Pak. J. Bot., 36(3): 487-501, 4004.

CAN COMPLEXITY OF THE GENUS *ALLIUM* L., BE RESOLVED THROUGH SOME NUMERICAL TECHNIQUES?

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Abstract

Allium L., is the largest genus of petaloid monocotyledons except orchids, with 750 species all over the world and 46 species in Pakistan. Numerical techniques were used to study the taxonomic relationship of the *Allium* L., from Pakistan. Both vegetative and reproductive characters were taken into account. Bulb plays a major role in identification of various species of this genus. *A. fedtschenkoanum* Regel and *A. semonovii* Regel are quite confusing but can be separated on the basis of outer tunic nature, scape length and floral characters. Tepals colour of *A. fedtschenkoanum* Regel is yellow and *A. semenovii* Regel has double coloured tepals, yellow above and red below. *A. baluchistanicum* Wendelbo is a rare species in Pakistan because it was recorded only once from Quetta in 1966. *A. lilacinum* Royle ex Regel was previously reported from Pakistan, but no herbarium specimen was available to verify the report.

A. jacquemontii Kunth showed confusion with *A. przewalskianum* Regel**,** *A. griffithianum* Boiss., and *A. roylei* Stearn. Differentiation between *A. griffithianum* Boiss and *A. jacquemontii* Kunth can be made by using characters of scape and flowers. Some taxonomists recognized *A. roylei* Stearn and *A. rubellum* L., as separate species. Our results revealed that both are conspecific. *A. rubellum* L., is a synonym of *A. roylei* Stearn. This species is closely related to *A. griffithianum* Boiss and *A. jacquemontii* Kunth. *A. longicupis* Regel is a new record and for the first time reported from Pakistan. This species has pink flower, glabrous leaf sheath and the inflorescence is a bulbiferous umbel. It is closely related to *A. roylei* Stearn.

Introduction

Allium L., is the largest genus of petaloid monocotyledons except orchids, with 750 species all over the world (Stearn, 1992). *Allium* L., includes economically important food crops such as onions, garlic, leeks and chives, also the species with medicinal properties and others of horticultural merits. Out of the 30 genera of the family Alliaceae, the only representative of this family in Pakistan is *Allium* L., (Nasir, 1975).

The taxonomy of this genus remained controversial. Bentham & Hooker (1883) considered it as part of the family Liliaceae. Lotsy (1911) was the first one who separated Alliaceae from Liliaceae. Hutchinson (1934, 1959) included Alliaceae in the Amaryllidaceae. Nasir (1975) in Flora of Pakistan followed Lotsy (1911) and recognized Alliaceae as a family. The family Alliaceae was included in the order Asparagales by Robert (1992).

Iftikhar (1964) reported three species of *Allium* viz., *A. griffithianum* Boiss., *A.* rubellum L., and *A. ascalonicum* L., from Salt Range. He recognized *A. rubellum* L., and *A. jacquemontii* Kunth as two distinct species. Davis (1965) in Flora of Turkey reported six such species that are also found in Pakistan. He described *A. rubellum* L., as the separate species while in the Flora of Pakistan Nasir (1975) treated it a synonym of *A. roylei* Stearn. Komarov (1968) reported 288 species in the Flora of USSR out of which

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15 species are common in Pakistan. Nicholoson *et al*., (1973) in "The Oxford Book of Food Plants" reduced *A. porrum* L., as a variety of *A. ampeloprasum* L., Nasir (1975) revised this genus in "Flora of West Pakistan". Though he provided taxonomical description for 41 species but he missed few species to report. He could not differentiate certain species e.g., *A. macranthum* Baker, *A. tripterum* E. Nasir, *A. atrosanguineum* Schrenk, *A. fedtschenkoanum* Regel, *A. jacquemonti* Kunth and *A. griffithianum* Boiss.

Recent techniques like molecular systematics (Shinwari *et al*., 1994a, b) solved several complex issues. One of these could be the use of various computer software for the better understating of phylogeny of Angiosperms (Gilani *et al*., 2003). Numerical taxonomy is the grouping of taxonomic units into taxa by numerical methods based on their character states. Adanson (1763) gave the concept of numerical taxonomy. He believed that natural taxa are based on the concept of "affinity" which can be measured by considering all characters. Different taxa are separated by means of correlated features (Adanson, 1763).

Materials and Methods

Morphology: The taxonomic characters of the genus *Allium* L., were studied from the specimens of the major herbaria of Pakistan including Quaid-I-Azam University Herbarium (ISL), National Herbarium, NARC, Islamabad (RAW) and Pakistan Museum of Natural History (PMNH). About 300 specimen of the genus *Allium* L., were studied. Morphological characters were examined under the dissecting microscope. These characters are of two main types i.e., 1. Vegetative characters and 2. Reproductive characters.

Numerical analysis: For the numerical analysis 46 operational taxonomical units (OTU) were selected. This selection was based on the morphological variation. Forty-three morphological characters were identified that appear to show variation between OTU's. Characters were coded according to the method of the Boratynski & Davis (1971). For the most of the quantitative characters there was considerable range of variation. Therefore minimum and maximum values were taken as separate characters. The data matrix or the spreadsheet was prepared in Microsoft Excel, so that each row represents one taxon and each column represents one character. The final matrix was subjected to the analysis. Cluster analysis is employed to work out the relationship among these taxa. The Euclidean distance measured similarity matrix and a dendrogram was constructed by using the complete linkage method. Using the Statistical (version 5.0), Excel and SPSS 10.0 (Statistical Procedure for Social Science) computer package did this analysis. By using the same software co-relation between the species and between the quantative characters to know the extent to which they are contributing in the identification of species was calculated.

Results

Allium L., in Pakistan is represented by 46 species and distributed in two important phytgeographical zones i.e., Sino-Japanese and Irano-Turanian. Thirty species are found in the Sino-Japanese region and about 16 species in the Irano-Turanian region. Mostly species are uniregional but a few are biregional e.g., *A. farctum* Wendelbo.

The resulting dendrogram (Fig. 1) showed that the whole genus at the level of 97% of linkage distance divided into three clusters, each of them are further divided into two sub clusters. Division of the species into different groups is entirely different from its division into sections given by Wendelbo (1971) (Fig. 2). *A. longicupis* Regel which is new addition to the flora of Pakistan form cluster with *A. roylei* Stearn. *A. baluchistanicum* Wendelbo a rare species of Pakistan comes to lie with *A. dolichostylum* Vved.. Co-relation among species on the basis of dissimilarities index is highly significant (Tables 2, 3, 4). All species have considerable distance from each other and occupy the rank of the species. It is interesting to note that when the correlation among the quantitative characters was calculated plant height has negative relation with pedicel length and characters related to tepals (Table 1). Bulb characters have negative association with leaf length, pedicel length and leaf sheath length. Relationship of plant height with bulb width and leaf sheath length, leaf length with pedicel length and tepals length with tepals width is highly important and show the significant basis for the classification of this genus.

Key for species

1a.	Bulb present, conical to subglobose	2.
1b.	Bulb absent1b. Bulb absent	*A. wallichii*
2a.	Bulb clustered, conical to cylindrical	3
2b.	Bulb solitary, ovoid to subglobose	39
3a.	Leaves almost basal to sheath lower half of stem, spathe shorter than pedicel	4
3b.	Leaves sheath half of the stem, spathe almost equal to pedicel	16
4a.	Rhizomes present, stem not fistulose	5
4b.	Rhizomes absent, stem fistulose	29
5a.	Outer tunic mostly papery rarely fibrous	6
5b.	Outer tunic mostly fibrous, rarely fibrous to papery	10
6a.	Outer tunic reddish brown to dull brown in colour	7
6b.	Outer tunic brownish to greyish in colour	9
7a.	Scape cylindrical, solitary, longer than leaves	8
7b.	Scape fistular with two branches leaves are smaller than scape	*A. roylei*
8a.	Tepals rose coloured, ovoid to oblong	*A. carolinianum*
8b.	Tepals white, ovoid to elliptical	*A. farctum*
9a.	Leaves 1-3, cylindrical with obtuse apex	*A. fedtschenkoanum*
9b.	Leaves 4-7, fistular with obtuse to acute apex	*A. schenoprasum*
10a.	Scape cylindrical with papillate leaf base	11
10b.	Scape cylindrical with smooth base	14
11a.	Inflorescence few flowered, laxly arranged hemispherical	12
11b.	Inflorescence many flowered, spherical in shape	13
12a.	Flower white, elliptical to oblong in shape	*A. baluchistanicum*
12b.	Flower purple, lanceolate in shape	*A. tenuicaule*

13a.	Leaves almost equal to scape with prominent veins on leaf sheath	*A. dolichostylum*
13b.	Leaves smaller than scape without prominent veins on leaf sheath	*A. barszczewskii*
14a.	Style simple with one stigma, filaments narrow triangular, simple	15
14b.	Style with three stigmas, filaments triangular, toothed	*A. semenovii*
15a.	Mid vein of the tepals of same colour, with obtuse apex	*A. consanguineum*
15b.	Mid vein of the tepals of dark colour, with acute apex	*A. atrosanguineum*
16a.	Perianth campanulate, filaments simple	17
16b.	Perianth stellate to campanulate, stamens with small teeth at the base of inner filaments	20
17a.	Spathe persistent, perianth broadly campanulate, filaments equal	18
17b.	Spathe caducous, perianth campanulate to ovate, filaments unequal	22
18a.	Tepals rose purple, mucro is absent	19
18b.	Tepals white to pink, mucro is present	*A. oreoprasum*
19a.	Small size plant 5-10 cm in length, bulb ovoid to globose	*A. oreophilum*
19b.	Medium sized plant, upto 50cm in length, bulb cylindrical	*A. gilgiticum*
20a.	Stem fistulose, leaves sheathing cover lower part of the stem	*A. cepa*
20b.	Stem fistulose, leaves sheathing high up of the stem	21
21a.	Bulb cylindrical, elongated, outer tunic papery, blackish brown in color, leaves broadly lanceolate to ovate apex obtuse	*A. victorialis*
21b.	Bulb ovoid to cylindrical, reticulate fibrous membrane dark brown in color, leaves linear, acute to obtuse apex	*A. stoliczki*
22a.	Inflorescence hemispherical to globose without bulblets 10-60 cm long plant	23
22b.	Inflorescence globose, bulbiferous, 22-100cm long plant	28
23a.	Filaments shorter than tepals, outer narrow and inner broad triangular	24
23b.	Filaments as long as the tepals, inner are longer than tepals outer broad and inner narrow triangular	*A. porrum*
24a.	Leaves filifolium, 1cm broad; apex acute	*A. filifolium*
24b.	Leaves linear to lanceolate; 0.2-1.5cm broad, apex obtuse	25
25a.	Pedicel 0.8-1.4cm in length, scape simple, flowers white in color	26
25b.	Pedicels 1.7-3cm long, slightly curved scape arises from the centre of the bulbs	*A. borszczowii*
26a.	Tepals white; 0.7-14cm; obtuse to acute; filaments linear to narrowly triangular	*A. humile*

26b.	Tepals dark purple; 0.6-0.7cm long; obtuse to acute; filaments triangular	27
27a.	Bulb elliptical to ovoid, adventitious roots thin and small	*A. filidens*
27b.	Bulb cylindrical to ovoid, adventitious roots	*A. logicollum*
28a.	Bulb with 6-10 bulblets, scape recurved before flowering, flower white in color	*A. sativum*
28b.	Bulb with 2-4 bulblets, scape straight before flowering, flower pink in color	*A. longicupis*
29a.	Bulb divided, outer tunic of bulb papery	30
29b.	Bulb solitary, outer tunic of bulb fiberous	37
30a.	Outer tunic with purplish veins, white in color leaf sheath slightly papillate	*A. caesioides*
30b.	Outer tunic with same colour veins, brown in color, leaf sheath smooth	31
31a.	Leaf sheath pubescent, 8.9-20 cm long, leaf sheath covers the half of the scape	32
31b.	Leaf sheath smooth, 5-9.8cm long, leaf sheath covers the upper half of the scape	34
32a.	Inflorescence hemispherical bulbiferous, pedicels 1.4-3.6 cm long	*A. umbilicatum*
32b.	Inflorescence umbel with laxly arranged flowers	33
33a.	Pedicel unequal in length, curved, flowers form the star shape of the infloresence	*A. gillii*
33b.	Pedicel almost equal in length, straight, inflorescence round	*A. miserabile*
34a.	Scape cylindrical, longer than leaves, scape rarely divided into two	35
34b.	Scape semi cylindrical, small than leaves, solitary to clustered scape	36
35a.	Pedicel 0.3-0.6 cm long, solid, flower red in colour	*A. przewalskianum*
35b.	Pedicel 0.5-2 cm long, filifolium, flower purple	*A. micranthum*
36a.	Flower pink with obtuse apex, outer membrane greyish black	*A. griffithianum*
36b.	Flower white with acute apex, outer membrane white to brown	*A. jacquemontii*
37a.	Flower ovate to elliptical, plant is of intermediate size	38
37b.	Flowers ovate in shape, plant of small size, 4-15 cm long	*A. stocksianum*
38a.	Tepals 0.5-0.6cm long, white, inner filaments broadly triangular	*A. lamondiae*
38b.	Tepals 0.3-0.6cm long, white to pink, inner filaments narrow triangular	*A. tuberosum*
39a.	Short above ground sheath, ovary with two ovules per locule	40
39b.	Long above ground sheath, ovary with 3-8 ovules per locule	42

40a.	Scape cylindrical leaves smaller than scape	41
40b.	Scape fistular, leaves longer than scape	*A. tripterum*
41a.	Leaves flat, 0.4-2cm broad, apex obtuse to acute leaf sheath 4.5-14.3cm	*A. neapoliatanum*
41b.	Leaves linear, width upto 0.4cm apex acute leaf sheath small upto 4.4cm	*A. macranthum*
42a.	Long plant with 30-100 cm in length, stem is distinctly ribbed	43
42b.	Small sized plant 13-50 cm long, without distinct ribs	44
43a.	Inflorescence spherical umbel, pedicel 2.4-5.7 cm long, flower dark pink	*A. rosenbachianum*
43b.	Inflorescenec globose umbel, pedicel 3 cm long. Flower purple	*A. macleanii*
44a.	Sheath papery, smooth, length upto 4.4cm, inflorescence dense	45
44b.	Sheath fibrous, length upto 16 cm, inflorescence few flowered	*A. chitralicum*
45a.	Outer tunic dark brown in color, flower star shape	*A. stipitatum*
45b.	Outer tunic dark brown with pink dots flower ovate to oblong	*A. caspium*

Discussion

Allium is characterized by specialized features of bulb (shape, number, length, width, nature of the outer tunic), which are helpful in the identification of the species (Stewart, 1972). It is also obvious from the correlation of quantitative characters (Table 1). The characters related to the bulb have a positive relation with plant height, tepal length/width and have a negatively significant relation with leaf sheath length. Other important morphological characters are leaf shape, leaf length, leaf sheath length, inflorescence, colour and shape of tepals, which are very useful in delimiting various species. Komarov (1968), Davis (1965) and Nasir (1975) also stressed on these characters. Correlation (based on dissimilarity matrix) of the species is significant (Tables 2, 3, 4).

Wendelbo (1958) did not treat *A. fedtschenkoanum* Regel and *A. semonovii* Regel as conspecific rather he cited *A. semenovi* sensu Wendelbo non Regel. These two species have a clear difference, since *A. fedtschenkoanum* Regel is a tall herb while the latter is medium sized. The outer tunic of the bulb of both species is different for *A. somonovii* Regel, it is fibrous while in *A. fedtschenkoanum* Regel it is papery. The scape of the former is longer than the leaves while in *A. semonovii* Regel is shorter than leaves. Another difference of the both species is the flower colour. In *A. fedtschenkoanum* Regel it is yellow while in *A. semonovii* Regel it is double coloured yellow below and red above. Correlation between these two species is 0.84 (Table 4), which is highly significant. From this number, separate status of species is quite evident. In the dendrogram they grouped together in third cluster. *A. baluchistanicum* Wendelbo is a medium sized herbaceous plant with cylindrical bulb, leaves are smaller than scape, inflorescence of few flowered. Flowers are laxly arranged. This species is rare and was collected only once from Quetta in 1966.

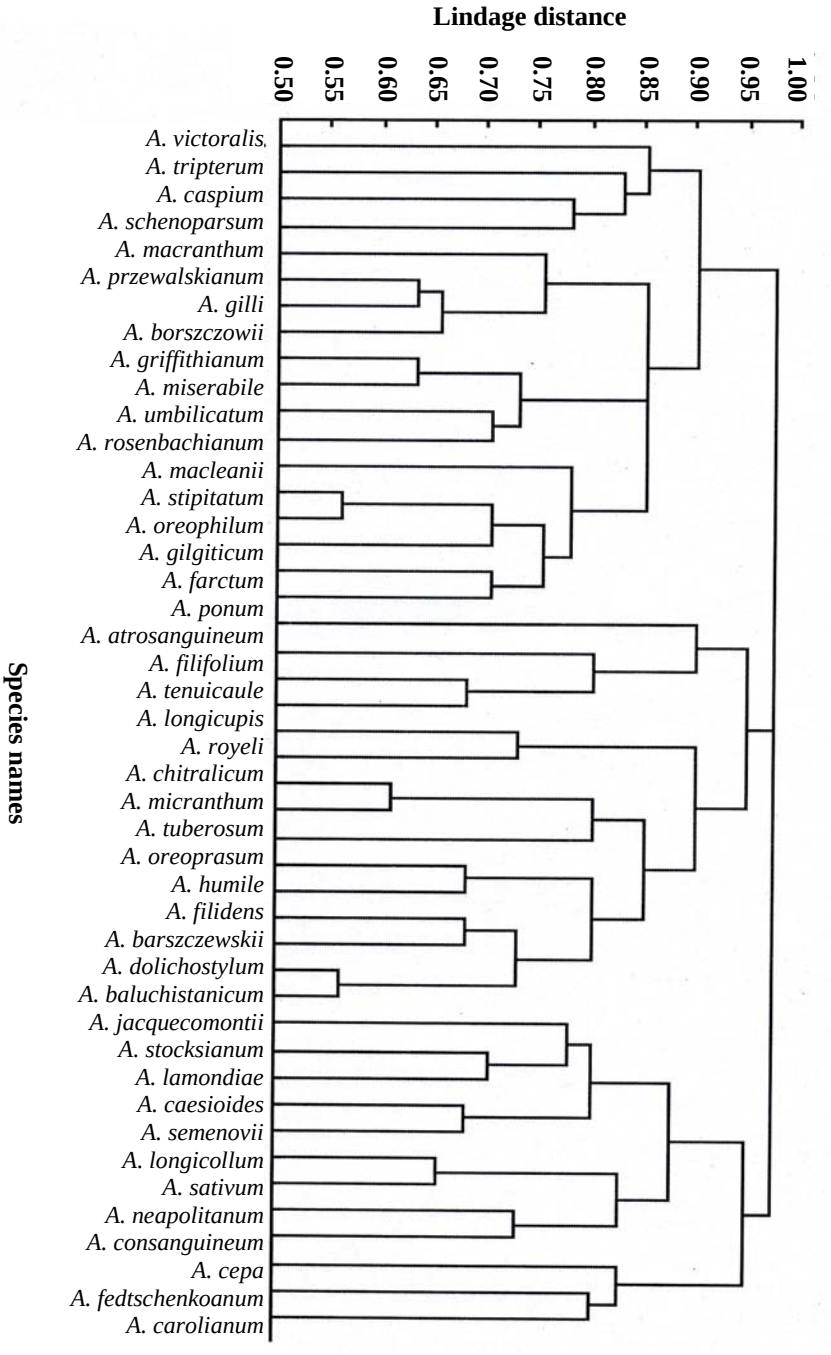

Fig. 1. Cluster analysis of *Allium* on the basis of nine morphological characters.

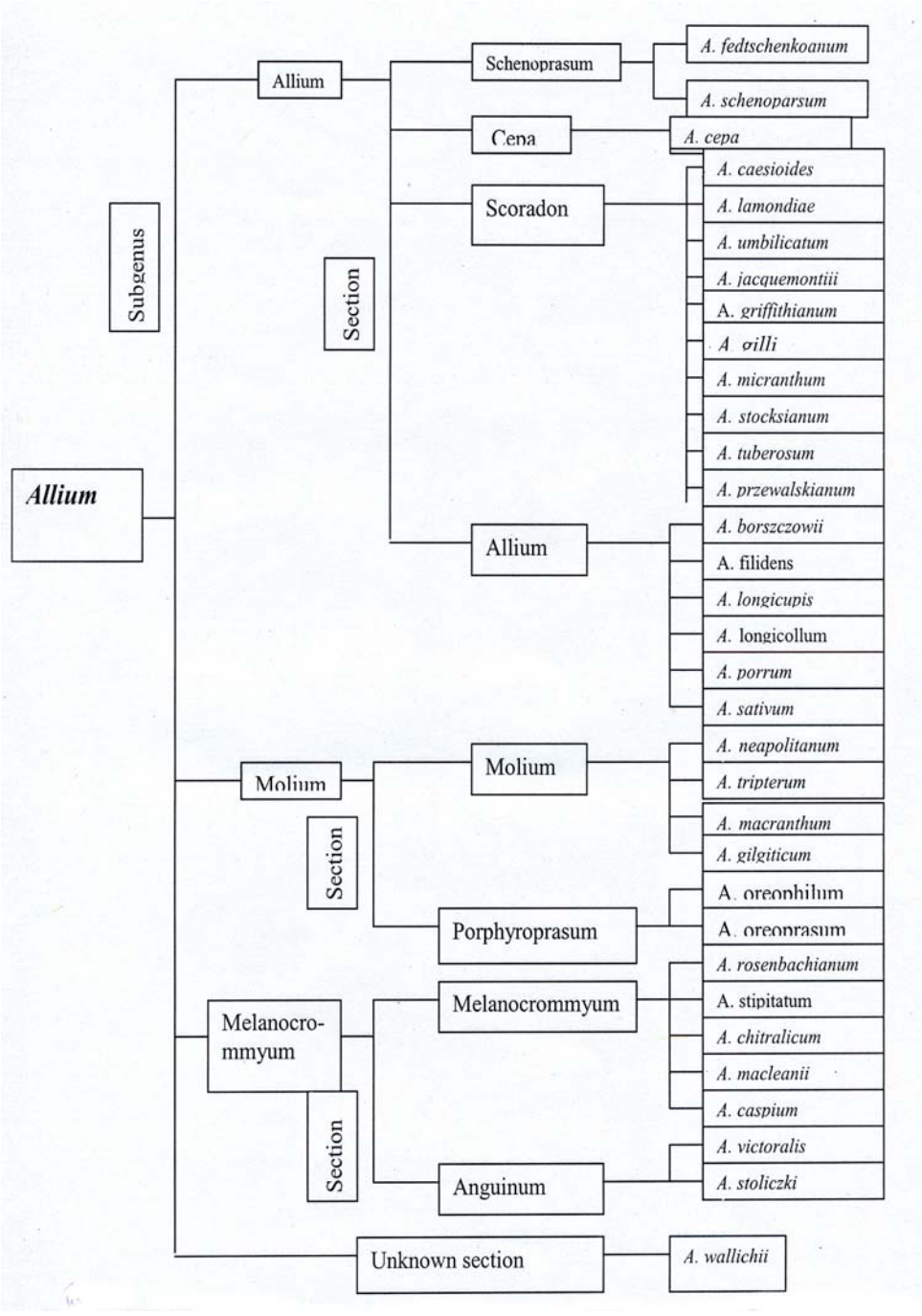

Fig. 2. Pictoral representation of Wendelbo's division of *Allium* into subgenera, sections and species.

Table 1. Correlation among the quantitative characters of genus *Allium* L., of Pakistan.

	Plant height	Bulb length	Bulb width	Leaf sheath length	Leaf length	Leaf width	Pedicel length	Tepal length	Tepal width
Plant height	1								
Bulb length	0.06	1							
Bulb width	0.37	0.47	1						
Leaf sheath length	0.49	-0.13	-0.11	1					
Leaf length	0.17	-0.09	-0.05	0.19	1				
Leaf width	0.10	0.24	0.34	-0.09	0.14	1			
Pedicel length	-0.07	-0.16	-0.17	-0.07	-0.10	-0.02	1		
Tepals length	-0.09	0.49	0.34	-0.19	0.11	0.18	0.14	1	
Tepals width	-0.09	0.37	0.34	-0.11	-0.04	-0.12	0.00	0.74	1

Table 2. Correlation of *Allium* species contained in the first cluster.

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	*A. farctum*	1																	
2.	*A. griffithianum*	0.81	1.00																
3.	*A. gilli*	0.85	0.97	1.00															
4.	*A. przewalskianum*	0.76	0.78	0.81	1.00														
5.	*A. schenoprasum*	0.91	0.93	0.96	0.86	1.00													
6.	*A. victorialis*	0.84	0.81	0.82	0.86	0.91	1.00												
7.	*A. tripterum*	0.75	0.92	0.92	0.85	0.91	0.88	1.00											
8.	*A. caspium*	0.78	0.86	0.87	0.78	0.86	0.84	0.87	1.00										
9.	*A. macranthum*	0.94	0.89	0.92	0.83	0.97	0.92	0.89	0.87	1.00									
10.	*A. stoliczki*	0.79	0.94	0.95	0.87	0.95	0.89	0.96	0.87	0.92	1.00								
11.	*A. borszczowii*	0.82	0.93	0.92	0.82	0.95	0.87	0.91	0.85	0.93	0.93	1.00							
12.	*A. miserabile*	0.74	0.94	0.93	0.88	0.91	0.84	0.97	0.89	0.87	0.95	0.91	1.00						
13.	*A. rosenbachianum*	0.96	0.91	0.94	0.80	0.96	0.84	0.83	0.87	0.96	0.88	0.91	0.84	1.00					
14.	*A. umbilicatum*	0.90	0.94	0.95	0.87	0.96	0.89	0.93	0.85	0.94	0.92	0.94	0.93	0.93	1.00				
15.	*A. stipitatum*	0.99	0.81	0.85	0.76	0.90	0.80	0.72	0.78	0.92	0.79	0.84	0.72	0.96	0.89	1.00			
16.	*A. macleanii*	0.94	0.92	0.93	0.76	0.95	0.84	0.85	0.87	0.96	0.90	0.91	0.85	0.99	0.92	0.94	1.00		
17.	*A. oreophilum*	0.29	0.57	0.60	0.63	0.61	0.61	0.69	0.57	0.57	0.72	0.61	0.69	0.40	0.55	0.22	0.44	1.00	
18.	*A. gilgiticum*	0.81	0.95	0.94	0.82	0.94	0.87	0.94	0.94	0.93	0.95	0.93	0.94	0.92	0.92	0.79	0.93	0.66	1.00

Table 3. Correlation of *Allium* species present in second cluster.

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	*A. porrum*	1														
2.	*A. atrosanguineum*	0.81	1													
3.	*A. tenuicaule*	0.41	0.38	1												
4.	*A. filifolium*	0.75	0.95	0.39	1											
5.	*A. roylei*	0.88	0.69	0.41	0.69	1										
6.	*A. longicupis*	0.87	0.81	0.48	0.81	0.90	1									
7.	*A. micranthum*	0.83	0.89	0.44	0.91	0.82	0.94	1								
8.	*A. chitralicum*	0.94	0.85	0.44	0.84	0.93	0.95	0.92	1							
9.	*A. oreoprasum*	0.78	0.95	0.40	0.93	0.70	0.85	0.93	0.85	1						
10.	*A. tuberosum*	0.88	0.93	0.44	0.91	0.84	0.90	0.97	0.93	0.94	1					
11.	*A. baluchistanicum*	0.91	0.84	0.43	0.81	0.90	0.95	0.94	0.95	0.89	0.93	1				
12.	*A. dolichostylum*	0.87	0.97	0.44	0.93	0.79	0.90	0.95	0.92	0.95	0.98	0.91	1			
13.	*A. humile*	0.78	0.95	0.42	0.89	0.67	0.86	0.88	0.84	0.93	0.89	0.83	0.94	1		
14.	*A. filidens*	0.86	0.80	0.45	0.81	0.92	0.97	0.93	0.95	0.86	0.90	0.97	0.88	0.82	1	
15.	*A. barszczewskii*	0.90	0.82	0.46	0.81	0.93	0.98	0.94	0.96	0.85	0.93	0.97	0.91	0.84	0.98	1

Table 4. Correlation of *Allium* species present in second cluster.

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11	12
1.	*A. jacquemontii*	1											
2.	*A. lamondiae*	0.93	1										
3.	*A. stocksianum*	0.91	0.92	1.00									
4.	*A. semenovii*	0.92	0.88	0.83	1.00								
5.	*A. caesioides*	0.77	0.74	0.65	0.87	1							
6.	*A. sativum*	0.78	0.78	0.66	0.90	0.96	1.00						
7.	*A. longicollum*	0.91	0.95	0.87	0.86	0.77	0.81	1.00					
8.	*A. cepa*	0.95	0.91	0.84	0.94	0.88	0.89	0.93	1				
9.	*A. neapolitanum*	0.88	0.93	0.83	0.87	0.81	0.84	0.95	0.92	1.00			
10.	*A. fedtschenkoanum*	0.88	0.75	0.71	0.84	0.83	0.78	0.79	0.89	0.78	1.00		
11.	*A. consanguineum*	0.96	0.94	0.89	0.92	0.74	0.78	0.93	0.94	0.90	0.85	1	
12.	*A. carolinianum*	0.91	0.90	0.83	0.87	0.75	0.77	0.95	0.93	0.93	0.83	0.96	1

Regel (1875) and Boissier (1882) confused other two important species via., *A. carolinianum* DC., and *A. aitchisonii* Regel. The former species is found in Pakistan while the latter is found in China and Iran. *A. aitchisonii* Regel is not part of the flora of Pakistan. *A. carolinianum* DC., has white to pink colored flowers, leaves are smaller than the scape and outer tunic of the bulb is papery to fibrous. Bulb is divided into two only from the base while the upper portion usually remains undivided. In Pakistani flora this species has minimum correlation with *A. stocksianum* Boiss., and *A. fedtschenkoanum* Regel i.e., 0.83 and maximum with *A. consanguineum* Kunth that is about 0.96 (Table 4). This range of correlation with other species confirmed its status of separate species.

A. roylei Stearn and *A. lilacinum* Royle ex Regel are quite related species because of certain similar characters. In both the species, height of the plant, bulb and inflorescence are similar. The two species can be easily differentiated on the basis of their flower colour, and by the number of bulbs. In *A. roylei* Stearn, bulb is divided into two while in *A. lilacinum* Royle ex Regel it is solitary. Klotzsch (1862) and Hooker (1892) misidentified *A. roylei* Stearn as *A. lilacinum* Royle ex Regel. Stewart (1972) treated them as two distinct species. According to him both the species occur in Pakistan. In the present study no specimen belonging to *A. lilacinum* Royle ex Regel could be found. It is therefore concluded that *A. lilacinum* Royle ex Regel does not occur in Pakistan. The authors could not find a single character by which these two species could be separated. *A. lilacinum* Royle is treated as a synonym of *A. royle*i Stearn.

A. przewalskianum Regel found in W. Himalayas is very similar to *A. jacquemontii* Kunth but both species can be differentiated on the basis of bulb shape and tunic. *A. przewalskianum* Regel have elongate bulb with reticulate fibrous yellow to brown colour tunic while *A. jacquemontii* Kunth has a small oval shape bulb with papery to fibrous white to brown colour membrane. Dendrogram showed that much difference exist between these two species to separate them in two different clusters (Fig. 1). *A. jacquemontii* Kunth is also closely related to *A. griffithianum* Boiss. These species are so closely related to each other that they cause trouble for the taxonomists. Wendelbo placed them in one section (Fig. 2). These two species also offer confusion with *A. rubellum* L., *A. jacquemontii* Kunth and *A. griffithianum* Boiss., can be easily separated from each other on the basis of scape status. *A. griffithianum* Boiss., have branched scape with pinkish white flowers while *jacquemontii* Kunth have solitary scape with white flowers. The difference between two species is also indicated by the dendrogram where they are present into two different clusters (Fig. 1).

Hooker in 1892 misidentified *A. tuberosum* Rottl.ex Sreng as *A. odorum* L. The latter species also shows a resemblance to *A. oreoprasum* Schrenk. *A. odorum* L., and *A. oreoprasum* Schrenk are similar in size of the plant and shape of the bulb which is cylindrical with fibrous tunic and the difference is on the basis of flower colour. Flower of *A. tuberosum* Rottl. ex Sreng is white to pink in colour and ovate to elliptical in shape. *A. oreoprasum* Schrenk flower is white with ovate shape. *A. odorum* L., has scape smaller than leaves while in *A. tuberosum* Rottl.ex Sreng scape is longer than leaves.

A. longicupis Regel is a tall plant with the height upto 100cm. Bulb with ovoid bulblet (Wendelbo, 1971; Davis, 1965). The feature of this species is the bulbiferous inflorescece and presence of the very long pedicels. Pedicels are unequal in length and 5-7 cm in length. Species has resemblance with *A. sativum* L., and *A. umbilicatum* Boiss., in the above mentioned characters. *A. umbilicatum* Boiss., is different from this species on the basis of the pedicel length. The length of pedicel in *A. umbilicatum* Boiss., is only

1cm. Another difference of both species is of leaf base. In *A. longicupis* leaf base is smooth while in *A. umbilicatum* Boiss., it is papillate on veins. Diference from *A. sativum* L., are the bulblet no in bulb. *A. sativum* L., has many bulblet while in *A. longicupis* Regel only two to three bulblets are present. Outer tunic of the bulblet in *A. sativum* L., is white and in *A. longicupis* Regel it is golden brown. Flower colour is white in *A. sativum* L., and pink in *A. longicupis* Regel.

Certain taxonomic problems still remain unresolved regarding the taxonomy of the genus *Allium* L., due to its high polymorphism. However numerical techniques other than cluster analysis, such as ordination and discrimination analysis may also provide useful information regarding continuity and discontinuity of characters and help in the delineation of taxa. For a more refined classification, work at DNA level is also required. This would perhaps greatly help in removing some of the existing anomalies.

Acknowledgment

Zubaida Yousaf is grateful to Dr. Murata TASO-PGR for the financial support to complete some part of this work.

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(Received for publication 17 April 2004)