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Scanning Electron Microscope Study of the Seed Surface Morphology of Some *Utricularia* (Lentibulariaceae) Species from India

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The present work relates to a study of the seed surface morphology of 22 species of *Utricularia* collected from various states on the subcontinent of India. This study was conducted with the scanning electron microscope to investigate whether the seed coat can serve as a useful taxonomic character. A clear indication of its usefulness is obtained from the micrographs, which show minute details unique to individual species. Based purely on the surface morphology the seeds may be broadly categorised into seven distinct groups, which are described in detail, while smaller differences within a group allow certain distinctions between closely related species. Some possible reasons for these differences are considered, in particular in relation to the habitat in which the species occurs.

Key Words: **Scanning electron microscope,** *Utricularia*, **Seed surface morphology, Taxonomy**

Introduction

The genus *Utricularia* comprises some 150 species distributed througout the tropical and temperate zones, being particularly concentrated in area of high rainfall. The taxonomy of the group is contentious due to considerable diversity within the diagnostic characters normally employed in their classification (Taylor 1964).

A preliminary study of the seed coat of 10 taxa of *Utricularia* from India at the light microscope (LM) level (Abraham & Subramanyam 1965) revealed considerable inter-specific variation. Taylor (1964) draws attention to the importance of the seed as a diagnostic, character for the genus *Utricularia*, stating that "About one-half of

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the African species can be certainly identified from the evidence of a single seed" (p. 17). On the basis of these observations a study has been conducted at the scanning electron microscope (SEM) level with the intension of investigating this feature as a useful taxonomic character, as was found to be the case in the genus *Cordylanthus* (Chuang & Heckard 1972).

Many species of *Utricularia* grow as free floating aquatic plants; some are found in marshy or semi-marshy soils, while others are epiphytic. It is possible that the seed morphology is related to the habitat in which the specimen is found.

Materials and Methods

Seed capsules on the verge of dehiscing were collected from various localities in India between 1962 and 1975 (table 1) and stored in formalin acetic acid alcohol (90ml 70% ethanol+5ml glacial acetic acid+5ml 50% formalin). Voucher specimens were deposited in the various herbaria of the Botanical Survey of India and maintained in the spirit collection by one of us (KS).

Seeds were prepared for SEM as follows. Capsules were dried between filter papers and the seeds were mounted on specimen stubs using double-sided 'Sellotape'. Specimens were sputter-coated in *vacuo* with 50 μm of gold in a Polaron E 5000 coating unit and viewed on a Cambridge Stereoscan mark 2a electron microscope operating at 30 kV with an aperture of 100 μm. The specimen stage was used at tilts of 07° to 66° and specimens were photographed at a magnification of 100 to 5500 times on 35 mm Ilford HP 4 or HP 5 film.

Results

The *Utricularia* seed capsules studied may be tabular, prismatic, lenticular, globose, ovoid, subovoid rhomboid or ellipsoid. The size of the seeds in the 10 species studied previously ranged from 220 to 1427 μm in length and 108 to 1193 μm in breadth (Abraham & Subramanyam 1965). Seed size and surface morphology are relatively constant for a given species but show great diversity from one species to another. Based purely on the surface morphology, the 22 species studied fall into 7 distinct groups while smaller differences within a group allow distinctions to be made between closely related species.

Group I Tabular seeds with a distinct hilum centred on one face and a regular reticulate surface

Group II Large, lenticular seeds with a crenate corky wing and a prominent hilum

Group III Large semiglobose seeds

Groups IV & V Small or minute globose, ovoid or lenticular seeds with a strongly reticulated irregular surface and a prominent terminal hilum

Group VI Minute obovoid seeds with regular allantoid testa cells

Group VII Minute ellipsoid, heavily glochidiate seeds

Group I

Five species, viz. *U. aurea*, *U. stellaris*, *U. equiseticaulis*, *U. graminifolia* and *U. squamosa*, with large tabular or prismatic seeds of square of polygonal outline. Both faces distinctly or slightly reticulated with polygonal or rectangular testa cells. Hilum prominent, centred on one face, with 3 or 4 distinct ridges running to the margins. Hilial surfaces composed of small, irregular cells; margins raised and prominent; considerable wax deposition.

(a) *U. aurea* and *U. stellaris:* Seeds tabular or prismatic, 4–6 angled (figures 1A & 1D);

Table 1 *Collection data for* Utricularia *species used for SEM observations*

Species	Locality, District (State)	Altitude (m)	Habitat	Collector and Date
1	2	3	4	5
U. albocaerulea Dalz.	Mahabaleshwar, Satara (Maharashtra)	1450	Terrestrial, damp soil or wet rocks	*K Rao* 3; 18/21 Oct. 1974
U. arcuata Wt.	Kuthikanam (Kerala)	1880	Terrestrial, wet soil	*N C Nair* 40038; 24 Oct. 1968
U. aurea Lour.	Ankamalli, Trichur (Kerala)	100	Aquatic	*K M Sebastine*; 26741; 10 Dec. 1975
U. baouleensis A. Chev.	"Woodlands compound", Bot. Survey of India; Shillong, East Khasi (Meghalaya)	1500	Terrestrial, wet places, marshes and swampy grass-land	*A S Rao* 36658; 16 Sept. 1966
U. bifida Linn.	Ward Lake Shillong, East Khasi (Meghalaya)	2150	Terrestrial, wet places	*R L Mitra s.n.*; 25 Sept. 1975
U. caerulea Linn.	Shevaroy hills, Salem (Tamil Nadu)	1450	Terrestrial, swampy places	*A N Rao* 3; 18 Oct. 1975
U. equiseticaulis Blatter & McCann	Dalkeith Springs, Panchagani, Satara (Maharashtra)	1450	Terrestrial, water-logged soil	*R S Raghavan s.n.*; 15 Oct. 1966
U. exoleta Br.	Kukanahalli tank, Mysore (Karnataka)	1090	Aquatic, submerged or floating in shallow water or in wet mud	*V Bhaskar* 283d; 15 Aug. 1975
U. furcellata Oliver	Elephant Falls, Upper Shillong, East Khasi (Meghalaya)	2160	Epiphytic on moss-covered trunks shaded moss-covered wet rocks near water falls	*A S Rao* 37995; 20 Aug. 1967
U. graminifolia Vahl	Kavaledurga, Shimoga (Karnataka)	323	Terrestrial, bogs, wet places	*R S Raghvan* 82904; 2 Oct. 1962
U. hirta Klein *ex* Link	Halekote, Hassan (Karnataka)	924	Terrestrial, wet, sandy soils	*V Bhaskar* 409a; 24 Nov. 1973
U. minutissima Vahl	Puri coast, Cuttack (Orissa)	sea level	Terrestrial, water logged soil,	*T A Rao* 5697 (b); 4 Dec. 1965
U. ogmosperma Blatter & McCann	Panchagani, Satara (Maharashtra)	1300	Terrestrial, water logged soil	*K Subramanyam* 50; 6 Oct. 1965
U. polygaloides Edgeworth	Ranganathittu, near Mysore, Mandya (Karnataka)	1093	Terrestrial, wet swampy places, amidst moss	*K Subramanyam* 48; 20 Jan. 1974

Table 1 (*Contd.*)

1	2	3	4	5
U. pubescens Sm.	Rajpur, near Dehradun,* Dehradun (Uttar Pradesh)	950	Terrestrial, damp marshy places, amidst boggy grass-land	*M A Rau s.n.*;
U. reticulata Sm.	Olavakkot, Palghat (Kerala)	75	Terrestrial in rice fields	*V Nair s n.* 1 Sept. 1965
U. scandens Benj. subsp. *scandens* P. Taylor	Ranganathittu, near Mandya, Mandya (Karnataka)	1093	Terrestrial, in wet places, boggy grassland	*K Subramanyam* 47; 23 Jan. 1963
U. smithiana Wt.	Monica Estate, Coimbatore (Tamil Nadu)	950	Terrestrial in wet places	*J Joseph* 15588; 23 Jan. 1963
U. stellaris Linn. f.	Bannerghatta, near Bangalore, Bangalore (Karnataka)	1025	Aquatic, floating in shallow water, marshes, rice fields and small lakes	*K Subramanyam* 115; 25 Dec. 1976
U. striatula Sm.	Periyar Dam Idikki (Kerala)	1180	Epiphytic on moss-covered tree trunks, under shaded wet, moss-covered rocks, near streams and especially near water falls	*N C Nair* 40119; 18 Oct. 1968
U. squamosa Wt.	Shiruvani, Coimbatore (Tamil Nadu)	1000	Terrestrial, wet places	*A N Henry s.n.*; 9 Jun. 1965
U. uliginosa Vahl	Periyar Dam, Idikki (Kerala)	1180	Terrestrial swampy places	*N C Nair* 40183; 20 Oct. 1968

testa cells polygonal, retiform, radiating from centre on both faces (figures 1A, 1B & 1D); both polygonal walls and concavities minutely tuberculate (figures 1B, 1C & 1E); upper surface divided into 4 by heavy ridges in cruciform array; outermost cells form marginal pallisade; margins partly winged; hilum round, flat, central with filamentous wax deposits (figure 1F).

(b) *U. equiseticaulis, U. graminifolia* and *U. squamosa:* Seeds tabular and polygonal (figures 1G, 1J & 2A); testa cells of upper surface irregular rectangular and radiate from centre (figures 1H, 1J & 2C), those on lower face much more regular and aligned parallel to the major axis (figures 1G, 1K & 2B); surfaces slightly scrobiculate (figures 1I, 1L & 2B). Hilum less prominent, central to upper surface with 3 or 4 indistinct ridges radiating to margins; margins raised, not winged. Surface of *U. squamosa* traversed by fine striae (figure 2B) in a criss-cross, irregular array. Hilum of *U. graminifolia* with globular waxy formations (figure 1L); 'wormy' wax deposits on hilum and lower side of *U. equiseticaulis* seeds (figure 1J).

Group II

One species *U. exoleta* (formerly *U. gibba* subsp. *exoleta*). Lenticular seeds with highly crenate, irregular sides and a corky wing (figure 2D). Hilum cup-shaped, prominent and central to upper face (figure 2E); centre of lower face planar, retiform with hexagonal or polygonal testa cells (figure 2F) with grooved ridges and verrucose concavities. Small, globular wax deposits on some of the crenular projections (figure 2 G).

Group III

One species *U. hirta:* Ovate seeds with a nodular projection at the constricted end (figure 2H). Whole seed surface crenate with some fine grooving on the crenations (figures 2J & 2K); verrucose wax deposits over much of surface (figures 2I & 2L).

Group IV

Seven species *U. smithiana, U. albocaerulea, U. uliginosa, U. scandens* subsp. *scandens, U. bifida, U. minutissima* and *U. pubescens* with minute globose, subglobose or trapezoid seeds. Testa cells irregular, wavy reticulate or irregular reticulate and radiating from terminal, semi-prominent hilum.

(a) *U. smithiana:* Seeds globose (figure 3A); testa cells regular hexagonal or pentagonal and as wide as broad with prominent ridges which are stepped (figure 3B); concavities with fine criss-cross striae and somewhat verrucose (figures 3B & 3C); Hilum terminal. Some small, flaky wax deposits (figure 3B).

(b) *U. albocaerulea* and *U. uliginosa:* Seeds subglobose or trapezoid (figures 3D & 3G); testa cells heavily ridged, irregular, may be subhexagonal but angles much more rounded than in *U. smithiana* (figures 3E & 3H). Concavities of *U. albocaerulea* less broad than those of *U. uliginosa*, with a few criss-cross striae in *U. uliginosa* (figure 3H). Domes of flaky wax in *U. uliginosa* contrast with large wax flakes in *U. albocaerulea* (figures 3I & 3F).

(c) *U. scandens* subsp. *scandens* and *U. bifida:* Seeds ovoid to elliptic (figures 3J & 4A); testa cells regularly reticulated, more elongated than broad, with sharply angled corners (figures 3K & 4B). Ridges prominent; in *U. scandens* subsp. *scandens* ridges and concavities minutely verrucose (figure 3L) whereas in *U. bifida* ridges slightly grooved and concavities tuberculate (figure 4C). Hilum prominent only in *U. scandens* subsp. *scandens* (figure 3J). Some globular wax deposits, particularly in *U. bifida* (figures 4B & 4C).

(d) *U. pubescens* and *U. minutissima:* Seeds trapezoid and may be plano-concave (figures 4D & 4G); testa cells of *U. pubescens* regular, pentagonal or rectangular with semi-prominent allantoid ridges and distinct spurs running perpendicular to ridges into concavities (figure 4E); testa cells at larger end of *U. minutissima* mostly polygonal, much less ridged, with broad flat ridges lacking spurs (figure 4G) but regular and rectangular around hilum (figure 4H). In *U. pubescens* regular lines of 'wormy' wax deposits line the ridges and run in clearly defined bands across the concavities (figures 4E & 4F) with some larger deposits in the angles of the ridges. *U. minutissima* has a scrobiculate surface to both ridges and concavities with a few flakes of wax (figure 4H).

Group V

Five species, *U. arcuata, U. ogmosperma, U. baoulëensis, U. polygaloides* and *U. reticulata* all with small or minute obovoid, rhomboid or ellipsoid seeds. Testa cells extremely retiform, very elongated with acutely angled or rounded ends; concavities irregularly verrucose or furrowed.

(a) *U. arcuata:* Seeds obovoid (figure 4J); testa cells elongated and irregular, may form wavy pattern or be orientated parallel to

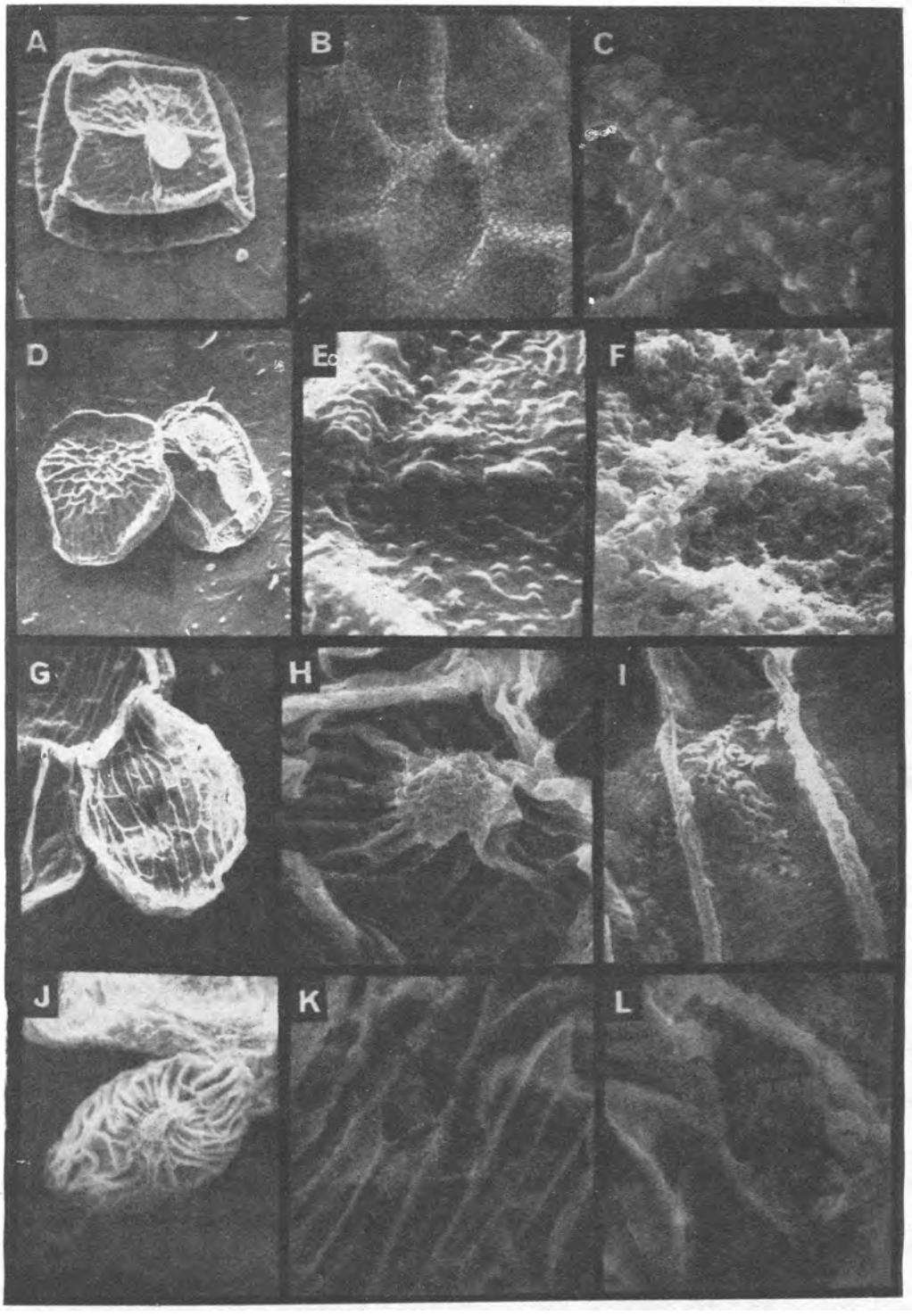

Figure 1 A–L. *A–C, U. aurea*: *A*, whole seed, hilial face (4×8); *B*, Central cells of lower face (×238); *C*, surface details (×950); *D–F, U. stellaris*; *D*, whole seeds, both faces (×28); *E*, detail of surface (×1100); *F*, detail of hilum (×2520); *G–I, U. equiseticaulis*: *G*, whole seed, lower face (×110); *H*, hilum (×280); *I*, wax deposits (×1100); *J–L, U. graminifolia*; *J*, whole seed, hilial face (×98); *K*, cells of lower face (×270); *L*, wax deposits (×540)

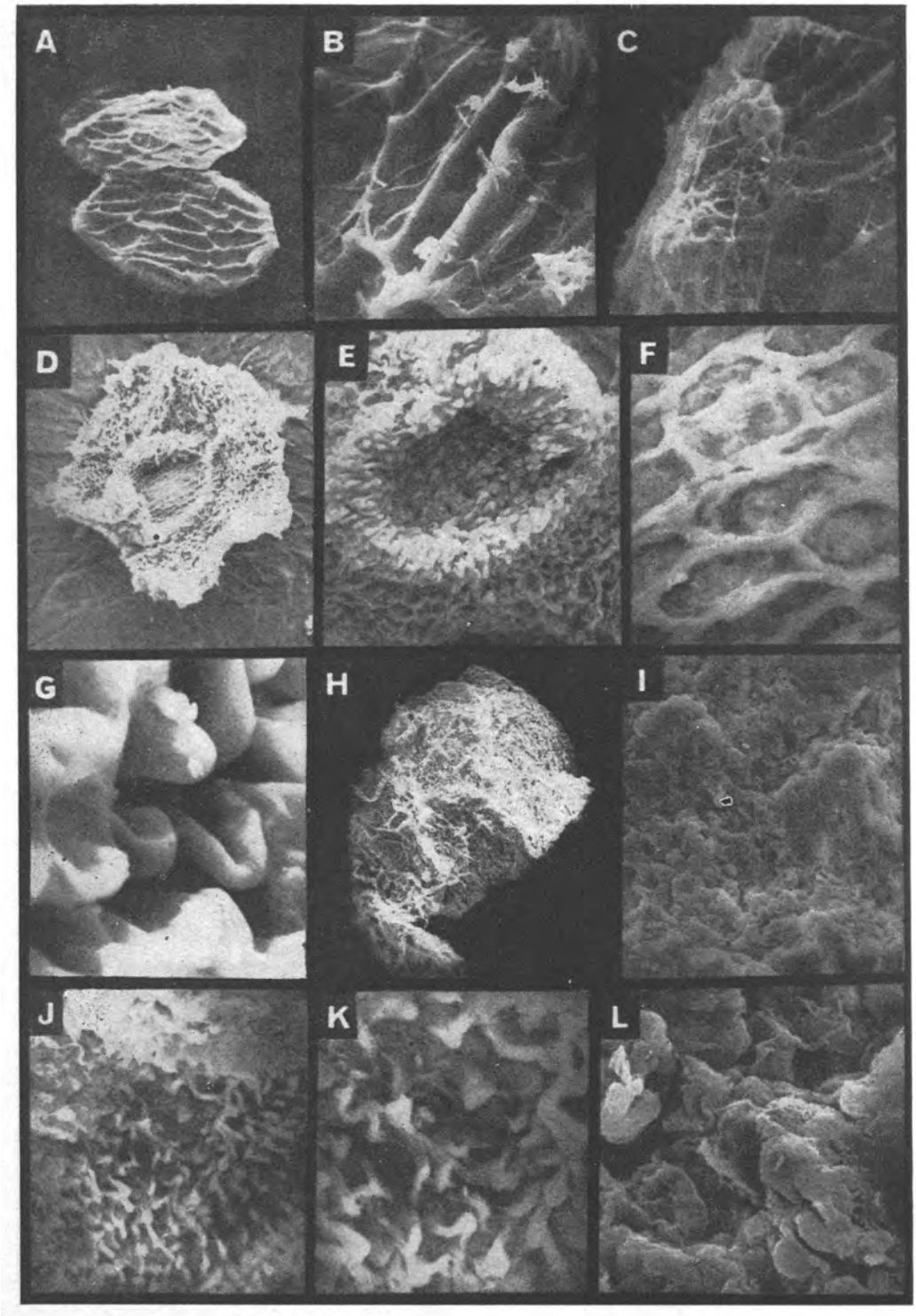

Figure 2 A–L. *A–C, U. squamosa*: *A*, whole seeds, lower faces (×144); *B*, detail of lower face (×560); *C*, detail of hilum (×525); *D–G, U. exoleta*; *D*, whole seed (×58); *E*, hilum (×15); *F*, detail of testa cells (×575); *G*, detail of wing cells (×1150); *H–L, U. hirta*; *H*, whole seed (×50); *I*, wax deposits (×250); *J*, general surface detail (×285); *K*, detail of surface crenations (×575); *L*, detail of wax deposits (×1005)

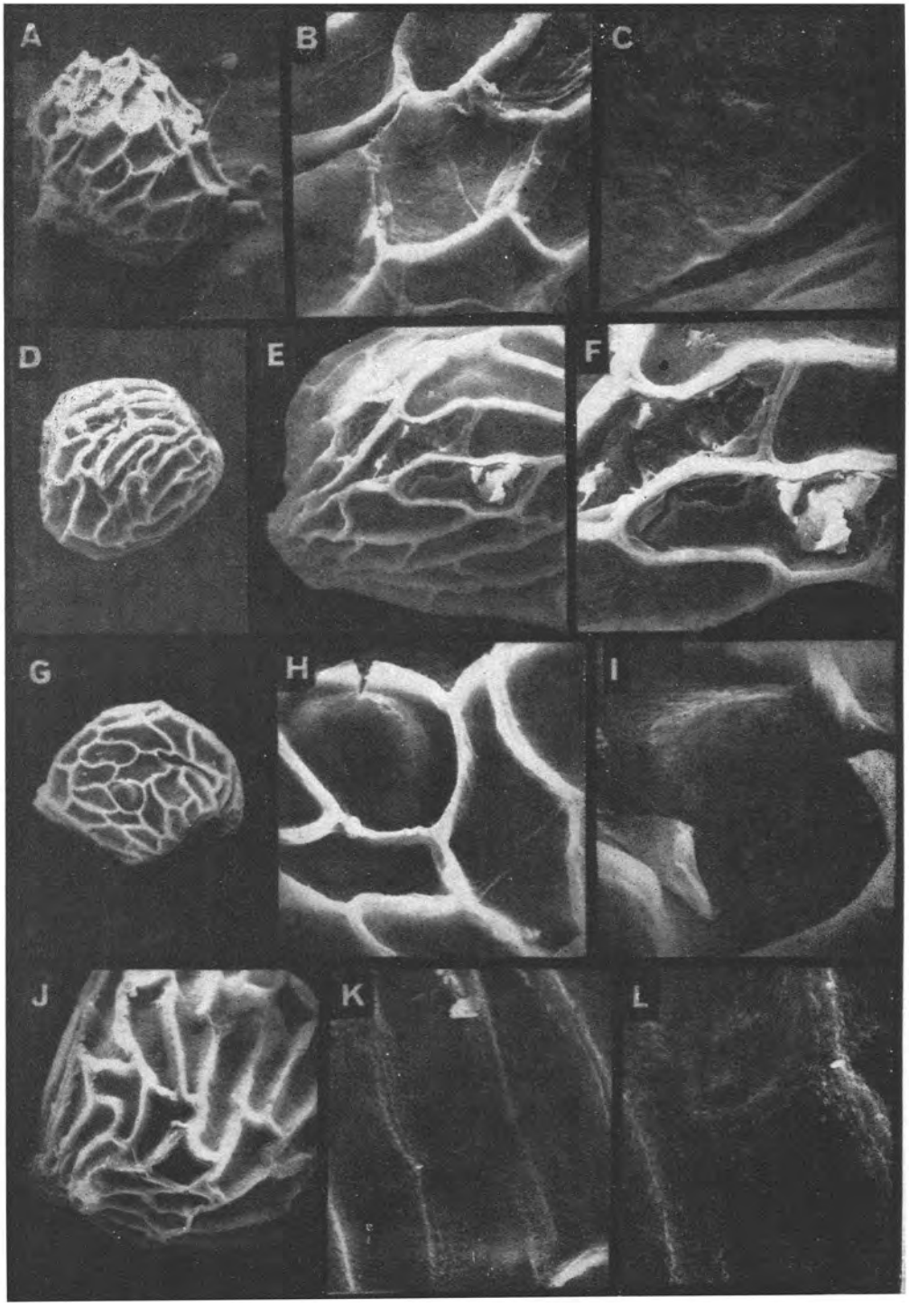

Figure 3 A–L. *A–C*, *U. smithiana*: *A*, whole seed (×105); *B*, testa cells (×350); *C*, detail of surface (×2650); *D–F*, *U. albocaerulea*: *D*, whole seed (×114); *E*, hilum and testa cells (×238); *F*, wax flakes (×475) *G–I*, *U. uliginosa*: *G*, whole seed (×110); *H*, detail of testa cells (×555) *I*, wax dome (×1150), *J–L*, *U. scandens* subsp. *scandens*; *J*, seed showing hilal end (×225); *K*, testa cells (×525); *L*, detail of cellular surface (×1050)

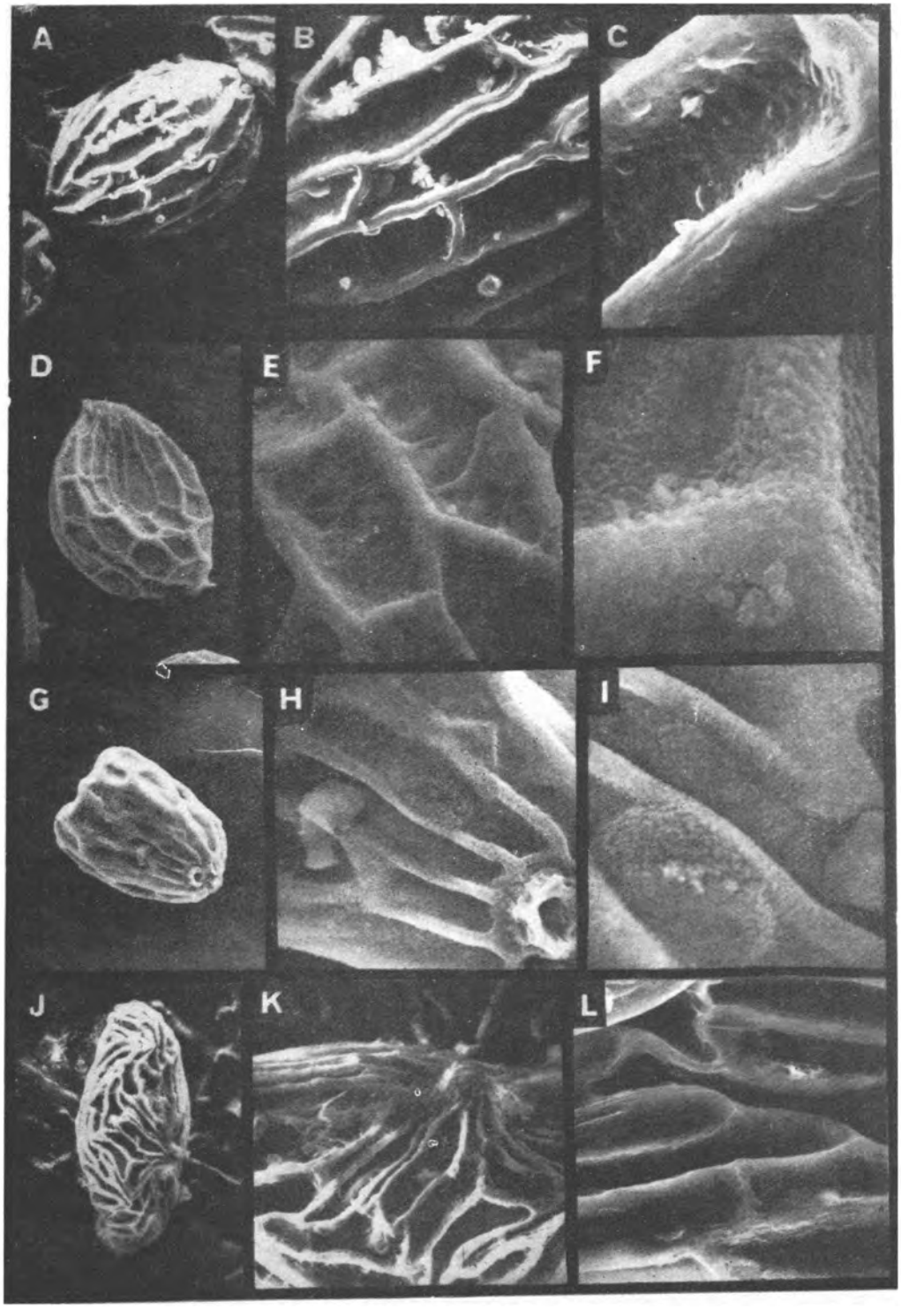

Figure 4 A–L. *A–C*, *U. bifida*: *A*, whole seed (×95); *B*, testa cells (×238) *C*, detail (×950) *D–F*, *U. pubescens*: *D*, whole seed (×126); *E*, testa cells (×525); *F*, wax deposits (×2550) *G–I*, *U. minutissima*; *G*, whole seed (×126); *H*, hilum and testa cells (×525); *I*, wax deposits (×1025); *J–L*, *S. arcuata*; *J*, whole seed (×88); *K*, hilum (×233); *L*, testa cells (×460)

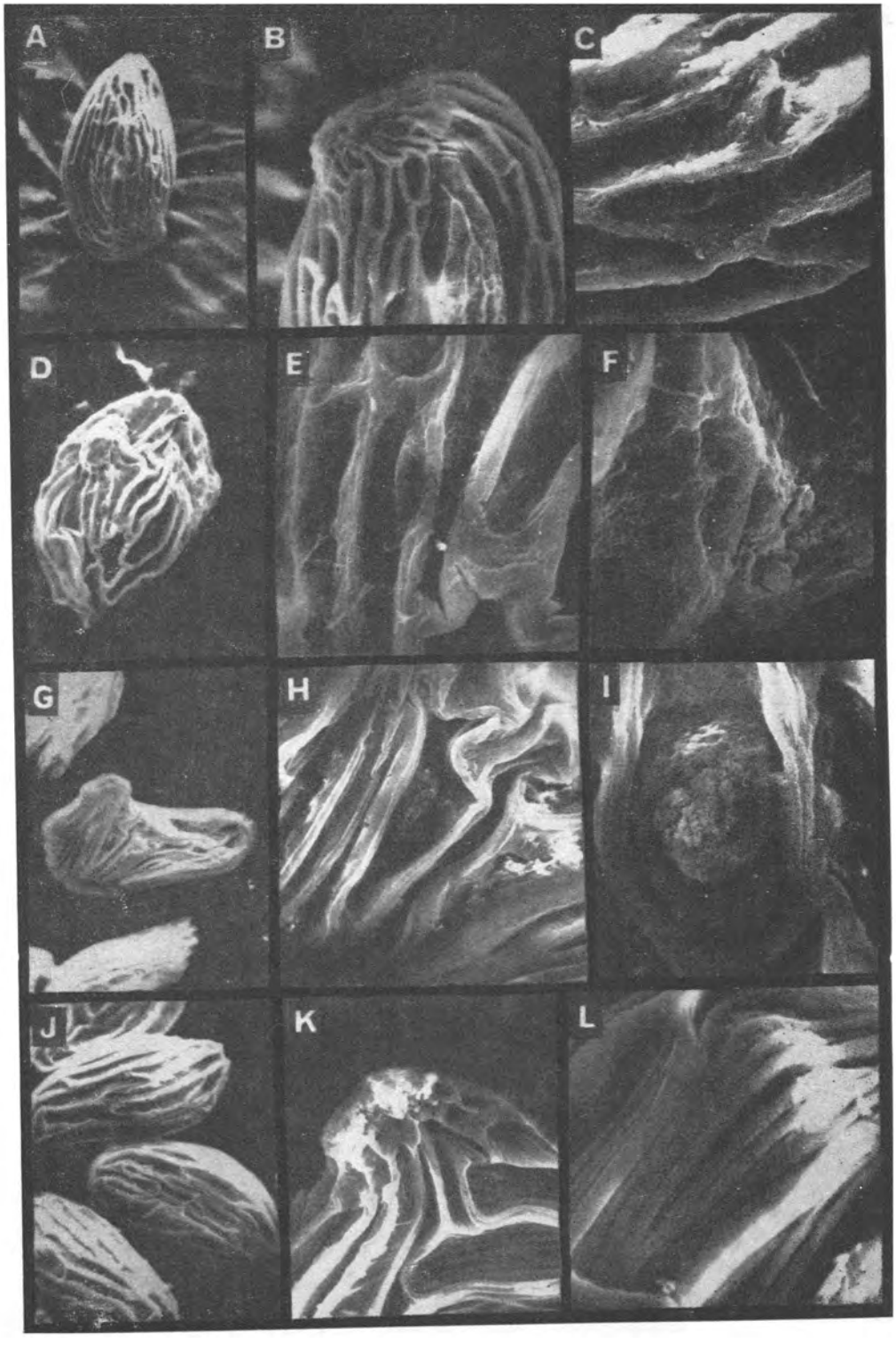

Figure 5 A–L. *A–C, U. ogmosperma*; *A*, whole seed (×95); *B*, hilal end (×240); *C*, testa cells (×450); *D–F, U. baouleensis*: *D*, whole seed (×123); *E*, testa cells (×625); *F*, wax deposits (×1200); *G–I, U. reticulata*: *G*, whole seeds (×138); *H*, testa cells (×575); *I*, wax dome (× 1100); *J-L, U. polygaloides*: *J*, whole seed (× 133); *K*, hilum (× 490); *L*, allantoid striae (× 950)

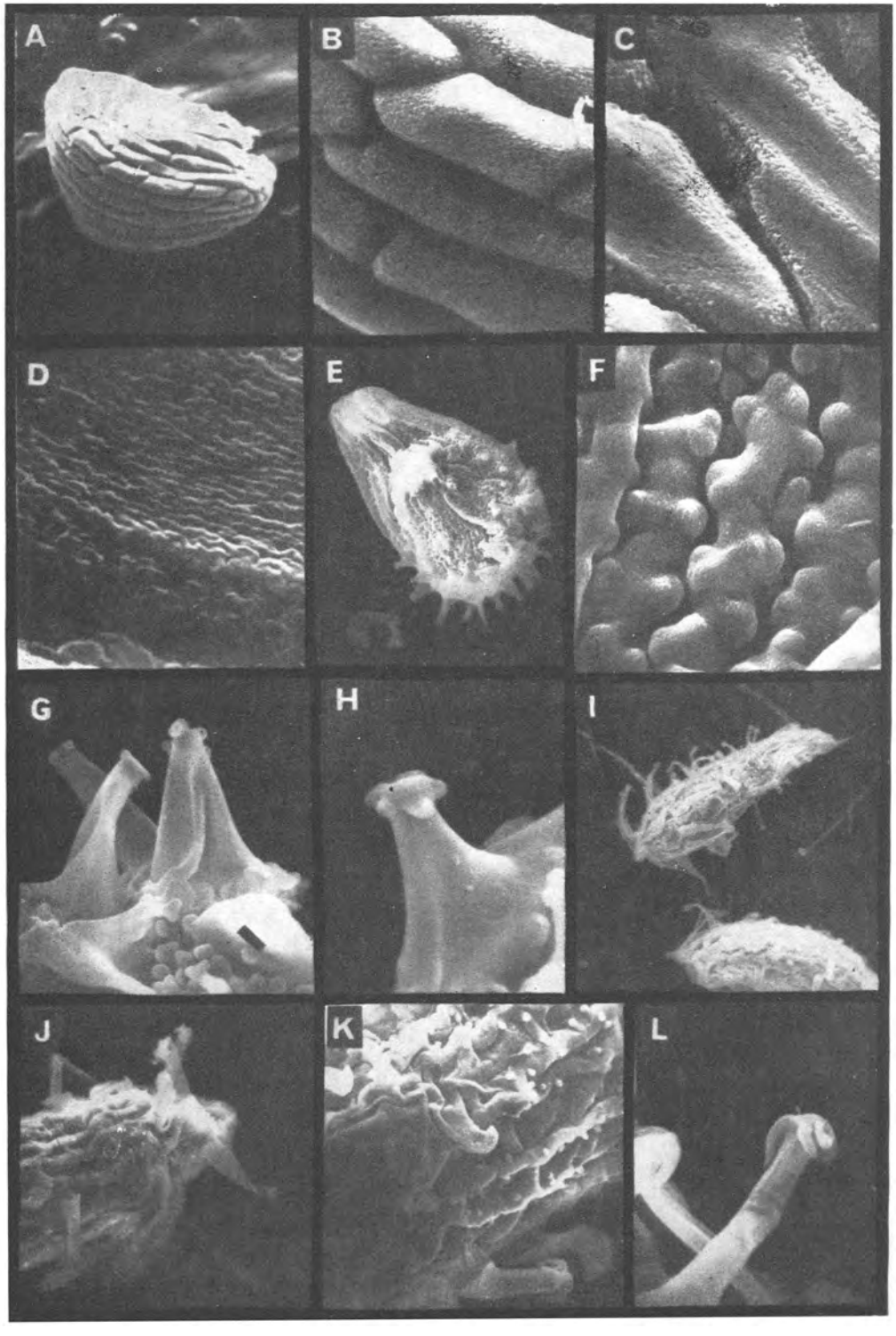

Figure 6 A–L. *A–D, U. caerulea*: *A*, whole seed (× 110); *B*, allantoid testa cells (× 550); *C*, grooved testa cells (× 1125) *D*, wax deposits (× 2800); *E–H, U. furcellata*; *E*, whole seed (× 105); *F*, testa cells (× 1075); *G*, group of glochidia (× 600); *H*, glochid showing tip (× 1050); *I–L, U. striatula*; *I*, whole seed (× 126); *J*, group of glochidia (× 225); *K*, testa cells

major axis. Cells very heavily reticulated with ridges radiating out from hilum, which is one third way down the seed (figure 4K). Ridges occasionally furrowed; concavity surfaces verrucose with a few irregular striae (figure 4L).

(b) *U. ogmosperma:* Seeds obovoid and sharply tapered towards one end (figure 5A); testa cells elongated, regular and parallel to major axis or slightly corkscrewed at narrower end. Cells heavily reticulated with ridges broader and more furrowed than *U. arcuata*; concavities verrucose with some criss-cross striae (figure 5C). Hilum offset at broader end (figure 5B).

(c) *U. baouleensis:* Seeds ovoid and slightly tapered towards one end (figure 5D); testa cells retiform, irregular and elongated with a wavy outline but broader than *U. arcuata* and with an overall orientation parallel to major axis. Ridges broad like *U. ogmosperma* but less furrowed; concavities verrucose with some criss-cross striae (figure 5E). Hilum central, not prominent. Some globose wax deposits (figure 5F).

(d) *U. reticulata:* Seeds rhomboid with heavy irregular reticulation (figure 5G); testa cells elongated with irregular wavy outline radiating from hilum (figure 5H). Ridge spacing similar to *U. arcuata* but more wavy and furrowed; concavities verrucose with some flaky wax in dome-shaped deposits (figure 5I). Hilum very prominent and central.

(e) *U. polygaloides:* Seeds ellipsoid and minute (figure 5J); testa cells elongated with even, prominent ridges running parallel to major axis, but not corkscrewed Ridges similar to *U. ogmosperma* and may be slightly furrowed; concavities coarsely striate with allantoid ridges running parallel to major axis (figure 5L). Hilum terminal and slightly offset as in *U. ogmosperma* (figure 5K).

Group VI

One species *U. caerulea:* obovoid, minute seeds (figure 6A); testa cells elongated, allantoid and may have regular or irregular ends (figure 6B), sometimes obliquely grooved (figure 6C). Surface mostly covered with small flaky or rod-shaped wax deposits which may be over-lapping or fissured with reference one to another (figure 6 D). Hilum not prominent.

Group VII

Two species *U. furcellata* and *U. striatula* both with minute ellipsoid or obovoid glochidiate seeds. Glochidia slender, crowned with four or five short barbs or nodules.

(a) *U. furcellata:* Seeds obovoid (figure 6E); both areoles and edges of epidermal cells with fine and compactly arranged nodules which in turn are further reticulate-striate (figure 6F). Hilum terminal at lesser end with several distinct ridges running along length of seed; hilum covered in overlapping wax flakes. Glochidia mostly confined to broad end (figure 6E), elongated pyramidiform (figure 6G) and capped with five nodular projections (figure 6H).

(b) *U. striatula:* Seeds ellipsoid (figure 6I); testa cells irregular, crispate and orientated parallel to major axis (figure 6K). Hilum terminal at lesser end but lacks distinct ridges. Epidermal cell surface finely verrucose with some globular-wax deposits (figure 6K). Glochidia extend almost whole length of seed (figure. 6I), very slender, cylindrical (figure 6J) and capped with five recurving barbs (figure 6L).

Discussion

Various attempts have been made to classify the species of *Utricularia* using different criteria. Thanikaimoni (1966) after studying the pollen morphology of 22 Indian species of *Utricularia* has presented a pictorial table wherein, according to him, some kind of

correlation can be made between habit, seed and pollen characters. Basing their classification on the several types of trichomes that occur on the different floral parts of *Utricularia*, Farooq (1966), Farooq and Siddiqui (1966) and Shamina and Siddiqui (1974) have divided the types of trichomes into 20 subheadings (A to T) and suggested that the genus *Utricularia* could be classified to a certain extent on the basis of these trichomes.

Komiya (1973) has suggested a new subdivision of Lentibulariaceae in which he has included the genus *Utricularia* into a new subfamily Utricularioideae which in turn has been further divided into tribes, genera, subgenera and sections. He thus places the genus *Utricularia* under seven new subgenera which in turn include several sections in which various species of *Utricularia* are placed. The classification is based upon habitat and certain salient vegetative and floral characters. Attempts to subdivide the genus are, however, not new (see Taylor 1964; 5-6) but Taylor (1964) considered the genus too polymorphic and too poorly characterized to warrant generic segregation at present.

A very important and comprehensive contribution towards unravelling the complexities of the genus *Utricularia* is that of Taylor (1964), who has made a detailed study of those species (31) occurring in Africa (south of the Sahara) and Madagascar. He does not subdivide the genus, and provides very useful keys using vegetative and floral characters to differentiate the various species found in this continent. Pointing out the importance of seeds Taylor (1964, 17) rightly remarks that "the seeds exhibit a range of form as wide as or quite probably wider than that shown by any other genus and, as they are durable and easily observed in dried species, they supply taxonomic characters of great importance. About one half of the African species can be certainly identified from the evidence of a single seed." Again, in the same paper while discussing the analysis of the diagnostic characters of the several taxa of *Utricularia* he states (Taylor 1964, 17) "About half (15) may be distinguished on the evidence of a single seed, while the combination of seed and flower increases this number to 29—all but two." These statements of Taylor prompted Abraham and Subramanyam (1965) to study the seeds of 10 taxa of *Utricularia* occurring in the state of West Bengal. This preliminary study of surface morphology under the light microscope showed that the shape of seeds, pattern in the arrangement of epidermal cells, of seed coat, striations (if any) in these cells epidermal projections and wings and measurements of seeds are distinct from species to species and could be well used for identification, strongly supporting Taylor's (1964) conclusions.

Because of this great variation in the surface morphology of the seeds of different species of *Utricularia*, this study was extended further to the scanning electron microscope (SEM) level to find additional details for differentiation of the 22 taxa of this genus collected from various parts of the sub-continent of India on a population basis. The present work at the SEM level has shown that, purely on the basis of the surface morphology, the seeds of these species can be broadly categorised into seven distinct groups; at the same time the smaller differences within a group permit certain distinctions to be drawn between closely related species.

The presence of waxy deposits is an interesting feature, noticed in most of the seeds of the taxa studied. They have a variety of peculiar shapes, being filamentous in *U. aurea* and *U. stellaris*, verrucose in *U. hirta*, flaky in *U. minutissima*, flaky or rod-shaped, overlapping or fissured with reference to one another in *U. caerulea*, large and flaky in *U. albo caerulea*, dome-

shaped in *U. uliginosa, U. exoleta, U. graminifolia, U. baouleensis* and *U. bifida* 'wormy' in *U. equiseticaulis* and as a 'wormy' lining along ridges or as clearly defined bands running across the concavities in *U. pubescens*. Wax seems to be commonly present on the seeds of many plants and the wax types have been described by Amelunxen et al. (1967).

Other noteworthy and interesting features in the surface morphology of the seeds relate to the testa cells, their ridges and the concavities which they enclose. The cells of the testa in *U. caerulea* are elongated, allantoid and may have regular or irregular ends and sometimes are even obliquely grooved. The ridges and concavities in *U. scandens* subsp, *scandens* are minutely verrucose whereas in *U. bifida* the ridges are slightly grooved and concavities tuberculate The ridges in *U. polygaloides* are slightly furrowed and the concavities are coarsely striate with allantoid ridges running parallel to the major veins, The surface of the seeds in *U. squamosa* is traversed by fine striae, in criss-cross, irregular array.

The three acquatic taxa studied are *U. aurea, U. exoleta* and *U. stellaris.* Whereas *U. aurea and U. stellaris* are placed in Group I, *U. exoleta* is placed in Group II which includes only this species. The seeds in *U. aurea* and *U. stellaris* are tabular-prismatic with polygonal testa cells radiating from the centre. A careful comparison at SEM level shows that the surface details of these taxa are distinct although the waxy deposits are tubercular in both *U. aurea* and *U. stellaris.* In the other aquatic taxon, *U. exoleta,* the seed is remarkably different in shape being lenticular having a highly crenate, irregular-sided waxy wing; further, the hilum is cup-shaped and the testa consists of hexagonal or polygonal cell with grooved ridges and verrucose concavities. The globular wax deposits on some of the crenular projections are small. These differences in these aquatic taxa are quite significant and though the seeds of *U. aurea* and *U. stellaris* are similar in general shape, they exhibit sufficient differences to be clearly distinct. The seeds of these three species, however, have in common a flattened cross-section and large size, features which may confir buoyancy to the seeds during their aquatic dispersal. Taylor (1964) notes that the seeds of *U. rigida,* an African aquatic species, found in fast running water are mucilaginous "presumably to prevent them being washed downstream (Taylor 1964, 17)." These seeds are, however, small and ovoid, more like our Group VI than Group I and II species and possibly, therefore, the mucus is to prevent waterlogging while the seed is dispersed through the aqueous medium.

In the epiphytic taxa, *U. furcellata* and *U. striatula* the seeds are both glochidiate yet still show remarkable interspecific differences. Thus in *U. furcellata* the seeds are obovoid or pear-shaped ond the glochidia are more or less restricted towards the broader end of the seeds; the areoles and edges of the epidermal cells show fine and compactly arranged nodules and these in turn are reticulate-striate; the terminal, situated hilum at the lower end shows several distinct ridges running along the length of the seed; the glochidia are slender, elongated, pyramidiform and capped with five nodular projections. The surface morphology of *U. striatula* under the SEM is totally different. The seeds are ellipsoid, cylindrical with glochidia almost extending up to the base; the epidermal cells of the testa ore irregular, crispate and run parallel to the major axis; further, their surface is finely verrucose with some globular waxy deposits the hilum lacks distinct ridges; the slender glochidia are more elongated and each one of them is capped by recurving barbs which are pointed. It wil be thus seen that, although these taxa are closely allied in

having glochidiate seeds, similar habitat and floral features, there are sufficient features of contrast for recognising them as distinct species. Taylor (1964) observed these glochidia in *U. striatula* and suggested that they aid the seed to settle in an epiphytic situation by becoming entangled with associated epiphytic vegetation. The presence of glochidia in *U. furcellata* supports this conclusion.

Some correlation between habitat and seen surface morphology is also apparent in the grouping of the other species considered. All the 5 species in Group V are found in waterlogged soils, while those in Group IV, with the exception of *U. minutissima*, grow in wet soils but under less saturating conditions than the species of Group V. *U. hirta*, the sole member of Group III, also inhabits wet soils but is normally found in sandy rather than boggy habitats This was the only species studied from such a habitat. There these appears to be an important relationship between the surface structures of the seed and the habitat in which the species grows. The exact nature of this, however, remains to be clarified in all but the epiphytic and aquatic species examined.

It is thus clear that the surface morphology of the seeds of *Utricularia* when studied under the SEM provides additional evidence for their delineation at the specific level. The present work also suggests that there is in a general way, some correlation between habitat and seed surface morphology, thus supporting Thanikaimoni (1966). In addition it provides support for present ideas as to the reasons for certain features of the sculpturing by showing that features observed in one species of epiphytic *Utricularia*, known to be an epiphyte, only occur in the one other epiphytic species studied out of a total of 22 species.

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