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MORPHOLOGICAL FEATURES AND RELATIONSHIP OF GENUS *CONVOLVULUS* (CONVOLVULACEAE) FROM PAKISTAN

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A B S T R A C T

A systematic study of 15 taxa of genus *Convolvulus* from Pakistan was carried out by means of 71 morphological traits, including 22 vegetative, 40 floral, 4 fruit and 5 seed. Data were analyzed by cluster analysis for species discrimination and relation. Cluster analyses delimit all species within the genus and distinguished five distinct groups. All herbaceous species are separated from shrubs. From all five spiny species, *C. fruticosus, C. psedocantabricus* and *C. spinosus* are group together. While, *C. cephalopodus* separated with *C. virgatus* and *C. rhyniospermus*. C. *leiocalycinus* found to be distinct from all species of all groups.

Keywords: morphological traits, discrimination, herbaceous, shrubs.

INTRODUCTION

The genus *Convolvulus* is one of the diverse genus of Convolvulaceae, included in the sub family Convolvuloideae and tribe Convolvuleae (Austin, 1997). It is a cosmopolitan genus also distributed in different areas of Pakistan. It comprises of approximately 250 species all over world (Mabberley, 2008). The centers of biodiversity of *Convolvulus* are western Asia, Mediterranean and Macronasia that present wide range of growth forms (Carine et al., 2003). Species of *Convolvulus* restricted to dry, moist sandy and rocky areas and also in cultivated areas as severe crop weeds, many of them are economically important used as ornamental, food, fodder, laxative and as a brain tonic traditionally (Agarwal et al., 2014; Badar et al., 2014).
In the flora of Pakistan it represents 20 species. Out of the total species found in Pakistan only one species (*Convolvulus scindicus*) is endemic (Shahina, 1979). The high rate of variations in the phenotypic characteristics of *Convolvulus* made it difficult to identify, Sometimes variations found in same species in response to the environmental conditions. The phenotypic plasticity as a result of environmental changes is a challenging aspect of systematics (Tod, 2009).

Morphological characters are basic and most reliable source in the field of taxonomy to define, delimit and to relate the taxa (Khalil, 2008). It has an obvious dominance in plant systematics in old time as well as in recent studies. Most of available facts about the phylogeny of life based on morphological data and these hierarchical classifications successfully reveal many accurate phylogenetic nodes (Scotland et al., 2003), but many aspects of morphological studies are controversial specially at intraspecific level because at lower taxonomic level morphological characters are not much diverse and species delimits on the basis of least number of characters. Despite of this, the most persuasive reason to collect morphological data is to resolve the Phylogenetic relationships of fossil taxa and their relationships to living taxa long into the future (Maddison, 1996; Hillis & Wiens, 2000; Jenner & John, 2004).

In Pakistan, there are several threatened or endangered taxa in the genus *Convolvulus* L. and the last revision was long ago by Shahina (1979). Therefore, there is a need to provide a taxonomic revision and phylogeny of *Convolvulus*, using morphological characters. The present study was designed to analyze Pakistani representation of *Convolvulus* by their morphological characters both qualitative and quantitative and to confer their placement and relationship.

MATERIALS AND METHODS

Plant Materials

Total 15 *Convolvulus* species were studied, which comprised both fresh and herbarium material. All studied herbarium material is available at Karachi University Herbarium (KUH).

Identification of Plants on Morphological Basis

All species were identified with the help of literature, floras and authentic herbarium specimens. Morphological observations were made with the help of light and stereo microscope. For every species three replicates were studied that were collected from different localities. Herbarium sheets were prepared for the identified species and deposited to Karachi University Herbarium. The plant materials, their location, herbarium voucher numbers are listed in Table 1.

Table 1. List of plant material used in this study along with their locations, nature, voucher number

S. #	Species	Nature	Locality	Specimen Voucher No.
1	Convolvulus arvensis	Herb	Botanic garden(KU)	GH86574
2	Convolvulus prostratus	Herb	North Nazimabad	GH87720
3	Convolvulus scindicus	Shrub	Thanobulla Khan	GH88468
4	Convolvulus glomeratus	Herb	North Nazimabad	GH86572
5	Convolvulus spinosus	Shrub	Thatta	GH86624
6	Convolvulus fruticosus	Shrub	Herbarium	GH58159
7	Convolvulus virgatus	Herb	Herbarium	GH61452
8	Convolvulus pseudocantabricus	Shrub	Herbarium	GH61485
9	Convolvulus cephalopodus	herb-undershrub	Herbarium	GH46285
10	Convolvulus rhyniospermus	Herb	Herbarium	GH61370
11	Convolvulus lineatus	Herb	Herbarium	GH46811
12	Convolvulus kotscyanus	herb	Herbarium	GH74622
13	Convolvulus acanthocladus	under-shrub	Herbarium	GH46700
14	Convolvulus leiocalycinus	under-shrub	Herbarium	GH58353
15	Convolvulus pyrrhotrichus	Herb	Herbarium	GH45068

Dendogram Reconstruction using Morphological Data

Total 71 characters were taken into consideration out of which, 22 vegetative, 40 floral, 4 fruit and 5 seed characters were studied. Each character state was converted into numeric data (1-9) and a data matrix was prepared (Table 2). Data were analyzes with SPSS software v.21. In order to group the species, having morphological similarities and to construct a dendogram, agglomerative hierarchical cluster analysis was performed by average taxonomic distance. The Euclidean distance was used as dissimilarity coefficient in cluster analysis of morphological data.

Table 2. List of characters studied in all species of genus *Convolvulus* and their states

S.#	Character	State
1	Habit	Herb(1),shrub(2),sub-shrub(3),herb-undershrub(4)
2	Height:	Average(mm)(1),(2),(3),(4),(5),(6)
3	Longitivity	Annual(1),biennial-perennial(2),perennial(3)
4	Stem colour	Green(1),dull green(2),grayish green(3) green-brown(4), brown(5), pale yellow(6), greyish white-green(7)
5	Stem orientation	Prostrate-twining (1),decumbent-twining(2), ascending-prostrate(3), erect-procumbent(4)erect-decumbent(5)
6	Stem type	Woody(1),herbaceous(2),herbaceous-woody(3)
7	Stem surface	Hairy(1),glabrous(2),glabrous to pubescent(3)
8	Hair type	Ciliary-hirsute(1),tomentose(2)sericeous-pilose(3),wolly-hirsute(4),sericeous-wolly(5),tomentose-sericeous(6),hirsute-tomentose(7),
9	Leaf structure	Ovate oblong –linear oblong(1),oblong-lanceolate(2),linear-oblanceolate(3),obovate(4),elliptic-oblanceolate(5),ovate-elliptic(6),ovate-lanceolate(7),oblanceolate(8)
10	Leaf length	Average(mm)(1),(2),(3),(4),(5),(6),(7)
11	Leaf breath	Average(mm)(1)(2),(3),(4),(5),(6)
12	Leaf apex	Acute-obtuse(1),acute-acuminate(2),subacute-obtuse(3),subacute(4),obtuse-acute(5),obtuse(6),acute-mucronate(7)acute(8)
13	Leaf base	Sagitate-hastate(1),cordate(2),obtuse(3),attenuate(4),cuneate(5)cuneate-auriculate(6)
14	Leaf margin	Entire(1),undulate(2)
15	Leaf texture	Simple(1)
16	Leaf attachment	Petiolate(1),sessile(2),sub-sessile(3)
17	Petiole size	Average(mm)(1),(2),(3),(4),(5)
18	Stipule +/-	Exstipulate(0)

19	Leaf surface	Glabrous(1),hairy(2)
20	Hair type	Ciliary-hirsute(1),tomentose(2)sericeous-pilose(3),wolly-hirsute(4),sericeous-wolly(5),tomentose-sericeous(6), sericeous hirsute (7)
21	Inflorescence type	Axillary cymose(1), axillary-terminally cymose(2)
22	Inflorescence structure	simple(1),compound(2)
23	No of flowers	One(1),two-three(2),four-six(3),one-two(4),one-many(5)three-four(6),one-four(7), four-ten(8), one-three(9)
24	Peduncle +/-	Pedunculate(1),sessile(2),sub-sessile(3)
25	Size of peduncle	average(mm) (1), (2), (3),(4),(5),(6),(7),(8)
26	Peduncle surface	Hairy(1),glabrous(2)
27	Sepal apex	Obtuse(1),acuminate(2),acute-acuminate(3),subobtuse(4),acute(5),obtuse-subacute(6),mucronate(7),obtuse-mucronate(8)
28	Flower diameter	average(mm) (1), (2), (3),(4),(5),(6),(7)
29	Flower shape	Campanulate(1)
30	Flower colour	Pink(1),white(2),pale-cream(3),pinkish-white(4)
31	Bract+/-	Bracteate(1)
32	Bract size	Average(mm)(1),(2),(3),(4),(5),(6),(7)
33	Bract shape	Linear(1),Ovate(2),ovate-elliptic(3),lanceolate(4),linear-lanceolate(5)
34	Bract surface	Hairy(1),hairy(2)
35	Bract apex	acute(1)acuminate(2)
36	Calyx aestivation	Valvate(1),twisted(2)
37	No. of sepals	Five(1)
38	sepal shape	Oblong(1),ovate-lanceolate(2),lanceolate(3),oblong-obovate(4),linear-oblong(5),ovate-oblong(6),lanceolate-oblanceolate(7)
39	Sepal size	average(mm) (1), (2), (3), (4),(5)
40	Sepal surface	Hairy(1),glabrous(2)
41	Sepal longitivity	Persistent(1)
42	Corolla aestivation	Valvate(1)
43	No. of petals	Five(1)
44	Petal size	average(mm) (1), (2), (3),(4),(5),(6)
45	Petal margin	Undulate(1)
46	Petal surface	Hairy(1),glabrous(2)
47	No. of stamens	Five(1)
48	Filament size	Unequal(1)
49	Anther shape	Oblong(1)
50	Anther attachment	Adnate(1)
51	Stigma shape	cylindrical(1), filiform(2),
52	No of stigma	Two(1)
53	Stigmatic surface	Glabrous(1)
54	Stigmatic orientation	Included(1)
55	Stigmatic longitivity	Deciduous(1)
56	Style longitivity	Persistent(2),deciduous(1)
57	Style surface	Hairy(1),glabrous(2),glabrous to pubescent(3)
58	Style size	Average mm(1),(2),(3),(4)
59	Ovarian surface	Hairy(1),glabrous(2)
60	Ovarian shape	Globose(1),sub-globose(2)
61	Fruit type	Capsule(1)
62	Fruit shape	Globose(1),sub globose(2),ovoid(3),oblong-ovoid(4),obovoid(5), oblong-ovoid(6)
63	Fruit surface	Hairy(1),glabrous(2),membranous(3)
64	Fruit enclosed +/-	+(1)
65	No. of seeds	One(1),two-four(2),one-four(3),two(4)
66	Seed shape	Ovoid(1),oblong(2)
67	Seed size	average mm(1),(2),(3),(4),(5),(6)
68	Seed colour	Brown(1),black(2)
69	Seed surface	Rough(1),smooth(2)
70	Spine +/-	+(1),-(0)
71	Spine size	Average(mm)(1),(2),(3)

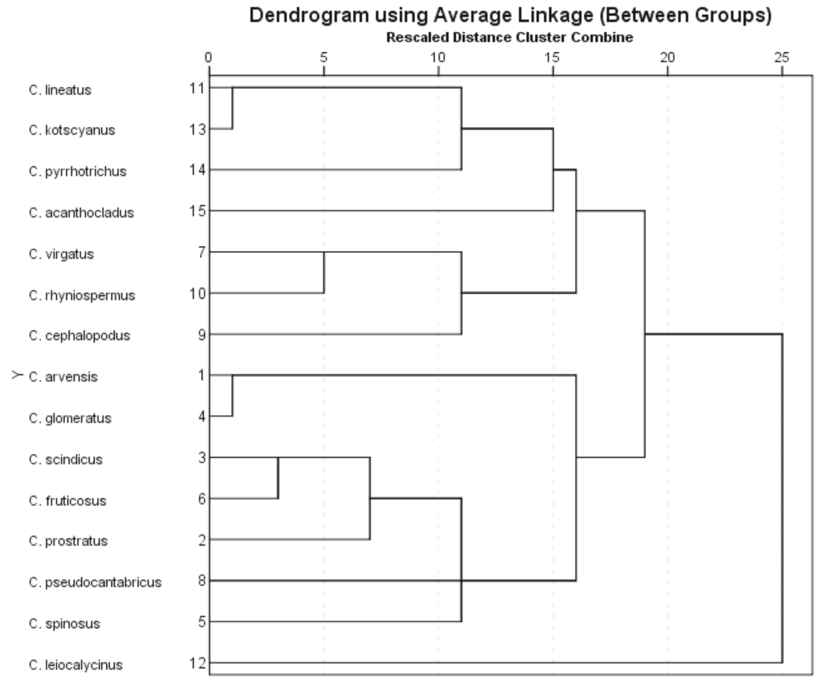

Figure 1. Dendogram showing the relationship of *Convolvulus* species

RESULTS AND DISCUSSION

RESULTS

In the present study, the investigated species of *Convolvulus* were found to show differences in their morphological traits. It was revealed that vegetative parts of genus *Convolvulus* contain most diverse characters, whereas some floral characters were found to be constant for all investigated species. Geological and environmental conditions also affect many characters within same species such as stem colour and pubescence, leaf and flower shape and size as noted in *Convolvulus arvensis, Convolvulus glomeratus and Convolvulus prostratus* collected from different localities.

A dendogram was constructed by using morphological characters as shown in Figure 1. It distinguished the genus *Convolvulus* into five branching groups. The first branching group comprises of four species viz. *C. lineatus*, *C. kotscyanus*, *C. pyrrhotrichus* and *C. acanthocladus.* The group is further divided into three clusters from which, the cluster of *C. acanthocladus* is fairly distant from the other two clusters of this group. The phenon similarity in this group is based mainly on habit, plant longitivity, stem orientation, leaf attachment, leaf surface, bract shape, leaf apex, flower diameter, ovarian surface and leaf size. Second group includes three species, *C. virgatus*, *C. rhyniospermus* and *C. cephalopodus.* It is subdivided into two clusters from which, *C. cephalopodus* formed its own separate cluster. The main sharing characters in this group are, plant size, leaf attachment, hair type, inflorescence type and structure, style and ovary surface and fruit type. Third group is the smallest group, consists of only two species *C. arvensis* and *C. glomeratus,* included in single cluster. The sharing characters of both species are habit, stem type, leaf size, inflorescence type, style size, number of seed, fruit shape and surface. Group four is the largest group consists of five species which further divided into three clusters. Cluster one comprises of two species *C. scindicus* & *C. fruticosus*. While *C. prostratus* separated from cluster one with very little difference. *C. psedocantabricus* and *C. spinosus* formed a third cluster. Habit, longitivity, stem orientation, leaf surface, leaf attachment, leaf structure, inflorescence structure and type, bract apex, stigma shape, and ovary surface are main sharing characters of this group. *C leiocalycinus* found to be in a separate group distant from all species of all groups.

DISCUSSION

The current study encompasses morphological dataset to delimit and infer relationship between *Convolvulus* species. Morphological characters are fundamental to all fields of science. They are suitable for identification and phylogenetic reconstruction at different hierarchal level, as they deal with the change of form during time. Vegetative and floral characters widely contribute for morphological differentiation and species delimitation (Sivarajan, 1991; Eduardol et al., 2002; Ashley, 2015).

All the investigated species exhibited different constant and variable traits which were used to establish their relationship. The constant characters for all species are fruit type, bract and petal margin, anther shape, anther attachment, no. and surface of stigma and ovary size.

There are high degree of similarity among the species of genus *Convolvulus* based on leaf margin and surface, inflorescence type, bract and petal margin, bract apex, calyx aestivation, shape of stigma and ovary, fruit shape, seed shape, colour and surface. The main characters explaining the separation of the species based on stem orientation, hair type, leaf shape, size and apex, no of flowers, flower diameter, sepal shape peduncle size and no of seed and seed size. Most diverse vegetative characters are seen in *C. prostratus* which may be due to the process of hybridization as described in literature (Malik & Tendon, 1959; Vij & Satpal, 1974). Beside the process of hybridization, any alteration in a certain defined environmental condition of a species leads to phenotypic plasticity (Pham et al., 2014; Junqi et al., 2015). In *C. arvensis* and *C. glomeratus,* diversity seen in leaf shape, size, colour and flower colour and size, resulted from change in environmental conditions.

Boisser (1875) delimited the genus *Convolvulus* into 10 infrageneric group based on growth form and ovary pubescent. Sa'ad (1967) modified Boisser classification and divided the genus *Convolvulus* into three sections, twelve subsections and four series, based on spine and habit.

The resultant dendogram constructed by numeric analysis distinguished four groups. The first branching group with *C. lineatus, C. kotscyanus, C. pyrrhotrichus* and *C. acanthocladus* are herb to undershrub with erect-procumbent stem orientation and pubescent ovary except *C. kotscyanus* (glabrous ovary). While, *C. acanthocladus* is spiny undershrub parted in a separate cluster within the group. *C. virgatus, C. rhyniospermus* and *C. cephalopodus* are non-spiny herbaceous species with glabrous ovary, included in second branching group. The third smallest group with *C. arvensis* and *C. glomeratus,* both are non- spiny twining herb with glabrous ovary, formed a single cluster. The fourth largest group comprises of *C. scindicus, C. fruticosus, C. prostratus C. pseudocantabricus* and *C. spinosus.* All species within the group are shrub with pubescent ovary except *C. prostratus,* which is non-spiny erect herb with glabrous ovary. A branch with C. *leiocalycinus,* spiny shrub segregated from all other species of *Convolvulus*. In Central Asia it is distinct from other spiny species with abruptly narrowed leaves at the base into a distinct petiole and the lax sepals which are not appressed to the base of the corolla (wood et al., 2015).

CONCLUSION

The result of our study is fairly congruent with traditional classification of *Convolvulus* based on habit and ovary pubescent (Boisser, 1875 and Sa'ad, 1967). However, there is need to utilize micro morphological features and other advanced & reliable techniques such as molecular data to analyze and identify the ancestral character states at intraspecific level.

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