



Full Length Article

Systematic Value of Foliar Anatomical Features in *Polygonum* species, Family Polygonaceae from Pakistan

GHAZALAH YASMIN¹, MIR AJAB KHAN, NIGHAT SHAHEEN, MUHAMMAD QASIM HAYAT, ZAHID ULLAH AND SHAKIRA MUNSIF

Department of Plant Sciences, Quaid-i-Azam University Islamabad, Pakistan

¹Corresponding author's e-mail: ghaza00@hotmail.com

ABSTRACT

A study of foliar epidermis in thirteen species of *Polygonum* was performed. The study revealed some distinctive anatomical features such as epidermal cells outline, single or mixed type of stomata on the single leaf surface and presence or absence of trichomes adaxially and abaxially. The shape of epidermal cells was variable; stomata were constant in most of the species and one-three celled glandular peltate trichomes were examined in few species, while non-glandular trichomes were totally absent. Although the analyzed epidermal characters have systematic value, they are to likely be stable at specific level.

Key Words: Polygonaceae; Trichomes; Anaisocytic; Staurocyclic; Peltate

INTRODUCTION

Polygonaceae is a large dicot family of 48 genera and 1200 species (Freeman & Reveal, 2005; Sanchez & Kron, 2008). In Pakistan it is represented by 19 genera and 103 species (Qaiser, 2001).

Polygonum L. comprises of about 60 species, distributed nearly worldwide and in Pakistan represented by 20 species (Qaiser, 2001). The genus is characterized by prostrate habit, sometimes subprostrate or erect, alternate leaves, presence of ochreae on nodes, axillary flowers, tepals with only one main vein, stamen in two whorls, outer smaller in size than inner, filaments swollen at the base and absence of nectaries (Ronse Decraene & Akeroyd, 1988).

The systematic potential of foliar anatomical features is well recognized in botanical literature (Stace, 1965). For instance, epidermal characters of different genera of Polygonaceae have been studied by Metcalfe and Chalk (1950), Inamdar (1971), Kapoor *et al.* (1971), Mitchell (1971), Lersten and Curtis (1992), Ayodele and Olowokudejo (2006) and Yasmin *et al.* (2009) and found that epidermal characters are increasingly important source of taxonomic value. The intention here is to present a more precise characterization of the foliar epidermal anatomy with light microscopy and to identify the taxonomic potential of the characters in order to identify different species of the genus.

MATERIALS AND METHODS

Dried leaves (4-5) of representative specimens from

Quaid-i-Azam University Herbarium, Islamabad, Pakistan of *Polygonum* L. of the family Polygonaceae given in Table I, were used for anatomical studies. Dried leaves were placed in boiling water for few minutes so that they became soft and unfolded and then ready for epidermal scrapping. Leaf samples were prepared according to modified method of Cotton (1974), who followed Clark's (1960) technique. The leaves were placed in a tube filled with 88% Lactic acid kept hot in boiling water bath (Model, Memmert-91126-FRG, Germany) for about 30 to 40 min. Lactic acid softens the leaf due to which it was possible to scrap the leaf surface with sharp scalpel. Slides of both abaxial and adaxial surface of leaf were prepared and mounted in clean 88% Lactic acid. Both qualitative and quantitative micromorphological foliar characteristics were observed using LM. Microhistological photographs of both surfaces were taken by Nikon (FX-35) Camera equipped light microscope.

Cluster analysis. A dendrogram was constructed by un-weighted paired group method with EUCLIDEAN option, using MVSP software version 3.13 (Kovach, 2007).

RESULTS AND DISCUSSION

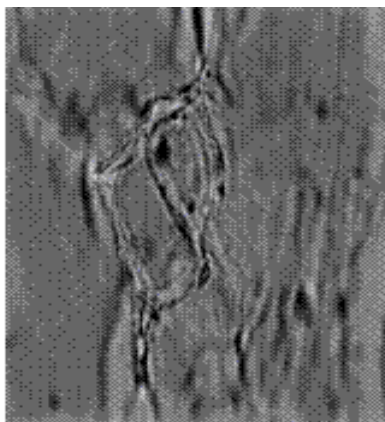
In the present study foliar anatomy of 13 species of the genus *Polygonum* L. was analyzed by its qualitative and quantitative characters. In the taxa of *Polygonum* L. the epidermal cells varied from tetrahedral, pentagonal, hexagonal and heptagonal, polygonal benzene ring like cells with thick pitted walls to irregular in shape with undulating walls (Fig. 1 A, E-G). In *P. cognatum*, epidermal cells on adaxial surface were polygonal, while irregularly shaped

Fig. 1. Light micrographs (LM) of foliar anatomy of selected species of the genus *Polygonum* L.

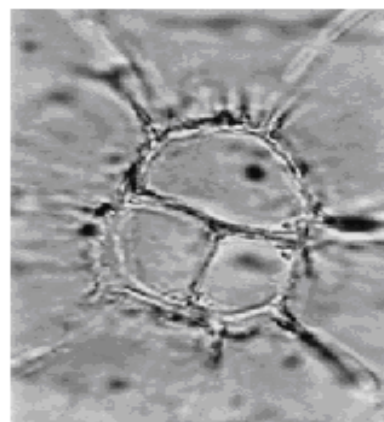
A. *P. cognatum*. A Polygonal, thick and pitted walled cells with anisocytic stomata (400X)



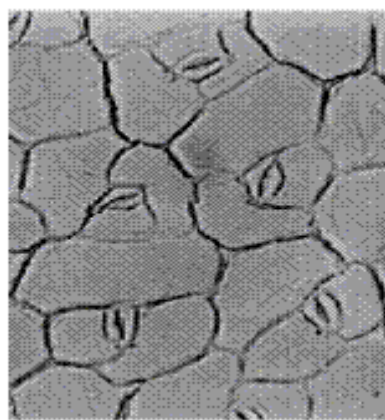
B. *P. cognatum*. Two-celled peltate trichomes (1000X)



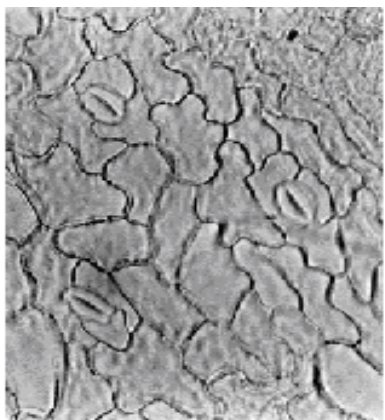
C. *P. cognatum*. Three-celled peltate gland with radiating walls (1000X)



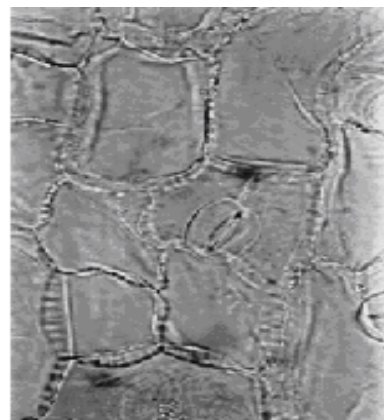
D. *P. arenastrum*. D. Epidermal cells with anisocytic stomata (200X).



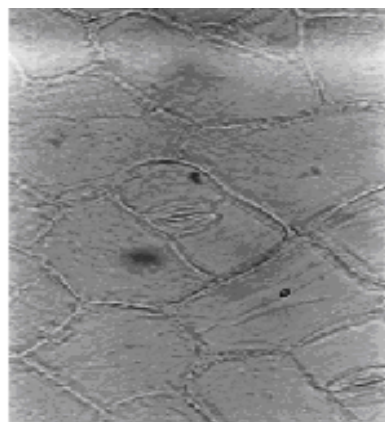
E. *P. sarobiense*. Irregularly shaped epidermal cells (200X)



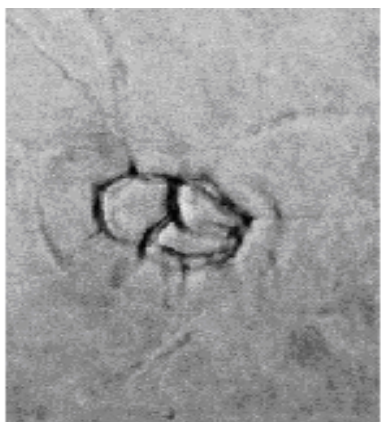
F. *P. plebijum*. Irregular pitted epidermal cells with pericytic stomata (400X)



G. *P. polycnemoides*. Benzene ring shaped epidermal cells with anisocytic stomata (400X)



H. *P. polycnemoides*. Three-celled peltate glands (400X)



I. *P. patulum*. Epidermal cells shape and anisocytic stomata (200X)



Table I. List of species investigated for anatomical studies with location, district Collector name and accession numbers

Species	Locality	District	Collector name	Acc. No
<i>P. aviculare</i> L.	Kawas	Quetta	Manzoor and Maqsood	69130
	Near Babusar top	Hazara	M.N. Choudhari <i>et al.</i>	122645
<i>P. paronychioides</i> C.A. May. ex Hohen	Chanbhri	Muzaffarabad	Shahzad <i>et al.</i>	940070
	Batakundi	Hazara	Mir Ajab and M. Afzal	74462
<i>P. afghanicum</i> Meisn	Landi Kotal	Khyber agency	M. Tanveer and Dilawar	106327
<i>P. olivascens</i> Rech. f. & Schiman-Czeika	Kolpur	Quetta	Manzoor and Maqsood	54286
<i>P. rottboellioides</i> Jaub. & Spach	4 miles on the way to Naltar	Northern areas	M.N. Choudhari <i>et al.</i>	117938
<i>P. molliiforme</i> Boiss	Gitti Das	Hazara	Iqbal Dar <i>et al.</i>	09230
<i>P. patulum</i> M. Bieb.	Nagar	Gilgit	Mir Ajab and M. Afzal	58927
	Mistar	Chitral	Wali-Ur-Rehman and Subhan	116202
<i>P. polycnemoides</i> Jaub. & Spach	Dudnial (stony soil)	Muzaffarabad	Shahzad and Ayaz	69157
	Uacub	Chitral	Wali-Ur-Rehman	116176
<i>P. cognatum</i> Meisn	Babusar top	Hazara	Iqbal Dar <i>et al.</i>	09245
<i>P. sarobiense</i> Rech. f.	Meiragean	Chitral	Wali-Ur-Rehman	116235
<i>P. plebijum</i> R. Br.	Dhulli	Poonch	Bashir Ahmad and Javed	109471
	Kot Jamal	Mirpur	Shahzad and Arif	49423
<i>P. effusum</i> Meisn.	Bajur	Dir	Ghulam Farooq	26448
	Nawal Nadi	Poonch	M.N. Choudhari <i>et al.</i>	26507
<i>P. arenastrum</i> Boreau	Nall	Khuzdar	Muqarrab Shah and Dilawar	108251

cells on its abaxial surface. Irregular cells with pitted, thick and undulating walls on both leaf epidermises were observed in *P. sarobiense*, *P. plebijum*, *P. effusum*, *P. olivascens* and *P. paronychioides*. Ayodele and Olowokudejo (2006) reported striated polygonal cells in *P. plebijum*, 50-100 μm wide on adaxial surface and 55-100 μm on abaxial surface. *P. rottboellioides* and *P. molliiforme* were characterized by tetrahedral, pentagonal and hexagonal epidermal cells. At specific level epidermal cell size is helpful to some extent for the distinction of species. Maximum cell size was recorded on the abaxial surface of *P. polycnemoides* (100-130 \times 35-55 μm) and *P. effusum* adaxial (90-120 \times 30-100 μm) and abaxial surface (100-120 \times 25-125 μm), while minimum in *P. paronychioides* adaxial (30-55 \times 25-35 μm), abaxial surface (30-65 \times 15-30 μm) and *P. rottboellioides* adaxial surface (25-60 \times 20-30 μm). In most of the species of *Polygonum* L. length of epidermal cells was more or less double the width of cells (Fig. 3, Table II).

Leaves in *Polygonum* L. were amphistomatic with different frequency of stomata distribution on both leaf surfaces and also more than one type of stomata were noted on the single leaf surface. Stomatal pattern is quite variable in the family Polygonaceae (Inamdar, 1971; Mitchell, 1971; Haraldson, 1978) and could not be used to delimit taxa (Lersten & Curtis, 1992). During the present study four stomatal types were recorded in genus (Anisocytic, paracytic, pericytic & staurocytic). Anisocytic was the most prevalent type of stomata in the genus (Fig. 1A, D, G, I). *P. rottboellioides* is the only species with staurocytic type of stomata along with common anisocytic type. Pericytic stomata were recorded in *P. plebijum* along with anisocytic type (Fig. 1F). Kapoor *et al.* (1971) noted anomocytic, anisocytic and paracytic type of stomata in *P. plebijum*, while Ayodele and Olowokudejo (2006) reported only large anisocytic stomata. Recently, Ahmad *et al.* (2009) suggested

diacytic and amphianisocytic stomata for the same species. Anisocytic and paracytic stomatal pattern was observed in *P. arenastrum* and *P. molliiforme*. Average stomata size varied between 15 \times 6 μm (*P. aviculare* adaxial surface) to 32 \times 21 μm (*P. polycnemoides* adaxial surface). In *P. patulum* size of stomata was of same range on both surfaces (15-25 \times 10-15 μm).

Schotsman (1950) proposed that epidermal glands of *Polygonum* L. are reliable characters for the identification of species. They originate from epidermal cells and are of significant importance in the study of angiosperms (Werker, 2000). Different taxa can be identified on the basis of trichomes (Munsif *et al.*, 2007). In the genus *Polygonum* L. non-glandular trichomes were totally absent, while centrally one to three-celled peltate glands with 5-6 subsidiary cells were present in few species (Fig. 1B-C, H). In *P. rottboellioides*, *P. paronychioides*, *P. arenastrum*, *P. afghanicum*, *P. patulum*, *P. aviculare*, *P. molliiforme*, *P. effusum* and *P. olivascens* no trichomes were seen. Lersten and Curtis (1992) reported the presence of glandular trichomes in *P. paronychioides*. *P. cognatum* can be identified due to the presence of one to three-celled peltate glands. In *P. polycnemoides* centrally one and three-celled peltate trichomes were in close proximity to stomata (Lersten & Curtis, 1992; reported the absence of glands). In *P. plebijum* two-celled peltate trichomes were present only on abaxial surface. Ayodele and Olowokudejo (2006) did not see any type of peltate trichomes on both epidermises of West African *P. plebijum*. Trichome size considerably showed variation in different taxa of *Polygonum* L. However, the size of three-celled trichomes in *P. cognatum* adaxial surface (37.5 \times 23 μm) and in *P. polycnemoides* adaxial surface (34 \times 38 μm) was recorded to be the maximum. Size of one-celled trichomes in *P. sarobiense* was same on both surfaces (Table II).

In order to show the relationship among different

Table II. Summary of qualitative and quantitative epidermal characteristics of genus *Polygonum* L. (All measurements are in μm)

Foliar characters	<i>P. cognatum</i>	<i>P. arenastrum</i>	<i>P. sarobiense</i>	<i>P. plebium</i>	<i>P. rottielliioides</i>	<i>P. aviculare</i>	<i>P. molliaeforme</i>	<i>P. paronychioides</i>	<i>P. polynemoides</i>	<i>P. patulum</i>	<i>P. effusum</i>	<i>P. afghanicum</i>	<i>P. olivascens</i>
Ordinary epidermal cells (Adaxial/Abaxial)	Polygonal cells with pitted and thick walls/ Irregular shaped cells with pitted walls	Hexagonal, heptagonal, smooth walled, slightly irregular and not much elongated/Hexagonal, heptagonal	Irregular shape cells with thick, pitted and undulating walls/ Irregularly shaped cells	Irregular in shape, slightly pitted and undulating walls / Irregular in shape	Tetrahedral, pentagonal, hexagonal, pitted walls/ Tetrahedral, pentagonal, hexagonal cells with pitted walls	Pentagonal, hexagonal and polygonal/ Pentagonal, hexagonal and polygonal	Tetrahedral, pentagonal, hexagonal in out line, pitted walls with slight undulation/ Tetrahedral, pentagonal, hexagonal	Irregular cells with undulating and pitted thick walls/ Irregular shape cells with pitted undulating walls	Hexagonal cells making benzene ring like structure / Benzene ring like hexagonal cells	Hexagonal, benzene ring like cells with straight thick and slightly pitted walls/ Hexagonal cells with slightly pitted walls	Irregular in shape with pitted walls/ Irregular cells	Large tubular cells, irregular in shape with thick pitted walls / Irregular cells with undulating and pitted walls	Irregular in shape with undulating walls/ Irregular shape cells
Stomata (Adaxial/Abaxial)	Anisocytic / Anisocytic, frequently distributed	Anisocytic, paracytic/ Anisocytic and paracytic, stomata are equally distributed on both surfaces	Anisocytic/ Anisocytic	Anisocytic / pericytic/ Anisocytic, pericytic	Anisocytic, staurocytic/ Anisocytic, staurocytic	Paracytic/ Paracytic	Anisocytic, paracytic / Anisocytic, paracytic	Anisocytic/ Anisocytic	Anisocytic/ Anisocytic	Anisocytic/ Anisocytic	Anisocytic/ Anisocytic	Anisocytic/ Anisocytic	Anisocytic / Anisocytic
Non-glandular trichomes (Adaxial/Abaxial)	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent
Glandular trichomes (Adaxial/Abaxial)	One to three-celled peltate glands with striations/One-celled peltate	Absent/ Absent	One-celled peltate / One-celled peltate	Absent/ Two-celled peltate gland	Absent/ Absent	Absent / Absent	Absent/ Absent	Absent/ Absent	One and three-celled peltate glands / same as on adaxial surface	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent
Length of ordinary epidermal cells in μm (Adaxial/Abaxial)	52 \pm 1.5 (40-75)/ 52 \pm 1.8 (35-75)	80 \pm 7.07 (40-100)/ 73 \pm 13.5 (35-95)	55 \pm 11.6 (40-100)/ 54 \pm 1.87 (50-60)	69 \pm 8.42 (50-90)/ 91 \pm 9.79 (70-125)	39 \pm 5.78 (50-90)/ 45 \pm 5.70 (35-65)	50 \pm 6.51 (25-60)/ 52 \pm 7.51 (35-80)	42 \pm 5.38 (25-55)/ 49 \pm 6.20 (35-65)	37 \pm 5.04 (30-55)/ 42 \pm 6.44 (30-65)	97 \pm 4.35 (85-110)/ 112 \pm 5.8 (100-130)	52 \pm 7.17 (35-70)/ 56 \pm 8.06 (40-80)	102 \pm 5.00 (90-120)/ 106 \pm 4.00 (100-120)	80 \pm 10.20 (60-100)/ 65 \pm 12.41 (35-95)	72 \pm 5.14 (60-90)/ 68 \pm 13.0 (45-100)
Width of ordinary epidermal cells in μm (Adaxial/Abaxial)	35 \pm 3.53 (25-45)/ 26 \pm 1.0 (25-30)	31 \pm 2.44 (25-35)/ 34 \pm 4.22 (25-45)	33 \pm 3.39 (25-45)/ 32 \pm 3.39 (25-40)	36 \pm 5.07 (25-45)/ 36 \pm 6.20 (20-55)	25 \pm 2.23 (20-30)/ 25 \pm 2.23 (25-35)	32 \pm 3.74 (25-45)/ 27.5 \pm 1.2 (25-30)	25 \pm 2.2 (20-30)/ 30 \pm 1.5 (25-35)	30 \pm 1.58 (25-35)/ 21 \pm 2.50 (15-30)	44 \pm 1.87 (40-50)/ 44 \pm 3.31 (35-55)	27 \pm 1.22 (25-30)/ 31 \pm 4.0 (20-40)	72 \pm 12.41 (30-100)/ 70 \pm 23.3 (25-125)	30 \pm 1.58 (25-35)/ 32.5 \pm 4.78 (25-45)	42 \pm 3.3 (30-50)/ 34 \pm 4.8 (25-50)
Length of stomata in μm (Adaxial/Abaxial)	30 \pm 1.5 (25-35)/ 25 \pm 2.53 (15-35)	13 \pm 2.2 (10-15)/ 25	24 \pm 4.84 (15-40)/ 23 \pm 4.4 (10-35)	18 \pm 1.22 (15-20)/ 20 \pm 2.23 (15-25)	17 \pm 1.22 (15-20)/ 21 \pm 2.10 (15-25)	15 \pm 2.2 (10-20)/ 27 \pm 1.2 (15-25)	17 \pm 0.5 (15-20)/ 20 \pm 2.2 (15-25)	31.5 \pm 3.3 (25-42.5)/ 16 \pm 0.5 (15-20)	32 \pm 3.74 (20-40)/ 22 \pm 1.22 (20-25)	17 \pm 2.69 (15-25)/ 17 \pm 2.69 (15-25)	25.5 \pm 0.3 (25-26.5)/ 20 \pm 1.22 (15-25)	20 \pm 2.88 (15-25)/ 17.5 \pm 1.35 (15-25)	28 \pm 0.55 (25-30)/ 20 \pm 2.23 (15-25)
Width of stomata in μm (Adaxial/Abaxial)	12 \pm 2.0 (10-20)/ 22 \pm 1.22 (20-25)	14 \pm 1.00 (10-15)/ 18 \pm 1.22 (15-20)	14 \pm 2.44 (10-20)/ 20 \pm 1.58 (15-25)	12 \pm 1.22 (10-15)/ 12 \pm 3.0 (5-20)	11 \pm 1.00 (10-15)/ 11 \pm 1.00 (10-15)	6 \pm 1.00 (5-10)/ 14 \pm 1.00 (10-15)	12 \pm 1.22 (10-15)/ 12 \pm 1.22 (10-15)	21 \pm 2.91 (15-30)/ 12 \pm 1.22 (10-15)	21 \pm 2.44 (15-25)/ 12 \pm 1.22 (10-15)	12 \pm 1.22 (10-15)/ 12 \pm 1.22 (10-15)	13 \pm 1.22 (10-15)/ 12 \pm 1.22 (10-15)	12 \pm 1.22 (10-15)/ 17.5 \pm 1.35 (15-20)	16 \pm 1.00 (15-20)/ 13 \pm 1.22 (10-15)
Length of non glandular trichomes in μm (Adaxial/Abaxial)	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent
Width of non glandular trichomes in μm (Adaxial/Abaxial)	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent
Length of glandular trichomes in μm (Adaxial/Abaxial)	One-celled 22 \pm 1.4 (20-25)/ 22.5 \pm 0.9 (20-25) Two-celled 24 \pm 3.64 (20-30)/ Absent Three-celled 37.5 \pm 1.2 (35-40)/ Absent	Absent/ Absent	One-celled 18 \pm 1.2 (15-20)/ 18 \pm 1.2 (15-20)	Two-celled Absent/ 12 \pm 1.2 (10-15)	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	One-celled 25/12 \pm 1.2 (10-15) Three-celled 34 \pm 3.67 (25-45)/ 21 \pm 2.50 (15-30)	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent
Width of glandular trichomes in μm (Adaxial/Abaxial)	One celled 9.5 \pm 1.7 (5-15) Two-celled 21 \pm 0.5 (20-22.5)/ Absent Three-celled 23 \pm 1.2 (20-25)/ Absent	Absent/ Absent	One celled v13 \pm 1.22 (10-15)/ 13 \pm 1.22 (10-15)	Two-celled Absent/ 10 \pm 1.11 (7.5-12.5)	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent	One-celled 22 \pm 1.22 (20-25)/ 14 \pm 1.87 (10-20) Three-celled 38 \pm 2.54 (30-45)/ 22 \pm 2.5 (15-30)	Absent/ Absent	Absent/ Absent	Absent/ Absent	Absent/ Absent

*Mean values followed by min-max in parentheses. \pm = Standard error

species of *Polygonum* L., cluster analysis was performed. A dendrogram was made on the basis of length / width of epidermal cells, presence or absence of stomata, non-glandular and glandular trichomes on adaxial and abaxial surface. *P. aviculare* and *P. cognatum* were found to be

closely related to each other. *P. molliaeforme*, *P. rottielliioides* pair and *P. patulum*, *P. sarobiense* pair were equally similar. This analysis proved that foliar anatomical investigations are taxonomically significant in understanding the relationships between the species (Fig. 2).

Fig. 2. Cluster analysis of different species of *Polygonum* L. based on foliar anatomical characters

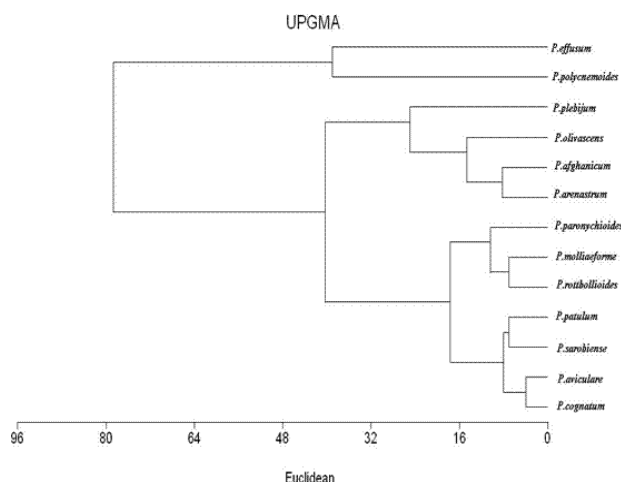
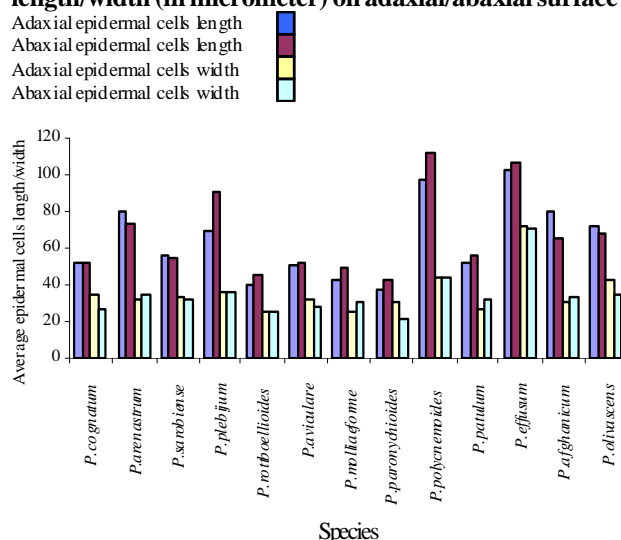


Fig. 3. Comparison of different species of *Polygonum* L. of Polygonaceae on the basis of epidermal cells length/width (in micrometer) on adaxial/abaxial surface



Key to the species of *Polygonum*

- 1a.** Epidermal cells polygonal on adaxial surface, one to three-celled peltate trichomes present on adaxial leaf surface.....1. *P. cognatum*
- 1b.** Epidermal cells tetrahedral, pentagonal, hexagonal, heptagonal or irregular on adaxial surface, mostly two-celled peltate trichomes, sometimes one and three-celled trichomes present or totally absent.....2
- 2a.** Epidermal cells hexagonal and heptagonal in outline, same range of stomata length and width on adaxial surface i-e 10-15×10-15 µm.....2. *P. arenastrum*
- 2b.** Epidermal cells tetrahedral, pentagonal, hexagonal or irregular in outline, variable length and width of stomata on adaxial surface.....3
- 3a.** Nearly equal epidermal cells on adaxial and abaxial surface, centrally one-celled peltate trichomes present.....3. *P. sarobiense*

3b. Epidermal cells with variable size on adaxial and abaxial surface, trichomes two-celled or one and three-celled.....4

4a. Two-celled peltate trichomes present only on abaxial surface, stomata anisocytic and pericytic.....4. *P. plebium*

4b. Two-celled peltate trichomes on both surfaces or absent, stomata anisocytic, staurocytic or paracytic.....5

5a. Anisocytic and staurocytic stomata on the same surface, same epidermal cells width on both surfaces (25 µm).....5. *P. rothboellioides*

5b. Stomata anisocytic and paracytic, epidermal cells width different on both surfaces.....6

6a. Epidermal cells pentagonal, hexagonal and polygonal on both surfaces, stomata with minimum width on adaxial surface (5-10 µm).....6. *P. aviculare*

6b. Epidermal cells tetrahedral, pentagonal, hexagonal, polygonal or irregular on both leaf surfaces, width of stomata on adaxial surface more than 10 µm.....7

7a. Epidermal cells tetrahedral, pentagonal and hexagonal on both leaf surfaces, anisocytic and paracytic stomata on the same leaf surface.....7. *P. molliiforme*

7b. Epidermal cells hexagonal or irregular in outline on both leaf surfaces, single type of stomata, either anisocytic or paracytic.....8

8a. Small sized epidermal cells on adaxial surface i-e., 42×21 µm, stomata length on adaxial surface varies from 25-42.5 µm.....8. *P. paronychioides*

8b. Epidermal cells larger in size on adaxial surface, stomata length less than 42.5 µm.....9

9a. One and three-celled peltate trichomes present, epidermal cells length on abaxial surface varies from 100-130 µm.....9. *P. polycnemoides*.

9b. Peltate trichome absent and length of epidermal cells less than 130 µm.....10

10a. Epidermal cells hexagonal in outline; equal sized stomata on both leaf surfaces.....10. *P. patulum*.

10b. Epidermal cells irregular in outline; size of stomata different on both leaf surfaces.....11

11a. Both leaf surfaces with nearly equal sized epidermal cells, same range of stomata width on both surfaces i-e, 10-15 µm.....11. *P. effusum*

11b. Cell size different on both surfaces, width range different on both surfaces.....12

12a. Stomata width on adaxial leaf surface varies from 10-15 µm, 80 µm long epidermal cells on adaxial surface.....12. *P. afghanicum*.

12b. Stomatal width on adaxial surface varies from 15-20 µm, epidermal cells on adaxial surface 72 µm long.....13. *P. olivascens*

CONCLUSION

Based on present study, it would appear that although there is considerable variation in the qualitative foliar anatomical characters at specific level, but insufficient

grounds for using these to recognize different taxa. Nevertheless, it is clear from cluster analysis that the combination of qualitative and quantitative anatomical features is potentially significant to identify species.

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