rows, solitary spine cells are small to rudimentary and there is two rows of stipulodes that are variable in size. High morphological similarities of these two species lead us to measure some quantitative characters to show the differences between species and varieties. the species may co-occur in the same habitat. Therefore, the aim of the paper is to compare the length of internodes, number of branchlets and length of branchlets, number of branchlet segments, number of corticated branchlet segments, number of cells in end segment and the ratio between the length of branchlets and internodes of *C. gymnophylla* and *C. vulgaris* varieties, occurring in different and same ecosystems. Additionally, the features of oospores, length, wide, length to wide ratio, fossa breath and number of striae were determined.

Materials and Methods

Samplings were done during August to September of year (2009) and (2014) in Iran. 172 populations were collected for 2 species of *Chara* from 162 localities (Details of the localities are given in Table 4). The specimens were homothalic with oogonium and antheridium, as well as diploid oospore. Collections were made by hand, as well as with the help of a grapnel at the various depth of water. Herbarium mounts and preserved material were prepared and deposited in Herbarium of Shahid Beheshti University (HSBU). The voucher numbers are given in Table 4. Overall morphology of the specimens was examined with stereoscopic microscope (×10). The specimens were identified according to description provided by Wood and Imahori (1964), Krause (1997), Wood and Mason (1977), Gollerbach and Krasavina (1983). Taxon names are in accordance with the names in Algaebase (www.algaebase.org), and the Synopsis of the Characeae (Van Raam and Stewart, 2009). Name of the taxa is given in Table 1 according to different authors.

Characters were selected based on those reported by Wood and Imahori (1964), Casanova (2005), Van Raam and Stewart (2009) and Ahmadi et al. (2012a). 19 quantitative and qualitative morphological characters were studied (Table 2). For analyses the mean of quantitative characters were used while qualitative characters were coded as binary characters. Variables were standardized (mean=0, variance=1) for multivariate statistical analyses (Podani 2000, Sheidai et al. (2002). The ANOVA test of quantitative characters showed significant differences among the species (Table 3). In order to determine the species relationships, ordination based on PCoA (Principal Coordinate Analysis) was performed. SPSS ver. 16.6 (2007) were used for multivariate statistical analysis.

Results

Wood and Imahori (1964) place *C. gymnophylla* as a variety of *C. vulgaris*. Two varieties of two species have been identified. *Chara gymnophylla* (A. Braun) A. Braun var. *gymnophylla* and *Chara gymnophylla* var. *rohlenae* (Vilhelm) Ahmadi in Ahmadi et al., 2012a, *Chara vulgaris* var. *longibracteata* (kutzing) J. Groves & Bullock-Webster and *Chara vulgaris* L. var.

vulgaris. *Chara gymnophylla* is a diplostichous species with aulacanthous or sometimes isostichous, axes and about 3-30 cm high, upper parts much compacted ("foxtails"). Spine cells short, stipulodes in 2 rows, branchlets 6–11 in a whorl, ecorticated or with 0– 2 corticated segments. Anterior bractcells 1–2 times as long as the oogonium. Gametangia conjoined at corticated and ecorticatedbranchlet nodes. Oogonia solitary, 400-650µm long (excl. coronula). Mature oospores brown to black, 350-550µm long, 250-350µm wide, 9-11 low ridges ending in small claws, membrane nearly smooth or finely granulated. Antheridia solitary, 300–450µm in diameter. *C. gymnophylla* var. *rohlenae* with ecorti cated branchlets. Plant small, less than 10 cm high, bushy, very compacted differ from *C. gymnophylla* var. *gymnophylla* having 1-2 corticated branchlet segments. 15-30 cm long, lower internodes elongated.

Chara vulgaris is highly polymorphic, up to 30 cm tall, much branched, axes slender, moderately to heavily encrusted. Cortex diplostichous, aulacanthous. Spine cells solitary, rudimentary, stipulodes in 2 rows. Internodes 1–3 times the length of the branchlets; branchlets 6-10 in a whorl, 1-4 corticated segments.Gametangia conjoined at 1–4 corticated branchlet segments, oogonia solitary, 500-650 µm long. Mature oospores dark brown or black, 400-550µm long, 300-375µm wide, with 10 weak ridges, membrane nearly finely granulate. Antheridia small and solitary, up to 480µm in diameter. *C. vulgaris* var. *vulgaris* (short bract cells, 2-4

Table 1. Classification of Chara species according to different authors.

Name of the taxa	Wood 1962, Wood & Imahori 1964	Wood 1965 microspecies appendix	Pal et al. 1962 (India)	Gollerbach & Krassavina 1983 (Russia)	Han & Li 1994 (China)	Krause (1997) (Europe)
***Chara gymnophylla* (A.Braun) A. Braun 1835 var. gymnophylla**	*Chara vulgaris* var. *gymnophylla* (A.Br.) R.D. Wood 1962 f. *gymnophylla*	*Chara squamosa* Desfontaines 1800	*Chara vulgaris subsp. squamosa* (Desfontaines) Zaneveld 1940	*Chara gymnophylla* (A.Braun) A. Braun 1835	not	*Chara gymnophylla* (A.Braun) A. Braun 1835
***Chara gymnophylla* (A.Braun) A. Braun 1835 var. *rohlenae* (Vilhelm) Fil.**	*Chara vulgaris* var. *gymnophylla* (A.Br.) R.D.W. f. *rohlenae* (Vilhelm) R.D. Wood 1962	*Chara rohlenae* Vilhelm 1913	Not	*Chara gymnophylla* (A.Braun) A. Braun 1835	not	*Chara gymnophylla* (A.Braun) A. Braun 1835
***Chara vulgaris* L. 1753 var. *longibracteata* (Kützing) J. Groves & Bullock-Webster 1924**	*C.vulgaris* L. var. *vulgaris* f. *longibracteata* (Kützing in Reichenbach) H. & J. Groves 1880	*Chara longibracteata* Kützing in Reichenbach 1832	Not	*Chara vulgaris* L 1753.	*Chara vulgaris* L. 1753 var. *longibracteata* (Kützing) J. Groves & Bullock-Webster 1924	*Chara vulgaris* f. *longibracteata* Kützing 1832
Chara vulgaris* L. 1753. var. *vulgaris	*C.vulgaris* L. var. *vulgaris* f. *vulgaris* pro parte	*Chara vulgaris* L. 1753	*Chara vulgaris* L. 1753. pro parte	*Chara vulgaris* L. 1753.	*Chara vulgaris* L. 1753. var. *vulgaris*	*Chara vulgaris* L. f. *vulgaris*

Table 2. List of quatitative and qualitative characters

Internodes length (mm)	Oospores length (µm)
Number of branchlets	Oospores wide (µm)
Branchlet length (mm)	Length/ wide ratio
Number of branchlet segments	Fossa breath (µm)
Number of corticated branchlet segments	Number of striae
Number of cells in end segment	End segment short and corticated
End segment length (mm)	End segment long and ecorticated
(Branchlets/ internodes) length ratio	Branchlets most segments corticated
Antheridia diameter (µm)	Branchlets most segments ecorticated
Oogonium length (µm)	

corticated branchlet segments) separated from *C. vulgaris* var. *longibracteata* (long bract cells and 1-2 corticated branchlet segments).

Table 3 shows statistical characteristics of morphological measurements. Number of branchlets in *C. vulgaris* for both varieties is more than *C. gymnophylla* varieties but number of corticated branchlet segments in *C. vulgaris* var. *vulgaris* is more than others. The above evidenced morphometric differences between *C. vulgaris* and *Chara gymnophylla* were confirmed by the Principal Coordinates Analysis (Fig. 1). In PCOA plot we can see two separate species of *C. gymnophylla* and *C. vulgaris*. In upper part of PCOA plot there is *C. vulgaris* var. *vulgaris* and *C. vulgaris* var. *longibracteata* and in other part we can see *C. gymnophylla* var. *gymnophylla* close to *C. gymnophylla* var. *rohlenae*.

Table 3. Statistical characteristics of morphological quantitative features of *C. gymnophylla* var. *gymnophylla*, *C. gymnophylla* var. *rohlenae*, *C. vulgaris* var. *longibracteata* and *C. vulgaris* var. *vulgaris*.

	C. gymnophylla var. *gymnophylla*				*C. gymnophylla* var. *rohlenae*			
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
Internodes length (mm)	12.3	55	23.13	9.40	11	50	23.24	9.95
Number of branchlets	9	11	9.75	0.72	5	11	10.19	1.08
Branchlet length (mm)	10	30	16.62	4.84	8	40	18.84	6.32
Number of branchlet segments	4	7	5.00	0.92	4	7	5.65	0.66
Number of corticated branchlet segments	0	2	0.40	0.60	0	3	0.42	0.67
Number of cells in end segment	1	7	3.15	1.14	2	5	3.03	0.66
End segment length (mm)	3	18.3	9.17	3.42	4.5	15.7	10.05	2.97
(Branchlets/ internodes) length ratio	0.4	1.2	0.77	0.22	0.42	2.1	0.90	0.35
Antheridia diameter (µm)	250	500	365.25	76.54	200	548	395.87	79.92
Oogonium length. (µm)	400	825	561.13	98.85	238	750	592.42	119.33
Oospores length (µm)	388	553.1	474.43	49.86	380	622.3	488.02	56.27
Oospores wide (µm)	213	390	294.42	46.37	190	384.3	289.40	41.16
Length/ wide ratio	1.28	1.95	1.62	0.16	1.33	2.1	1.69	0.19
Fossa breath (µm)	36	65.5	48.33	8.34	38	68.6	51.49	8.15
Number of striae	9	14	12.25	1.62	8	14	11.77	1.96

	C. vulgaris var. *longibrateata*				*C. vulgaris* var. *vulgaris*				
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	ANOVA
Internodes length (mm)	8	50	24.82	12.42	6.5	70	20.61	8.63	.183
Number of branchlets	7	10	8.41	1.10	5	12	9.63	1.23	.000
Branchlet length (mm)	9	50	19.99	10.03	9.9	30	18.72	4.69	.319
Number of branchlet segments	5	7	5.73	0.70	5	8	6.87	0.70	.000
Number of corticated branchlet segments	0	3	1.45	0.80	1	4	2.93	0.62	.000
Number of cells in end segment	1	5	3.00	0.98	1	4	2.95	0.50	.683
End segment length (mm)	4	30	11.42	6.87	3	22.6	11.48	4.00	.084
(Branchlets/ internodes) length ratio	0.43	1.9	0.85	0.30	0.42	3.92	1.03	0.52	.004
Antheridia diameter (µm)	200	520	358.82	71.61	200	566	406.52	61.86	.006
Oogonium length. (µm)	300	780	590.91	108.39	400	875	649.85	100.65	.001
Oospores length (µm)	387	608.7	482.10	51.32	366	738.1	506.92	65.64	.062
Oospores wide (µm)	247	414.7	291.27	43.79	247	422	324.47	42.46	.000
Length/ wide ratio	1.3	1.98	1.67	0.19	1.2	2	1.57	0.15	.001
Fossa breath (µm)	32	72.6	48.50	8.15	32	69.7	50.22	7.47	.399
Number of striae	8	14	11.82	1.30	8	14	11.40	1.13	.062

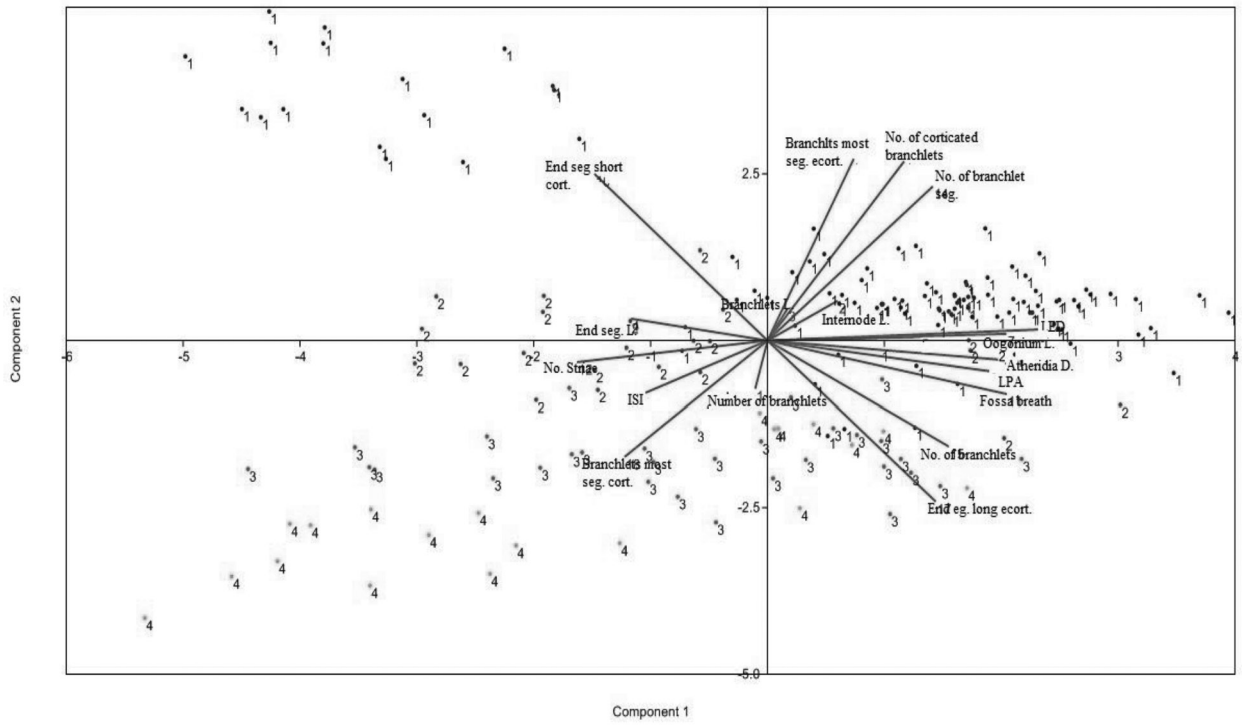

Fig. 1. PCA output for morphological features analyzed in *C. gymnophylla* var. *gymnophylla*=4, *C. gymnophylla* var. *rohlenae*=3, *C. vulgaris* var. *longibracteata*=1 and *C. vulgaris* var. *vulgaris*=2.

Discussion

There is not more information on charophytes in Iran, just a few works have been done on some species (Ahmadi et al., 2012 a,b). Based on morphological characters, multivariate methods on characters allow the differentiation of the investigated taxa belonging to *C. vulgaris* and *C. gymnophylla* varieties. The results of this study consider *C. vulgaris* and *C. gymnophylla* as close species. *C. vulgaris* typically is found both in the streams and ponds, but *C. gymnophylla* are common in ponds and less frequency in the streams. On the assessed diagram both charophytes were spread into two groups, It seems it should be placed these two species as distinct species: *C. vulgaris* and *C. gymnophylla* and accept both varieties for them. *C. vulgaris* var. *vulgaris* has the highest value in branchlet and internode length but the number of branchlet in *C. gymnophylla* is more than *C. vulgaris* and is more compacted. Corticated segments in *C. vulgaris* var. *vulgaris* is more than other varieties. Branchlet segments in *C. vulgaris* var. *vulgaris* is more than others but the length of branchlets in *C. vulgaris* var. *longibracteata* show the highest value. We could not easily distinguish these two species from each other but with described characters it could be done. The measurements undertaken in this work are consistent with the general conclusion that *C. gymnophylla* is more condensed than *C. vulgaris* and in some cases is taller than *C. vulgaris*. Importantly, this became true also when both species co-occur under similar conditions where habitat-related morphological variability can be excluded. The branchlets length mean value in *C. vulgais* var. *longibracteata* is longer than *C. gymnophylla* varieties and the branchlet corticated segments in *C. vulgaris* varieties is more than *C. gymnophylla*. This study provides evidence for a set

of additional morphological differences, which supplement the basic species differences concerning number of corticated branchlet segments, Branchlet/ internode length ratio characteristics of end segment: number of cells, number of corticated segments, end segment length can be helpful in the species and varieties identification.

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Table 4. Details of the localities and voucher numbers

C.gymnophylla* var. *gymnophylla

Fras province
30°27’37” N 51°47’22” E 2143 HSBU-8808719; 25.08.2009
Zanjan Province
36°21’40” N 48°53’42” E 1852 HSBU -8800241; 30.08.2009
36°14’17” N 49°04’06” E 1706 HSBU -8800242; 30.08.2009
Markazi province
39°13’84” N 38°98’15” E 2100 HSBU -8808627; 10.06.2009
34°87’96” N 37°81’28” E 1800 HSBU -8808611; 29.05.2009
34°80’96” N 37°71’76” E 1900 HSBU -8808614; 29.05.2009
Ardebil Province
38°32’07” N 47°53’55” E 1076 HSBU -8800451; 28.08.2009
38°32’15” N 48°08’23” E 1259 HSBU -8800453; 28.08.2009
37°50’47” N 48°20’47” E 1578 HSBU -8800456; 28.08.2009
West Azarbaijan
37°36’58” N 47°09’12” E 1620 HSBU -8800418; 27.08.2009
37°31’56” N 47°20’37” E 1438 HSBU -8800420; 27.08.2009
East Azarbaijan
37°21’13” N 45°09’18” E 1334 HSBU -8800444; 26.08.2009
Kordestan Province
34°47’01” N 46°55’57” E 1427 HSBU -8800871; 24.08.2009
34°55’17” N 46°56’10” E 1598 HSBU -8800872; 24.08.2009
35°17’07” N 46°22’37” E 1111 HSBU -8800874; 24.08.2009
35°36’15” N 46°18’35” E 1432 HSBU -8800876; 25.08.2009
Isfahan Province
32°40’39” N 51°39’01” E 1578 HSBU -8800314; 9.08.2009
31°25’01” N 51°34’21” E 2453 HSBU -8800316; 9.08.2009
Qom Province
34°21’10” N 50°54’19” E 1600 HSBU -8800253; 6.08.2009
24°3342” N 50°09’41” E 1983 HSBU -8800257; 6.08.2009
Guilan Province
36°42’54” N 49°51’21” E 1463 HSBU-2011522; 14.8.2012
Semnan Province
35°37’13” N 53°21’40” E1284 HSBU-2011477 12.07.2012
Isfahan Province
33°36’34” N 51°42’23” E1697 HSBU-2011403 15.07.2012
Mazandaran Province
36°33’48” N 53°05’09” E37 HSBU-2011508 10.08.2012
Kerman Province
30°37’31” N 57°00’38” E2222 HSBU-2011487 11.07.2012
Guilan Province
36°46’32” N 49°44’19” E1178 HSBU-2011495 12.08.2012
36°42’23” N 49°48’54” E1547 HSBU-2011497 13.08.2012
36°40’57” N 49°34’52” E1048 HSBU-2011499 13.08.2012

C. gymnophylla* var. *rohlenae

Fras province
30°37’36” N 53°10’41” E 2313 HSBU -8800711; 25.08.2009
30°37’51” N 53°10’50” E 2319 HSBU -8800712; 25.08.2009
30°31’17” N 53°31’37” E 2332 HSBU -8800713; 25.08.2009
29°42’26” N 52°01’39” E 2026 HSBU -8800717; 25.08.2009
30°22’02” N 51°47’25” E 2105 HSBU -8800718; 25.08.2009
Hamedan Province
34°15’37” N 48°16’15” E 1521 HSBU -8800812; 23.08.2009
34°12’53” N 48°26’04” E 1889 HSBU -8800811; 23.08.2009
Markazi province
34°80’96” N 37°71’76” E 1900 HSBU -8808614; 29.05.2009
Lorestan Province
45°61’60” N 37°72’86” E 1523 HSBU -8800662; 20.08.2009
Ardebil Province
38°32’07” N 47°53’55” E 1076 HSBU -8800451; 28.08.2009
38°30’13” N 48°01’51” E 1124 HSBU -8800452; 28.08.2009
West Azarbaijan
37°56’09” N 47°31’32” E 1675 HSBU-8800416; 27.08.2009
East Azarbaijan
37°07’34” N 45°09’46” E 1767 HSBU-8800443; 26.08.2009
Kermanshah Province
34°24’01” N 47°26’44” E 1290 HSBU-8800834; 24.08.2009
Kordestan Province
36°18’01” N 46°15’12” E 1535 HSBU-88008710; 25.08.2009
Chaharmahal and Bakhtiari Province
32°17’24” N 50°38’52” E 2059 HSBU-8800381; 15.08.2009
Kohkiliyo and BoyerahmadProvice
30°51’56” N 51°20’06” E 1542 HSBU-8800741; 14.08.2009
Isfahan Province
32°47’07” N 51°01’50” E 1979 HSBU-8800313; 9.08.2009
31°22’14” N 51°36’07” E 2244 HSBU-8800315; 9.08.2009
33°20’09” N 50°20’41” E 1996 HSBU-8800318; 15.08.2009
Isfahan Province
31°43’02” N 51°48’33” E 2247 HSBU-2011405 13.07.2012
31°51’21” N 51°36’02” E 2236 HSBU-2011408 13.07.2012
Tehran Province
35°42’50” N 52°39’57” E1809 HSBU-2011410 13.08.2012
North Khorasan Province
30°17’43” N57°13’25” E 1465 HSBU-2011457 1.07.2013
30°11’53” N57°27’56” E 2194 HSBU-2011486 11.07.2012
Kerman Province
30°30’10” N57°16’16” E 2008 HSBU-2011488 12.07.2012
Mazandaran Province
36°25’45” N 53°08’49” E 154 HSBU-2011505 12.08.2012
36°21’58” N 53°10’33” E 272 HSBU-2011507 12.08.2012
Semnan Province
36°11’26” N 54°23’23” E 1137 HSBU-2011475 18.07.2012
Yazd Province
31°43’45” N 54°08’38” E 1608 HSBU-2011516 9.07.2012
Guilan Province
36 °4’23” N49°48’54” E 1548 HSBU-2011498 13.08.2012
Mazandaran Province
36°11’02” N51°43’54” E 2161 HSBU-2011512 11.08.2012
Kerman Province
30°36’06” N 56°58’47” E 2107 HSBU-2011479 11.07.2012
30°11’46” N 57°26’54” E 2292 HSBU-2011483 11.07.2012
29°5’59” N 57°26’10” E 2356 HSBU-2011485 11.07.2012

C. vulgaris* var. *longibracteata

Isfahan Province
33°57’56” N 51°15’03” E 1994 HSBU-8800311; 07.06.2009
31°12’36” N 51°45’12” E 2360 HSBU-8800317; 10.06.2009
Chaharmahal and Bakhtiari Province
32°27’16” N 50°18’43” E 2479 HSBU-8800382; 15.06.2009
Fars province
30°20’35” N 53°53’40” E 1891 HSBU-8800714;12.06.2009
30°31’17” N 53°31’37” E 2332 HSBU-8800720;14.06.2009
East Azarbaijan Province
36°55’58” N 45°53’27” E 1287 HSBU-8800441; 27.08.2009
36°59’06” N 45°30’56” E 1289 HSBU-8800442; 26.08.2009
West Azarbaijan Province
38°10’16” N 45°37’19” E 1410 HSBU-8800411; 27.08.2009
38°69’50” N 45°44’13” E 1364 HSBU-8800412; 27.08.2009
37°57’35” N 47°42’55” E 1784 HSBU-8800415; 27.08.2009
37°55’25” N 47°19’26” E 1628 HSBU-8800417; 27.08.2009
Ardebil Province
38°07’37” N 48°27’11” E 1429 HSBU-8800454; 28.08.2009
38°03’04” N 48°28’10” E 1639 HSBU-8800455; 28.08.2009
38°07’37” N 48°27’12” E 1429 HSBU-8800457; 28.08.2009
Markazi province
39°87’23” N 38°28’31” E 2105 HSBU-8800864; 10.06.2009
33°84’34” N 37°99’36” E 1800 HSBU-8808615; 31.07.2009
34°36’20” N 50°21’21” E 1446 HSBU-8808619; 10.06.2009
34°07’56” N 50°50’04” E 2211 HSBU-8808624; 06.06.2009
39°13’84” N 38°98’15” E 2100 HSBU-8808628; 10.06.2009
Zanjan Province

36°08’10” N 49°04’18” E 1694 HSBU-8800243; 30.08.2009
Ghazvin Province
36°10’41” N 49°52’24” E 1244 HSBU-8800281; 30.08.2009
Kerman Province
30°36’15” N 56°58’42” E 2096 HSBU-2011480 11.07.2012
RazaviKhorasan Province
36°19’25” N 59°13’02” E 1784 HSBU-2011450 11.09.2013
Gilan Province
36°40’24” N 49°31’31” E 625 HSBU-2011492 13.08.2012
Yazd Province
31°43’36” N 54°09’25” E 1645 HSBU-2011515 9.07.2012

C. vulgaris* var. *vulgaris

Qom Province
34°21’10” N 50°54’19” E 1600 HSBU-8800254; 06.08.2009
Kordestan Province
35°21’28” N 46°40’42” E 1525 HSBU-8800873; 24.08.2009
35°31’47” N 46°16’26” E 1327 HSBU-8800875; 25.08.2009
Kermanshah Province
34°27’01” N 47°55’59” E 1442 HSBU-8800831; 24.08.2009
34°44’61” N 46°53’58” E 1367 HSBU-8800833; 24.08.2009
East Azarbaijan Province
37°27’45” N 44°55’32” E 1521 HSBU-8800445; 26.08.2009
36°23’46” N 47°06’20” E 1834 HSBU-8800446; 26.08.2009
37°27’21” N 44°50’03” E 1638 HSBU-8800447; 26.08.2009
West Azarbaijan Province
38°18’05” N 46°52’01” E 1625 HSBU-8800413; 27.08.2009
Ardebil Province
38°63’09” N 48°03’18” E 1560 HSBU-8800458; 28.08.2009
Markazi province
39°05’52” N 38°24’71” E 1943 HSBU-8800865; 10.06.2009
35°30’40” N 37°55’25” E 1995 HSBU-8800869; 20.07.2009
24°33’42” N 50°09’41” E 1983 HSBU-8808620; 10.06.2009
33°88’30” N 37°23’17” E 1857 HSBU-8808623; 29.05.2009
Lorestan province
36°30’91” N 37°49’09” E 2000 HSBU-8800661; 20.08.2009
Isfahan Province
33°36’51” N 51°43’32” E 1606 HSBU-2011401 15.07.2012
33°36’43” N 51°43’03” E 1641 HSBU-2011402 15.07.2012
33°56’51” N 51°22’30” E 1029 HSBU-2011406 16.07.2012
33°21’03” N 52°22’06” E 1267 HSBU-2011407 13.07.2012
Tehran Province
35°45’14” N 52°45’10” E 1947HSBU-2011409 13.08.2012
35°44’34” N 52°40’29” E 1881HSBU-2011411 13.08.2012
South Khorasan Province
34°47’57” N 57°49’21” E 777 HSBU-2011413 8.07.2012
33°47’57” N 56°49’21” E 777 HSBU-2011414 8.07.2012
RazaviKhorasan Province
37°36’02” N58°37’37” E 1027 HSBU-2011415 30.08.2012
37°22’02” N59°03’26” E 651 HSBU-2011416 30.08.2012
35°17’47” N57°38’40” E 1056 HSBU-2011417 8.07.2012
36°48’33” N58°50’47” E 1201 HSBU-2011418 5.08.2012
36°49’57” N 58°48’38” E 1214 HSBU-2011419 5.08.2012
37°05’58” N 59°34’39” E 770 HSBU-2011420 30.08.2012
37°75’09” N 59°30’16” E 819 HSBU-2011421 27.08.2012
37°25’33” N 58°30’24” E 1668 HSBU-2011422 30.08.2012
37°23’30” N 58°31’35” E 1697 HSBU-2011423 30.08.2012
37°23’30” N 58°31’35” E 1697 HSBU-2011424 30.08.2012
37°26’46” N 58°29’09” E 1634 HSBU-2011425 30.08.2012
37°26’46” N 58°29’09” E 1634 HSBU-201142630.08.2012
37°26’13” N 58°29’35” E1645 HSBU-2011427 30.08.2012
37°26’46” N 58°29’08” E 1634 HSBU-2011428 30.08.2012
37°14’21” N 58°28’38” E 1632 HSBU-2011429 17.08.2012
37°27’35” N 58°28’12” E 1613 HSBU-2011430 30.08.2012
37°26’11” N 58°27’55” E 1598 HSBU-2011431 30.08.2012
37°26’55” N 58°29’55” E 1733 HSBU-2011432 30.08.2012
36°48’33” N 58°50’45” E 1200 HSBU-2011433 5.08.2012
36°06’40” N 60°28’31” E 733 HSBU-2011434 6.06.2012
35°59’06” N 59°13’35” E 1360 HSBU-2011435 7.07.2012
36°04’13” N 59°20’18” E 1834 HSBU-2011436 6.06.2012
37°16’04” N 59°20’32” E 546 HSBU-2011437 30.08.2012
37°11’13” N 59°26’24” E 652 HSBU-2011439 30.08.2012
37°37’32” N58°43’55” E 908 HSBU-2011440 30.08.2012
37°37’40” N 58°39’32” E 979 HSBU-2011441 30.08.2012
36°19’08” N 60°28’34” E 855 HSBU-2011443 6.06.2012
36°17’00” N 60°24’20” E 1194 HSBU-20114446.06.2012
37°06’38” N 58°32’48” E 1332 HSBU-2011445 5.08.2012
37°06’27” N 58°34’53” E 1362 HSBU-2011446 5.08.2013
36°20’32” N 59°26’26” E 1163 HSBU-2011447 5.04.2012
36°20’11” N 59°26’44” E 1158 HSBU-2011448 5.04.2013
36°20’11” N 59°26’44” E 1158 HSBU-2011448 5.04.2013
36°20’16” N59°26’50” E1162 HSBU-2011449 5.04.2013
36°29’23” N 59°10’30” E 1380 HSBU-2011451 20.07.2012
36°29’54” N59°11’17” E 1336 HSBU-2011452 20.07.2012
36°13’34” N 59°34’18” E 1188 HSBU-2011453 27.07.2012
36°13’31” N 59°34’12” E 1192 HSBU-2011454 27.07.2012
35°42’06” N 58°30’22” E 1545 HSBU-2011455 7.07.2012
North Khorasan Province
37°29’09” N 57°25’54” E 1037 HSBU-2011456
Khuzestan Province
30°30’04” N 50°18’43” E 800 HSBU-2011458 15.05.2013
31°31’41” N 48°45’45” E 800 HSBU-2011459 5.04.2013
31°46’27” N 49°48’43” E 800 HSBU-2011460 25.05.2013
30°34’14” N 50°14’09” E 342 HSBU-2011464 16.05.2013
30°29’55” N 50°21’31” E 423 HSBU-2011467 25.04.2012
30°36’59” N 50°09’06” E 354 HSBU-2011468 25.04.2012
30°29’24” N 50°22’12” E 437 HSBU-2011469 25.04.2012
30°29’07” N 50°20’32” E 393 HSBU-2011470 25.04.2012
30°25’53” N 50°19’37” E 353 HSBU-2011471 25.04.2012
30°39’15” N50°12’87” E 302 HSBU-2011472 27.04.2012
30°39’18” N 50°11’24” E 343 HSBU-2011473 27.04.2012
Semnan Province
35°37’13” N 53°21’40” E 1284 HSBU-2011474 12.06.2013
35°34’18” N 53°22’27” E 1157 HSBU-2011476 17.07.2012
Kerman Province
30°01’31” N 57°17’00” E 2010 HSBU-2011478 11.07.2012
30°24’48” N 57°11’48” E 1985 HSBU-2011481 12.07.2012
29°52’20” N 56°11’21” E 2405 HSBU-2011482 12.07.2012
29°56’54” N 56°33’43” E 2024 HSBU-2011484 12.07.2012
Gholestan Province
37°23’47” N 55°45’59” E 422 HSBU-2011489 16.08.2012
37°25’46” N 56°34’41” E 1406 HSBU-2011490 16.08.2012
Gilan Province
36°38’53” N 49°30’23” E 390 HSBU-2011491 13.08.2012
36°40’45” N 49°33’43” E 842 HSBU-2011493 13.08.2012
36°40’24” N 49°31’31” E 624 HSBU-2011494 13.08.2012
Mazandaran Province
35°51’29” N 52°05’24” E 2100 HSBU-2011501 10.08.2012
36°21’04” N 52°51’36” E 157 HSBU-2011502 15.08.2012
36°21’03” N 53°11’20” E 246 HSBU-2011503 12.08.2012
36°20’18” N 53°10’32” E 258 HSBU-2011504 12.08.2012
36°23’28” N 53°09’44” E 194 HSBU-2011506 12.08.2012
36°33’48” N 53°05’09” E 37 HSBU-2011509 10.08.2012
36°11’44” N 52°10’17” E 1294 HSBU-2011510 10.08.2012
36°11’53” N 52°07’34” E 1407 HSBU-2011511 10.08.2012
36°10’42” N 51°45’13” E 2140 HSBU-2011513 11.08.2012