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FOLIAR AND FLORAL INVESTIGATIONS OF SOME *Ipomoea* SPECIES

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ABSTRACT

Foliar and floral investigations of some *Ipomoea* species are described. The mature stomata types present were anisocytic, anomocytic, paracytic, diacytic, brachyparacytic, staurocytic and laterocytic. Laterocytic stomata type were the commonest followed by paracytic, anisocytic, anomocytic, brachyparacytic and diacytic. Diacytic stomata were distributed only on the upper surface of *I. involucrata* and *I. alba* but absent in other species. Four different abnormal stomata which are a stoma with one guard cell, vertical and parallel contiguous stomata and two stomata sharing one subsidiary cell were also observed. Species diagnostic features include long unicellular trichome which was straight to curve on both surfaces of *I. involucrata*, striations on both surfaces of *I. aquatica* and *I. triloba*. The nature of the epidermal and anticlinal cell walls, guard cell area, stomatal index and trichomes revealed in this species can be used as distinguishing character among the genus *Ipomoea.*

Keywords: Convolvulaceae, *Ipomoea* Species, Stomata, Foliar, Floral, Epidermal, Anticlinal Walls

INTRODUCTION

The Convolvulaceae also known as the morning glory or bindweed consists of about 50 genera and over 1200 species **[22]**. In Nigeria *Ipomoea* species are distributed in rather open vegetation such as roadside, River banks, Rainforest, Edges, Lake Shore, margin of pond and ditches, open forest, Orchard and around village **[5]**. In dry Mediterranean or semi-dry desert climate, they are mostly shrubs, and in rich busy vegetation or open drier places, they are usually climbers with long trailing or twinning stems. There are one or two trees and some species grows in almost pure sand on tropical beaches e.g. *Calystegig speiun* and field *Bindweed Convolulus* and

sometimes parasitic e.g. common dodder (*Cuscuta epithymum)*. Plants which may be weed in the native country are sometimes grown as ornamental and there are now many hybrids of *Ipomoea purpurea* grown in gardens.

Ipomoea is the largest genus in the family Convolvulaceae of about 500 species made up of shrubs and trees which are annual, perennials and ever-green. Many of the annual and perennials are trailing or twinning climbers although mainly grow for their-funnel-shaped flowers'; some are grown for their foliage **[7]**.

Human use *Ipomoea* for their content of medical and psychoactive compound, mainly alkaloid, *I. aquatic*a is consumed as food in Sri lanka, Hong Kong, Taiwan and Chain **[24, 36]**. The leaves of *Ipomoea nil* contain adequate quantities of most of the essential amino and are comparable to conventional foodstuff such as soya bean or whole egg **[37]**. Other species consumed for nutritional purpose are *I. alba, I. albivenia, I. involucrata* and *I. nil.*

Many herbivores avoid morning glories such as *Ipomoea,* as the high alkaloids content makes these plants unpalatable, if not toxic. Nonetheless, *Ipomoea* species are used as food plant by the caterpillars of certain *Lepidoptera* (butterflies and moths). Due to their content of ergot type alkaloids, several species of *Ipomoea* are used as hallucinogenics. Some of them were used in pre-columbian times by ancient people to attain a state of mind suitable for divination during religious ceremonies and magical healing practices **[9]**. Two species of *Ipomoea* are detached in the enthengena use, they are *I. corymbosa (River corymbosa)* and *I. violacee.* The seeds are still used even today by certain natives in Mexico **[9, 15]**.

Ipomoea aquatica leaves are used for the treatment of diabetes, snake venorn antidote, ringworms, leucoderma, leprosy, fever, against nose bleed and high blood pressure **[25, 26, 36]**. *I. cairica* is used for the treatment of rheumatism and inflammations **[13]**. *Ipomoea nil* is used for the treatment against cancer (East Asia) **[41]**.

Taxonomic significance of foliar epidermis in some member of the family Convolvulaceae has been investigated by **[1, 3, 19]**. Metcalfe and Chalk **[27]** gave a spare description of the general anatomy of the family Convolvulaceae. Inamdar **[17]** recorded stomatal ontogeny on the foliar and floral organs of the two species of *Ipomoea.* Karatela and Gill **[21]** studied epidermal morphology and stomatogenes in ten species belonging to genera *Ipomoea* and *Merremia*. Ugborogho *et al*. **[43]** investigated stomatal morphology and distribution in six species of *Ipomoea*. The

other type of stomata such as anisocytic, amphianomocytic, hemiparacytic and continuous types are recorded for the first time in Nigeria specices of the genus *Ipomoea*. Rodella and Schlitter **[45]** observed morphological and anatomical characteristics of seeds of *Ipomoea cairica* (L.) sweet.

Verma and Dave **[44]** investigated surface structure of the fruit in five species of *Ipomoea*. They recorded variation in the epidermal cell frequency, stomatal type, stomatal frequency stomatal index and trichomes etc. they also noted stomatal abnormalities. Govil **[14]** reported on the structure of root and the process of tuberisation in *Ipomoea batatas* he reported primary root in the species as teetrach to hexarch. In his opinion, tuberization is caused by the activization of xylem parenchyma cell and cells of cambium. Metcalfe and Chalk **[27]** reported that latex cell in the ground tissue are found only in two species of *Ipomoea* viz, *Ipomoea illustins* and *Ipomoea triloba*.

The present study reports the use of flower and leaf anatomical features in establishing intra-specific relationship among these taxa.

MATERIALS AND METHODS

Plant Collection

The fresh leaves of *Ipomoea alba,* and *Ipomoea nil*, and fresh leaves and flowers of *I. triloba, I. cairica, I. involucrata* and *I. aquatic* were collected on October, 2012 from a farmland in Uyo Local Government Area of Akwa ibom State. The plants were authenticated by Dr. (Mrs.) U. A. Essiett, a taxonomist in the Department of Botany and Ecological Studies, faculty of Science, University of Uyo, Uyo. Anatomical studies were carried out from this plant using the method below.

Microscopic Examination

For the purpose of anatomical studies, small sizeable portions of the species were obtained from the standard median leaves and flowers of mature and well expanded leaves. Epidermal peel of both abaxial and adaxial surface was made by placing the leaf blade taken from standard median portion of the leaves and flower on a clean glass slab. The specimen surface to be studies facing down the specimen were irrigated with water holding it down ward from one end, the epidermis above the desired surface was scrapped off carefully with a sharp razor blade. Loose cells were washed away from the epidermal peel with the aid of soft camel hairbrush and water until the desired epidermis below was reached. The epidermal peels were stained in 1% aqueous solution of Safranin for 4 - 8 minutes, then rinsed carefully in water to removed excess stain and mounted in 10% glycerol.

Guard cells was calculated by Franco's constant method (Guard cells area = Length x Width x 0.7854). The stomata index was determined according to Metcalfe and Chalk **[28]** using the formula:

$$\frac{S}{E+S} \times \frac{100}{1} = Stomatal.Index(SI)$$

Where: S= Number of stomata per unit area; E= Number of epidermal cells in the same area

All measurement were made with the aid of an ocular micrometer an finally converted by the ocular constant with respect to the power under which they were taken. Images were computerized digitally with a Motic image plus version 2.0 ml mounted on Zeiss Light Microscope.

RESULTS

Ipomoea nil

Adaxial Surface

Epidermal cell show wide variation in shape and size from polygonal to irregular shape. Anticlinal cell walls were undulating. Four stomatal types were mostly found. anisocytic, laterocytic, staurocytic and paracytic **(Plate 1A-1F)**. laterocytic stomata were abundantly present followed by paracytic, anisocytic and staurocytic. Peltate scales were also present **(Plate 1A)**. Abnormal stomata such as a stoma with one guard cell were also present **(Plate 1E)**.

Abaxial Surface

On the abaxial surface, epidermal cell show wide variation in shape and size from polygonal to irregular shape. Six stomatal types were present on the abaxial surface laterocytic, diacytic, staurocytic, anisocytic, hemiparacytic and anomocytic stomata type **(Plate 1G-1M)**. Paracytic stomata were abundantly present followed by laterocytic, anisocytic diacytic, anomocytic, hemiparacytic and staurocytic. Abnormal stomata such as unopened stomatal pore, parallel contiguous stomata, stomata with one guard cell and two stomata sharing on subsidiary cell were also observed **(Plate 1G-1P)**. Pelltate scale was also observed **(Plate 1G)**. The distribution of stomata in the investigated taxa is amphistomatic. Guard cell area on the adaxial surface (average 8µm) is large than those of the abaxial surface (average 7µm) **(Table 1)** while stomata size on the abaxial surface (44 x 18µm) were larger in size than those on the adaxial surface (35.8 x 16.12µm), **(Table 1)**.

Ipomoea aquatic

Abaxial Surface

Epidermal cell on the abaxial surface shows wide variation in shape and size from polygonal to irregular shape. Anticlinal cell walls were mostly straight to undulating with striations present. Four stomatal types were recorded on this surface anisocytic, laterocytic, staurocytic and paracytic **(Plate 2A – F)**. Laterocytic stomata were abundantly present followed by Paracytic anisocytic and staurocytic. Abnormal

stomata with one guard cell, unopened stomatal pore, aborted stomata and two stomata sharing a subsidiary cell were also observed **(Plate 2A –D)**.

Adaxial Surface

Epidermal cell were mostly polygonal to pentagonal with straight to undulating anticlinal walls. Five stomatal types were observed on this surface brachyparactic, anisocytic, laterocytic, paracytic and staurocytic types **(Plate 2K – 2N)**. Laterocytic stomata were abundantly present followed by Paracytic, anisocytic, staurocytic and brachyparactic. Abnormal stomatal type such as unopened stomatal pore was observed **(Plate 2O)**. Peltate trichome was also observed **(Plate 2O)**. The distribution of stomata in the investigated taxa is amphistomactic (stomata present on both surface). Guard cell area on the adaxial surface (average 5 µm) is longer than those of the abaxial surface (3 µm) **(Table 1)** while the epidermal cell on the abaxial surface (35 x 16 µm) is smaller in size than adaxial cell (49 x 20 µm) as shown in **(Table 1)**. Epidermal cell size in the adaxial surface (35 x 16 µm) are larger in size than that of abaxial surface (35 x 16 µm), **(Table 1)**.

Ipomoea alba

Adaxial surface: Epidermal cell on the adaxial surface were mostly polygonal to pentagonal with straight anticlinal walls. Four stomata types were present on this surface paracytic, lacterocytic, diacytic and staurocytic **(Plate 3B – 3G)**. Laterocytic stomata were abundantly present followed by Paracytic, anisocytic and staurocytic. Abnormal stomata such as unopened stomatal pore, two stomata sharing one subsidiary cell, one guard cell and vertical contiguous stomata was also observed **(Plate 3B – 3G)**. Peltate scales were also present **(Plate 3A)**.

Abaxial Surface

On the abaxial surface, epidermal cell were mostly polygonal to pentagonal in shape with straight to slightly undulating anticlinal walls. Five stomata types were recorded on this surface lactercocytic, anisocytic, paracytic, diacytic and brachyparactic **(Plate 3H- 3N)**. Laterocytic stomata were abundantly present followed by Paracytic, anisocytic, brachyparactic and diacytic. Abnormal stomata such as a stoma with one guard cell, vertical and parallel contiguous stomata, and unopened stomata pore was also observed **(Plate 3H, J and M)**. Peltate scales were also recorded **(Plate 3L)**. The distribution of stomata in the investigated taxa is amphistomatic. Guard cell areas on both adaxial and abaxial surface were the same (11µm) **(Table 1)**. Epidermal cell on the adaxial surface (44 x 15µm) are smaller in size than those of the abaxial surface (74 x 15µm) **(Table 1)**.

Ipomoea involucrata

Adaxial Surface

Epidermal cell on the adaxial surface show wide variation in shape and size from polygonal to irregular shape with undulating anticlinal walls. Four stomata type are recorded on this surface anisocytic, laterocytic, staurocytic and diacytic stomata type **(Plate 4B-4D)**. Laterocytic stomata were abundantly present followed by staurocytic, anisocytic and staurocytic. Abnormal stomata type such as stomata with an aborted guarded cell, stomata with one guard cell, and unopened stomata pore were observed **(Plate 4D-4F)**.

Abaxial Surface

Epidermal wall were mostly polygonal to irregular shape with to straight to slightly undulating anticlinal walls. Three stomata types were recorded on this surface, laterocytic, anisocytic and paracytic stomata type **(Plate 4I-4K)**. Laterocytic stomata were abundantly present followed by paracytic and anisocytic. Abnormal stomata with unopened stomatal pore were also recorded **(Plate 4L)**. Unicellular non-glandular trichome and peltate scale was observed on both surface **(Plate 4A, D, H, K)**. The distribution of stomata in the investigated taxa is amphistomatic (stomata present on both surface). Guard cell area on adaxial surface (average 9µm) are longer in size than those of the abaxial surface while stomatal size on the abaxial surface (37 x 17 um) were larger in size than those on the adaxial surface (42 x 12 um) as shown in **Table (1)**.

Ipomoea triloba

Abaxial Surface

Epidermal cell on the abaxial surface were mostly polygonal to pentagonal with straight anticlinal walls. Six stomatal type are recorded on the surface anisocytic, brachyparacytic, anomocytic, staurocytic, paracytic and laterocytic stomatal type **(Plate 5A – 5I)**. Abnormal stomata with unopened stomata pore, aborted guard cell, a stoma with one guard cell, two stomata sharing a subsidiary cell and parallel contiguous stomata was recorded **(Plate 5A, D, E, H, J)**.

Adaxial Surface

Epidermal cell on the adaxial surface were mostly polygonal to pentagonal with straight undulating anticlinal walls. Five matured stomata types were observed paracytic, anisocytic, laterocytic, staurocytic and brachy paracytic **(Plate 5K-5P)**. Abnormal stomata with unopened stomatal pore, two stomatal sharing a subsidiary cell and vertical contiguous stomata were recorded **(Plate 5M, Q-R)**. The distribution of stomata in the investigated taxa is amphistomatic. Peltate scale is recorded on both surface (Plate 5A and 5O). Guard cells are on the adaxial surface (7µm) are longer

than that of the adaxial surface (5 µm). While stomata size on the abaxial surface are larger than those in the adaxial surface **(Table 1)**.

Ipomoea cairica

Epidermal cell on the adaxial surface shows wide variation in shape and size from polygonal to pentagonal with straight anticlinal walls. Four stomata types were observed anisocytic, lacterocytic, paracytic and brachyparacytic stomata types **(Plate 6A-6D)**. Abnormal stomatal type with unopened stomatal pore, two stomata sharing one subsidiary cell and parallel contiguous stomata were also observed **(Plate 6E-6G)**.

Abaxial Surface

Epidermal cell are on the abaxial surface shows wide variation in shape and size from polygonal to pentagonal with straight anticlinal walls. Five stomata types were observed laterocytic, anisocytic, paracytic, staurocytic and brachyparacytic **(Plate 6I-6P)**. Few abnormal stomata such as unopened stomatal pore and two stomata sharing one subsidiary cell were observed **(Plate 6M and 6N)**.

Peltate trichomes were also observed on both surfaces **(Plate 6H and 6K)**. abaxial cell (25 x 19 µm) was smaller in size than those on the adaxial surface (33 x 26 µm). Guard cell area on the adaxial surface (11µm) was longer than that of abaxial surface (6 µm) , **(Table 1)** while abaxial stomatal size (27 x 16 µm) are smaller in size than those on the adaxial surface (30 x 20 µm) as shown in **Table 1**. The distribution of stomata in the investigated taxa is amphistomatic (stomata present on both surface).

Lamina In Surface View of Flower

Ipomoea aquatica

Adaxial Surface

Epidermal cell show wide variation in size and shape with straight to slightly undulating anticlinal walls. Stomata and hairs were absent **(Plate 8B)**. Adaxial surface show wide variation in shape and size with straight to slightly undulating walls **(Plate 8A)**. Stomata and hairs were also absent. Epidermal cell on the adaxial surface (21.8 x 6.9 µm) are smaller in size than those of the abaxial surface (23 x 9 µm) **(Table 3)**.

Ipomoea involucrate

Epidermal walls on the adaxial surface varies in shape and size with straight to undulating anticlinal wall **(Plate 9A)** stomata were absent. Non-glandular unicellular trichomes which were straight to curve were present with a length of (163 x 3.9 µm) **(Table 3)**.

Abaxial Surface

Epidermal cells on the abaxial surface showed wide variation in shape and size from polygonal to pentagonal **(Plate 9B)**.

With straight anticlinal wall stomata and hairs were absent.

Ipomoea cairica

Adaxial Surface

Epidermal cell on the adaxial surface shows wide variation in shape and size with undulating anticlinal cell walls **(Plate 10A)**. Stomata and hairs were absent.

Abaxial Surface

Epidermal cell on the abaxial surface shows wide variation in shape and size from polygonal to pentagonal with straight anticlinal wall. **(Plate 10B)** stomata and hairs were absent. Epidermal cell on the adaxial surface (25 x 4 µm) were smaller in size than those on the abaxial surface (35 x 4 µm) **(Table 1)**.

Ipomoea triloba

Epidermal cell on the adaxial surface show wide variation in shape and size with undulating anticlinal wall **(Plate 7A)**. Stomata and hair were absent.

Abaxial surface

Epidermal walls show wide variation in shape and size with straight anticlinal wall **(Plate 7B)** stomata and hairs were absent. Epidermal cell size on the abaxial surface (24 x 4 µm) is longer than those of the adaxial surface (21 x 5 µm), **(Table 3)**.

Table 1: Epidermal Features of the Leaves of *I. nil, I. alba, I. aquatica, I. triloba, I. involucrata and I. cairica*

	Stomatal size (µm)		Epidermal cells (µm)		Guard cell areas (µm)		Stomatal index (%)		Stomatal distribution	Epidermal cell wall	
Species	Ad	Ab	Ad	Ab	Ad	Ab	Ad	Ab		Ad	Ab
I. cairica	30 x 20	27 x 16	25 x 19	33 x 20	11	6	25	66	Amphistomatic	Undulating	Undulating
I. nil	35 x 16	44 x 18	78 x 48	46 x 18	8	7	49	45	Amphistomatic	Undulating	Undulating
I. aquatica	40 x 15	24 x 15	49 x 20	35 x 16	5	3	40	52	Amphistomatic	Straight to Undulating with striations	Straight to slightly Undulating with striations
I. triloba	37 x 13	41 x 15	49 x 20	69 x 17	5	7	65	68	Amphistomatic	Straight to Straight to Undulating with striations	Straight to Undulating with striations
I. alba	47 x 17	31 x 16	44 x 15	74 x 15	11	11	28	75	Amphistomatic	Straight	Straight to Undulating with striation
I. involucrata	37 x 17	42 x 12	42 x 32	54 x 16	9	7	48	88	Amphistomatic	Straight to curve Undulating with striation	Straight to Undulating striations

Keys: Ad = Adaxial Surface; Ab = Abaxial Surface

Table 2: Trichomes Characteristics of the Leaves of *I. nil, I. alba, I. aquatica, I. triloba, I. involucrata* and *I. cairica*

	Peltate trichomes		Non-Galndular trichomes	
Species	Ad	Ab	Ad	Ab
I. involucrata	79 x 21	81 x 20	388 x 28	250 x 18
I. alba	75 x 59	70 x 63	-	-
I. aquatica	19 x 7	41 x 19	-	-
I. triloba	77 x 52	79 x 58	-	-
I. nil	45 x 34	42 x 35	-	-
I. cairica	31 x 22	31 x 20	-	-

Keys: Ad = Adaxial Surface; Ab = Abaxial Surface

Table 3: Epidermal Features of Flower of *I. nil, I. alba, I. aquatica, I. triloba, I. involucrata* and *I. cairica*

	Stomata size (µm)		Epidermal cell (µm)		Epidermal cell wall		Trichomes Non-glandular	
Species	**Ad**	**Ab**	**Ad**	**Ab**	**Ad**	**Ab**	**Ad**	**Ab**
I. aquatica	-	-	22 x 7	23 x9	Straight to undulating	Straight to undulating	304 x28	-
I. involucrata	-	-	36 x 5	18 x5	Straight to undulating	Straight	-	-
I. cairica	-	-	25 x 4	35 x 4	Undulating	Straight to undulating	-	-
I. triloba	-	-	21 x 5	24 x4	Undulating	Straight	-	-

Keys: Ad = Adaxial Surface; Ab = Abaxial Surface

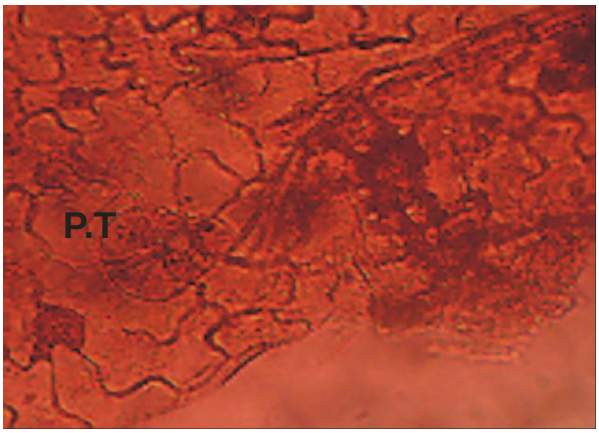

Plate 1A: (P.T) Peltate trichome of I.*nil* (Upper Surface) x400

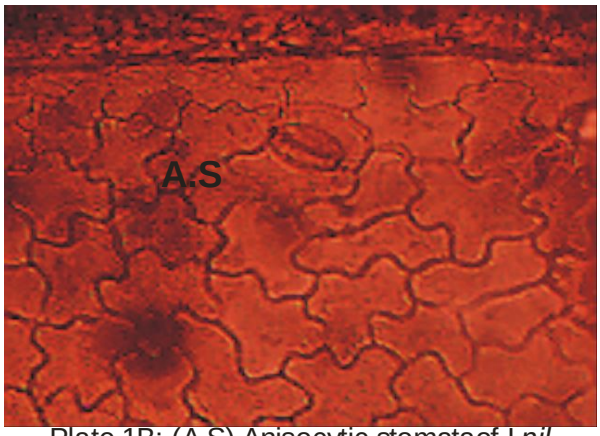

Plate 1B: (A.S) Anisocytic stomataof I.*nil* (Upper Surface) x400

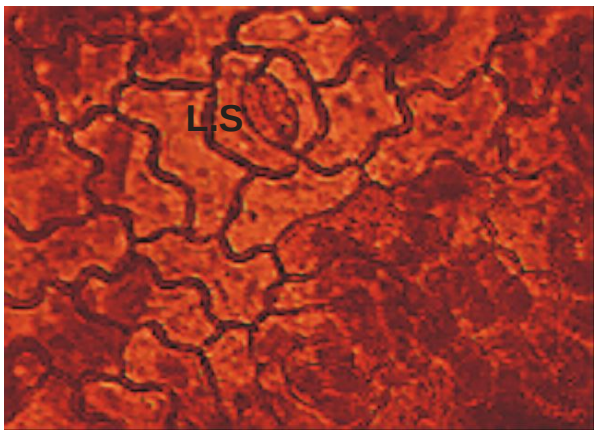

Plate 1C: (L.S) Laterocytic stomata of I.*nil* (Upper Surface) x400

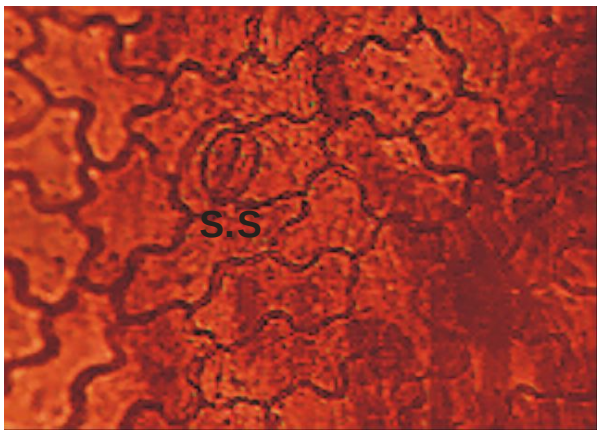

Plate 1D: (S.S) Staurocytic stomata of I.*nil* (Upper Surface) x400

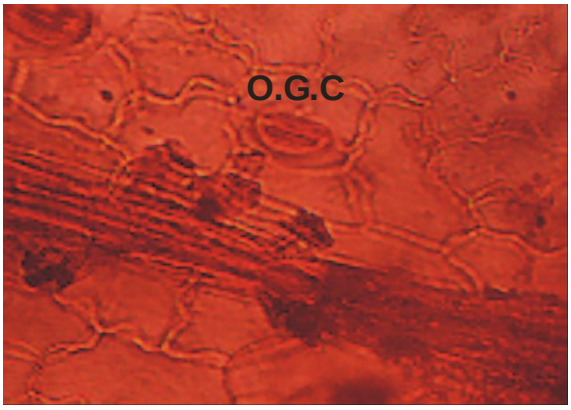

Plate 1E: (O.G.C) One guard cell with striation on theepidermal cell of I.*nil* (Upper Surface) x400

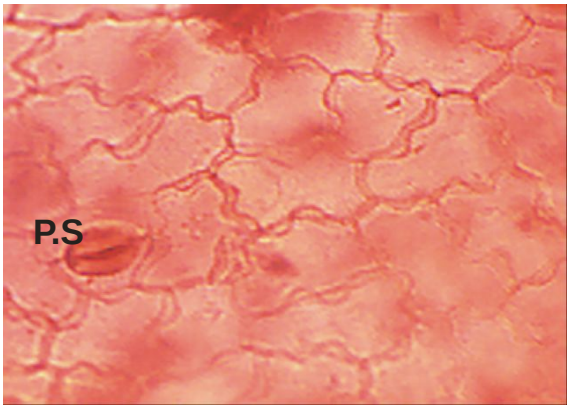

Plate 1F: (P.S) Paracytic stomata of I.*nil* (Upper Surface) x400

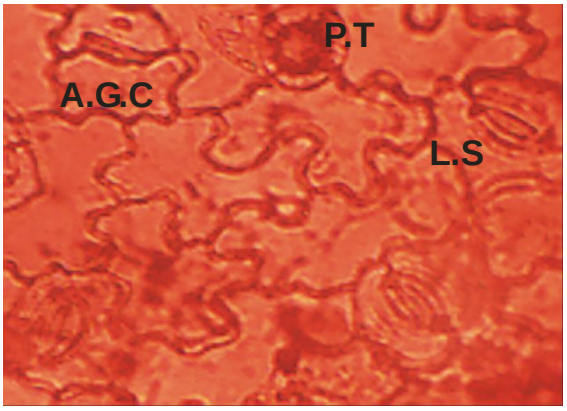

Plate 1G: (P.T) Peltate trichome, (L.S) laterocytic and (A.G.C) aborted guard cell of I.*nil* (lower Surface) x400

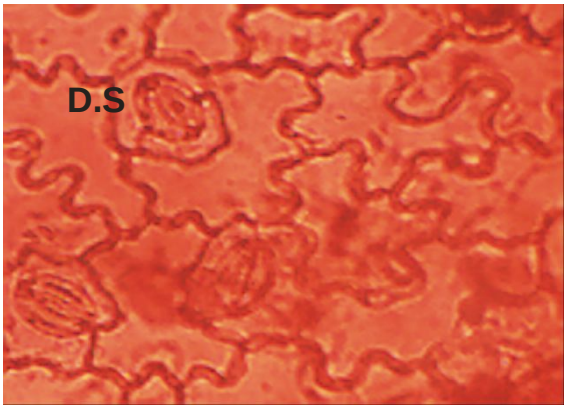

Plate 1H: (DS) Diacytic stomata of I.*nil* (lower Surface) x400

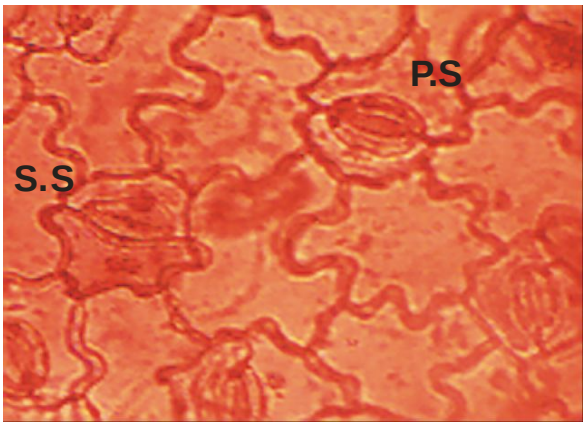

Plate 1I: (S.S) Staurocytic and Paracytic stomata of I.*nil* (lower Surface) x400

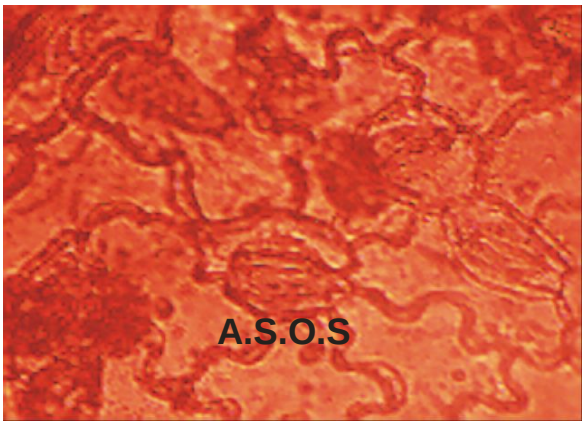

Plate 1J: (A.S.O.S) Anomocytic stomata of I.*nil* (lower Surface) x400

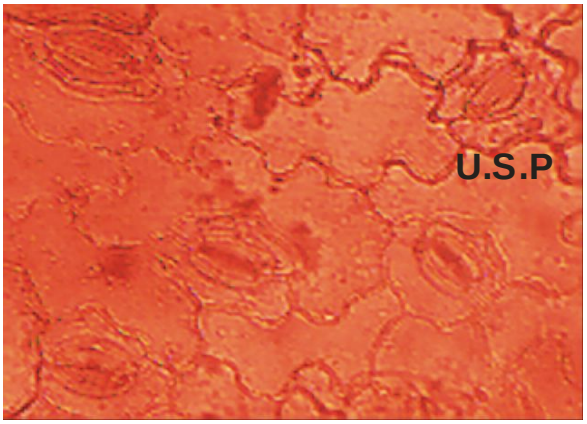

Plate 1K: (U.S.P) Unopened stomatal pore of I.*nil* (lower Surface) x400

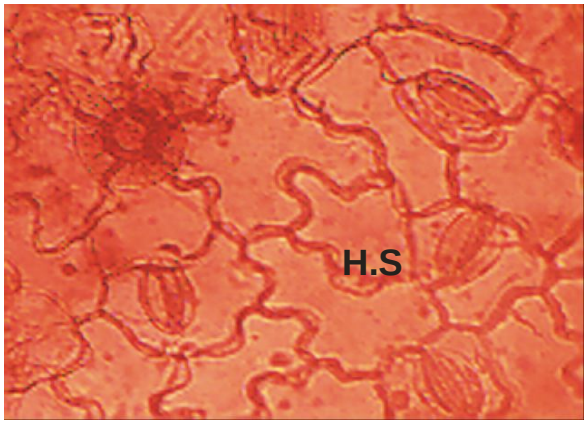

Plate 1L: (H.S) Hemiparacytic stomata of I.*nil* (lower Surface) x400

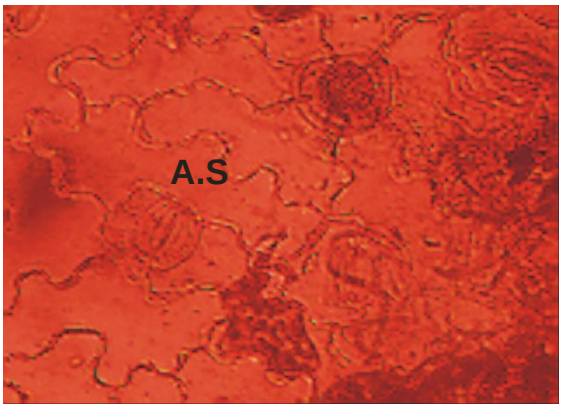

Plate 1M: (A.S) Anisocytic stomata of I.*nil* (lower Surface) x400

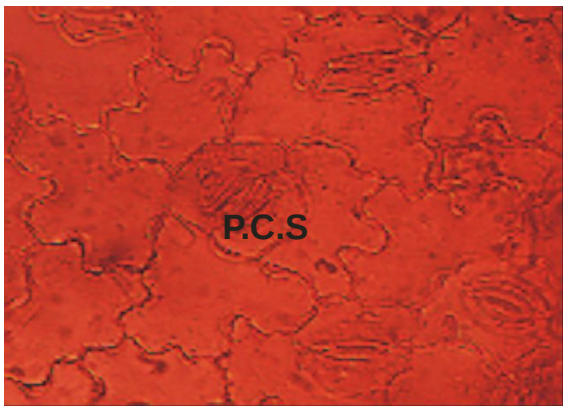

Plate 1N: (P.C.S) Parallel contiguous stomata of I.*nil* (lower Surface) x400

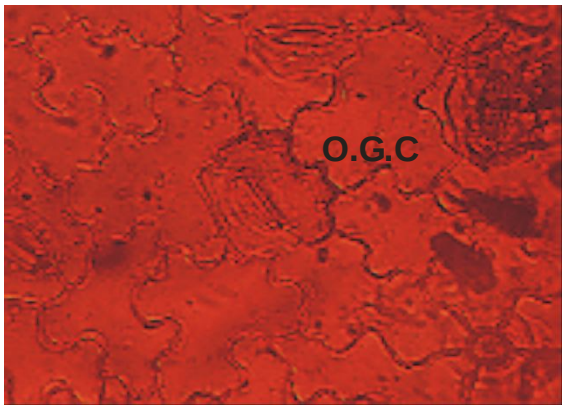

Plate 1O: (O.G.C) One guard cell of I.*nil* (lower Surface) x400

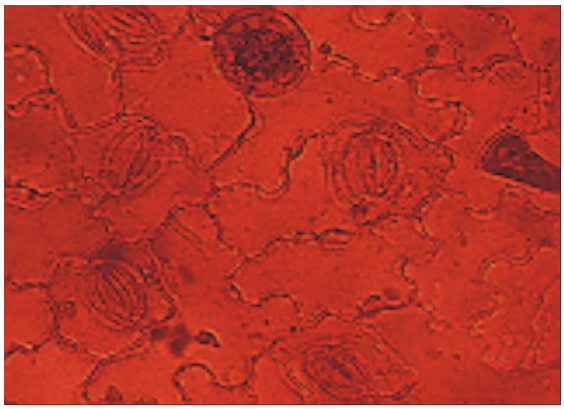

Plate 1P: (T.S.S) Two stomata sharing one subsidiary cell of I.*nil* (lower Surface) x400

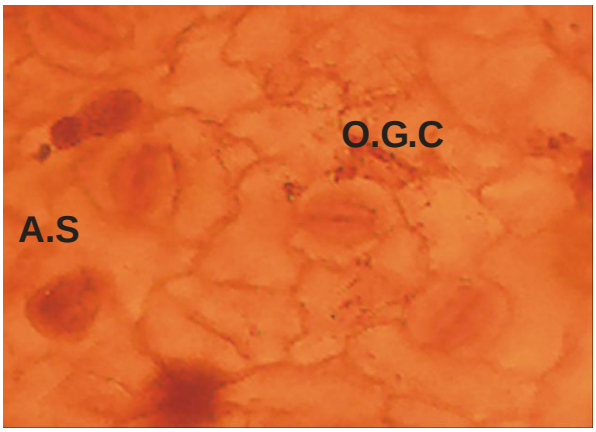

Plate 2A: (A.S) Anisocytic stomata, (O.G.C) one guard cell of *I. Aquatica* (lower Surface) x400

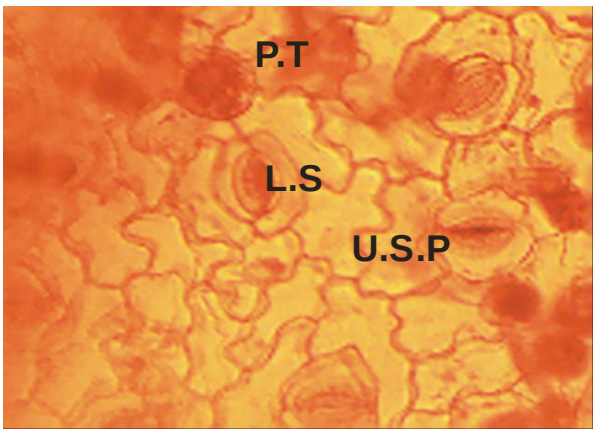

Plate 2B:(L.S) Laterocytic, (U.S.P) unopened stomatal pore and (P.T) peltate trichome of *I. aquatica* (lower Surface) x400

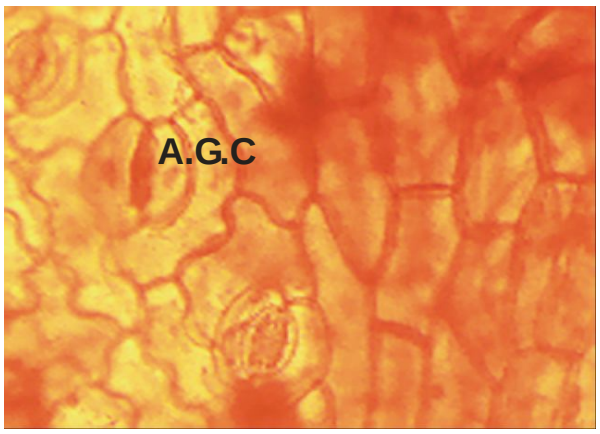

Plate 2C: (A.G.C) Aborted Guard Cell of *I. aquatica* (lower Surface) x400

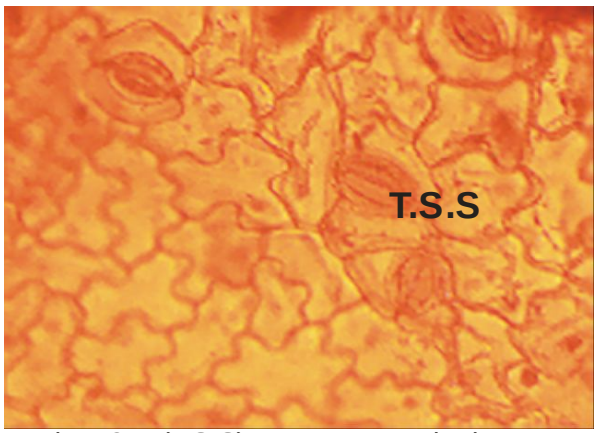

Plate 2D: (T.S.S) Two stomata sharing one subsidiary cell of *I. aquatica* (lower Surface) x400

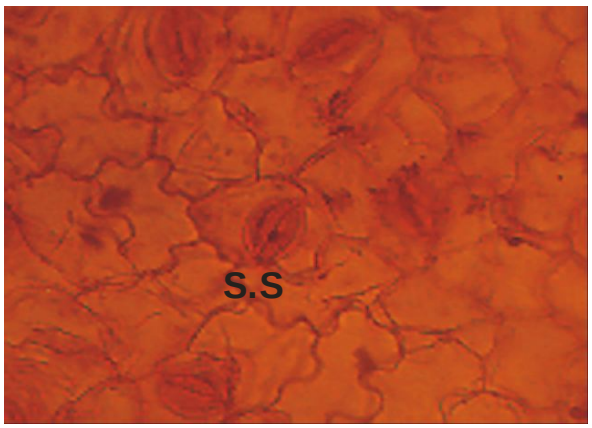

Plate 2E: (S.S) Staurocytic stomata of *I. aquatica* (lower Surface) x400

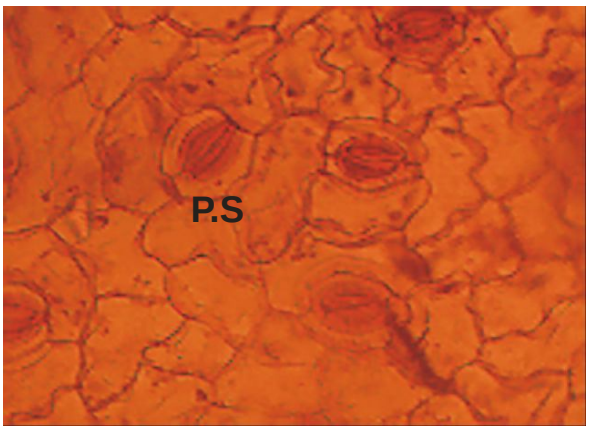

Plate 2F: (P.S) Paracytic stomata of *I. aquatica* (lower Surface) x400

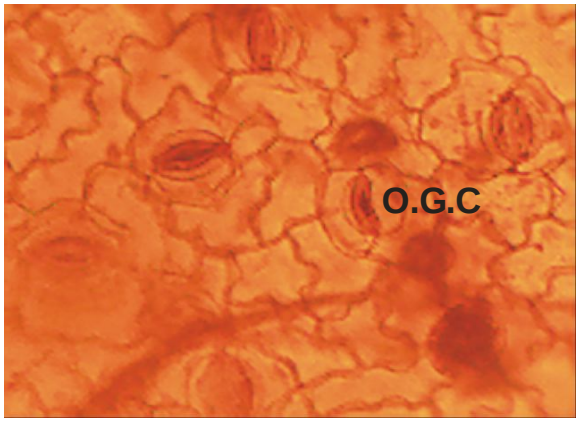

Plate 2G: (O.G.C) One guard cell of *I. aquatica* (lower Surface) x400

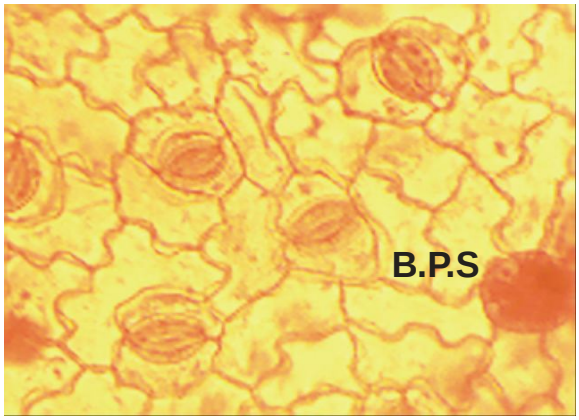

Plate 2H: (B.P.S), Brachyparacytic stomata of *I. aquatica* (lower Surface) x400

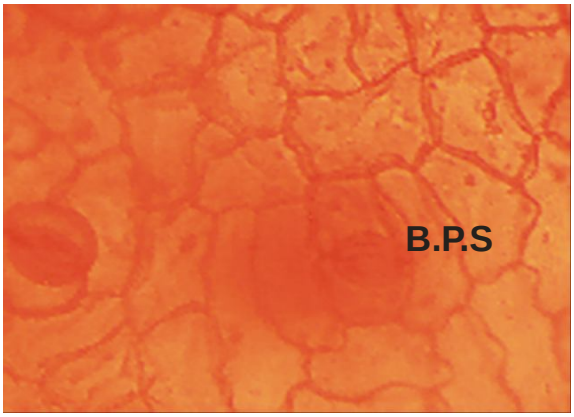

Plate 2K: (B.P.S) Brachyparacytic stomata of *I. aquatica* (upper surface) x400

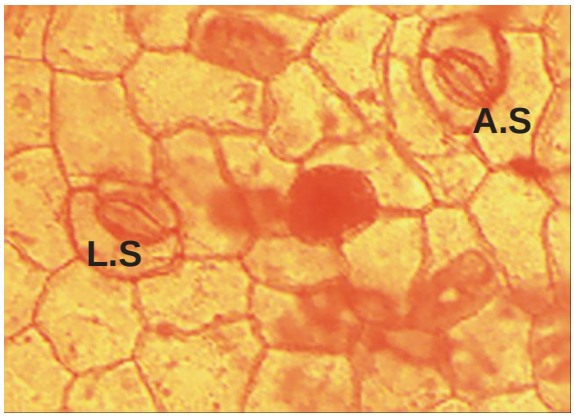

Plate 2L: (A.S) Anisocytic and (L.S) laterocytic stomata of I. *aquatica* (upper surface) x400

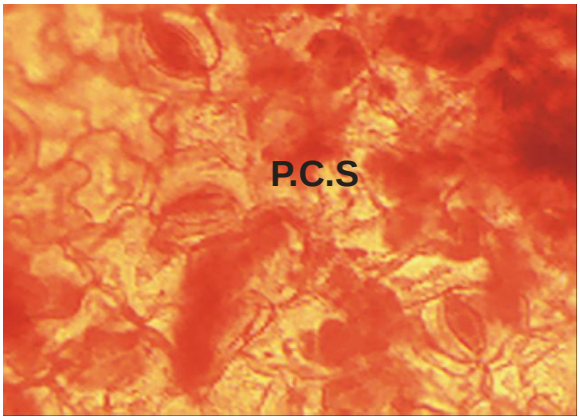

Plate 2I: (P.C.S), Parallel contiguous stomata of *I. aquatica* (lower Surface) x400

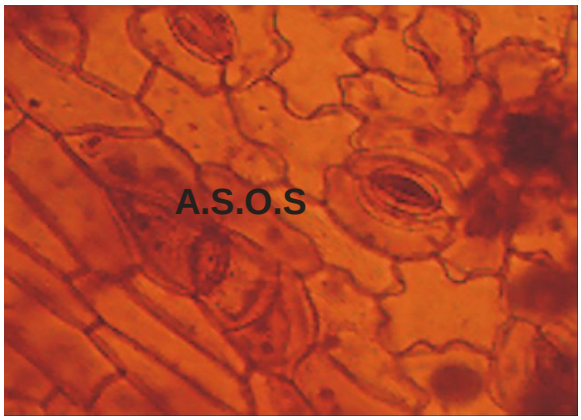

Plate 2J: (A.S.O.S), Anomocytic stomata of *I. Aquatica* (lower Surface) x400

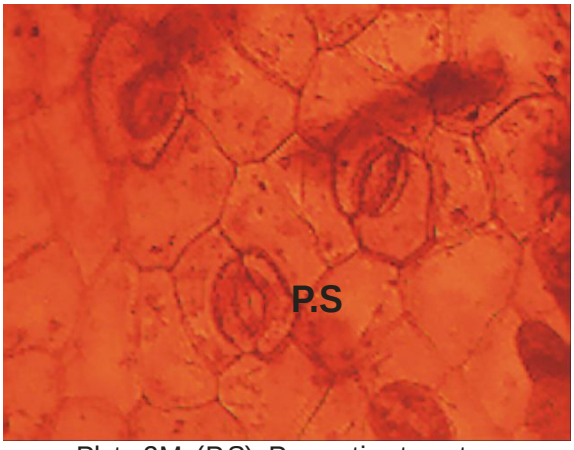

Plate 2M: (P.S) Paracytic stomata of I. *aquatica* (upper surface) x400

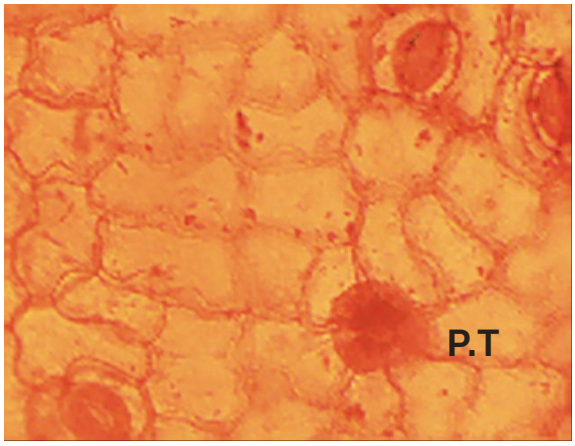

Plate 2N:(P.T) Peltate trichome of I. *aquatica* (upper surface) x400

Plate 2O: (U.S.P), Unopened stomatal pore of I. *aquatica* (upper surface) x400

Plate 2PI: (S.S) Staurocytic stomata of I. *aquatica* (upper surface) x400

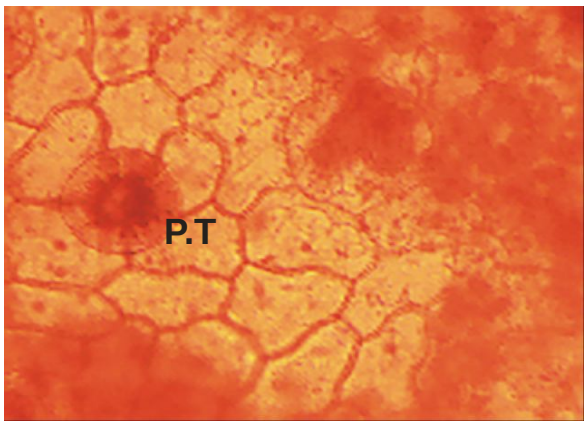

Plate 3A: (P.T) Peltate trichome of I. *alba* (Upper Surface) x400

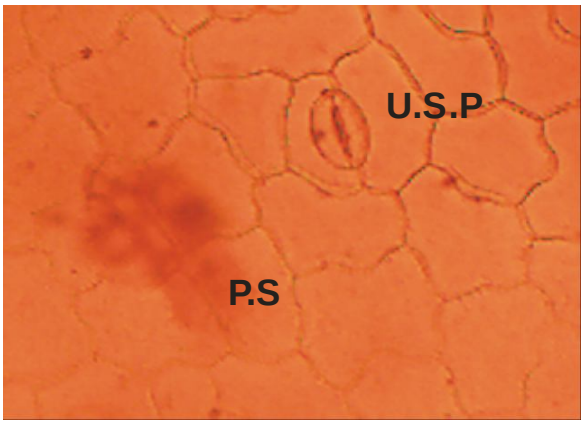

Plate 3B: (P.S) Paracytic stomata and (U.S.P) Unopened stomatal pore of I. *alba* (Upper Surface) x400

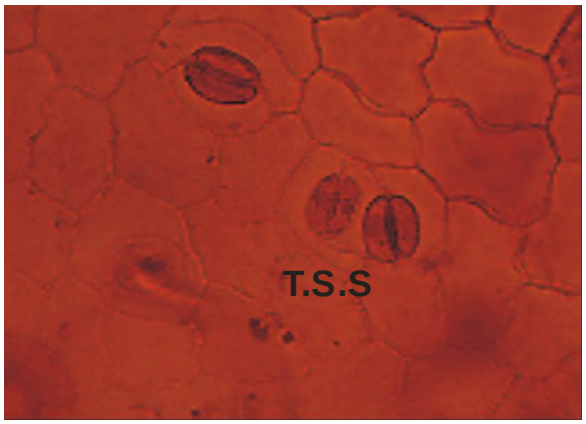

Plate 3C: (T.S.S) Two stomata sharing one subsidiary cell of I. *alba* (Upper Surface) x400

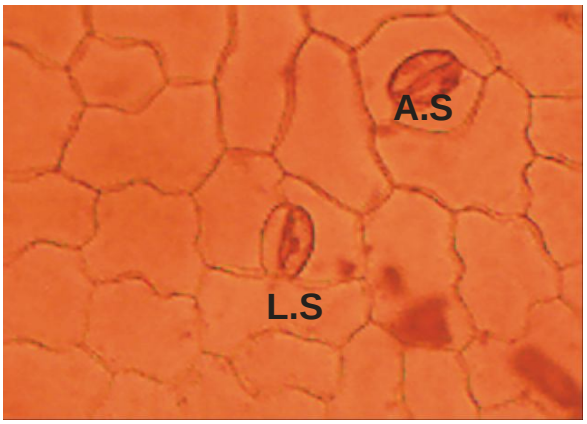

Plate 3D: (L.S) Laterocytic stomata and (A.S) Anisocytic stomata of I. *alba* (Upper Surface) x400

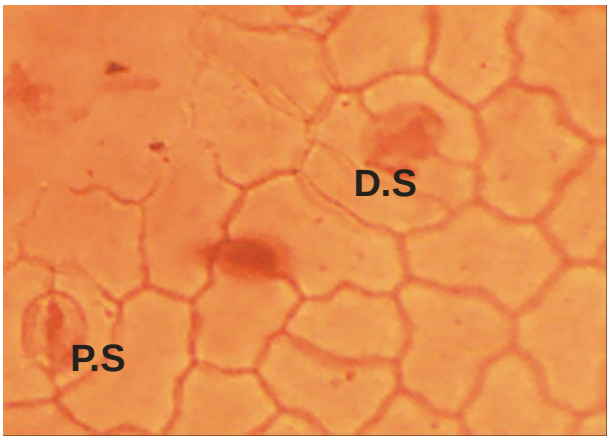

Plate 3E: (P.S) Paracytic stomata and (D.S) Diacytic stomata of I. *alba* (Upper Surface) x400

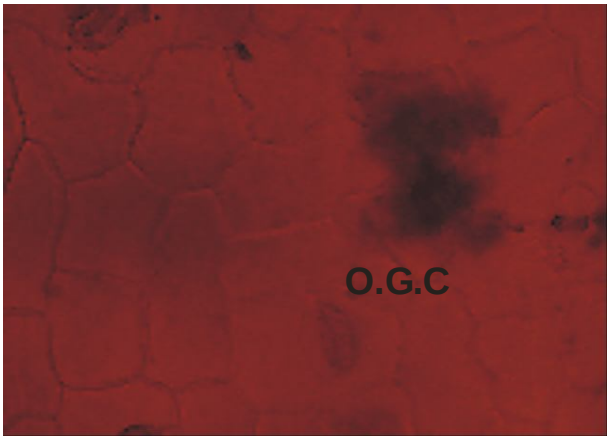

Plate 3F: (O.G.C) One guard cell of I. *alba* (Upper Surface) x400

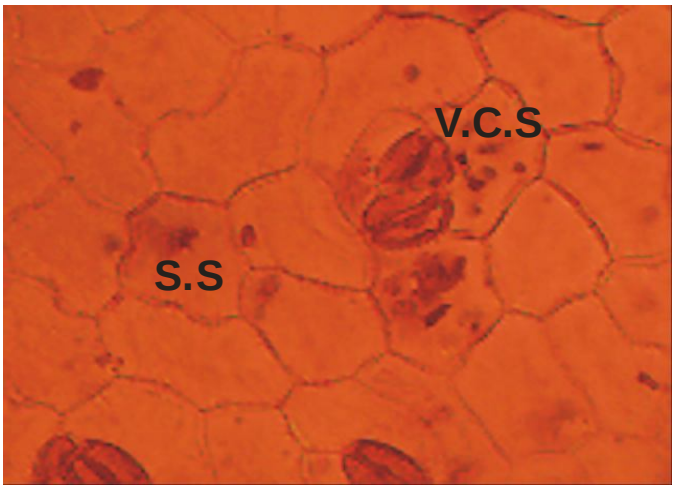

Plate 3G: (S.S) Staurocytic stomata (V.C.S) Vertical contiguous stomata of I. *alba* (Upper Surface) x400

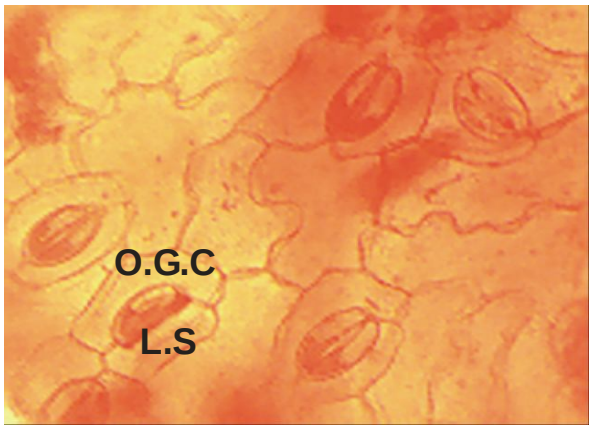

Plate 3H: (O.G.C) One guard cell and (L.S) Laterocytic stomata of I. *alba* (lower Surface) x400

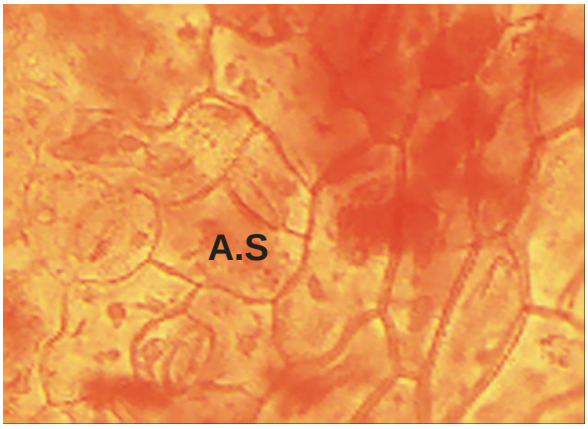

Plate 3I: (A.S) Anisocytic stomata of I. *alba* (lower Surface) x400

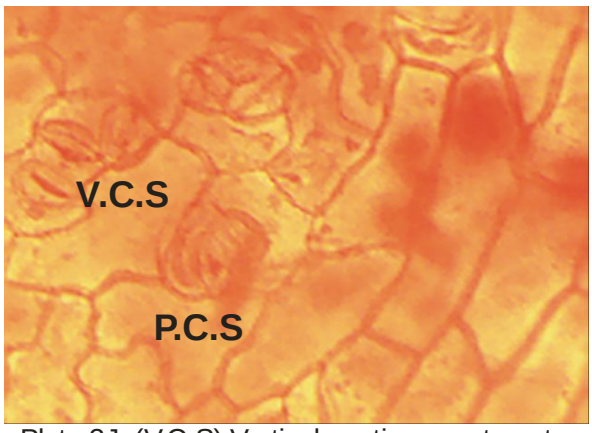

Plate 3J: (V.C.S) Vertical contiguous stomata and (P.C.S) Parallel contiguous stomata of I. *alba* (`lower Surface) x400

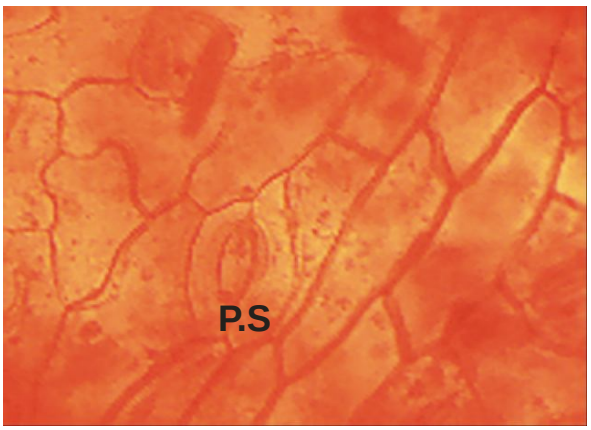

Plate 3K: (P.S) Paracytic stomata of I. *alba* (Lower Surface) x400

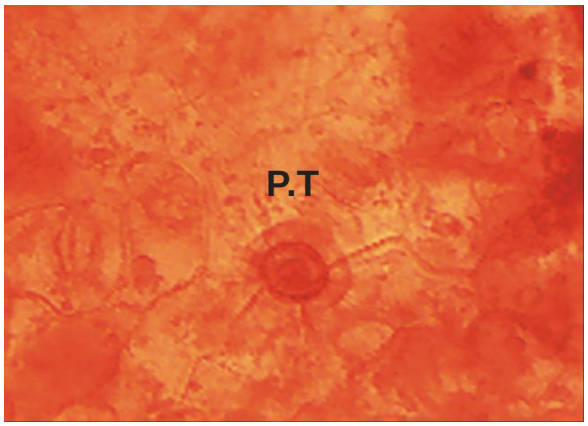

Plate 3L: (P.T) Peltate trichome of I. *alba* (lower Surface) x400

Plate 3M: (U.S.P) Unopened stomatal pore of I. *Alba* (lower Surface) x400

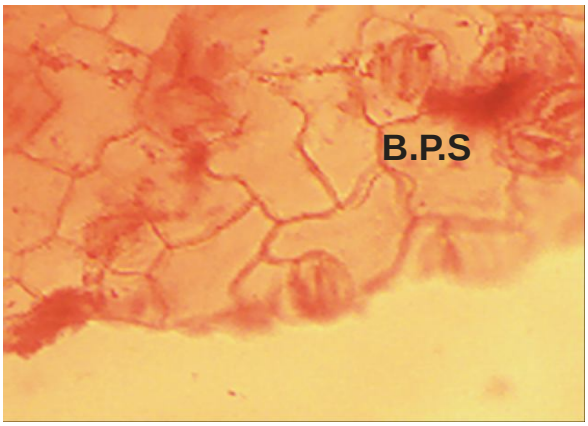

Plate 3N: (B.P.S) Brachyparacytic stomata of I. *alba* (lower Surface) x400

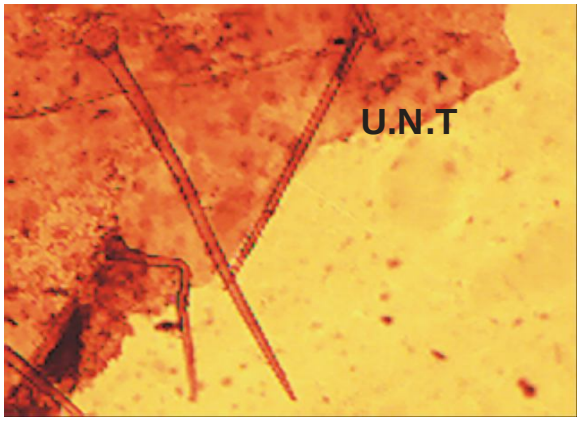

Plate 4A: (U.N.T) Unicellular trichome
of I. *involucrata* (lower Surface) x100

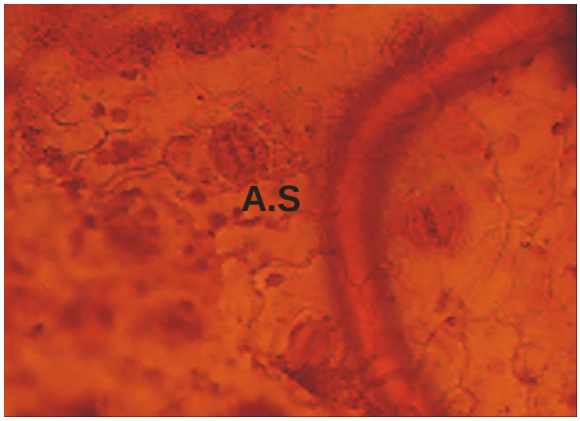

Plate 4B: (A.S) Anisocytic stomata of
I. *involucrata* (lower Surface) x400

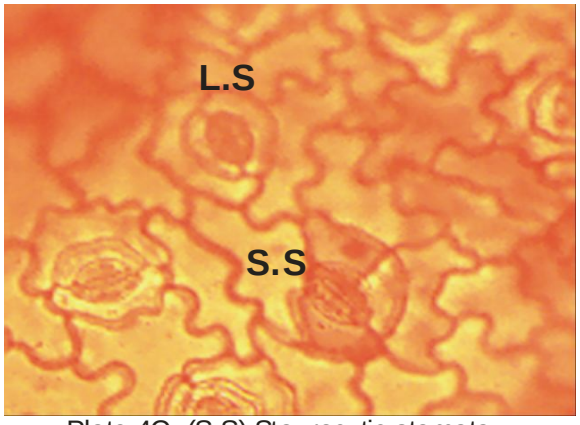

Plate 4C: (S.S) Staurocytic stomata
(L.S) Laterocytic stomata
of I. *involucrata* (lower Surface) x400

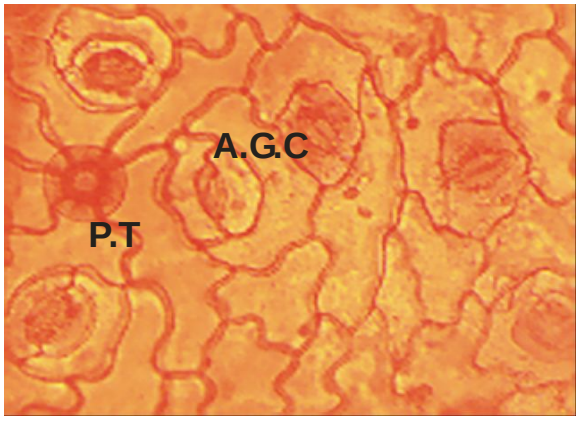

Plate 4D: (P.T) Peltate trichome and
(A.G.C) Aborted guard cell
of I. *involucrata* (lower Surface) x400

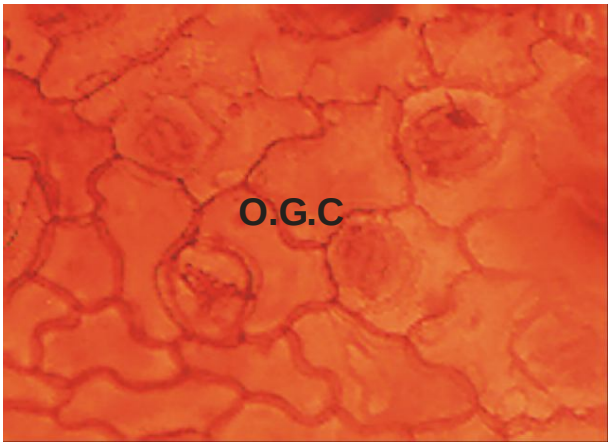

Plate 4E: (.O.G.C) One guard cell
of I. *involucrata* (lower Surface) x400

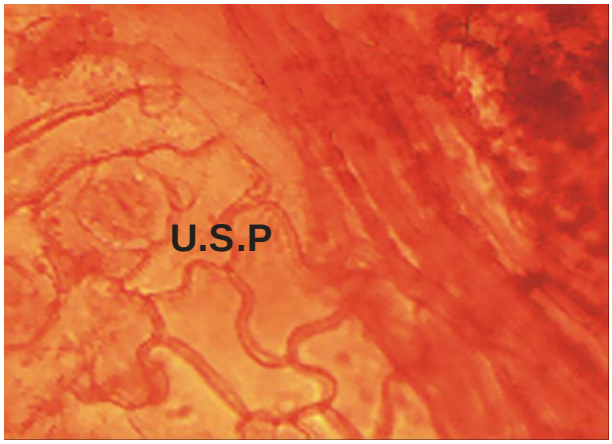

Plate 4F: (U.S.P) Unopened stomatal pore
of I. *involucrata* (lower Surface) x400

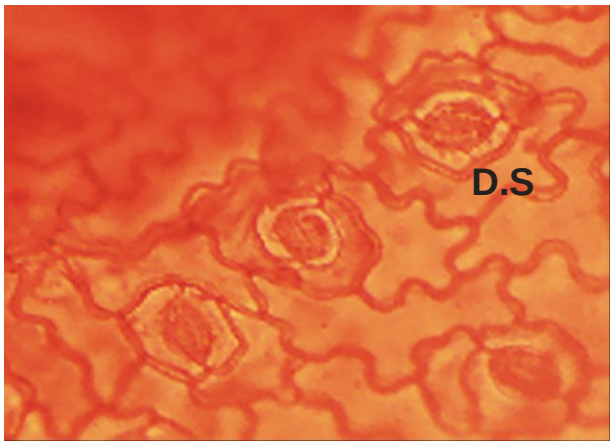

Plate 4G: (D.S) Diacytic stomata
of I. *involucrata* (lower Surface) x400

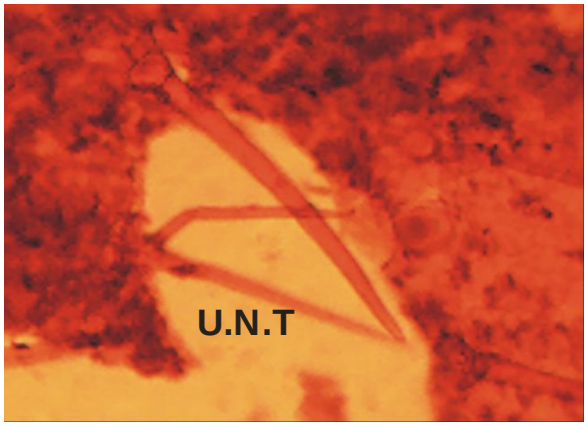

Plate 4H: (U.N.T) Unicellular trichome
of I. *involucrata* (upper Surface) x100

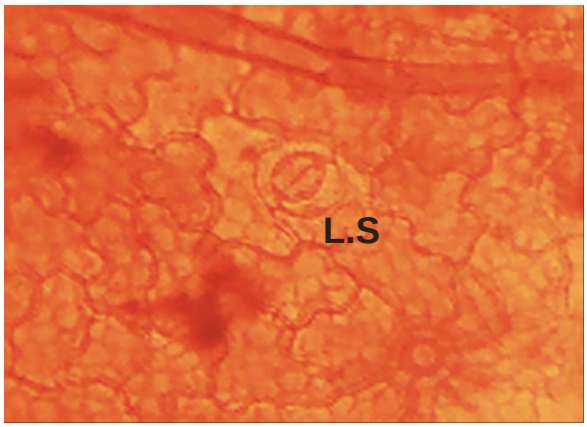

Plate 4I: (L.S) Laterocytic stomata
of I. *involucrata* (upper Surface) x400

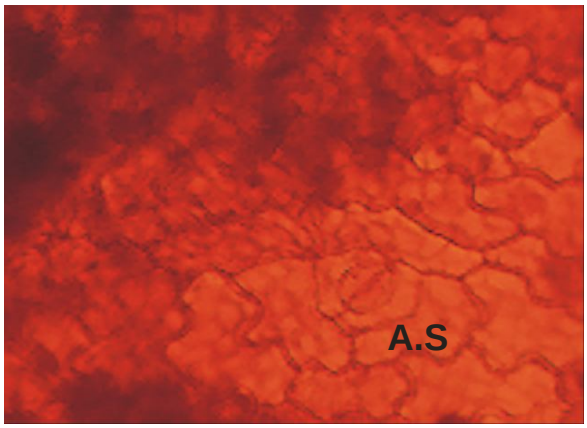

Plate 4J: (A.S) Anisocytic stomata
of I. *involucrata* (upper Surface) x400

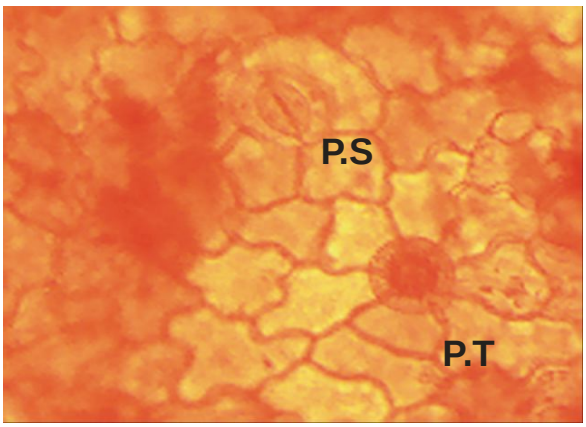

Plate 4K: (P.T) Peltate trichome and
(P.S) Paracytic stomatal
of I. *involucrata* (upper Surface) x400

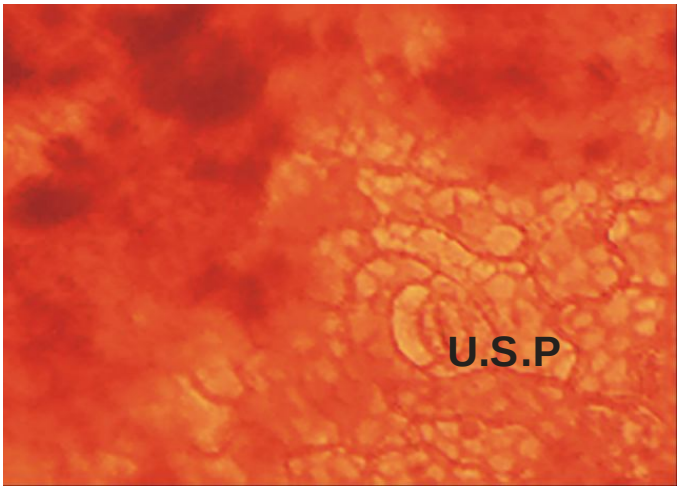

Plate 4L: (U.S.P) Unopened stomatal pore of I. *involucrata* (upper Surface) x400

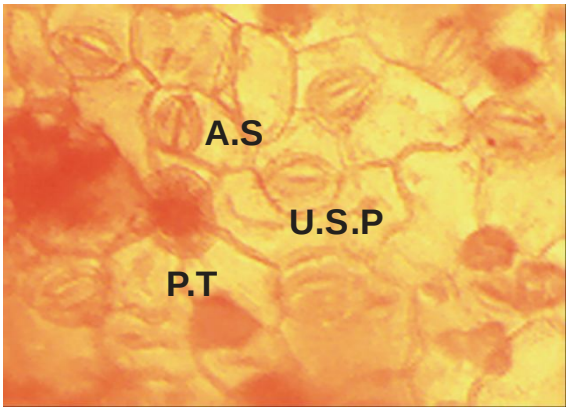

Plate 5A: (P.T) Peltate trichome, (A.S) Anisocytic stomata and (U.S.P) and Unopened stomatal pore of I. *triloba* (lower Surface) x400

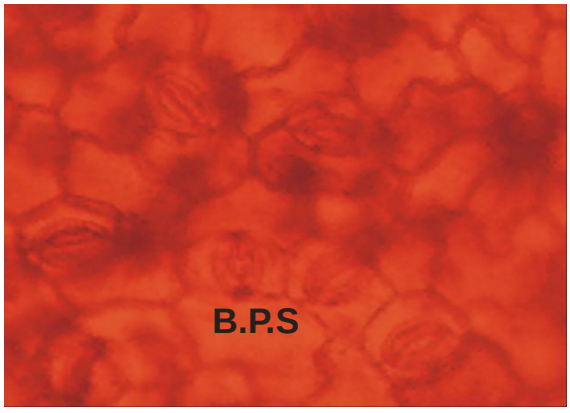

Plate 5B: (B.P.S) Brachyparacytic stomata of I. *triloba* (lower Surface) x400

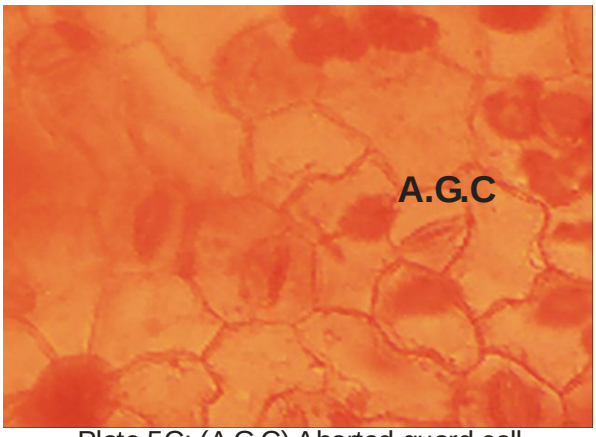

Plate 5C: (A.G.C) Aborted guard cell of I. *triloba* (Lower Surface) x400

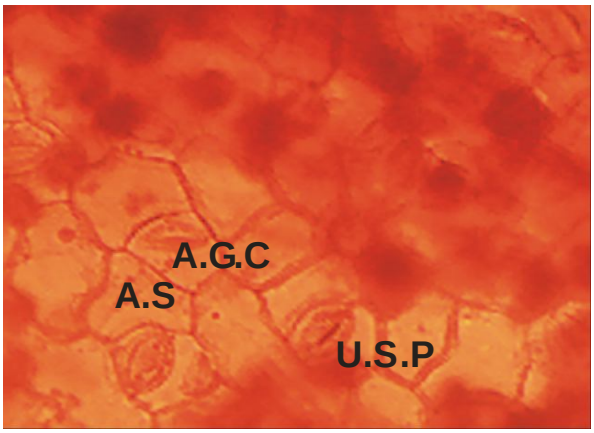

Plate 5D: (A.G.C) Aborted guard cell, (A.S) Anisocytic stomata and (U.S.P) and Unopened stomatal pore of I. *triloba* (Lower Surface) x400

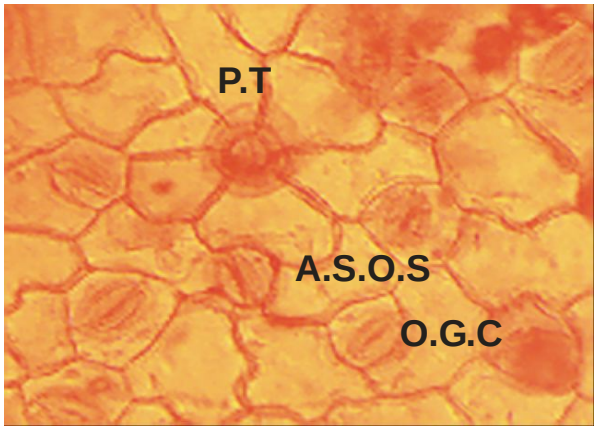

Plate 5E: (P.T) Peltate trichome, (O.G.C), One guard cell and (A.S.O.S) Anomocytic stomata of I. *triloba* (lower Surface) x400

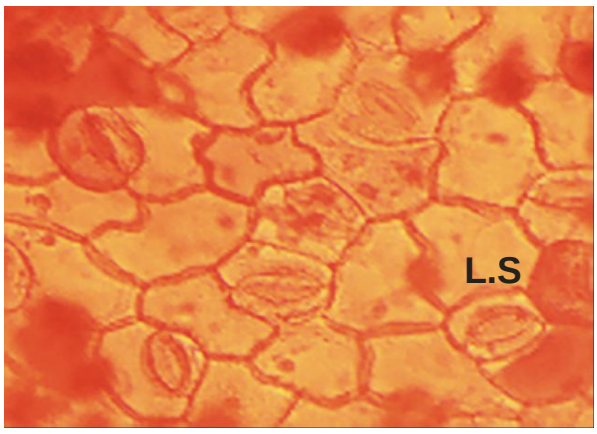

Plate 5F: (L.S) Laterocytic stomata of I. *triloba* (lower Surface) x400

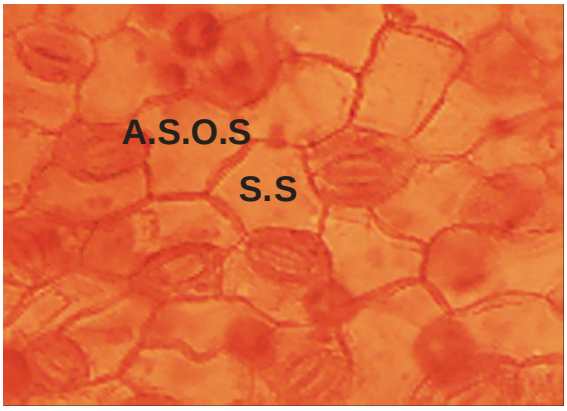

Plate 5G: (S.S) Staurocytic (A.S.O.S) Anomocytic stomata of I. *triloba* (Lower Surface) x400

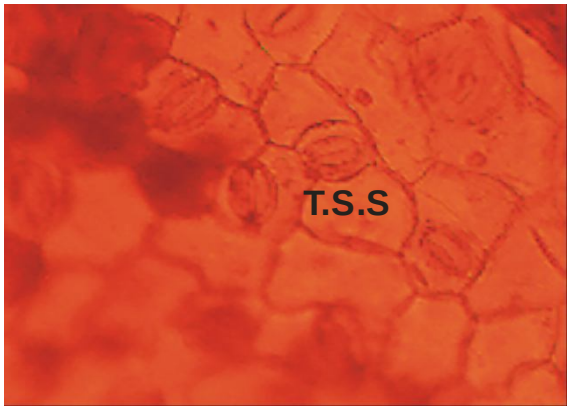

Plate 5H: (T.S.S) Two stomata sharing one subsidiary cell of I. *triloba* (Lower Surface) x400

Plate 5I: (P.S) Paracytic stomata of I. *triloba* (Lower Surface) x400

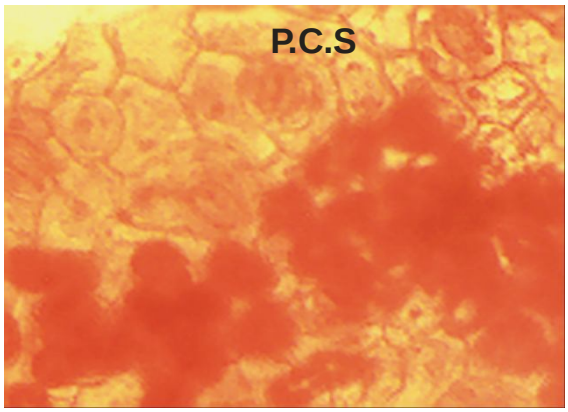

Plate 5J: (P.C.S) Parallel contiguous stomata of I. *triloba* (Lower Surface) x400

Plate 5K: (P.S) Paracytic stomata
of I. *triloba* (upper surface) x400

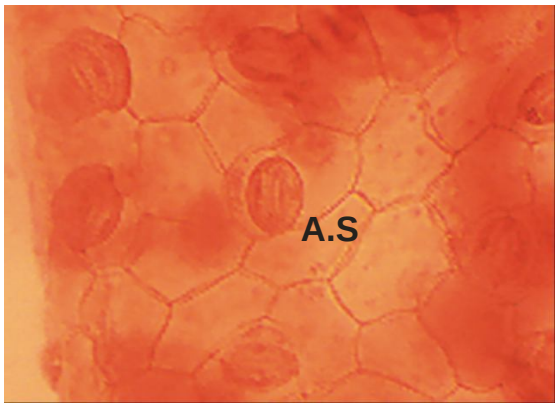

Plate 5L: (A.S) Anisocytic stomata
of I. *triloba* (upper surface) x400

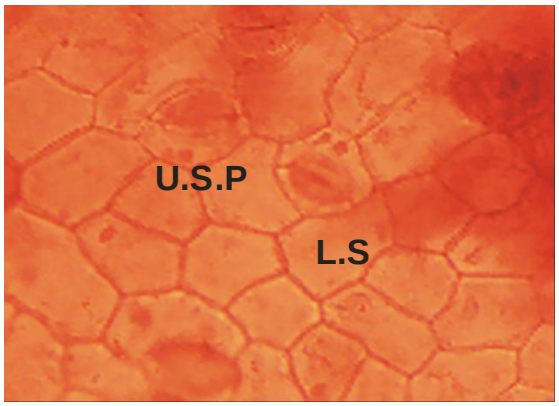

Plate 5M: (L.S) Laterocytic stomata and
(U.S.P) Unopened stomatal pore
of I. *triloba* (upper surface) x400

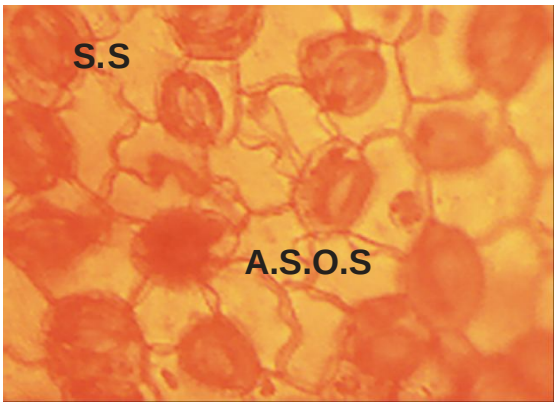

Plate 5N: (S.S) Staurocytic (A.S.O.S) Anomocytic
stomata of I. *triloba* (upper Surface) x400

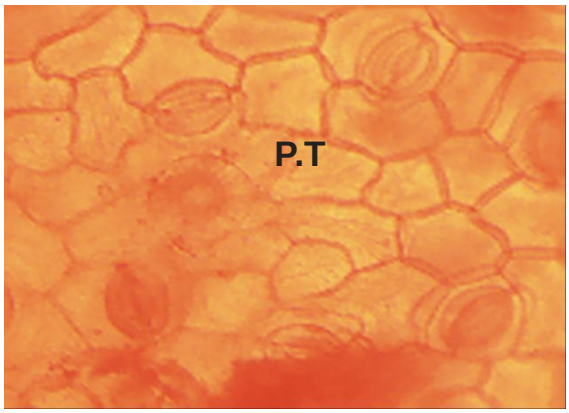

Plate 5O: (P.T) Peltate trichome, of I. *triloba* (upper surface) x400

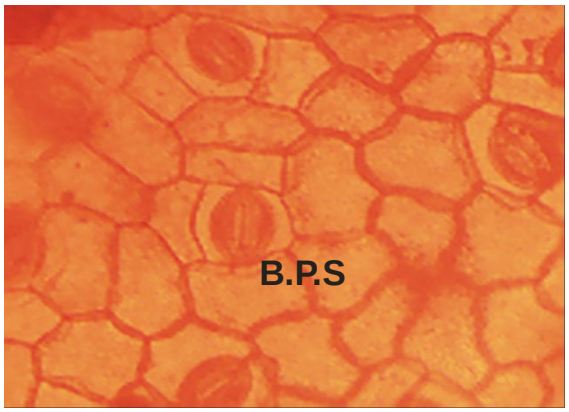

Plate 5P: (B.P.S) Brachyparacytic stomata of I. *triloba* (upper surface) x400

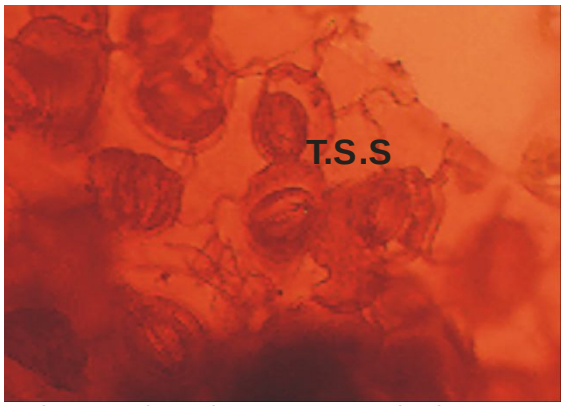

Plate 5Q: (T.S.S) Two stomata sharing one subsidiary cell of I. *triloba* (upper surface) x400

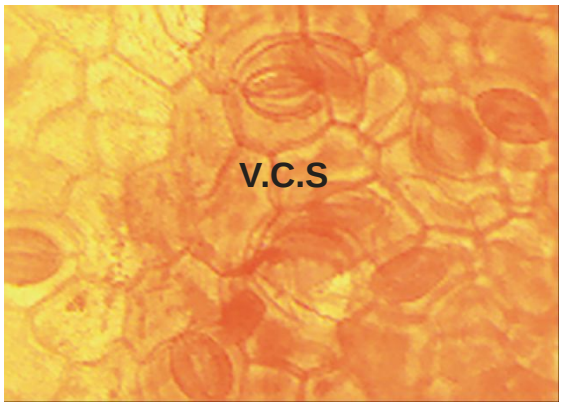

Plate 5R: (V.C.S) Vertical contiguous stomata of I. *triloba* (upper surface) x400

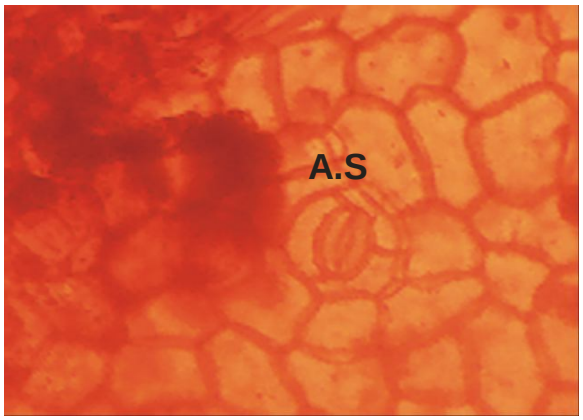

Plate 6A: (A.S) Anisocytic stomata of I. *cairica* (upper surface) x400

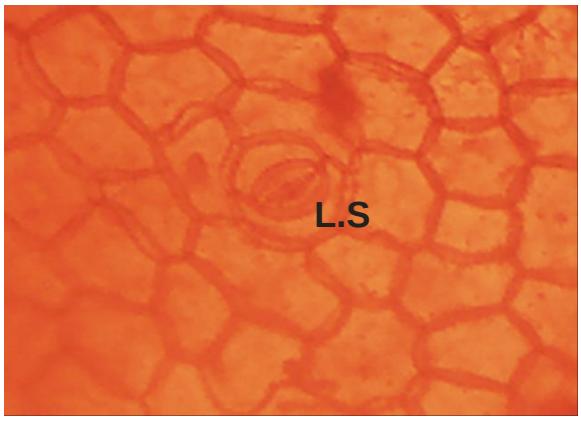

Plate 6B: (L.S) Laterocytic stomata of I. *Cairica* (upper surface) x400

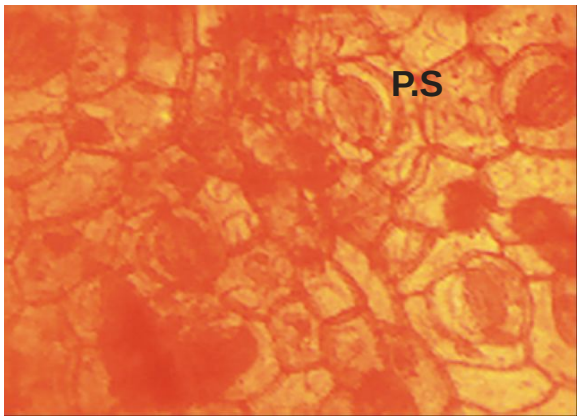

Plate 6C: (P.S) Paracytic stomata of I. *Cairica* (upper surface) x400

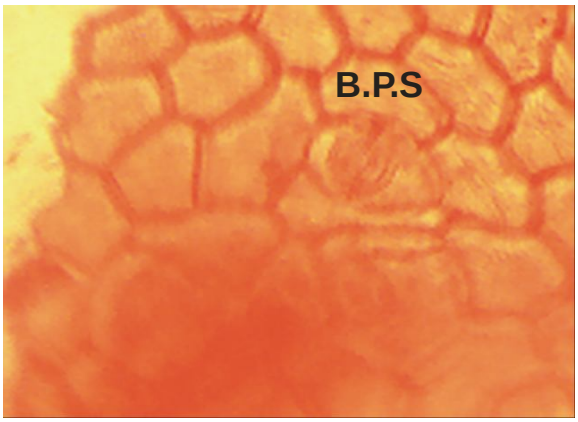

Plate 6D: (B.P.S) Brachyparacytic stomata of I. *Cairica* (upper surface) x400

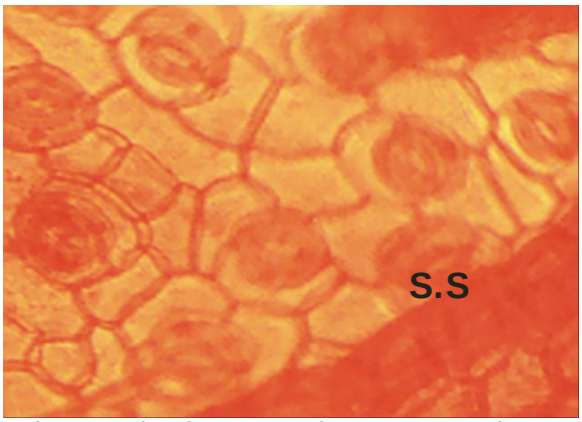

Plate 6E: (S.S) Staurocytic stomata and Two stomata sharing one subsidiary cell of I. *Cairica* (upper surface) x400

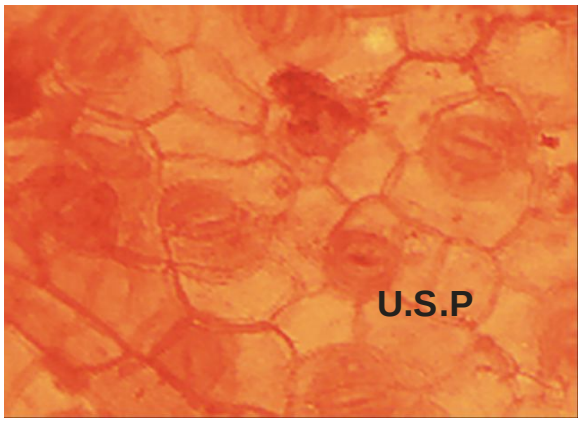

Plate 6F: (U.S.P) Unopened stomatal pore of I. *cairica* (upper surface) x400

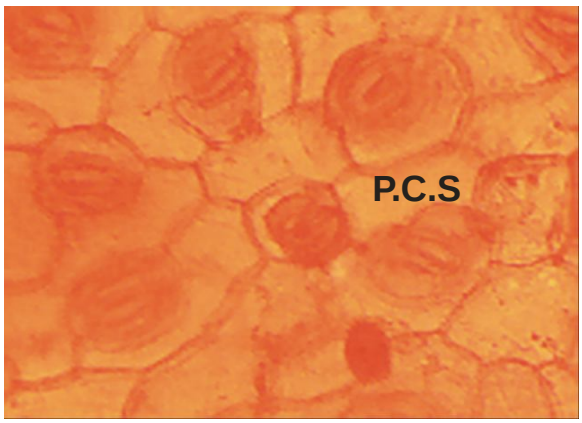

Plate 6G: (P.C.S) Parallel contiguous stomata of I. *cairica* (upper surface) x400

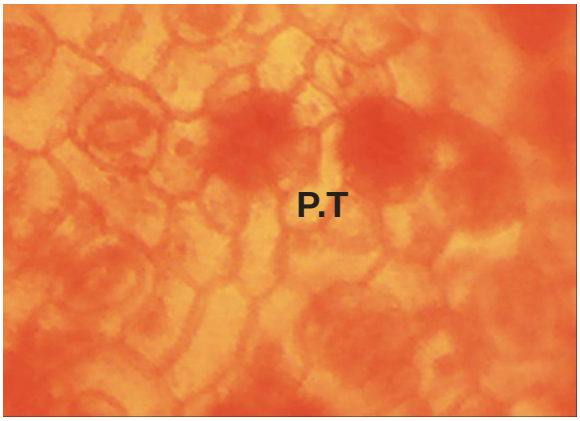

Plate 6H: (P.T) Peltate trichome of I. *cairica* (upper surface) x400

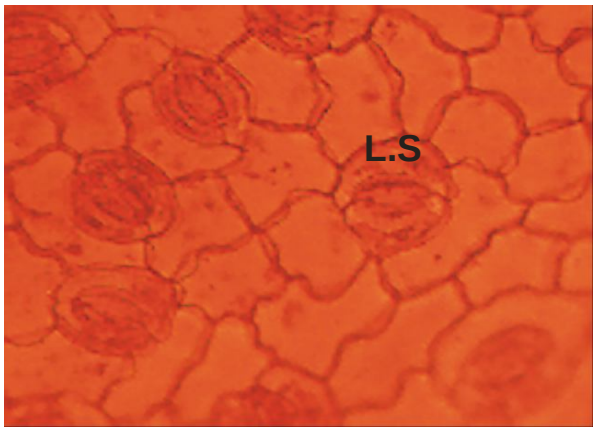

Plate 6I: (L.S) Laterocytic stomata of I. *cairica* (lower surface) x400

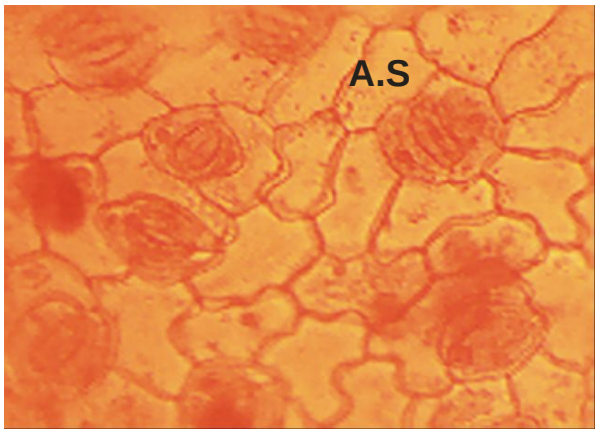

Plate 6J: (A.S) Anisocytic stomata of I. *Cairica* (lower surface) x400

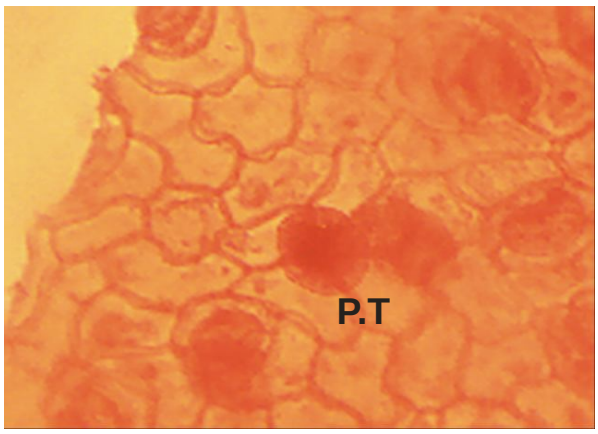

Plate 6K: (P.T) Peltate trichome of I. *Cairica* (lower surface) x400

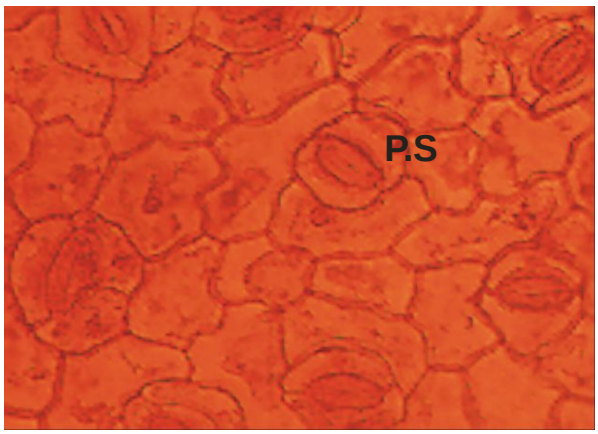

Plate 6L: (P.S) Paracytic stomata of I. *Cairica* (lower surface) x400

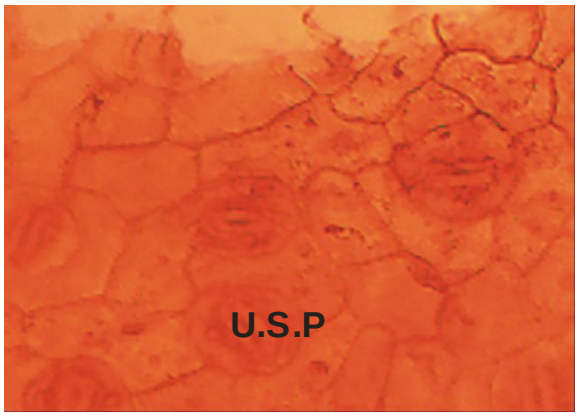

Plate 6M: (U.S.P) Unopened stomatal pore of I. *Cairica* (lower surface) x400

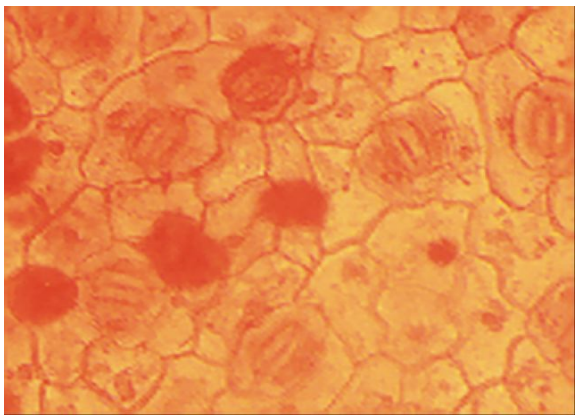

Plate 6N: Two stomata sharing one subsidiary cell of I. *Cairica* (lower surface) x400

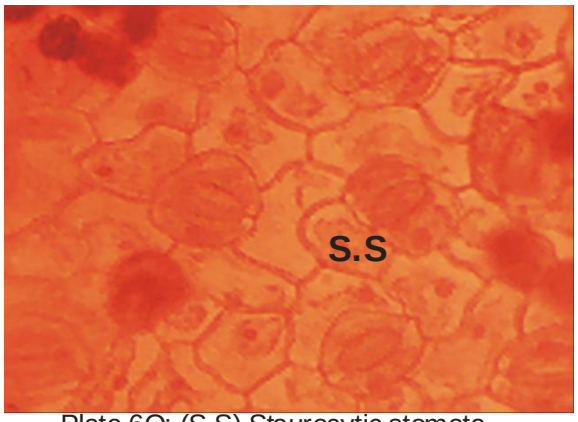

Plate 6O: (S.S) Staurocytic stomata of I. *Cairica* (upper surface) x400

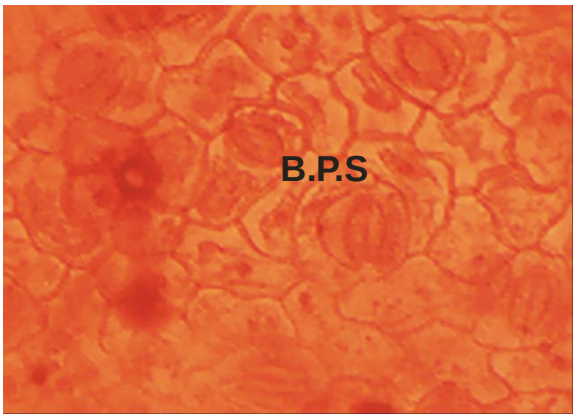

Plate 6P: (B.P.S) Brachyparacytic stomata of I. *Cairica* (lower Surface) x400

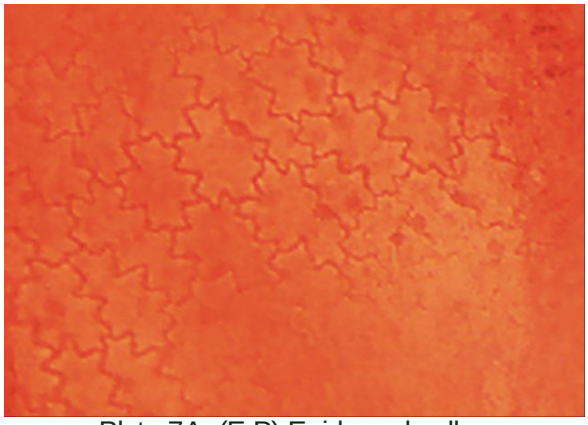

Plate 7A: (E.P) Epidermal cell
of I*. triloba* (upper surface) x400
Lower *I. Aquatica* flower

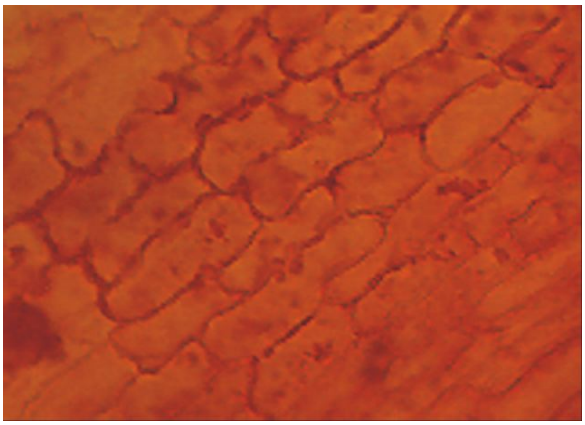

Plate 7B: (E.P) Epidermal cell
of I*. triloba* (lower surface) x400
Upper *I. aquatica* flower

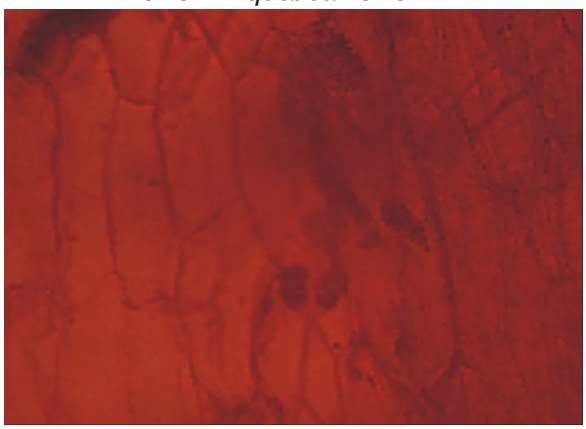

Plate 8A: (E.P) Epidermal cell
of I*. aquatica* (lower surface) x400

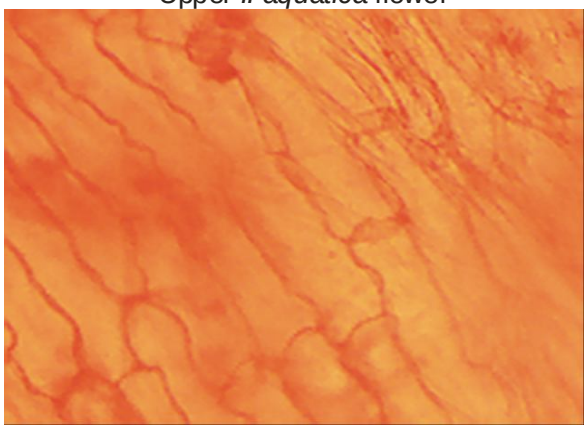

Plate 8B: (E.P) Epidermal cell
of I*. aquatica* (upper surface) x400

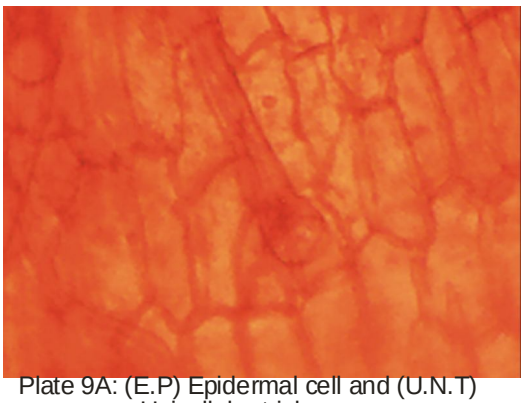

Plate 9A: (E.P) Epidermal cell and (U.N.T) Unicellular trichome of I. *involucrata* (lower surface) x400

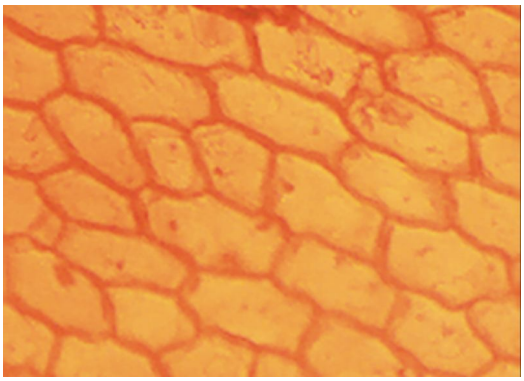

Plate 9B: (E.P) Epidermal cell of I. *involucrata* (upper surface) x400

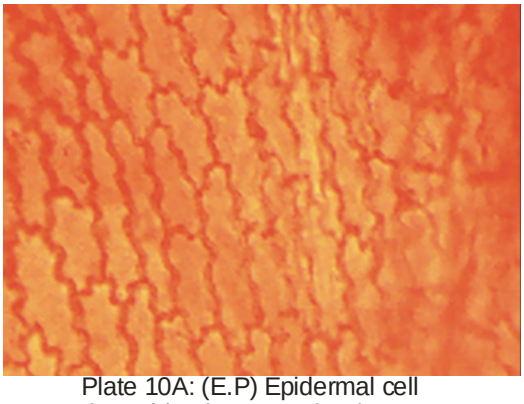

Plate 10A: (E.P) Epidermal cell of I. *cairica* (upper surface) x400

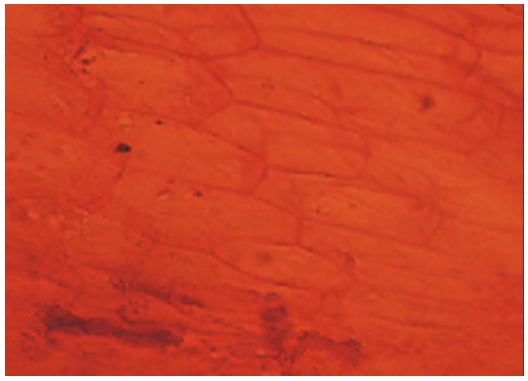

Plate 10B: (E.P) Epidermal cell of I. *Cairica* (lower surface) x400

DISCUSSION

Anatomical features are widely used in systematic for identification, facilitation of taxanomic classification and for indicating pattern of relationship that may have been observed by superficial convergence in morphological features **[11]**. Anatomical evidence has provided useful information in characterization of *Ipomoea* species. The morphological observations made in the study are not different from the records **[27, 39, 42]**. The functions of epidermis are water regulation, protection against sunlight and defense to other organism **[29]**. The epidermal cell on both adaxial and abaxial surface in the six species of *Ipomoea* studied differ in respect of shape, size, forms, stomatal distribution, distribution of

trichomes etc. The shape varies from polygonal to pentagonal of irregular shaped and can be fairly used for the separation of the species. Stomata were large in all the six species studied with larger once on the adaxial surface of *I. alba* (42 x 17µm) while smaller once were observed on the adaxial surface of *I. aquatica* (24 x 15 µm) respectively. This is in corroboration with earlier study of Pataky **[35]** that stomata with guard cell less than (15 µm) are "small" while those with guard cell more than (36µm) in size are "large".

Cell walls were mostly undulate and sometimes straight. Straight cell walls were observed on both abaxial and adaxial surface of *Ipomoea carica* and undulate cell wall on both surfaces in *Ipomoea triloba* and *I. nil*. The occurrence of curved walls in *I. nil* and *triloba* of the species agreed with the suggestion of Stace **[40]** that curved wall is a mesomorphic character and that environmental conditions such as humidity play significant role in determining the pattern of anticlinal cell walls. Striations were also recorded on both surfaces of *Ipomoea triloba*. This also corroborates with Tayade and Patil **[42]**. It is possible for most species to have more than one type of stomata on either surface. This has been shown by Inamdar **[17]**, Pant and Baneji **[34]** in some Polemoniales, Essiett and Akpabio **[10]** on the species of *Talinum*, Pant and Baneji **[34]** in the *Dicotyledonous* family. The findings in the six species of *Ipomoea* studied exhibited this and this can be useful in classification and delimitation of *Ipomoea* species.

The species studied though amphistomatic (stomata present on both surfaces) but with higher frequency of stomata on the abaxial surface has different stomata type such as brachyparacytic, anisocytic, laterocytic, anomocytic, paracytic and diacytic. Laterocytic stomata were abundantly present in *I. involucrata, I. triloba* and *I. alba*. The most dominant stomata types in this investigation were the laterocytic followed by paracytic type. This was also observed by Leela and Shanukha-Roa **[23]**. This dominant and co-dominant stomata are taxonomically important. The role of stomatal index is highly constant for any given species and the value is more uniform upon the abaxial than the adaxial surface in isobilateral leaves **[2, 28, 33]**. The role of stomatal index in systematic work to separate species has also been reported by Abdulrahaman and Oladele **[46]**, Isawumi **[16]** and Aworinde *et al.* **[6]**. The stomatal index varied between the six species studied on both adaxial and abaxial surface. The highest stomatal index is observed on the abaxial surface of *I. involucrata* while the lowest was observed on the lower surface of *I. cairica*. Stomatal index is independent of

the environmental size of the leave surface of the epidermal cell and it is a reliable factor for identification **[30]**. The function of stomata was associated with various physiological process and success of each individual plant **[11]**. The guard cell and stomatal index provides values that would serves as parameter for comparison among taxa.

Another important character are the presence of contiguous stomata on both surface of the six species studied, guard cell with unopened stomata pore, two stomata sharing one subsidiary cell and aborted guard cell. This can be fairly used for the separation of the species. Abnormalities in stomata are conceived to be freaks during stomata ontogeny. The abnormalities in leaves have been the result of environmental factor as confirmed by Carr and Carr **[8]**.

Many plant groups show great diversity in their indumenta, some of which are of taxanomic importance while ecological variation may affect the degree of hairiness, the type of hair is usually constant in many species or specie in the group **[32]**. Many researchers have found the presence or absence and types of trichomes on the epidermal surface as classificatory tools **[4, 38]**. Metcalfe and Chalk **[28]** has long suggested that the types of epidermal trichomes can frequently delimit species, genera or families in plant. Differences in trichomes type were employed by Isawumi **[18]** to delimit species in the *Vernonia* genus and also Johnson **[20]** and Essiett *et al.* **[12]**.

In this study, trichomes were of different shape and size and are of diagnostic interest. Non-glandular trichomes are present only on the abaxial and adaxial surface of *Ipomoea involucrate* while peltate trichomes were present on both adaxial and abaxial surface in all the species observed. The importance of trichome in taxonomy has been highlight by Stace **[41]**, Illoh and Inyang **[16]** and Obute and Ndukwu **[31]**.

The anatomy of the flower of *I. triloba, I.aquatica, I. cairica* and *I. involucrata* studied, showed the absence of stomata on both adaxial and abaxial surface. Trichomes were only observed on the abaxial surface of *I. involucrata*. The epidermal wall varies in shape and size from polygonal to pentagonal. The anticlinal walls were mostly straight to slightly undulating. Straight anticlinal wall were observed on both surfaces of *I. aquatica* and *I. involucrata*. This can be fairly used for the classification of the taxa.

CONCLUSION

In conclusion, observation made from the study shows that the six species of *Ipomoea* studied are not quite distinct. The additional information gotten can be useful in the classification and identification of *Ipomoea*

species in intra-specific relationship among these taxa.

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