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A NUMERICAL TAXONOMY OF THE GENUS *SEDUM* L., FROM PAKISTAN AND KASHMIR

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Abstract

The phenetic relationship between the species of the genus *Sedum* L. was investigated. Data from macro and micromorphology, including pollen and seed morphology, chemistry and distribution pattern was utilized. Two distinct groups of taxa are recognized from which one group comprises *S. multicaule* Wall. ex Lindl., and *S. hispanicum* L., while other group consists of *S. trullipetalum* Hook. f. & Thomson *S. fischeri* Raym. - Hamet and *S. oreades* (Decne.) Raym. – Hamet. A key of the taxa is provided and distribution maps of the species are also presented.

Introduction

The importance of statistical methods in biological sciences can hardly be over emphasized. Many workers were of the view that numerical analysis is the comprehensive way of evaluating and analyzing the data and producing a phenetic classification (Sokal & Sneath, 1963; Mc Neil *et al*., 1969; Sneath & Sokal, 1973). Cronquist (1964) debated the same issue and emphasized that data collected subjectively should not become objective, when analyzed and presented objectively.

Considerable work has been done on family Crassulaceae to elucidate the phylogenetic relationship. Uhl (1963) studied the phylogeny of the family Crassulaceae. Hart (1982) analyzed the relationships within the subfamily Sedoideae. Mes (1995) did the phylogenetic analysis of 22 taxa belonging to Sempervivoideae and five taxa of Sedoideae. Mes (1997) analyzed the phylogenetic relationships in the genus *Monanthes*. Ham & Hart (1998) studied 44 species representing 19 genera and the six subfamilies. The subfamilies Cotyledonoideae, Sempervivoideae, Sedoideae and Echeveroideae were indicated to be polyphyletic. Mort *et al*., (2001 & 2002) studied the phylogenetic relationships and evolution of Crassulaceae. Mayuzumi & Ohba (2004) studied the phylogeny of Eastern Asian Sedoideae. According to Ham & Hart (1998) and other workers *Sedum* L., is paraphyletic.

There are no reports of statistical studies on the genus *Sedum* L., from Pakistan. The aim of the present study was to determine and tracing the close relationships among various species belonging to the genus *Sedum* L.

Materials and Methods

Plant material: Thirty macro and micromorphological characters including general, pollen and seed morphology and chemical characters were used for numerical analysis. The data was collected from c. 300 specimens present in the herbaria BM, E, K, KUH, KYO, LINN, RAW and US (abbreviated according to Holmgrem *et al*., 1990). However, in addition to herbarium specimens, living material was also studied in the field.

Numerical analysis: A hierarchical cluster analysis of 5 taxa belonging to the genus *Sedum* L., was carried out on the basis of multistate or binary variables (Table 2). For the analysis, characters were used from macro as well as micromorphology (i.e., seed and pollen) along with flavonoid. In most of the cases, the qualitative characters were recorded in binary state and in some cases, multiple state. The binary characters were recorded as 1 and 2. Multiple state characters were recorded as 1, 2, 3, 4, 5 and 6. For quantitative characters their average values were used, while in case of presence or absence, certain characters were coded as 1 or 0 respectively (Table 2). However, weightage was given to those characters which were thought to be more informative than others. The numerical analysis was performed by using the Euclidean distance index and group average strategy with the computer package (Anon., 1998). Each of the taxon was treated as operational taxonomic unit (OTU).

Results and Discussion

The cluster analysis revealed the existence of five discrete clusters within the genus *Sedum* L., (Fig. 1). Each cluster was named after the taxon which inclded the type specimen.

These five clusters form two groups largely based on inflorescence type (raceme to spike or corymbose to cyme) and habit (annual or perennial). Group one comprises *S. hispanicum* and *S. multicaule* whereas second group consists of three species viz., *S. trullipetallum, S. oreades* and *S. fischeri. S.hispanicum* comes closer to *S. multicaule* than *S. fischeri*, *S. oreades* and *S. trullipetalum* (Fig. 1).

S. multicaule and *S. hispanicum* clusters are fairly close together (Fig. 1). They resemble in having perennial habit and raceme to spike inflorescence, none of the other member exibit these characters. They are morphologically identical in corolla shape lanceolate and stamens in two whorls but differ by shape of seed, nectar scale and pollen. *S. multicaule* has obovoid seeds, square oblong nectar scale and suboblate pollen while in *S. hispanicum* ovoid seeds, spathulate nectar scale and obloid spheroidal pollen. Phytogeographically, *S. multicaule* is Sino-Japanese element distributed in Pakistan, India, Nepal, Sikkim, Bhutan, Myanmar and China while *S. hispanicum* is Irano-Turanian element, distributed in Iraq, Iran, Afghanistan, Pakistan, Turkmenistan and Russia (Figs. 2&3).

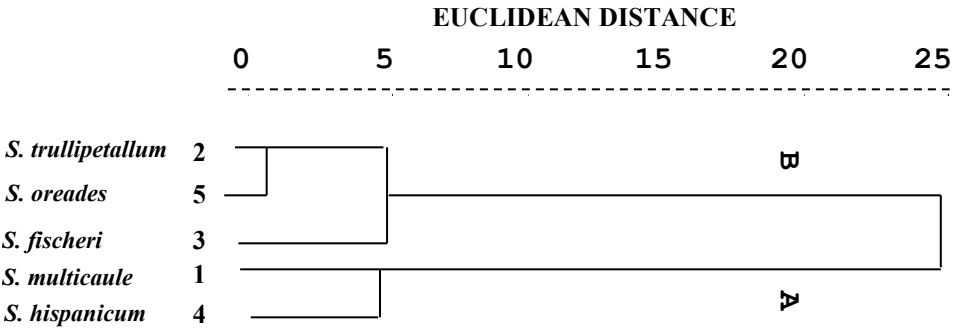

Fig. 1. Dendrogram showing the relationships of the species of the genus *Sedum* L.

Table 1. List of characters scored for cluster analysis for the species of *Sedum* L., listed in Table 2.

No.	Characters description
1.	Habit
2.	Plant height in (cm)
3.	Leaf length in (mm)
4.	Leaf breadth in (mm)
5.	Leaf shape (1) one type (2) two types
6.	Inflorescence (1) raceme to spike like (2) corymbose (3) cymes 1-3 flowered to cymes 2-5 flowered
7.	Flowers (1) 5-merous (2) 5-9 merous
8.	Colour of flower (1) one type (2) two types
9.	Pedicel size in (mm)
10.	Sepal length in (mm)
11.	Sepal breadth in (mm)
12.	Shape of sepals (1) one type (2) two types
13.	Petal length in (mm)
14.	Petal breadth in (mm)
15.	Shape of petals (1) lanceolate (2) ovate (3) oblong (4) obovate-spathulate
16.	Stamens (1) one whorl (2) two whorls (3) one to two whorls
17.	Stamens length in (mm)
18.	Nectar scales length in (mm)
19.	Nectar scales breadth in (mm)
20.	Shape of nectar scales (1) spathulate (2) oblong (3) square oblong
21.	Fruit length in (mm)
22.	Fruit breadth in (mm)
23.	Seed length in (mm)
24.	Seed breadth in (mm)
25.	Seed shape (1) ellipsoid (2) ovoid (3) obovoid (4) oblong
26.	Caffeic acid (0) absent (1) present (2) Not comparable NC
27.	Quercetin 3-glucoside (0) absent (1) present
28.	Quercetin 3-rhamnoside (0) absent (1) present
29.	Pollen (1) oblate-spheroidal (2) suboblate (3) Not comparable NC
30.	Phytogeographical regions (1)Sino-Japanese region (2) Irano-Turanian region

S. trullipetalum and *S. oreades* are evolved from the same point due to the similarity in characters except inflorescence i.e., corymbose in former taxon whereas cymes 1-3- flowered in later taxon, seed shapes oblong in former taxon while ellipsoid in latter taxon and presence of caffeic acid in former taxon which is not found in latter taxon. These two taxa differ from each other on the basis of petal and seed shapes i.e., oblong seed in *S. trullipetalum* while *S. oreades* has ellipsoid seed. Both the taxa are Sino-Japanese element, the former taxon is distributed in Kashmir, India, Nepal, Bhutan, Sikkim and China whereas the latter taxon is distributed in Pakistan, China, Bhutan, Myanmar and India (2&3).

S. fischeri is closely related to *S. trullipetalum* and *S. oreades*. *S. fischeri* differs from former two taxa on the basis of petal length, petal shapes and nectar scale shapes i.e., petal length 5 mm, petal shape oblong and nectar shape oblong while petal length 10 mm, nectar shape spathulate in both the taxa, petals shape ovate in *S. trullipetalum* and obovate-spathulate in *S. oreades*. *S. fischeri* is also Sino-Japanese element and it is distributed in Kashmir, N.W. India, Sikkim, Bhutan and China (Fig. 3).

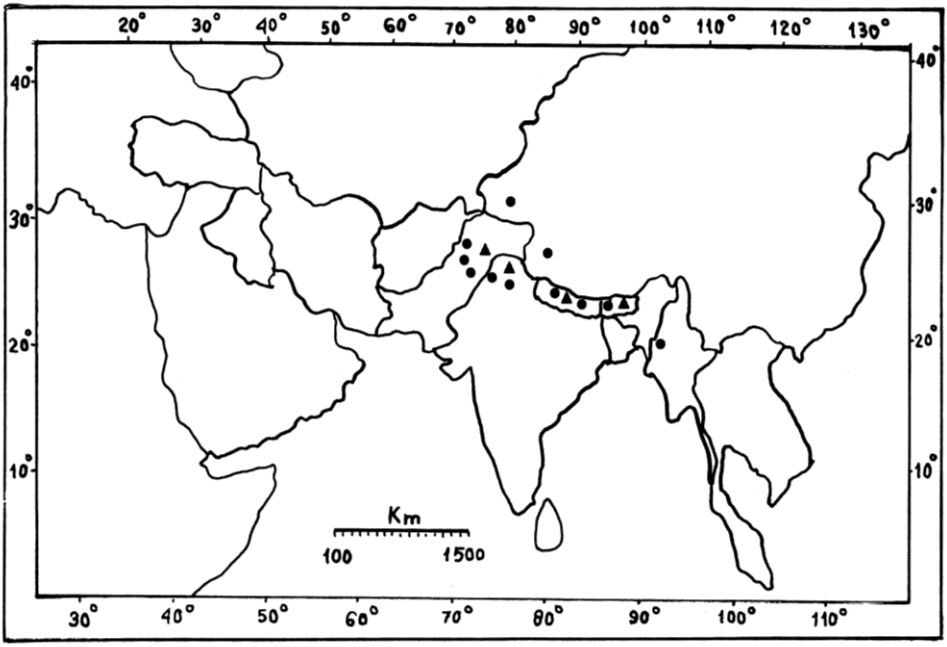

Fig. 2. Distribution pattern of *Sedum multicaule* (●) and *S. trullipetalum* (▲)

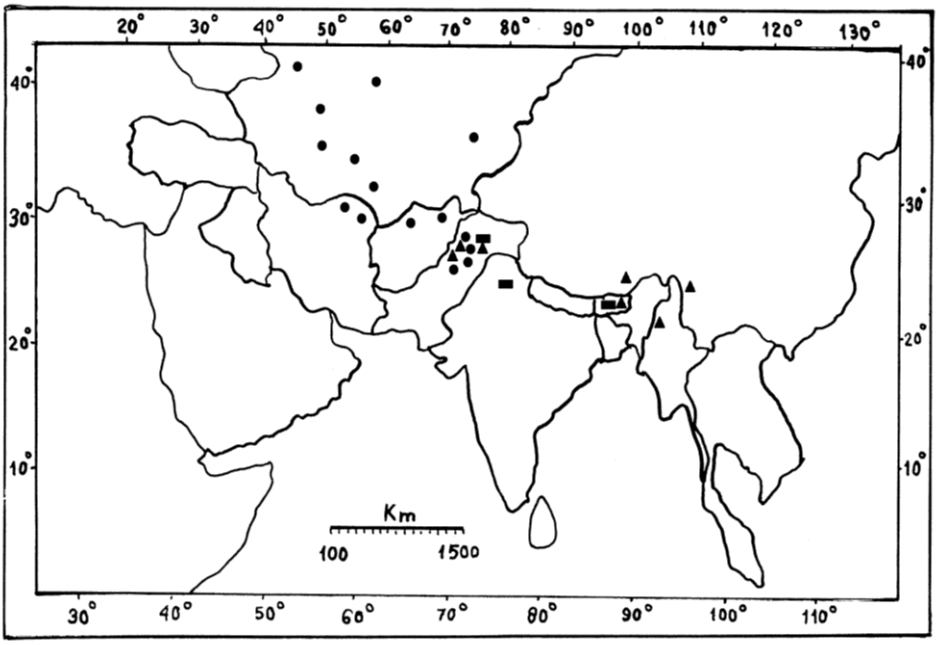

Fig. 2. Distribution pattern of *Sedum hispanicum* (●), *S. oreades* (▲) and *S. fischeri* (■)

Table 2. Data matrix of *Sedum* scored for 30 characters presented in Table 1.

No.	Taxa	1	2	3	4	5	6	7	8	9	10	11	12
1.	*S. multicaule*	2	13.5	26	2	2	1	1	1	1.5	6	2	2
2.	*S.trullipetalum*	1	11	6	2	2	2	1	1	6	3	1	1
3.	*S. fischeri*	1	5	6	1.5	2	3	1	1	2	4	1.5	1
4.	*S. hispanicum*	3	20	18	3	2	1	2	1	1.5	3	1.5	2
5.	*S. oreades*	1	12	8	2	1	3	1	2	3	6	2	1

Table 2. (Cont'd.).

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
5	2.5	1	2	3.5	0.5	0.3	3	5	1.5	0.8	0.2	3	1	1	1	2	1
10	2	2	2	9	1	0.2	1	6	1	1	0.2	4	2	2	2	3	1
5	1.5	3	1	4	1	0.2	2	4	1.5	1	0.3	1	2	2	2	1	1
6	3	1	2	4.5	0.8	0.2	1	6	2	1	0.3	2	0	0	0	1	2
10	4	4	3	6	1.5	0.3	1	8	1.5	1	0.3	1	0	1	1	1	1

Key to the species

1. \+ Stamens as many as petals ……. ***S. fischeri***
   \- Stamens twice as many as petals …….. **2**

2. \+ Inflorescence corymbose, many flowered; petals with basal appendages …….. ……... ***S. trullipetalum***
   \- Inflorescence and petals not as above …….. **3**

3. \+ Inflorescence a raceme or spike-like. Follicles spreading, star-shaped at maturity …… **4**
   \- Inflorescence 1-5 flowererd cyme. Follicles not as above …… ***S. oreades***

4. \+ Petals equal to or shorter than the sepals. Sepals oblong to oblong-lanceolate. Stem much branched …….. ***S. multicaule***
   \- Petals longer than the sepals. Sepals ovate to broadly ovate. Stem branched only a few times …… ***S. hispanicum***

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