BULL. BOT. SURV. INDIA
Vol. 13, Nos. 3 & 4 : pp. 244-259, 1971

EPIDERMAL AND VENATION STUDIES IN THE INDIAN SPECIES OF *POLYGONUM* LINN. (POLYGONACEAE)—I.

S. L. Kapoor, P. C. Sharma* and L. D. Kapoor

National Botanic Gardens, Lucknow

ABSTRACT

Epidermal characters and venation pattern of leaves of ten Indian species of *Polygonum* Linn. belonging to five sections *viz., P. recumbens* Royle ex Bab. (Sect. Avicularia Meissn.) ; *P. affine* D. Don, *P. amplexicaule* Don, *P. vaccinifolium* Wall. ex Meissn. (Sect. Bistorta Tourn.) ; *P. glabrum* Willd., *P. lapathifolium* Linn., *P. serrulatum* Lagasc. (Sect. Persicaria Meissn.) ; *P. chinense* Linn., *P. nepalense* Meissn. (Sect. Cephalophilon) and *P. rumicifolium* Royle ex Bab. (Sect. Aconogon Meissn.) have been investigated for an appraisal of the extent of utility of these characters with regard to the taxonomy of this interesting group. The variability pattern in these features has been found to be independent of the established pattern at sectional level as set by criteria of external morphology. However, these do serve as helpful data of diagnostic value.

The genus *Polygonum* Linn. (Family: Polygonaceae) with its about 300 species is of a cosmopolitan but especially temperate distribution (Willis, 1966). About 80 species are known to occur in India (Hooker, J. D., 1886; Calder *et al.,* 1926; Razi, 1959).

The taxonomy of the Indian species of *Polygonum* as based on gross morphology alone has presented difficulties to the pioneer workers. Hooker (1886) observed, "A very troublesome genus, the Indian species of which have been much confused, and I cannot hope that I have finally settled the limits of those especially of the Persicaria and Avicularia sections......"

For an appraisal of the extent of utility of other morphological characters with regard to the taxonomy of Indian species of *Polygonum* the authors have presently undertaken a detailed study of the epidermis and the venation of their leaves. As has been concluded by Stace (1965), these characters are often of undoubted importance 'as further pieces of the jigsaw of complete systematic evidence' This study may also find use in determining and standardizing the crude drug material as sold in the market, for the leaves of several of the *Polygonum* species are employed in indigenous system of medicine or folklore for curing various ailments (Chopra *et al.,* 1956, 1969). Some of the species of *Polygonum* have also been correlated with esophageal cancer (Morton, 1970).

The present account includes ten Indian species of *Polygonum* belonging to five sections, *viz.,* 1. *P. recumbens* Royle ex Bab. (Sect. Avicularia Meissn.); 2. *P. affine* D. Don, 3. *P. amplexicaule* Don, 4. *P. vaccinifolium* Wall. ex Meissn. (Sect. Bistorta Tourn.); 5. *P. glabrum* Willd., 6. *P. lapathifolium* Linn., 7. *P. serrulatum* Lagasc. (Sect. Persicaria Meissn.); 8. *P. chinense* Linn., 9. *P. nepalense* Meissn. (Sect. Cephalophilon); and 10. *P. rumicifolium* Royle ex Bab. (Sect. Aconogon Meissn.).

Of the species investigated here, the ones numbered above as 1, 3, 5, 8 and 9 have been studied by Inamdar (1969, 1970) but he has not worked out the various details of stomatal index and size of stomata, the venation pattern and palisade ratio, etc. The observations made here will enrich the wealth of data accumulated so far.

MATERIAL & METHODS

The leaves of the species of Sect. Persicaria and of *P. chinense* were collected fresh at Lucknow and of the remaining species from herbarium specimens. In most of the cases one or two mature leaves of each specimen were examined and leaves were taken from at least 3 specimens. Dried leaves were soaked in warm water for sometime. These as well as fresh leaves were kept in 10% Nitric Acid for 24-48 hours and then washed in water. Epidermal peelings were taken from apical, middle and basal regions, stained with Delafield's haematoxylin and mounted in 50% glycerine. For study of venation, small pieces were cut from apical, middle and basal regions of mature leaves from portion between midrib and margin.

**Present address :* S.M.P. Unit of CCRIMH, Govt. Ayurvedic College, Patna-3

These were cleared with chloral hydrate, stained with safranin and mounted in canada balsam.

The stomatal index has been derived as follows: stomatal index $= \frac{S}{E+S} \times 100$, where 'S' indicates number of stomata per unit area and 'E', number of epidermal cells per same unit area. The palisade ratio has been obtained as follows: number of palisade cells within 'n' number of epidermal cells divided by number 'n'.

OBSERVATIONS

Whereas the important data have been summarized in tables 1 and 2, and venation has been illustrated in figures 13 to 22, the other interesting features are described below:

Section : Avicularia Meissn.

Polygonum recumbens Royle ex Bab.

Stomata on lower surface almost equally variable in length in middle and basal regions and less in apical, breadth equally variable in apical and middle regions and more in basal, average length maximum in middle, almost equalling in apical and least in basal region, average breadth almost equal in apical and middle regions but maximum in basal, on upper surface length and breadth almost constant in apical and middle regions while both variable—though slightly—in basal region ; *stomatal index* on lower surface exhibits widest range of variation in middle, less in basal region, and least in apical, on upper surface widest range of variation observed in apical region, less in basal and nominal in the middle, average index on lower surface tends to rise from base to middle and middle to apex while on upper surface it takes an almost equal leap from middle towards both apex and base. *Vein islets* more variable in number in middle and relatively less so in apical and basal regions, in last two regions almost equally variable, number per unit area tends to increase from base to middle and middle to apex. *Vein endings* follow same pattern of variability as the islets.

Section : Bistorta Tourn.

P. affine D. Don

Stomata more variable in length in basal region, a little less in apical and least in middle, breadth almost equally variable in apical and basal regions and a little less in middle, average length and breadth maximum in apical region, less in basal and least in middle, occasionally stomata may be as broad as long in middle and basal regions ; *stomatal index* exhibits widest range of variation in middle, less in apical region and least in basal, average index tends to rise from base to middle and from middle to apex. *Vein islets* almost equally variable in number in apical and basal regions while remaining almost constant in middle, figures, however, are quite high for apical region than for middle and basal regions, average number per unit area in middle and basal regions almost equal and the corresponding figure nearly doubled in apical region. *Vein endings* relatively more variable in number in middle, less in basal region and least in apical, average number per unit area is more or less same throughout the leaf.

P. amplexicaule Don

Stomata less variable in length in middle than in apical and basal regions (relatively more variable in basal region than in apical), breadth nearly equally variable throughout the leaf, however, the figures for basal region are lower than those of apical and middle regions, average length maximum in apical region, less in middle and minimum in basal, average breadth maximum in middle, almost equalling in apical region and least in basal ; *stomatal index* exhibits maximum variation in middle, and almost equal variation in apical and basal regions, average index highest in middle, lowering towards both apex as well as base but least in apical region. *Vein islets* vary most in number in middle and nominally in apical and basal regions ; average number per unit area almost same in three regions. *Vein endings* show maximum variation in number in middle, lesser in apical and least in basal region, the figures for apical region are significantly low, average number per unit area in middle region almost four times that of apical region and two times that of basal region.

P. vaccinifolium Wall. ex Meissn.

Stomata more variable in length in middle than in apical and basal regions, in last two regions variation is quite restricted and almost equal, breadth nearly equally variable in middle and basal regions but more or less constant in apical region, figures are highest for middle, lower for basal and least for apical region, stomata tend to be slightly longer and borader in middle region ; *stomatal index* exhibits widest range of variation in middle and minimum in apical region, however, the average index in middle and basal regions is almost same while in apical region nearly one and a half times more. *Vein islets* show an almost equal variation in number throughout the leaf, the number tends to increase from base to middle and middle to apex as indicated by the minimum, average and maximum of the range. *Vein endings* follow same pattern of variability as islets except that range of variation in number is nearly equal in middle and basal regions but wide in apical.

Section : Persicaria Meissn.

Polygonum glabrum Willd.

Stomata on both surfaces exhibit widest range of variation in length in basal region and restricted variation in middle and apical regions, in last two regions range of variation is almost equal, average length maximum in middle, breadth almost equally variable throughout the leaf on lower surface while on upper surface it is almost equally variable in apical and basal regions and slightly more variable in middle, average breadth on lower surface maximum in middle and minimum in basal region, on upper surface it is almost equal in basal and middle region, and lower in apical, rarely stomata on upper surface may be as broad as long in apical and basal regions, twin stomata occasionally present on lower surface, these may be contiguous along the side walls (Fig. 5) or apex of one conjoined with side wall of the other (Fig. 6) ; *stomatal index* on both surfaces exhibits minimum variation in apical region and maximum in basal, average index almost equal in apical and middle regions and lowest in basal. *Vein islets* almost equally variable in number in apical, middle and basal regions, average number per unit area tends to increase from base to middle and middle to apex. *Vein endings* too almost equally variable in number throughout the leaf, average number per unit area highest in middle and almost equally falling towards both apex and base.

P. lapathifolium Linn.

Stomata on lower surface show wider variation in length in middle than in apical and basal regions, in last two regions length almost equally variable, on upper surface length more variable in apical than in middle and basal regions, in last two regions range is almost same, average length on lower surface almost equal throughout the leaf while on upper surface it is almost equal in middle and basal regions and slightly less in apical, breadth on lower surface most variable in middle and least in basal regions, average breadth on lower surface maximum in middle, slightly lower in basal region and minimum in apical, on upper surface it is lowest in apical and almost equal in middle and basal regions ; stomata generally tend to be slightly bigger on upper surface than those on lower surface, on upper surface in middle region they may rarely be almost as broad as long ; *stomatal index* on lower surface exhibits almost equal variation throughout the leaf, on upper surface it is highly variable in middle where occasionally stomata are very much unevenly distributed, average index on upper surface highest in middle, slightly lower in basal region but quite low in apical. *Vein islets* show almost equal variation in number throughout the leaf, average number per unit area highest in apical region and almost equal in middle and basal regions. *Vein endings* too show equal variation in number throughout the leaf, average number per unit area increases from base to middle and middle to apex.

P. serrulatum Lagasc.

Stomata on lower surface showing relatively wider range of variation in both length and breadth in basal region, in apical and middle regions almost equally variable, average length and breadth maximum in apical region, on upper surface range of variation in length although quite restricted, yet it tends to be more restricted in apical region, variation in breadth nominal in apical and basal regions but quite significant in middle, average length maximum in basal region, almost equalling in middle and least in apical, average breadth almost same in apical and basal regions and a little less in middle ; *stomatal index* on lower surface exhibits widest range of variation in apical, lesser in middle and least in basal region, maximum average is observed in basal region and minimum in middle, on upper surface stomata are highly unevenly distributed, non-stomatiferous areas are frequently met with. *Vein islets* more variable in number in middle as compared to the apical region, average number per unit area is higher in middle than in apical region. *Vein endings* follow same pattern of variability as islets.

Section: Cephalophilon Meissn.

P. chinense Linn.

Stomata on lower surface show nominal variation in length in middle region, wider in basal region and widest in apical, breadth varies least in basal region, more in apical and most in middle, average length and breadth maximum in middle, stomata on upper surface significantly bigger ; *stomatal index* on lower surface exhibits widest range of variation in middle, lesser in apical region and least in basal, average index in apical and basal regions almost same and higher in middle, on upper surface stomata are rare, almost absent towards the base. *Vein islets* relatively less variable in number in basal region than in apical and middle regions, average number per unit area is, however, the same throughout the leaf. *Vein endings* highly variable in number in middle, much less in apical region and almost constant in the basal, average number per unit area highest in apical region, much less (nearly half) in middle and further reduced in basal (nearly half of the figure as in middle).

Polygonum nepalense Meissn.

Stomata highly variable both in length as well as breadth, on an average almost double in size than those of *P. chinense*, which belongs to same section ; *stomatal index* exhibits widest range of variation in middle, less in basal region and least in apical, average is maximum in apical region, less in middle and least in basal. *Vein islets* almost equally variable in number in middle and basal regions and more so in apical, average number per unit area is almost same in middle and basal regions and higher in apical. *Vein endings* show a much restricted variation in number in basal region as compared to that in apical and middle regions, average number per unit area is, however, almost same throughout the leaf.

Section: Aconogon Meissn.

P. rumicifolium Royle ex Bab.

Stomata highly variable in length, breadth also variable, occasionally stomata may in the apical region be almost of the same length and breadth ; *stomatal index* highly variable in apical, relatively much less so in middle and least in basal region, average index increases from base to middle and from middle to apex, at apex it is almost double of the average at base. *Vein islets* with restricted and almost identical range of variation in number throughout the leaf, average almost the same throughout. *Vein endings* more variable in number in middle, less so in apical region and almost constant in the basal, the number increases from base to middle and from middle to apex.

Of the species investigated here, *P. nepalense* possesses distinctively large stomata ($50.3 \times 39.5\mu$), followed by *P. rumicifolium* ($38.7 \times 25.5\,\mu$). Within a species the maximum variation in stomatal length on lower surface is observed in *P. nepalense* (over 20μ) followed by *P. rumicifolium* (18.5μ); *P. amplexicaule* also exhibits wide variation in stomatal length (10μ). The width varies maximum in *P. nepalense* followed by *P. amplexicaule* (variation around $10\,\mu$ or more).

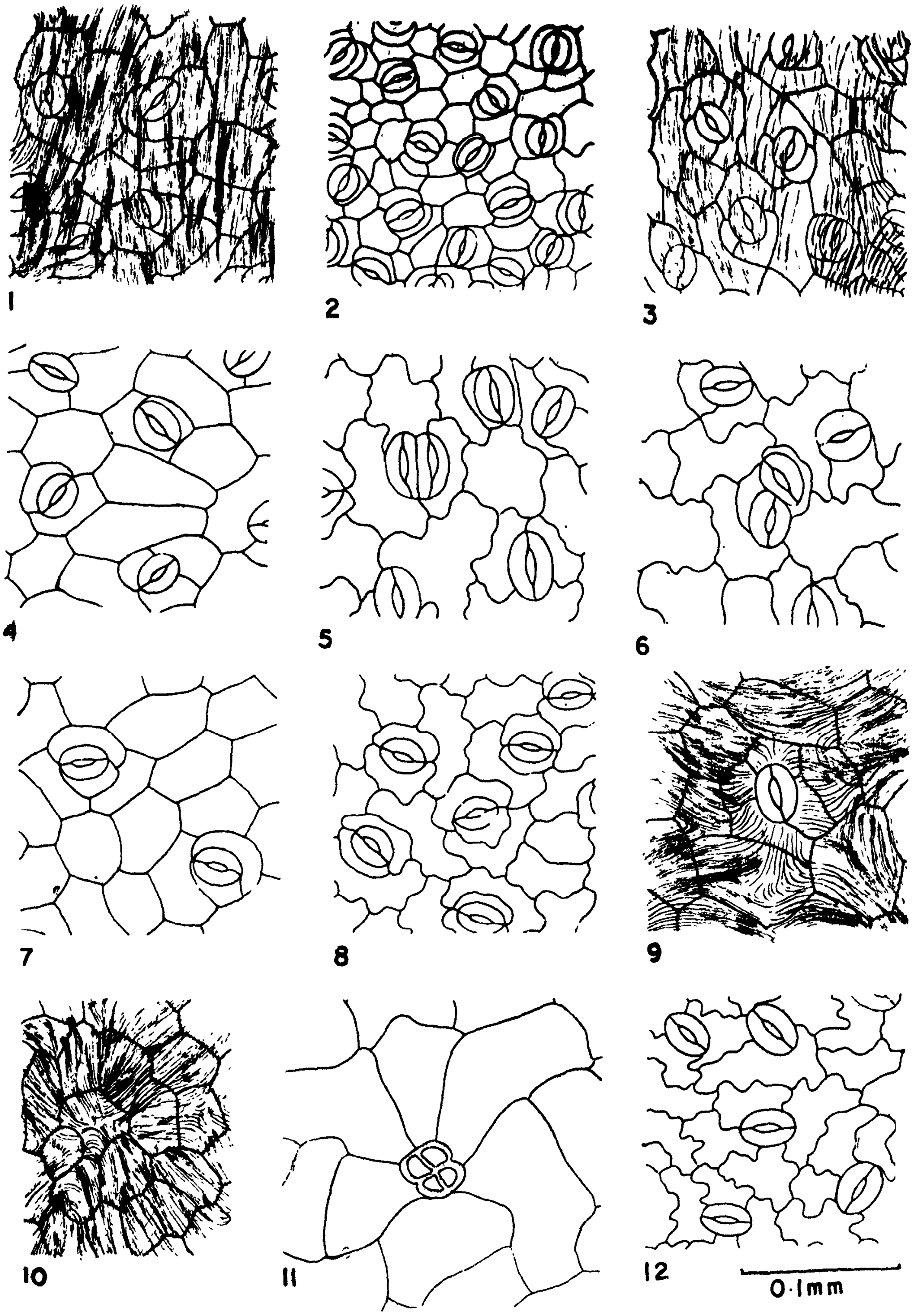
Stomata on upper surface, where present, tend to be slightly larger than those on lower surface ; in *P. chinense* upper surface stomata are much larger than lower surface ones.

The orientation and arrangement of stomata do not show any definite pattern.

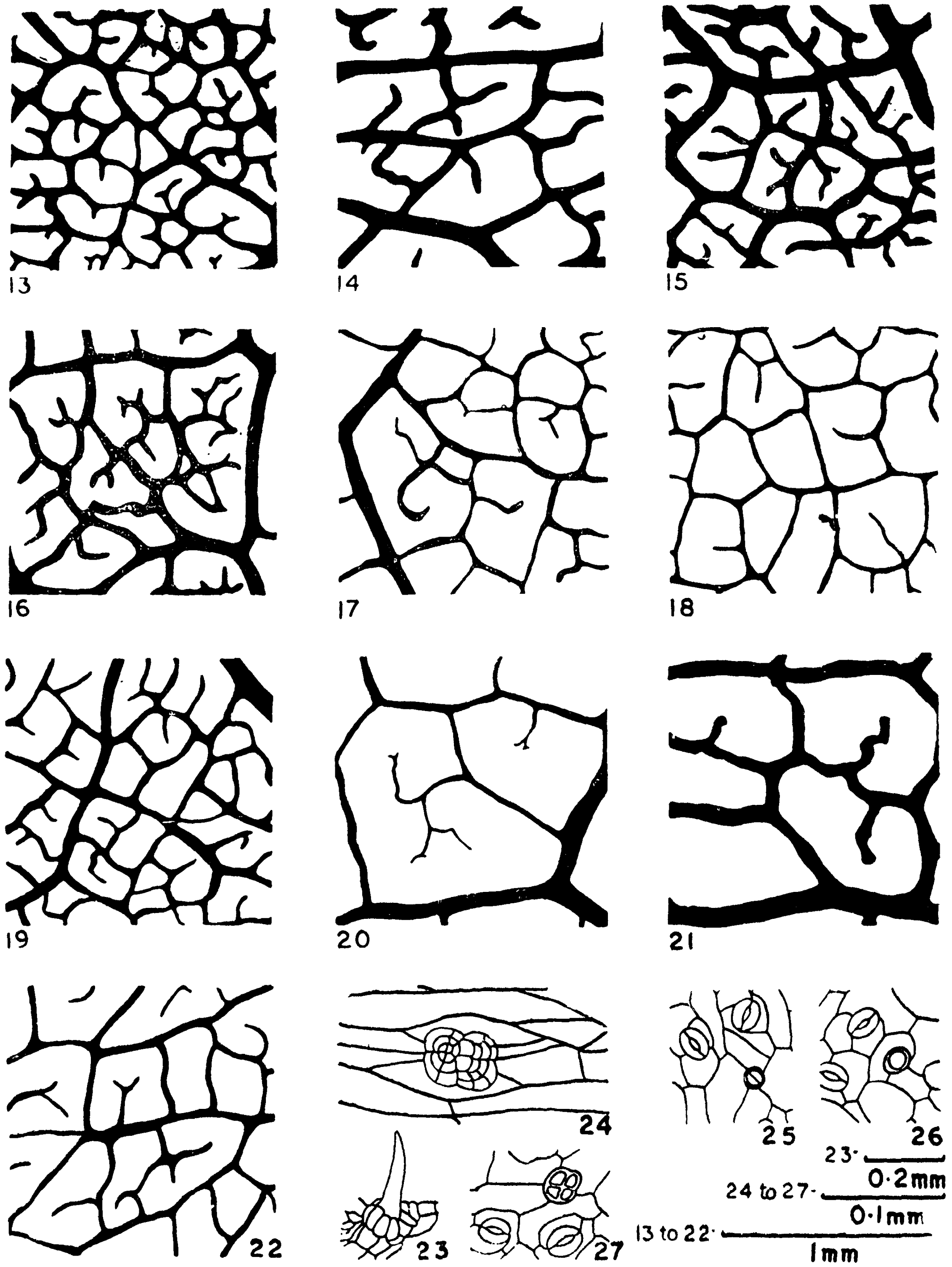
The stomatal size in a particular species in the apical, middle and basal regions does not show any remarkable variation. However, on the lower surface, the stomata tend to be longest in the apical region in *P. affine*, *P. amplexicaule* and *P. serrulatum* ; and in the middle region, in *P. recumbens*, *P. vaccinifolium*, *P. glabrum* and *P. chinense* (enough readings could not be taken for *P. nepalense* and *P. rumicifolium*). They are shortest in length on lower surface in middle region in *P. affine* and *P. serrulatum* and in basal region in *P. recumbens*, *P. amplexicaule*, *P. vaccinifolium* and *P. glabrum*. The width also does not show much variation in the three regions although it tends to be maximum in apical region in case of *P. affine* and *P. serrulatum*, in middle region in case of *P. vaccinfolium*, *P. glabrum*, *P. lapathifolium* and *P. chinense ;* it tends to be minimum in apical region in case of *P. vaccinifolium*, *P. lapathifolium* and *P. chinense* and in middle region in case of *P. affine*.

The lower epidermal cell wall is distinctly sinuous in *P. glabrum* (Figs. 5 & 6), *P. lapathifolium*, *P. serrulatum* (Fig. 8)—all belonging to the same section, *P. nepalense* and *P. rumicifolium ;* in remaining species it is straight or arched (in *P. affine* may be slightly sinuous also). The upper epidermal cell wall is in almost all the species straight or arched [only in *P. rumicifolium* (Fig. 10) it may also be slightly sinuous].

The cell wall on lower surface is distinctly striated in *P. recumbens*, *P. vaccinifolium* and *P. chinense* but in the latter the striations are radiating from stomata (Fig. 9) or glands and in the two former ones they run parallel to stomatal axis (Figs. 1 & 3 respectively). The cell wall on upper surface is striated in *P. recumbens* (faintly so in this case), *P. affine*, *P. chinense* and *P. nepalense* but while the striations are irregular in case of *P. affine* (small too in this) and *P. nepalense*, they are parallel to stoma-



FIGS. 1-12 : Epidermal peelings: 1. *Polygonum recumbens* (lower) ; 2. *P. affine* (lower) ; 3. *P. vaccinifolium* (lower) ; 4. *P. glabrum* (upper) ; 5. *P. glabrum* (lower) ; 6. *P. glabrum* (lower); 7. *P. serrulatum* (upper) ; 8. *P. serrulatum* (lower); 9. *P. chinense* (upper) ; 10. *P. nepalense* (upper) ; 11. *P. rumicifolium* (upper) ; 12. *P. rumicifolium* (lower).



FIGS. 13-22. Venation : 13. *Polygonum recumbens* ; 14. *P. affine* ; 15. *P. amplexicaule* ; 16. *P. vaccinifolium* ; 17. *P. glabrum* ; 18. *P. lapathifolium* ; 19. *P. serrulatum* ; 20. *P. chinense* ; 21. *P. nepalense* ; 22. *P. rumicifolium*.
FIG. 23. Trichome : *P. rumicifolium*.
FIGS. 24-27. Sessile glands (lower surfaces) : 24. *P. rumicifolium* ; 25. *P. vaccinifolium* ; 26. *P. recumbens* ; 27. *P. serrulatum*.

tal axis in *P. recumbens* and radiating from stomata or glands in *P. chinense.*

In all the species sessile glands are present on both the surfaces of leaves mainly on or near midrib and main veins; however, they are relatively sparser on upper surface. In most of the species glands are 2- to many-celled(Figs. 24, 25 & 27) except *P. affine*, in which they are only 1-celled. In *P. recumbens* (Fig. 26), *P. amplexicaule* and *P. vaccinifolium* also 1-celled glands have been observed alongwith 2- or more-celled ones.

DISCUSSION

One of the major contributing factors towards fruitful taxonomic research is the understanding that only a synthesis of all evidence—macroscopic, microscopic and other—will provide anything approaching a complete picture of any taxon. Epidermal features including stomata and trichomes, and venation have found a prominent place among the parts of the plants which have been studied for this purpose and have frequently provided valuable supplementary evidence (Hall & Melville, 1951; Carolin, 1954; Watson, 1962, 1965; Ahmad, 1964 a, b, c; Stace, 1965 and others). The genus *Polygonum* remains yet to be thoroughly studied with regard to these characters and their systematic value.

Metcalfe & Chalk (1950) recorded that the stomata in Polygonaceae are nearly always ranunculaceous (anomocytic), except in *Coccoloba*, species of which have distinct subsidiary cells and in *Oxytheca* and *Triplaris*, which have rubiaceous stomata. *Husson (1966) observed that Polygonaceae stomata are fundamentally anisocytic (cruciferous) as seen in Erigoneae and less clearly in Rumiceae; they may also be paracytic (rubiaceous) in *P. hydropiper* and pseudoanomocytic, *e.g.* in *Rumex;* Coccolobeae have several narrow flat cells around the guard cells. Inamdar (1969) reported cruciferous (anisocytic), rubiaceous (paracytic) and ranunculaceous (anomocytic) stomata in the leaves of *Antigonon leptopus* as well as *Polygonum glabrum.* He, later (Inamdar, 1970), found all these three types of stomata occurring in *Polygonum plebeium, P. amplexicaule, P. amphibium, P. barbatum* var. *gracile, P. capitatum, P. chinense, P. dumetorum, P. lanigerum, P. nepalense, P. recumbens* besides *Fagopyrum cymosum, Muehlenbeckia platyclada* and *Rumex hastatus.*

The authors could not confirm the occurrence of rubiaceous stomata in *P. chinense* and *P. recumbens* in which only ranunculaceous and cruciferous ones have been seen. In *P. affine* cruciferous ones have not been seen; only rubiaceous and ranunculaceous have been observed alongwith a modification of tetracytic type in which the pair of polar subsidiary cells are of different size than the lateral ones (Fig. 2). In *P. nepalense* the cruciferous type is present though rare, alongwith ranunculaceous and rubiaceous ones. In *P. vaccinifolium* rubiaceous type is rarely present alongwith ranunculaceous and cruciferous ones. Only in *P. lapathifolium* all the three types are frequently present. *P. serrulatum* shows only rubiaceous type (Figs. 7 & 8) and *P. rumicifolium* only ranunculaceous ones (Fig. 12). Whereever the rubiaceous type of stomata are present, in most of the cases the two subsidiary cells are unequal in size (Figs. 2, 4, 7, 8).

With regard to the stomatal index as based on random readings taken throughout the leaf surface, a wide range is observed within a species. This is because of haphazard grouping of stomata in various but indefinite areas in most of the species investigated here. This tendency is most highly pronounced in *P. rumicifolium* in which the range of stomatal index for the lower leaf surface is 8-36.6. The variation in stomatal index of lower leaf surface is of a considerably high order in *P. vaccinifolium* (8.7-26), *P. nepalense* (18-33.5) and *P. recumbens* (10-25). *P. affine* exhibits least variation (14-21.8). Taking into account the average stomatal index for the lower leaf surface, *P. amplexicaule* (25.6) and *P. nepalense* (25.4) come closer to each other; on the other hand *P. vaccinifolium* (19.7), *P. glabrum* (19.5) and *P. rumicifolium* (19.8) come closer together; *P. affine* (17.2) and *P. lapathifolium* (17.3) form another group. *P. chinense* stands out for lowest average stomatal index (12.3) and for lowest minimum of the range (6).

The stomata are absent on upper surface in *P. affine, P. amplexicaule* (Inamdar, 1970 reports presence), *P. vaccinifolium, P. nepalense* (Inamdar, 1970 reports presence) and *P. rumicifolium;* in *P. chinense* these are rare with tendency to disappear towards the base. In the remaining species they are present but sparser when compared with the lower surface in the same species. Here too the variation in the stomatal index is of a high order reaching widest in *P. lapathifolium* (6.2-23.5); it is narrowest in *P. glabrum* (9.5-16.7), which incidentally belongs to the same section.

The ranges of stomatal index in apical, middle and basal regions of a particular species indicate some

*Original not seen.

interesting features. In *P. recumbens, P. affine, P. amplexicaule, P. glabrum, P. lapathifolium* and *P. chinense* the minimum of the range on lower surface does not vary much in the three regions, while in *P. vaccinifolium, P. serrulatum, P. nepalense* and *P. rumicifolium* it varies considerably; in maximum of the range in the three regions there is a considerable variation in case of *P. nepalense* and *P. rumicifolium.*

In matters of pubescence, *P. rumicifolium* is distinct in having on the margin of the leaf and both the surfaces multicellular papillae like swollen bases supporting long unicellular hairs (Fig. 23); *P. amplexicaule, P. lapathifolium* and *P. nepalense* possess simple, unicellular, filiform trichomes; in *P amplexicaule* and *P. recumbens* the margin of the leaf is papillate (in the latter such papillae are present on the midrib also). In remaining species the leaf surface is glabrous.

The venation pattern of the species investigated so far, yielded some encouraging data. The vein islets per sq. mm, considering the averages as based on random readings taken throughout the leaf surface, have yielded the distinctly high value (21.3) for *P. recumbens;* the corresponding values for *P. vaccinifolium* and *P. serrulatum* are also of a high order—17.9 and 16.5 respectively. These values are quite low for *P. chinense* and *P. nepalense*—2.8 and 3.7 respectively; in the remaining species it ranges from 6 to 10. However, the minimum of the range of variation in number of vein islets per sq. mm of one species overlaps with that of the maximum of the other species.

The vein islets per sq. mm in the different regions of the leaf, *i.e.*, apex, middle and base, of a particular species may also be compared. The minimum of the range in apical region as compared with the corresponding figure for middle and basal regions of the same species is highest in *P. recumbens, P. affine, P. vaccinifolium, P. glabrum* (in this case the minimum of the middle region is same) and *P. lapathifolium;* apical region shows the lowest minimum of the range in *P. chinense* which itself is distinctive for the lowest order of the number of vein islets per sq. mm. The minimum value in the three regions of the leaf of a species is same in case of *P. amplexicaule, P. nepalense* and *P. rumicifolium.* The average figures and the maximum of the range in apical, middle and basal regions follow the same pattern as the minimum value in the three regions in case of *P. recumbens, P. vaccinifolium* and *P. glabrum* (in this case the maximum is same for apical and middle regions). The average figures and maximum of the range show higher values in the middle region as compared to the apical and basal regions in *P. amplexicaule* and *P. serrulatum* (range for base could not be worked out for the latter).

The average number of vein endings per sq. mm. is recorded highest in *P. vaccinifolium* (19.8) followed by *P. recumbens* (13.4). In *P. affine, P. amplexicaule, P. glabrum, P. lapathifolium, P. serrulatum, P. chinense* and *P. rumicifolium* the number ranges from 4 to 7.5 while in *P. nepalense* it is lowest (2.5). The number is, however, highly variable particularly in *P. amplexicaule* (2-15), *P. vaccinifolium* (12-35) and *P. chinense* (1-8).

In a particular species the number may or may not be significantly variable in apical, middle and basal regions. The average for the three regions is nearly same in *P. affine* and *P. nepalense*, nearly same in apical and basal region but higher in middle region in case of *P. glabrum* and *P. amplexicaule,* in latter the reading for basal region is much higher, gradually increasing from base to middle and middle to apex (*i.e.* apical region having the highest reading) in case of *P. recumbens, P. vaccinifolium, P. lapathifolium, P. chinense* and *P. rumicifolium.*

The average palisade ratio shows highest figure in *P. rumicifolium* (15). In *P. vaccinifolium* and *P. amplexicaule* the maximum value reaches 13, otherwise the average is much less in the former (9) and still much less in the latter (7). In *P. nepalense* the average is 8. In *P. recumbens, P. affine, P. glabrum, P. lapathifolium* and *P. serrulatum* average is between 4-6. Lowest average is recorded for *P. chinense* (2), range of the palisade ratio being 1-2-3.

The pattern of stomatal index (lower leaf surface), vein islets, vein endings and palisade ratio as based on random readings taken throughout the leaf surface is presented in Fig. 28 indicating the average also to facilitate comparison.

Since the epidermal and venation characteristics of leaves are generally subject to variation by numerous factors, a statistical analysis of these features is given in table 3, indicating averages, number of observations made, standard deviations, and fiducial limits. This statistical analysis seems to suggest that the differences in the characters studied are by and large significant and the variations detected are of diagnostic value.

TABLE-1

SPECIES INVESTIGATED	STOMATA Type	Stomatal Index Lower	Stomatal Index Upper	Size range in μ Lower	Size range in μ Upper	EPIDERMAL CELL Cell wall and Striation Lower	Cell wall and Striation Upper
Section: Avicularia Meissn.							
Polygonum recumbens Royle ex Bab.	Ra & Cr	10-*15.7*-25	8.3-*12.1*-20	23.3-*25.3*-26.7 × 16.7-*17.7*-20	23.3-*26.3*-26.7 × 18.3-*18.7*-20	Straight or Arched Prominently striated [Str. parallel to stomatal axis]	Straight or Arched Faintly striated
Section: Bistorta Tourn.							
P. affine D. Don	Ru & Ra	14-*17.2*-21.8	Absent	20-*23.1*-26.7 × 16.7-*18*-20	Absent	Straight or Arched or Slightly sinuous	Straight or Arched Str. small irregular
P. amplexicaule Don	Ra & Ru & Cr	20-*25.6*-31.5	Absent	25-*31.7*-36.7 × 18.3-*23.7*-28.3	Absent	Sinuous	Straight or Arched
P. vaccinifolium Wall. ex Meissn.	Ra & Cr & rarely Ru	8.7-*19.7*-26	Absent	25-*26.7*-30 × 16.7-*17.8*-20	Absent	Straight or Arched Prominently str. [Str. parallel to stomatal axis]	Straight or Arched
Section: Persicaria Meissn.							
P. glabrum Willd.	Ru & Cr & Ra	13.9-*19.5*-23.1	9.5-*13.0*-16.7	26.7-*32*-35 × 20-*24*-28.3	30-*34.3*-38.3 × 23.3-*25.7*-28.3	Sinuous	Straight or Arched
P. lapathifolium Linn.	Cr & Ra & Ru	12.5-*17.3*-21	6.2-11.5-23.5	25-*26.3*-30 × 16.7-*19.7*-21.7	23.3-*27.7*-30 × 16.7-*21*-26.7	Sinuous	Straight or Arched
P. serrulatum Lagasc.	Ru	12.5-*18.1*-22.2	7-13.8-17.6	23.3-*26.3*-30 × 16.7-*19.7*-21.7	26.6-*29.3*-31.7 × 16.7-*20.7*-21.7	Sinuous	Straight or Arched
Section: Cephalophilon Meissn.							
P. chinense Linn.	Ra & Cr	6-*12.3*-19	Rare (almost absent towards base)	23.3-*28.3*-31.7 × 16.7-*18.3*-23.3	35-*37.7*-40 × 23.3-*26*-28.3	Slightly sinuous [Striated on both surfaces. Str. radiating from stomata and glands.]	Straight or Arched
P. nepalense Meissn.	Ra & Ru rarely Cr	18-*25.4*-33.5	Absent	37.4-*50.3*-60.3 × 31.2-*39.5*-45.8	Abesnt	Sinuous	Almost straight. Striated. Str. irregular
Section: Aconogon Meissn.							
P. rumicifolium Royle ex Bab.	Ra	8-*19.8*-36.6	Absent	28.7-*38.7*-47.2 × 23.3-*25.5*-28.7	Absent	Sinuous	Straight or Arched or slightly sinuous

Str., striation ; Ep, Epidermal ; Ra, ranunculaceous ; Ru, rubiaceous ; Cr, curciferous.

VENATION		PALISADE RATIO	REMARKS
Vein islets per sq. mm	Vein endings per sq. mm		
15-*21.3*-29	10-*13.4*-17	3-*6*-9	Ep. cells poly-hedral (5-6-walled) ; leaf margin and midrib beneath papillate, sessile glands on both surfaces, relatively sparser above, 1 to many-celled.
4-*7.6*-13	3-*4.8*-8	2-*4*-7	Ep. cells poly-hedral (5-7-walled) ; sessile glands on both surfaces, relatively sparser above, 1-celled.
8-*9.5*-13	2-*7.3*-15	3-*7*-13	Ep. cells poly-hedral (5-7-walled) ; leaf margin papillate, trichomes simple, uniseriate, filiform ; sessile glands on both surfaces, relatively sparser above, beneath usually 1-2-celled, many-celled above.
11-*17.9*-24	12-*19.8*-35	6-*9*-13	Ep. cells poly-hedral (5-8-walled) ; sessile glands on both surfaces, mostly 2-celled or occasionally 1- or 4-celled beneath, 2 to many-celled above.
7-*10.7*-14	2-*4*-7	2-*4.5*-7	Ep. cells poly-hedral (5-8-walled, rarely 9-walled), occasionally tetra-hedral ; sessile glands on both surfaces, mostly near midrib and main veins, many-celled. Rosettes of calcium oxalate crystals in mesophyll.
6-*10*-14	2-*4.5*-8	3-*5.3*-9	Ep. cells poly-hedral (5-7-walled) ; shaggy trichomes on both surfaces ; sessile glands on both surfaces, many-celled. Rosettes of calcium oxalate crystals in mesophyll.
13-*16.5*-22	4-*6.1*-11	2-*5.8*-9	Ep. cells tetra- or poly-hedral (5-7-walled, rarely 8-walled) ; sessile glands on both surfaces, more abundant near main veins, usually 2-4-celled. Large rosettes of calcium oxalate crystals in mesophyll.
1-*2.8*-4	1-*4.6*-8	1-*2*-3	Ep. cells poly-hedral (5-7-walled, rarely 8-walled) ; sessile glands on both surfaces, 2 to many-celled. Large rosettes of calcium oxalate crystals in mesophyll.
2-*3.7*-8	1-*2.5*-4	5-*8*-10	Ep. cells poly-hedral (5-7-walled), rarely tetra-hedral ; long unicellular hairs alongwith shaggy trichomes on both surfaces ; sessile glands on both surfaces, mostly near main veins, 2 to many-celled.
5-*6*-7	2-*4.8*-8	12-*15*-20	Ep. cells poly-hedral (5-7-walled), occasionally tetra-hedral ; leaf margin papillate, unicellular hairs with multicellular swollen bases on both surfaces ; sessile glands frequent beneath, occasional above, mainly on or near main veins, 2 to many-celled.

TABLE-2

NAME OF SPECIES		STOMATA				VENATION	
		Stomatal Index		Size range in μ		Vein islets per sq. mm	Vein endings per sq. mm
		Lower	Upper	Lower	Upper		
Polygonum recumbens Royle ex Bab.	a	11.5-*16.7*-20	8.3-*14.1*-20	25-*25.8*-26.7 × 16.7-*17.7*-18.3	26.7 × 18.3	26-*27.5*-29	13-*14.8*-17
	m	10-*16.4*-25	8.3-*9.1*-10	23.3-*26.3*-26.7 × 16.7-*17.7*-18.3	26.7 × 18.3	17-*20*-24	10-*13.8*-16
	b	10-*13.1*-20	9-*13*-18.1	23.3-*23.7*-26.7 × 16.7-*18*-20	23.3-*26*-26.7 × 18.3-*19.3*-20	15-*16.5*-18	10-*11.8*-13
P. affine D. Don	a	16-*17.3*-20.5	Absent	21.7-*24*-26.7 × 16.7-*18.7*-20	Absent	11-*11.5*-13	3-*4.5*-5
	m	14-*16.8*-21.8		20-*22.3*-23.3 × 16.7-*17.3*-18.3		6	3-*5*-8
	b	15-*16.6*-18.5		20-*22.7*-26.7 × 16.7-*18*-20		4-*5*-7	3-*4.8*-6
P. amplexicaule Don	a	20-*22.9*-27.5	Absent	28.3-*32.7*-36.7 × 20-*24.5*-28.3	Absent	8-*8.8*-10	2-*3*-6
	m	20-*26*-31.5		28.3-*31.2*-33.3 × 20-*24.7*-28.3		8-*10.4*-13	7-*11.1*-15
	b	20-*24.8*-28		25-*30.7*-33.3 × 18.3-*22.2*-26.7		8-*8.8*-9	4-*5*-7
P. vaccinifolium Wall. ex Meissn.	a	22-*23.9*-25	Absent	25-*26.3*-26.7 × 16.7	Absent	19-*21.5*-24	18-*26.3*-35
	m	8.7-*17.9*-26		25-*27.3*-30 × 18.3-*19.3*-20		15-*18*-21	16-*19.3*-24
	b	14-*17.8*-19.5		25-*26*-26.7 × 16.7-*17.3*--18.3		11-*14.3*-16	12-*15.8*-19
P. glabrum Willd.	a	18-*20*-21	11.9-*13.5*-15	30-*31.7*-33.3 × 21.7-*23.7*-26.7	30-*33.7*-35 × 23.3-*24.8*-26.7	9-*12.3*-14	2-*2.8*-4
	m	16.5-*20*-23.1	10.3-*13.6*-15.5	30-*33*-33.3 × 23.3-*25.3*-28.3	33.3-*36.3*-38.3 × 23.3-*26*-28.7	9-*11*-14	4-*5.6*-7
	b	13.9-*17.8*-21	9.5-*12.5*-16.7	26.7-*30.8*-35 × 20-*22.5*-25	30-*34.2*-38.3 × 25-*26.3*-28.3	7-*8.8*-11	2-*3.3*-4

TABLE - 2 *Contd.*

NAME OF SPECIES		STOMATA				VENATION	
		Stomatal Index		Size range in μ		Vein islets per sq. mm	Vein endings per sq. mm
		Lower	Upper	Lower	Upper		
P. lapathifolium Linn.	a	14.3-*17.9*-21	6.2-*8.2*-11.8	25-*26.2*-28.3 × 16.7-*19.2*-21.7	23.3-*26.7*-30 × 16.7-*19.8*-21.7	10-*12.6*-14	5-*6.5*-8
	m	12.5-*16.7*-20	6.3-*13.5*-23.5	25-*26.5*-30 × 20-*20.2*-21.7	26.7-*28.2*-30 × 18.3-*21.2*-26.7	6-*9.2*-10	3-*4.6*-5
	b	13.3-*16.7*-20	6.3-*11.6*-17.6	25-*26.5*-28.3 × 18.3-*19.8*-21.7	26.7-*28.5*-30 × 20-*21.3*-23.3	8-*9.6*-12	2-*3.4*-4
P. serrulatum Lagasc.	a	12.5-*17.1*-20	11.5-*14.6*-17.6	26.7-*27.5*-30 × 20-*20.7*-21.7	26.7-*28*-30 × 20-*20.7*-21.7	13-*14.8*-17	4-*5*-6
	m	14.3-*16.7*-19	9-*12.8*-17.6	23.3-*25.7*-26.7 × 18.3-*19*-20	26.7-*29.5*-31.7 × 16.7-*20.3*-21.7	15-*18.3*-22	5-*7.3*-11
	b	20-*21*-22.2	7-*12.9*-16.7	23.3-*26.3*-28.3 × 16.7-*19*-20	26.7-*29.7*-31.7 × 20-*20.7*-21.7	—	—
P. chinense Linn.	a	6-*10.6*-15	Rare	23.3-*27.3*-30 × 16.7-*18*-20	Rare	1-*3*-4	6-7.3-8
	m	7-*14*-19		30-*30.2*-31.7 × 16.7-*20*-23.3		1-*2.5*-4	1-*4.5*-8
	b	7.5-*9.8*-13.5		23.3-*27.2*-28.3 × 16.7-*17.2*-18.3		2-*3*-4	2
P. nepalense Meissn.	a	26-*27.3*-30	Absent		Absent	2-*4.8*-8	1-*2.5*-4
	m	21-*26.7*-33.5		37.4-*50.3*-60.3 × 31.2-*39.5*-45.8		2-*3.3*-4	1-*2.8*-4
	b	18-*20.5*-25				2-*3*-4	2-*2.3*-3
P. rumicifolium Royle ex Bab.	a	16.6-*25.1*-36.6	Absent		Absent	5-*6.3*-7	6-*7.3*-8
	m	16.6-*21*-25		28.7-*38.7*-47.2 × 23.3-*25.5*-28.7		5-*6*-7	4-*5.3*-8
	b	8-*11.8*-15.5				5-*5.5*-6	2

a = apical region ; m = middle region ; b = basal region.

TABLE 3 : Statistical analysis of various epidermal and venation characters showing average, standard deviation (S.D.), lower (L) and upper (U) fiducial limits (F. Lim.)

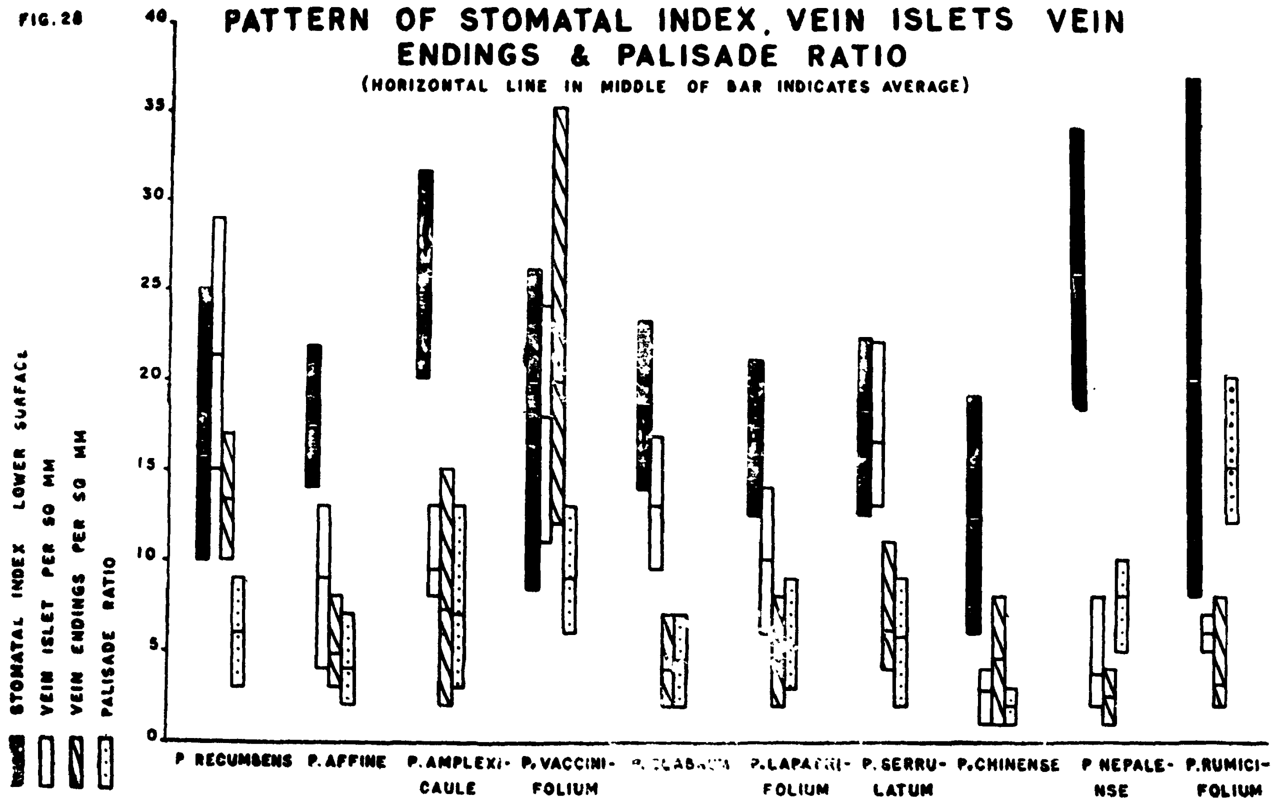
SPECIES INVESTIGATED — STOMATA (lower surface)

Species investigated		Size in μ				Stomatal Index			
		Average	S. D.	F. Lim.		Average	S. D.	F. Lim.	
				L.	U.			L.	U.
Polygonum recumbens Royle ex Bab.	l	25.26(20)	1.59	24.56	25.96	15.44(12)	8.09	10.29	20.59
	b	17.75(20)	0.95	17.34	18.16				
P. affine D. Don	l	23.09(20)	1.97	22.23	23.95	17.18(12)	2.37	15.85	18.51
	b	18.00(20)	1.26	17.45	18.55				
P. amplexicaule Don	l	31.49(30)	2.64	30.55	32.43	26.08(12)	4.08	23.77	28.39
	b	23.77(30)	2.93	22.72	24.82				
P. vaccinifolium Wall. ex Meissn.	l	26.78(19)	1.29	26.20	27.36	20.46(12)	3.76	18.32	22.60
	b	17.82(19)	1.35	17.21	18.43				
P. glabrum Willd.	l	31.83(30)	1.96	31.13	32.53	19.81(12)	3.11	18.05	21.57
	b	24.49(30)	2.15	23.72	25.26				
P. lapathifolium Linn.	l	26.40(30)	1.32	25.93	26.87	17.18(12)	2.94	15.51	18.85
	b	19.72(30)	1.18	19.30	20.14				
P. serrulatum Lagasc.	l	26.39(35)	1.43	25.92	26.86	17.87(13)	2.75	16.38	19.35
	b	19.52(35)	1.20	19.12	19.92				
P. chinense Linn.	l	27.95(26)	5.19	25.96	29.94	12.05(12)	4.04	9.76	14.34
	b	18.53(26)	1.77	17.85	19.21				
P. nepalense Meissn.	l	40.32(10)	5.80	36.73	43.91	25.51(12)	3.52	23.51	27.51
	b	31.67(10)	3.85	29.28	34.06				
P. rumicifolium Royle ex Bab.	l	38.66(10)	1.31	37.85	39.47	19.68(12)	6.94	15.74	23.62
	b	25.51(10)	1.40	24.64	26.38				

Note : The number of observations on which the average is based are given in parentheses ; l denotes length and b denotes breadth.

VENATION								PALISADE RATIO			
Vein. islets per sq. mm				Vein endings per sq. mm							
Average	S. D.	F. Lim.		Average	S. D.	F. Lim.		Average	S. D.	F. Lim.	
		L.	U.			L.	U.			L.	U.
21.25(12)	5.05	18.39	24.11	13.13(12)	2.35	11.80	14.46	6.36(11)	2.38	4.95	7.77
7.58(12)	3.03	5.86	9.30	4.75(12)	1.60	3.85	5.65	4.30(10)	1.49	3.38	5.22
9.53(15)	1.68	8.69	10.37	7.38(13)	5.01	4.66	10.10	6.40(10)	2.99	4.54	8.26
18.25(12)	3.65	16.19	20.30	20.58(12)	6.63	16.82	24.34	9.00(10)	2.16	7.67	10.33
10.69(13)	2.46	9.36	12.02	4.00(13)	1.68	3.08	4.92	4.50(10)	2.07	3.21	5.79
10.06(16)	2.02	9.06	11.06	4.53(17)	1.46	3.84	5.22	5.40(10)	1.78	4.30	6.50
16.58(12)	3.09	14.84	18.32	6.17(12)	1.80	5.15	7.19	5.70(10)	1.83	4.56	6.84
2.83(12)	1.11	2.20	3.46	2.83(12)	1.11	2.20	3.46	2.00(10)	0.82	1.49	2.51
3.67(12)	1.67	2.73	4.61	3.67(12)	1.67	2.73	4.61	7.80(10)	1.14	7.09	8.51
6.00(12)	0.74	5.59	6.41	6.00(12)	0.74	5.59	6.41	15.30(10)	2.26	13.89	16.71

FIG. 28



From what has been stated and discussed in the foregoing pages it is quite evident that the characters of epidermis and the venation and their pattern of variability do provide helpful data of diagnostic value with regard to the species investigated here. It may also be pointed out that the variability pattern in these features is independent of the established pattern at sectional level as set by criteria of external morphology. Although, a combination of all these characters as investigated here as well as those already known, may provide a sounder basis for the delineation and delimitation of the species, yet one may avoid drawing hasty conclusions before more species of the genus have been investigated.

ACKNOWLEDGMENTS

Authors are thankful to Dr. R. V. Sitholey, Acting Director, National Botanic Gardens, Lucknow, for providing facilities for work. Keeper, Central National Herbarium, Calcutta is thanked for confirming the identity of *Polygonum lapathifolium*. Sri S. N. Vishwakarma is thanked for help in sketch work and Sri R. S. Ojha for help in collecting plant material.

REFERENCES

Ahmad, K. J. Cuticular studies in Solanaceae. *Canad. J. Bot.* 42 : 793-303. 1964(*a*).

——Epidermal studies in Solanum. *Lloydia* 27 : 243-250. 1964(*b*).

——Cuticular studies with special reference to abnormal stomatal cells in Cestrum. *J. Indian bot. Soc.* 43 : 165-177. 1964(*c*).

Calder, C. C., V. Narayanaswami and M. S. Ramaswami. List of species and genera of Indian phanerogams not included in Sir J. D. Hooker's Flora of British India arranged in alphabetical order. 1906-1924. *Rec. bot. Surv. India* 11(1) : 109-110. 1926.

Carolin, R. C. Stomatal size, density and morphology in the genus Dianthus. *Kew Bull.* 9 : 251-258. 1954.

Chopra, R. N., S. L. Nayar and I. C. Chopra. *Glossary of Indian Medicinal Plants.* New Delhi. 1956.

——, I. C. Chopra and B. S. Verma. *Supplement to Glossary of Indian Medicinal Plants.* New Delhi. 1969.

Hall, J. P. and C. Melville. Veinlet termination number. A new character for the differentiation of leaves. *J. Pharm. & Pharmacol.* 3 : 934-941. 1951.

Hooker, J. D. *The Flora of British India* 5 : 23-24. 1886.

Husson, P. Stomates et cellules annexes : types stomatiques chez les Polygonacees (Types of stomata in the Polygonaceae.). *Bull. Soc. Hist. Natur. Tulouse* 102(1) : 308-318. Illus. [Abstr : Biol. Abstr. 49 (1-3) : 9518]. 1966.

Inamdar, J. A. Epidermal structure and stomatal ontogeny in some Polygonales and Centrospermae. *Ann. Bot.* 33 : 541-52. 1969.

——Epidermal structure and development of stomata in some Polygonaceae. *Proc. Indian Acad. Sci. Section B* 52(2) : 91-98. 1970.

METCALFE, C. R. AND L. CHALK. *Anatomy of the Dicotyledons* (London). Volume 2 (reprinted edition 1957). 1950.

MORTON, J. F. Tentative correlations of plant usage and esophageal cancer zones. *Economic Bot.* 24(2) : 217-226. 1970.

RAZI, B. A. A second list of species and genera of Indian phanerogams not included in J. D. Hooker's Flora of British India. *Rec. bot. Surv. India* 18(1) 42. 1959.

STACE, C. A. Cuticular studies as an aid to plant taxonomy. *Bull. Brit. Museum (Nat. Hist.) Botany* 4(1) : 1-78 Text Figures 10, Plates 1-5. 1965.

WATSON, L. The taxonomic significance of stomatal distribution and morphology in Epacridaceae. *New Phytol.* 61 : 36-40. 1962.

——The taxonomic significance of certain anatomical variations among Ericaceae. *J. Linn. Soc. London Bot.* 59 : 111-125. 1965.

WILLIS, J. C. *A dictionary of the flowering plants and ferns.* (7th edition as revised by H. K. Airy Shaw, London) p. 908. 1966.