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TAXIMETRY OF THE GENUS *PSYCHROGETON* BOISS. FROM PAKISTAN AND KASHMIR

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ABSTRACT

The phenetic relationship between the species of the genus *Psychrogeton* has been investigated by taximetry. Data obtained from Systematic treatment, Pollen morphology, Cypsela morphology and distribution patterns were utilized. Dendrogram of Hierarchical Cluster Analysis is presented and relationship among the species is discussed.

Key-words: Numerical taxonomy, taximetry, *Psychrogeton,* Kashmir, Pakistan.

INTRODUCTION

When systematic data is analyzed by mathematical or computerized method, the approach is called numerical taxonomy, Taximetry or taximetrics.

Adanson (1763) a French botanist was the first person who assigned numerical values to taxonomic characters. After 1960, the approach became faster due to usage of electronic devices. A number of classification systems came into existence after analysis of different data numerically.

Another term phenetics was also used. Phenetics is a biological classification system in Systematics (Sokal and Sneath, 1963). There were workers who put forth the concept of Numerical Taxonomy around the mid of previous century. Sneath (1957), Michener and Sokal (1957) and Sokal and Michener (1958) are the pioneers of this field. "Principles of Numerical Taxonomy" was published in 1963 by Sneath and Sokal; later on it was re-elaborated by the same authors (1973).

The aim of Numerical Taxonomy is to develop a method which is objective and repeatable both in the studies of evolution of taxonomic relationships and circumscription of taxa (Sokal and Sneath, 1962). Heywood (1984) defined Numerical taxonomy as the numerical analysis of the similar traits between groups of organisms and the arrangement of these groups into higher ranks on the basis of these similarities.

Bremer (1987) has carried out cladistic analysis based on morphological attributes to find out the inter-relationships of various tribes of the family Asteraceae. Anderberg (1989) also carried out cladistic analysis of different tribes of Compositae.

Siddique *et al.* (1989) carried out cladistic analysis of *Euphrasia* complex of Scrophulariaceae from Pakistan and its adjoining areas. Karis *et al.* (1992) analyzed numerically the relationships within the tribe Cichoridae (Asteraceae). Whitton *et al.* (1995) studied the phylogenetic relationships in the tribe Lactuceae- Asteraceae. This study was based on cDNA restriction site. Blackmore and Pearson (1996) carried out the cladistic analysis of the tribe Crepidinae- Lactuceae (Compositae) by using pollen attributes.

In 1998 Koopman *et al* studied phylogenetic relationships of *Lactuca* and its allied genera. Moylan *et al.* (2004) studied the systematic analysis of *Strobilanthes* (s.l) from Southern India and Srilanka.

From Pakistan and Kashmir, Abid and Qaiser (2006) carried out numerical analysis of 21 species belonging to 5 different genera of tribe Inuleae- Asteraceae. For this purpose not only macromorphological attributes were used but micromorphological attributes including chemical data were also used. Bano (2009) found Heirarchial Clustering and Principal Components Analysis (PCA) based on 23 morphological attributes of *Cicerbita* (Lactuceae-Asteraceae). Sarwar and Qaiser (2011) discussed the numerical analysis of the genus *Sedum* L. from Pakistan and Kashmir.

The main objective of this work is to quantify the species relationships among the species of the genus *Psychrogeton* Boiss. from Pakistan and Kashmir.

MATERIALS AND METHODS

Plant Material: Forty macro and micromorphological attributes including general, pollen and cypsela morphology were utilized for taximetry. The data was collected from 200 approx. herbarium sheets provided by different herbaria i.e. KUH, NHI, E & BM (abbreviated according to Holmgren *et al.*, 1990)

Taximetry: All the macro and micromorphological attributes were observed carefully and were given equal weight.

A hierarchial cluster analysis of 14 species belonging to the genus *Psychrogeton* Boiss. from Pakistan and Kashmir was carried out on the basis of multistate or binary variables. The quantitative attributes were recorded in both binary and multiple state. Terms 0 & 1 were used in the case of binary state. But in the case of multiple state, 1,2,3,4, and 5 were used.Characters and characters state used for phenetics are listed in the Table 1.

Table 1. List of characters for Cluster Analysis.

S.#	Characters: Characters State
1	Habit: annual (1), biennial (2), perennial (3)
2	Indumentum Colour: Obsolete (0) white (1), grey, ash/ off- white (2), yellow (3),
3	Plant: caespitose (1), fruiticose (2), erect/ ascending (3)
4	Branching thick (1); Branching thin (2)
5	Size of Stem: < 15 cm (1), > 15 cm (2)
6	Length of basal leaf : 0.0-1.0 cm (1), 1.1-2.0 cm (2), 2.1-4.0 cm (3), 4.1-6.0 cm (4)
7	Cauline leaves: Linear (1), well developed (2), lower linear upper well-developed (3)
8	No. of Cauline Leaves: 1-4 (1), > 4 up to 12 (2)
9	Presence of basal leaf after flowering: Absent (0), Present (1)
10	Basal Leaf Shape:Obsolete(0),Spathulate/ Oblanceolate (1) Orbicular (2), Lanceolate (3),Obovate (4)
11	Leaf Margins: Obsolete (0), 1-3 dentate (1), more than 3 dentations (2), entire (3)
12	Leaf Apex: Obsolete (0), Rounded (1), Obtuse (2), Acute (3), mucronate (4),
13	Fertile Cypsela Pappus Series: Single (1), Double (2)
14	Pappus Length: < female corolla (1), > / = female corolla (2)
15	Pappus barbles appressed (1); barbles not appressed (2), obsolete (0)
16	Pappus tapered at the apex (1); pappus feathery at the apex (2), Obsolete (0)
17	Female Florets Colour: White/ purple/pink (1); Yellow (2)
18	Female Corolla: Lower 25% tubular upper 75% ligulate (1), Lower 50% tubular, upper 50% ligulate (2), Lower 75% Tubular upper 25% ligulate (3), Only lobes slightly ligulate rest tubular (4), Completely tubular (5)
19	Female Floret Size: < 5 mm (1), > 5mm (2)
20	Female fl. Diameter: < 2 mm (1), > 2 mm (2)
21	Style slightly peeping out of female fl. corolla (1); style remarkably out of the corolla (2), Style inside corolla (3)
22	Max. length of Fertile Cypsela: up to 2 mm, (1); up to 9 mm (2)
23	Cypsela Surface: Hairy (1), glandular (2), Hairy + Glandular (3)
24	Cypsela hair density: Surface visible (0), Surface invisible (1), Obsolete (2)
25	Sterile Cypsela Shape: Obsolete (0), Slender (1), Oblanceolate (2), Oblong (3), lanceolate (4),
26	Carpopodium Position: Obsolete (0), Basal (1), Sub-basal (2),
27	Carpopodium shape: rounded (1), elliptic/ oblong (2), Pear-shaped (3), Obsolete (0)
28	Hair length: 0-150 µm (1), 150-300 µm (2),301-450 µm (3),>450 µm (4),Obsolete (0)
29	Carpopodium diameter: < 200 µm (1), >200 µm (2) , Obsolete (0)
30	No. of barbs in apex of pappus: Single (1), 2-3 (2), > 3 (3) , Obsolete (0)
31	Pollen Shape: Obsolete (0), Oblate (1), Suboblate(2), OblateSpheroidal (3), Oblate+Suboblate (4),
32	Polar diameter maximum: obsolete (0), 10-15 µm (1), 16-18 µm (2),>19 µm (3),
33	Equatorial diameter maximum: Obsolete (0). 15-20 µm (1), 21-25 µm (2),
34	P/E: Obsolete (0) , 0.60-0.70 (1), 0.71-0.80 (2), 0.81-0.90 (3), > 0.90 (4)
35	Colpi Length: Obsolete (0), up to 7 µm (1), >7 µm up to 10 µm (2)
36	Pore Diameter: Obsolete (0), 2-4.9 µm (1), 5-7 µm (2)
37	Surface Smooth (0); Perforate (1), Obsolete (2)
38	Spine Size: Obsolete (0), 1.6-2.29 µm (1), 2.3-2.99µm (2), 3.0-4.0 µm (3)
39	Spine Apex: Obsolete (0), Rounded (1); Acute (2); Obtuse-acute (3), Acuminate (4)
40	Interspinal Distance: Obsolete (0), 0.5-1.0 µm (1), 1.1-1.5 µm (2),1.6-2.0 µm (3)

The data was analyzed numerically. Cluster Analysis was carried out using computer package SPSS. Dendrogram was constructed on using average linkage between groups. Each taxon was used as Operational Taxonomic Unit (OTU). All the OTUs are represented in analysis.

RESULTS AND DISCUSSION

Dendrogram revealed that there were two main clusters in this genus. These groups are mainly based on ascending / erect habit, presence of Cauline leaves and absence of basal leaves at the time of flowering.

Group A: The group consists of two species *P. aucheri* and *P. nigromontanus.* This group is formed on the basis of erect stem, more Cauline leaves and less basal leaves as well as withering of them at the time of flowering. Floral characters, completely tubular corolla, shape of cypsela, pappus hair morphology and indumentum are the characters on which basis group is separated from the other group.

Group B: This group further divides into two subgroups;

Sub group I: This subgroup consists of two species *P. lumbricoides* and *P. persicus.* Both have certain common characters like thin branching, Cauline leaves up to nine, their shape, indumentum, corolla which is bilabiate (same in both species).

Table 2. Data Matrix of *Psychrogeton* Boiss Scored for Nos. 01-40 attributes presented in Table 1.

S.No.	Name of Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	*P. alexeenkoi* Krasch	3	2	1	1	1	3	2	1	1	1	1	2	2	2	2	1	1	1	2	2	3
2	*P.amorphoglossus* (Boiss.) Novopokr.	3	2	1	1	1	3	2	1	1	1	1	3	2	2	2	1	1	2	2	2	1
3	*P.andryaloides* (DC.) Novopokr. ex Krasch.	3	2	1	1	1	3	2	1	1	1	1	2	2	1	2	1	1	2	2	2	1
4	*P. aucheri* (DC.) Grierson	2	2	3	2	2	2	2	2	0	0	0	0	2	2	1	2	1	5	2	2	1
5	*P. cabulicum* Boiss.	3	3	2	1	1	4	2	1	1	1	3	3	1	1	2	1	2	3	2	2	1
6	*P.candidisimus* (Rech.f. & Edelb.) Grierson	3	1	1	1	1	3	2	1	1	1	3	1	2	2	2	1	1	3	2	2	1
7	*P.chitralicus* Grierson	3	2	1	2	2	2	2	2	1	1	2	3	1	2	1	1	1	4	2	1	2
8	*P. drabiformis* Grierson	3	2	1	1	1	2	1	1	1	1	2	2	2	2	2	1	1	2	1	1	2
9	*P. lumbricoides* (Gilli) Grierson	3	2	2	2	1	3	3	2	1	3	1	3	2	2	2	1	1	3	1	1	1
10	*P. nigromontanus* (Boiss. & Buhse) Grierson	2	3	3	2	2	3	2	2	0	0	4	0	1	2	2	1	1	5	1	1	2
11	*P. persicus* (Boiss.) Grierson	1	2	1	2	1	4	3	2	1	0	2	2	2	2	2	1	1	3	2	2	3
12	*P. poncinsii* (Franch.) Chen & Brouillet	3	2	1	1	1	3	1	1	1	1	1	2	2	1	2	1	2	2	2	2	1
13	*P. pseuderigeron* (Bunge) Novopokr. ex Nevski	3	2	2	1	2	3	2	2	1	1	2	2	2	1	2	1	1	2	2	2	1
14	*P. sphaeroxylus* (Gilli) Grierson	3	2	2	1	2	3	3	1	1	1	3	3	1	2	2	1	1	2	2	2	1

Table 2 … continues.

Table 2. Continue from p. # 635.

S.No	Name of Taxon	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1	*P. alexeenkoi*	1	3	1	1	2	1	2	1	2	2	1	2	2	2	1	0	2	4	2
2	*P. amorphoglossus*	2	3	1	2	1	3	2	1	2	3	3	2	3	2	2	0	2	3	0
3	*P. andryaloides*	2	1	0	1	2	3	2	2	1	2	1	1	3	2	2	0	1	2	3
4	*P. aucheri*	1	2	0	3	1	2	1	2	1	1	1	2	2	--	1	1	2	1	0
5	*P. cabulicum*	2	3	1	2	1	2	3	2	1	2	2	2	3	2	2	0	1	2	2
6	*P. candidissimus*	2	1	0	1	1	3	2	1	1	1	1	1	1	2	0	0	2	4	0
7	*P. chitralicus*	2	1	1	3	2	1	1	2	1	3	2	1	4	2	1	0	2	2	3
8	*P. drabiformis*	1	3	1	3	1	3	2	1	2	2	1	1	2	2	1	0	1	2	0
9	*P. lumbricoides*	2	2	0	3	2	1	4	1	2	3	1	1	4	1	2	0	2	4	0
10	*P. nigromontanus*	1	1	1	3	1	1	2	2	3	2	2	1	3	1	1	1	1	1	3
11	*P. persicus*	2	1	1	4	2	2	4	2	2	2	2	1	3	1	2	0	3	4	3
12	*P. poncinsii*	2	3	1	3	1	1	2	2	2	4	3	2	2	2	2	0	3	2	0
13	*P. pseuderigeron*	2	1	1	4	1	2	2	1	2	1	1	2	1	2	2	1	3	2	0
14	*P. sphaeroxylus*	2	1	1	1	1	3	2	2	1	3	2	1	4	2	1	0	1	2	3

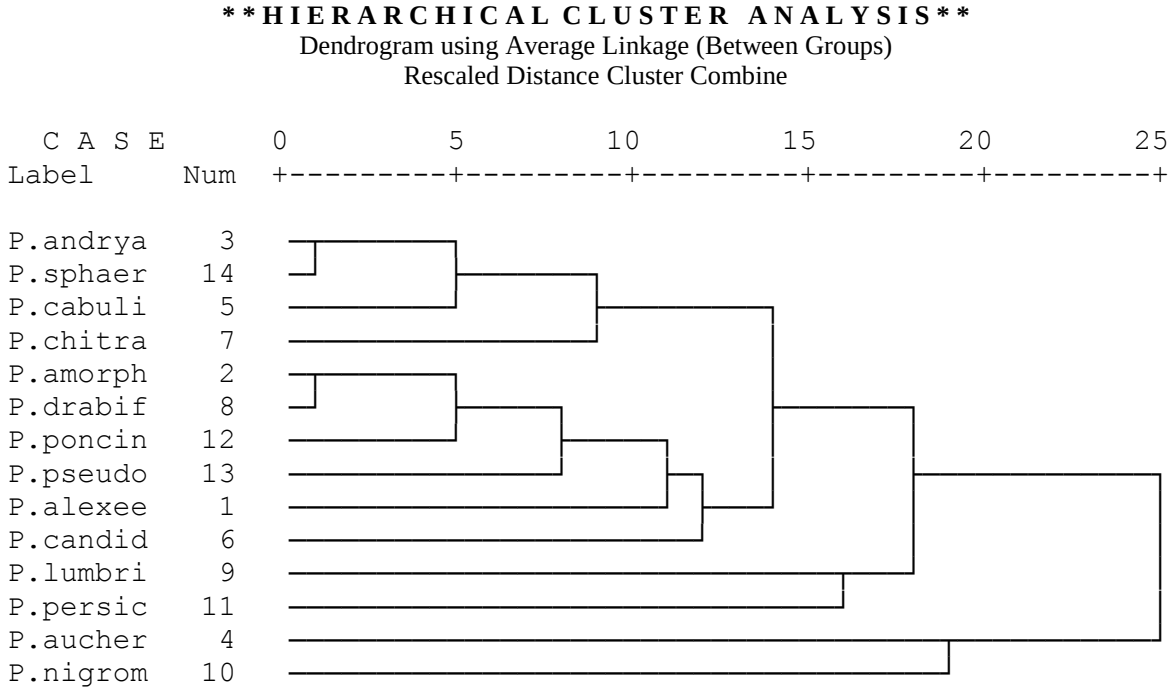
Subgroup II: It further bifurcates into two groups.

Subgroup (a):

It consists of *P. andryaloides, P. sphaeroxylus, P. cabulicum* and *P. chitralicus. P. andryaloides* and *P. sphaeroxylus* are mentioned as closely related due to their basal leaf characters, floret characters, pollen and trichome characters. Their pollen diameter, surface, spine size and interspinal distances lie in the same ranges as well as their floral characters size of corolla. The species which is next related to these two species is *P. cabulicum* has some of the leaf floral and pollen characters common with upper mentioned species. Same is the case with *P. chitralicus,* but the species has twice the distance as among *P. andryaloides, P. sphaeroxylus* and *P. cabulicum.*

Subgroup (b):

This is the largest group with 6 species. There are two species *P. amorphoglossus* and *P. drabiformis* which are closely related on the basis of following characters; habit, habitat, branching, stem size, Pappus series, length and morphology; corolla shape, its colour, cypsela indumentum, carpopodium position, shape, carpopodium diameter, colpi length etc. This group also includes *P. poncinsii, P. pseudoerigeron, P. alexeenkoi* and *P. candidissimis.* Rescaled distance between *P. amorphoglossus, P. drabiformis* and *P. poncinsii* is less than 5; *P. pseudoerigeron* is at 8 and *P. alexeenkoi* is at 12. This shows the presence of common characters among species of *Psychrogeton.*



Abbreviated Name	Extended Name
1. P.alexee	P.alexeenkoi Krasch.
2. P.amorph	P.amorphoglossus (Boiss.) Novopokr.
3. P.andrya	P.andryaloides (DC.) Novopokr. ex Krasch
4. P.aucher	P.aucheri (DC) Grierson.
5. P.cabuli	P.cabulicum Boiss.
6. P.candid	P.candidissimis (Rech. f. & Edelb.) Grierson.
7. P.chitra	P.chitralicus Grierson.
8. P.drabif	P.drabiformis Grierson.
9. P.lumbri	P.lumbricoides (Gilli) Grierson.
10. P.nigrom	P.nigromontanus (Boiss. & Buhse) Grierson.
11. P.persic	P.persicus (Boiss.) Grierson.
12. P.poncin	P.poncinsii (Franch.) Chen & Brouillet.
13. P.pseudo	P.pseudoerigeron (Bunge) Novopokr. ex Nevski.
14. P.sphaer	P.sphaeroxylus (Gilli) Grierson.

Fig.1. Dendrogram using Average Linkage (Between Groups).

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