1. FRUIT MORPHOLOGY OF THE GENUS FIMBRISTYLIS (CYPERACEAE): SEM STUDY

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Abstract

Twelve species of the genus *Fimbristylis* (Cyperaceae) fruits have been studied under scanning electron microscope to know the detailed micromorphological features of the pericarp. It was found that morphological characters can be grouped into two main categories: i) fruits having reticulate ornamentation in the pericarp ii) ornamentation with combination of reticulate-tuberculate. It was found that 4 species having characters referable to category (i) are plants that usually grow in marshy/waste lands, bear only reticulate ornamentation of the pericarp, while 8 species having characters of category (ii) adaptable to both higher elevation as well as the wet places of the plains, have pericarp with robustly developed reticulate-tuberculate ornamentation.

Key words: Fimbristylis (Cyperaceae), fruits, morphology, SEM.

Introduction

The cosmopolitan family of Cyperaceae generally grow as perennial and annual herbs in the tropical regions of the world thriving along the wet/marshy lands as well as higher elevations up to 1828 meters. Some of the taxa are also adopted to dry desertic condition.

The family Cyperaceae includes 90 genera and 3200 species where *Carex* (1100 species), *Cyperus* (700 species), *Scirpus* (200 species), *Rhynchospora* (200 species), *Eleocharis* (150 species) and *Scleria* (100 species), whereas *Fimbristylis*, a large genus of warm region - name compounded 'fimbria', a fringe and 'stylus' (style), the latter being fringed with hairs, has 125 species. In the present study 12 species of the genus *Fimbristylis: F. albo-viridis, F. argentea, F. bisumbellata, F. complanata, F. cymosa, F. ferruginea, F. lawiana, F. miliacea, F. podocarpa, F. polytrichoides, F. quinquangularis, F. tenera* were subjected to scanning electron microscopy. The detailed morphological characters of the pericarp of the above species were recorded. Fruit morphology of the genus *Fimbristylis* has been studied under light microscope by a number of workers, BHANDARI (1990), DAHLGREN and CLIFFORD (1982), FERNALD (1950), HOOKER (1894), HUTCHINSON (1959), LAWRENCE (1969), SAMVATSAR (1996), TRIMEN and HOOKER (1900). The present study has been undertaken to know the detailed micromorphological features of taxonomical importance.

Materials and Methods

The material for the above studies was procured from the herbarium of Birbal Sahni Institute of Palaeobotany, Lucknow. The specimens were thoroughly cleaned by treating with absolute alcohol to avoid any alteration in the micromorphological features. They were further subjected to ultrasonic cleaning by changing the absolute alcohol repeatedly to remove any artifacts. For different views 3-4 specimens of each species were selected and mounted in the desired orientation on the double sided scotch tape. The specimens were conducted with silver dag and were subjected to sputter coating by using gold palladium (Au/Pd) target. The thickness of coating varied from 100-200 Å depending on the requirement of specimens. The coated specimens were then observed under scanning electron microscope (Phillips 505). To achieve better resolution the accelerating voltage varied up to 30 kV. The final observations were recorded for each specimen.

Results

F. miliacea (LINN.) VAHL. (Plate 1.1., figs. 1,2)

Fruits obovoid, trigonoid, reticulate with finger-like projections (tubercles) regularly dispersed all over the surface, colour pale yellow to brown, apex mucronate, base narrow, size 300-400 µm long and 200-250 µm broad. Perigynium thin, translucent, covering pericarp. Pericarp with ridges and furrows associated with tubercles, the size of tubercles 5-10 µm long, prominent or trigonoid ridges. The size of the cells of reticulum ranges from 5-20 µm. These cells become smaller at the apical and basal region.

Distribution: *F. miliacea* is found at the altitude up to 1828 meters abundantly, grows in all the warm regions of the world. Occasional in waste lands among grassland throughout India (HOOKER, 1894, SAMVATSAR, 1996).

F. podocarpa NESS (Plate 1.1., figs. 3,4)

Fruit ovoid, texture finely striated (ridges and furrows), colour brown apex with stylar base, base flattened, size 500-600 µm long and 300-400 µm broad. Perigynium thin, translucent, forming fine striations at the base. Pericarp consists of 18-20 ridges and furrows on each face, running parallel to each other converging towards base and apex. The cells of the pericarp form "honeybee comb" pattern. Patches of tubercles (20-30 µm) present on the apical part of the fruit.

Distribution: Frequently found in Western Himalaya to Upper Assam and Bangla Desh (Dacca), Chota Nagpur, Malaya and China (HOOKER, 1894).

F. cymosa R. BR. (Plate 1.1., figs. 5,6)

Fruit ovoid-trigonoid, texture reticulate-tuberculate, colour black, apex triangularly flattened, base narrow with stylar ring, size 300-400 µm long and 200-250 µm broad. Perigynium absent. Pericarp reticulate, tuberculate, tubercles mostly at the apical region covering half length of the fruit. The size of the reticular cells very small ranging up to 10 µm long and 5 µm broad, irregularly arranged with wavy (frill-like) margin.

Distribution: Common along the river banks and also in dry areas of the tropical regions of the Old Word (RAO and RAZI, 1981).

F. quinquangularis KUNTH (Plate 1.1., figs. 7,8)

Fruits elongated ovoid, trigonoid with prominent ridges, texture tuberculate, colour yellow to pale brown, apex flattened, base narrow, size 200-250 µm long and about 200 µm broad. Perigynium present, translucent. Pericarp tuberculate-reticulate, tubercles transversely flattened, run lineolate. Thin elongated reticulate cell present throughout the pericarp surface. Size of the tubercles ranges from 10-30 µm long.

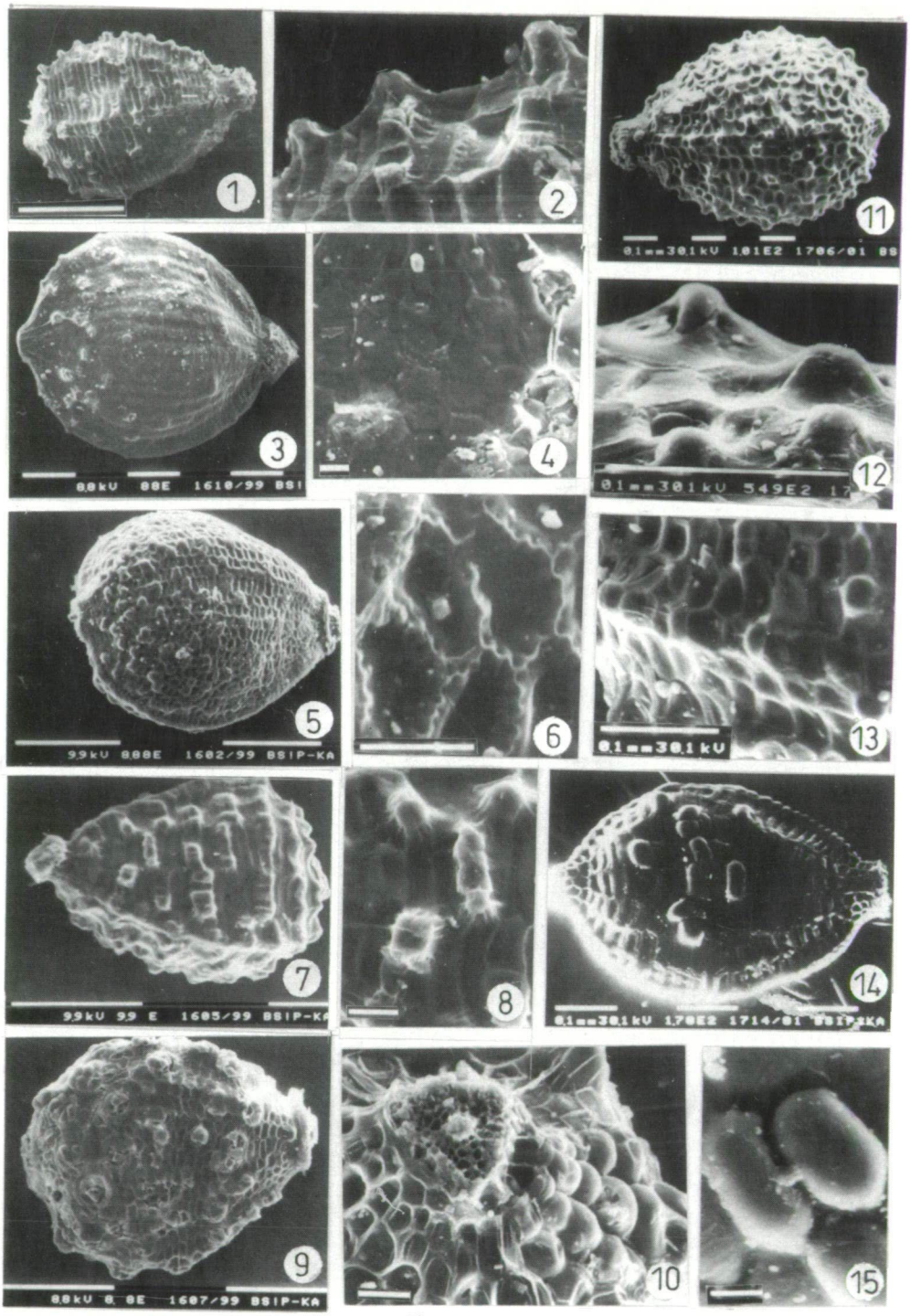

Plate 1.1.

SZTE Egyetemi Könyvtár
SZEGED
3.

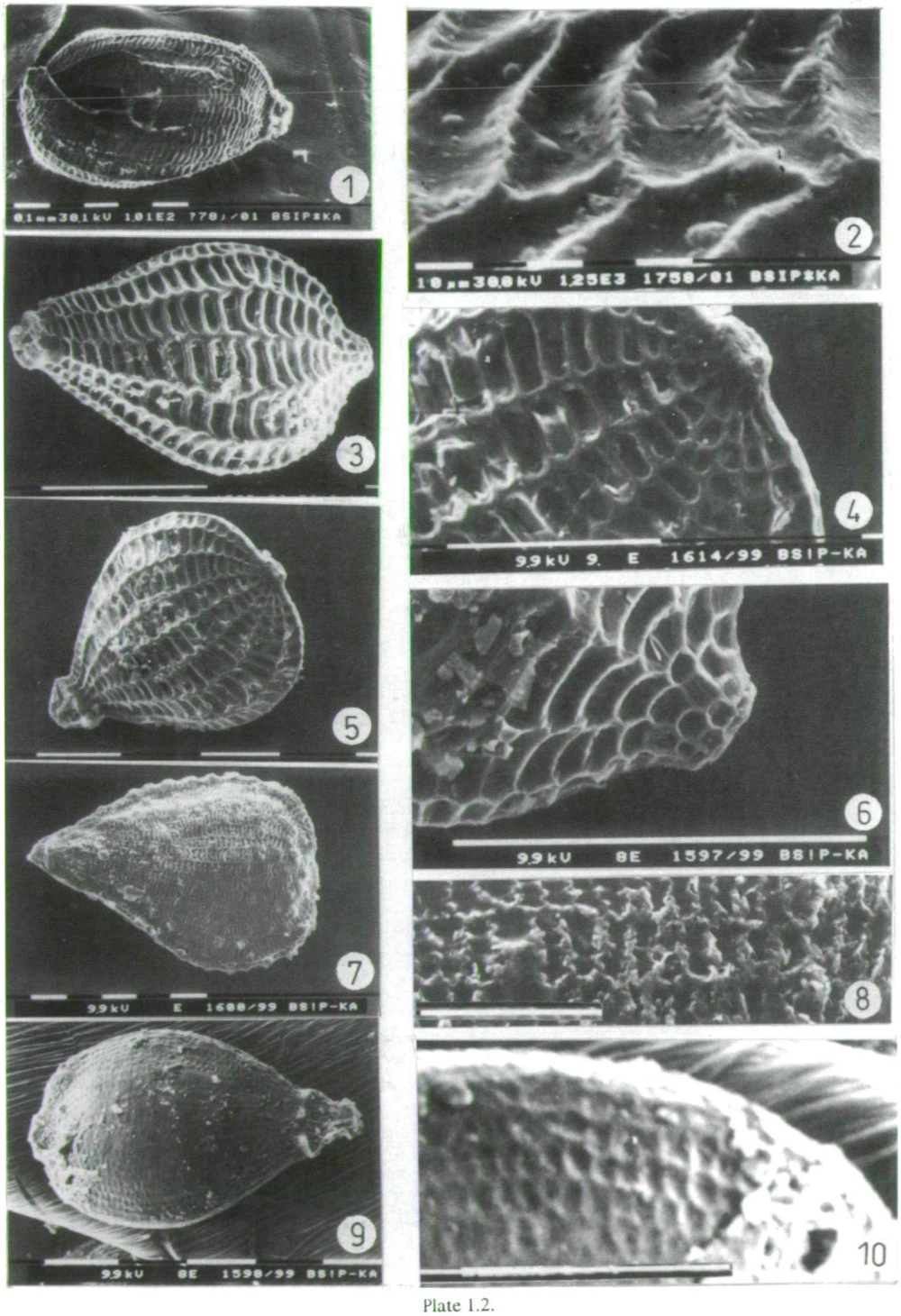
1
0.1mm 30.1kV 1.01E2 770µ/01 BSIP*KA
2
10µm 30.0kV 1.25E3 1758/01 BSIP*KA
3
4
9.9kV 9. E 1614/99 BSIP-KA
5
6
9.9kV 8E 1597/99 BSIP-KA
7
9.9kV E 1608/99 BSIP-KA
8
9
9.9kV 8E 1598/99 BSIP-KA
10

Plate 1.2.

Distribution: The species commonly grow in marshlands throughout India, Sri Lanka, Malaysia, China, Australia. It also grows at the height of 1220 meters (HOOKER, 1894, BHANDARI, 1990, SAMVATSAR, 1996).

F. complanata (RETZ.) LINK. (Plate 1.1., figs. 9,10)

Fruit obovoid, texture tuberculate - reticulate, colour brown, apex rounded, base narrow, attachment scar triangular with distinct vascular supply, size 250-300 µm long and 200 µm broad. Perigynium present, translucent, forming striations at the bases. Pericarp reticulate with sparsely arranged tubercles, each tubercle, consists of 3-7 bulbous cells mostly located along the ridges. The size of the tubercles ranges from 15-20 µm. The size of the pericarp cells is generally smaller and ranges from 10-15 µm. They become squarish at the base and apex of the fruit.

Distribution: Found throughout the warm regions of India growing commonly on wet places and fields (HOOKER, 1894, SAMVATSAR, 1996).

F. tenera SCHULT (Plate 1.1., figs. 11-13)

Fruit globose - ovoid, trigonoid, texture reticulate - tuberculate with distinct ridges, colour brownish, apex rounded slightly projected with flat tip, base slightly narrow. Size of fruit 700-800 µm long and 500-600 µm broad. Perigynium absent. Pericarp reticulate, cells more or less rectangular to squarish becoming smaller towards base and apex (20-50 µm), cells of the ridge area form prominent tubercles throughout the pericarp.

Distribution: Commonly found in wet grounds particularly on the margins of ponds, also commonly occurs as weed in the fields and waste lands, throughout India (HOOKER, 1894, SAMVATSAR, 1996).

Plate 1.1.

SEM micrographs of *Fimbristylis* fruit

1,2. *F. miliacea* - showing trigonoid ridges bearing prominent tubercles.
3,4. *F. podocarpa* - parallel ridges and furrows and sparse tubercles near apical region.
5,6. *F. cymosa* - pericarp showing reticulate and tuberculate ornamentation with frilled cell margins.
7,8. *F. quinquangularis* - showing distinct trigonoid ridges, pericarp reticulate with lineolate tubercles.
9,10. *F. complanata* - pericarp showing reticulate pattern with tubercles on the ridges.
11,12,13. *F. tenera* - showing reticulate pericarp and uniformly distributed tubercles on the surface.
14,15. *F. argentea* - fruit showing reticulate, sparsely tuberculate pericarp, cells in linear rows.
Figs.: 1,3,5,7, 9,11 and 14. bar = 0.1 mm
Figs.: 2,4,6,8,10,12,13 and 15. bar = 10 µm

Plate 1.2.

SEM micrographs of *Fimbristylis* fruit

1,2. *F. lawiana* - ladder-like arranged reticulate cells, cell margin wavy.
3,4. *F. bisumbellata* - pericarp cells horizontally elongated between the ridges.
5,6. *F. albo-viridis* - pericarp showing scalariform arrangement of the cells.
7,8. *F. polytrichoides* - pericarp reticulate, cells with wavy margin.
9,10. *F. ferruginea* - pericarp showing squarish arrangement of cells.
Figs.: 1,3,5,7 and 9. bar = 0.1 mm
Figs.: 2,4,6,8 and 10. bar = 10 µm

F. argentea VAHL (Plate 1.1., figs. 14,15)

Fruit obovoid - elongated, texture reticulate, ridges and furrows absent, colour yellow, apex with remnant of style, base narrow, size of the fruit 500-600 µm long and 250-300 µm broad. Perigynium very thin, translucent, covering pericarp, forming striations at apical and basal parts. Cells of the pericarp rectangularly arranged in linear rows, 30-50 µm long and 10-20 µm broad, at some places the cells are prominently projected.

Distribution: Occurring from Bengal to Central India, Sri Lanka and Mauritius. Very common in paddy fields (SAMVATSAR, 1996).

F. lawiana LINN. (Plate 1.2., figs. 1,2)

Fruit obovate, texture reticulate with ridges and furrows, colour dark brown, apex rounded, base narrow having ring-like structure. Size ranges up to 1 mm long and 500-600 µm broad. Very thin, translucent perigynium present. Pericarp with reticulate cells arranged ladder-like in between ridges. Cells more or less sinuate with wavy margin, rectangular, 40-50 µm long and 15-20 µm broad.

Distribution: Generally found along the moist places and paddy fields, it profusely grows in the waste lands of India, Sri Lanka (HOOKER, 1894).

F. bisumbellata (FORST.) BUB. (Plate 1.2., figs. 3,4)

Fruit obovoid - elongated, texture prominently reticulate with ridges and furrows converging towards base, colour white - light yellow, apex with remnant of style base, acuminate, base narrow, size 200-250 µm long and 150-200 µm broad. Pericarp covered with very thin perigynium, the cells of pericarp arranged in rows giving ladder-like appearance. The cells are longer than broad, 5-15 µm, smaller cells are present at the apical and basal area of the fruit.

Distribution: Mostly found in the warm areas of the world, prominently grows throughout India forming dense rosette-like structure, common in marshy places associated with other sedges. (BHANDARI, 1990, RAO and RAZI, 1981, SAMVATSAR, 1996).

F. albo-viridis CLARKE (Plate 1.2., figs. 5,6)

Fruit obovate, texture striated, reticulate (ridges and furrows distinct), colour brown apex rounded with stylar base, remnant of stalk present at the base. Size ranges from 300-400 µm long and 250-300 µm broad. Perigynium absent. Pericarp reticulate, cells vary from 10-30 µm long 5-15 µm broad, the smaller cells are prominently seen at the base and apical region. The cells of reticulum between two ridges form ladder-like pattern (scalariform), 8-9 ridges present on each face of the fruit converging towards base and apex.

Distribution: Chiefly found in East Bengal and Upper Assam (HOOKER, 1894).

F. polytrichoides VAHL (Plate 1.2., figs. 7,8)

Fruits obovoid, biconvex, tapering towards apex, texture reticulate with tuberculate projections prominently seen along the lateral ridges, colour pale yellow, apex flattened, base narrow. Size 700-800 µm long 400-500 µm broad. Perigynium not seen. Pericarp cells reticulate, dispersed in between fine ridges, cells rectangular 15-30 µm with thick, wavy margin.

Distribution: Chiefly found in Bengal to Sri Lanka along the sea banks. Common in the tropics of the Old World (HOOKER, 1894).

F. ferruginea (LINN.) VAHL (Plate 1.2., figs. 9,10)

Fruit obovoid - elongated, texture obscurely reticulate, ridges and furrows not seen, colour yellow, apex blunt, obtuse, base narrow with stylar ring, size of the fruit ranges 500-600 µm long, 300-400 µm broad. Perigynium absent. Pericarp cells uniformly arranged in vertical rows very small in size, more or less squarish in shape.

Distribution: Largely distributed in Australia, Polynesia, Malaysia and India, a gregarious sedge found in marshy places throughout these regions. It is also found abundantly near the sea-shores of the warmer regions (HOOKER, 1894, SAMVATSAR, 1996).

Species	Pericarp	Distribution
F. miliacea	Ridges and furrows associated with prominent tubercles (5-10 µm)	Found up to 1828 meters growing in warm regions and waste lands, grass lands of the world
F. podocarpa	Ridges and furrows (16-20 on each face), parallel, tuberculate patches at apical part	Frequent in Western Himalaya to upper Assam, Bangla Desh, Malaya, China
F. cymosa	Reticulate, tubercles (restricted apically), cell margin frilled	Common along the river banks and dry lands of tropical regions
F. quinquangularis	Reticulate-tuberculate (lineolate) throughout the pericarp	Common throughout marshy lands also grows up to 1220 meters in tropical regions
F. complanata	Reticulate with sparse tubercles, tubercles prominent on ridges (10-15 µm)	Common in warm regions, wet places
F. tenera	Reticulate, ridges and furrows prominent, fine tubercles throughout (20-50 µm)	Common in wet grounds along the margin of ponds as weed
F. argentea	Reticulate-sparsely tuberculate, cells in linear rows, rectangular (30-50 µm)	Commonly occur in paddy fields of warm regions especially India, Sri Lanka, Mauritius
F. lawiana	Reticulate cells arranged like 'ladder' in between ridges, sinuate, wavy (40-50 µm) margin	Commonly occur in paddy fields and waste lands in India and Sri Lanka
F. bisumbellata	Reticulate ridges and furrows, cells arranged ladder-like, horizontally elongated (5-15 µm)	Mostly in warm areas of the world forming dense rosettes throughout India and other parts of the world
F. albo-viridis	Cells smaller, arranged in between ridges, scalari form (10-30 µm)	Chiefly found in East Bengal and Upper Assam
F. polytrichoides	Reticulate with fine ridges, cells rectangular with wavy margins (15-30 µm)	Chiefly found in Bengal, Sri Lanka, along the sea banks, tropics of the Old World
F. ferruginea	Cells uniformly arranged in vertical rows small squarish (15-20 µm)	A gregarious sedge of marshlands throughout warmer parts of the world

Table 1.1.

Comparative characters of pericarp and distribution of different species of *Fimbristylis*.

Discussion and Conclusions

On the basis of micromorphological observations of different species of *Fimbristylis* the character can be used to understand the differences and relationship between different species of this genus. It can also be helpful in systematic classification of the family Cyperaceae to use the distinct micro-morphological characters of the fruits.

The different ornamentation pattern of the pericarp of 12 species studied under scanning electron microscope can be categorized in two groups i) reticulate type - including *F. albo-viridis, F. bisumbellata, F. ferruginea, F. lawiana,* ii) reticulate - tuberculate type including *F. argentea, F. complanata, F. cymosa, F. miliacea, F. polytrichoides, F. podocarpa, F. quinquangularis* and *F. tenera.* The cells of the pericarp in *F. albo-viridis* are smaller, arranged in scalariform pattern between ridges and measures 10-30 μm in size. However, in *F. bisumbellata* the pericarp cells though arranged ladder-like but are horizontally elongated, usually smaller, 5-15 μm in size. In *F. ferruginea* the cells of the pericarp are uniformly arranged in vertical rows, they are squarish in shape measuring 15-20 μm in size. It was observed that the reticulate ornamentation of the pericarp in *F. lawiana* shows that the cells are arranged ladder-like between the ridges. The cells are sinuate and show wavy margin, they are larger in size ranging between 40-50 μm (Table 1.1.).

The species with reticulate-tuberculate pericarp show difference in the distribution of tubercles. The tubercles in *F. argentea* are sparse, arranged in linear rows, in *F. complanata* the tubercles are prominent whereas in *F. cymosa* and *F. podocarpa* the tubercles can only be seen at the apical part of the fruit. In *F. miliacea* the tubercles are quite prominent.

HOOKER (1894) considered *F. podocarpa* and *F. albo-viridis* similar in pericarp ornamentation. However, the SEM studies reveal that though *F. podocarpa* bears ridges and furrows they are not as prominent as in *F. albo-viridis*. He also indicated the resemblance between *F. quinquangularis* and *F. miliacea*. Both can be distinguished from each others on the basis of pericarp characters: *F. miliacea* bears large number of tubercles mainly along the trigonoid ridges while *F. quinquangularis* has sparse and flattened tubercles in between the ridges as seen under SEM.

The genus *Fimbristylis* is adopted to various habitats ranging from sea level up to 1828 meters. Some species can also grow in cooler climate of the Himalayan region indicating a wide range of adoptable habitat. Sometimes they grow to form dense rosettes and also form gregarious sedge helping against soil erosion.

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