CHAPTER : VI

DISCUSSION

Discussion :

The comparative study of the habitat in which the ferns are growing and the anatomical details of pinnae, particularly the laminar part which is the main site of photosynthetic activity indicate that the Pteridophytes are very sensitive to the changing environmental conditions.

Arrangement of the Pinnae on the rhizome :

The ferns are characterised by underground rhizomatous stem. The pinnae are arranged in such a manner that they are easily exposed to sunlight. In the genera with horizontally running rhizome, they are borne in two rows on upper surface of the rhizome (ex. Bolbitis, Niphobolus; Microsorium etc.). When the rhizome is an erect structure, they are borne in close spirals and provided with long rachis. So that the pinnae are not over-lapping (Acrostichum, Angiopteris, Blechnum).

The presence of epidermal outgrowths, such as paleae or multicellular hairs in most of the genera protect the young parts as well as the mature parts in some cases from descication.

The pinnae lamina, which is the main site of photosynthetic activity, in various ecological types of pteridophytes show various types of adaptations.

Ephemeral annuals :

The ephemeral annuals like Selaginella deliculata and Adiantum lunulatum are drought escaping xerophytes. Their small size, large ffonds in relation to roots and short life span are their adaptation to avoid drought conditions.

These plants grow during rainy season when the sunlight is insufficient. So the plants have to make maximum use of available light. These leaves are devoid of normal upper epidermis. The palisade tissue which in other plants is subepidermal has become superficial. The cells are funnel shaped, the outer walls concave and narrow inner surface (Text Fig. I-A-2). These funnel like cells act as condensing lenses. Owing to concave form of the outer wall the rays of light that fall perpendicular upon the leaf surface are made to converge by refraction and total reflection towards the base ofthe cell, so that the chloroplasts assembled at that end of the cell are more brightly illuminated. This increases the photosynthetic efficiency of the pinnae. Outer walls of these cells are slightly thickened. Thus the epidermis functions both in photosynthesis and protection of the pinnae surface.

The mesophyll composed of 1-3 layers of cells (Text Fig. I-A-4; II-A-4). The cells are armed and loosely connected with each other for easy translocation of photosynthetic products.

In Adiantum lunulatum the lower epidermal cells are with papillae (Text Fig.II-A-7). The water drops which fall

upon this papillate surface spread out at once and thus causes rapid evaporation. This protects the excess wetting of the Pinnae surface.

Heliophytes :

The heliophytes are the plants exposed to full sunlight. Gleichenia dichotoma is thicket forming with superficial horizontally running rhizome. While Blechnum orientale is bracket forming fern with slightly horizontally running rhizome bearing large erect fronds. In Gleichenia dichotoma the fronds are trailing.

Many plants which grow in sunny situation have leaves with smooth and shining upper surface. This prevents a certain proportion of the incident light from penetrating into the leaf by means of reflection. In G.dichotoma the upper epidermis facing the sun-rays.show well developed cuticle and cells are thick walled. In Blechnum orientale the leaves are without any excrescences and the surface is smooth shining. The upper epidermal cells are thick walled and with a prominent cuticle.

The light intensity has affected the degree of differentiation of the photosynthetic system. The leaves show well developed palisade tissue below upper epidermis consisting of either elongated cylindrical cells or armed chlorophyllous cells compactly arranged (Text Fig.III-B-3; Fig.IV-B-3). The flanged type of palisade cells provide larger internal surface for

display of chloroplasts and hence the photosynthetic activity is increased. In Gleichenia dichotoma there are 1-2 layers of palisade parenchyma while in B.orientale with large fronds the leaves are thick and have 3-4 layered palisade tissue.

In G.dichotoma the spongy parenchyma present below the palisade tissue are horizontally elongated and enclose large air spaces (Text Fig.III-B-4). In B.orientale this tissue is also well developed. They are loosely arranged cells (Text Fig.IV-B-4). This tissue thus functions in the conveyance of photosynthetic products from palisade tissue to the vascular reticulum and also as principal ventilating tissue of the leaf.

In Glechenia dichotoma the lower epidermal cells have their outer walls protruding as papillae (Text Fig.III-B-5). G.dichotoma grows as heliophyte and hence has to face intense sunlight and high temperature. The papillose nature of lower epidermis might be functional in increased water-storing capacity of the epidermis.

Sciophytes :

These plants prefer lower light intensity. The genera Bolbitis presliana and Angiopteris evecta are the typical sciophytes.

A.evecta having large fronds is characterised by distinct pulvini at the base of main rachis as well as secondary rachis. These pulvini help in the heliotropic movement of the

leaf. So that the leaf is oriented in such a way as to receive maximum amount of available light.

Both B.presliana and A.evecta have epidermis with thick cuticle on the outer wall. (Text Fig.V-B-1; VI-B-1). The lateral walls of the epidermal cells in B.presliana are also thickened for mechanical reasons and are provided with numerous circular to oval pits, which facilitate movement of water between adjacent cells (Text Fig.V-B-3).

The light has direct influence upon the differentiation of photosynthetic tissue and since sciophytes prefer low light intensity the mesophyll is not differentiated into palisade and spongy tissue. The entire mesophyll is chlorophyllous and perform the function of photosynthesis. A few cells of the mesophyll arrange themselves more or less in a regular row just below the upper epidermis and form a weakly developed palisade tissue (Text Fig.V-B-4, VI-B-3). The rest of the cells which are chlorophyllous, loosely arranged perform the function of conveying photosynthetic products to vascular elements as well as photosynthetic activity to a minor degree.

Epiphytes :

The epiphytes take shelter of the other plants, but they are not dependent on the supporting plant for their food material. They can synthesise their own food material. But because they are not in contact with soil for the moisture

requirement, they are directly dependent on precipitation for their water supply. So they show adaptation in relation to water economy as in case of xerophytes.

Among them the low level epiphytes have not much to suffer from water scarcity as the moisture content is higher at low level from ground than the high level.

Following are the adaptations seen in the anatomy of leaves of low level epiphytes :

The epidermis of the vegetative organs and especially those of foliage leaves play the part of superficial water jackets, which protect the underlying tissues against damage through loss of water. Both the genera Pyrrosia adnascence and Pleopeltis linearis have leaves with upper epidermal cells having thick outer walls (Text Fig.VII, VIII; B-I, VIII-A-1). The lateral walls are also thick and show presence of pit connections which facilitate interchange of water between adjacent cells. (Text Fig.VIII, B-1, 7).

In P.adnascence the hypodermal layer consisting of larger cells than epidermal cell and which are non-chlorophyllous probably function in additional water storing function (Text Fig.VII, A-2). Such a layer is found to be absent in Pleopeltis linearis.

Compare to the over all size of the leaf, the leaves are thick P.linearis the lamina being 186 μ in thickness while

in P.adnascence it about 700 μ in thickness. The mesophyll is differentiated into spongy and palisade layers. The palisade is well developed consisting of 2-4 layers of cells in P.adnascence (Text Fig.VII, A-3-4), while in P.linearis, it is atleast 2 layered (Text Fig.VIII, B-3). This is because the leaf blades are well exposed to the sunlight with increased photosynthetic activity, for better ventilation the spongy tissue has large intercellular spaces. In P.adnascence they are between individual cells (Text Fig.VII, A-7) while in P.linearis large intercellular spaces are bound by parenchymatous lamellae (Text Fig.VIII-B-5).

The lower epidermis in P.adnascence show presence of stellate hairs which causes reduction of transpiratory activity and hence diminishes the risk of desication (Text Fig.VII-A-9).

Microsorium membranaceum and Drynaria quercifolia high level epiphyte have the pinnae lamina thin in texture. So that they can absorb directly the available moisture in atmosphere. The epidermis is thick-walled with thick cuticle (Text Fig.IX, B-1). Some of the cells of the epidermis are much enlarged (50 x 55 μ in size) which serve the function of storage of water (Text Fig.X, B-4).

The lamina in both genera is well exposed to sunlight and hence show well differentiated spongy and palisade tissues (Text Fig.X,B-4; IX-A-3). The spongy cells are also chlorophyllous thus helping in photosynthetic activity of the plant (Text Fig.X; B-3, IX-A-4).

Hygrophytes :

Cyclosorus parasiticus, a hygrophyte grows along or within the stream in shady places where moisture is in abundance. In their external morphology no adaptation to the hygrophilous habitat is seen.

In their anatomy the leaves have thin cuticle (Text Fig.XI-A, B-1). The plants because they grow in shaded areas, the epidermal cells are found to be photosynthetic in function. The cells contain chloroplasts and have broad convex outer walls, far better reception of available light (Text Fig.XI, B-2).

The mesophyll cells are not differentiated into spongy and palisade layers (Text Fig.XI-B-3). The mesophyll cells are thin walled, armed and chlorophyllous. They are loosely arranged with large intercellular spaces. Because these plant grow in abundance of moisture, they transpire actively thus accelerating the translocation of nutrient salt. For the sake of the resulting increases of transpiratory activity, the leaf shows enlarged intercellular spaces. Spongy tissue which is found to be making up of the mesophyll of the hygrophilous plants constitutes the mesophyll of the lamina. The active translocation of nutrient salts is indicated by prominantly developed plasmodesmatic connections between these cells, (Text Fig.XI-B-3,5).

The papillose nature of the lower epidermal cells helps in rapid evaporation (Text Fig.XI, B-6).

Chasmophytes :

Actiniopteris dichotoma growing as chasmophyte shows many adaptations to the xerophytic habitat.

For the maximum utilization of available moisture in the rock crevices the plants have well developed root system. The adventitious roots are much branched so that they can penetrate the rock-crevices. The fan-shaped lamina is coriaceous and divided into smaller lobes. This seems to be the adaptation for open, dry conditions.

Anatomically the lamina consists of upper epidermis formed of thick walled, hyaline non-chlorophyllous cells, purely protective in function (Text Fig.XII A,B-1). The cutined layer enables the plant to reduce transpiration enormously.

Below the upper epidermis, there are 2-3 layers of hypodermal sclerenchyma (Text Fig.XII-B-2). These sclerenchyma help in reducing the transpiration. The prominent pit connections between these sclerenchyma facilitate interchange of materials, especially of water, between adjacent cell walls.

As the plants are well exposed to sunlight the mesophyll is well developed consisting of 6-8 layers of cells. These towards upper epidermis are densely chlorophyllous and act as

palisade tissue (Text Fig.XII, B-3). The spongy parenchyma are armed and form contact with adjacent cells (Text Fig.XII, B-4,5). The air spaces inbetween spongy and palisade tissue are very much reduced in order to reduce the transpiration.

The uniseriate, multiseriate and hairs with glandular tips present on the lower epidermis also control transpiration to some extent.

Halophytes :

The degree of salinity is an important factor for halophytes. Acrostichum aureum grow in brackish water which is very often flooded with fresh water and thus has low salinity. Most of growth of the plant and even the sporangia are borne under such low salinity conditions. So most of the external adaptive features of the halophytes are not seen in A. aureum.

The plants are exposed to full sunlight and hence the pinnae have smooth and shining upper surfaces. This shining surface protects against excessive insolations. It prevents a certain proportion of the incident light from penetrating into the leaf. The epidermal cells have thick outer walls this also prevents excessive transpiration (Text Fig.XIII,B-1). The halophytes are physiologically xerophytes and they show economy in water loss through transpiration.

Just below the epidermis the hypodermal layer formed of somewhat larger, non-chlorophyllous cells also serves as water-storing tissue (Text Fig.XIII, B-3).

The plants being well exposed to sunlight, the pinnae show well developed mesophyll tissue. So the lamina is quite thick 218-232 μ in thickness. The mesophyll is differentiated into palisade and spongy tissue. Palisade is 2-3 layers in thickness (Text Fig.XIII, B-4). The upper most layer is formed of elongated cylindrical cells while the lower 1-2 layers are formed of armed cells. They are connected to spongy parenchyma which for active translocation of photosynthetic product are horizontally elongated. Those in the central part of lamina are larger in size and those towards lower epidermis are small in size forming lamellae enclosing large air spaces (Text Fig. XIII, B-7-8). These must be functioning as ventilating tissue.

The lower hypodermal layer though is not that prominently marked also functions as water-storing tissue (Text Fig. XIII, B-6).

A.aureum though a member of halophyte community, does not show adaptation to halophytic habitat. The succulent nature of leaves, sunken stomata or salt glands are absent.

Hydrophytes :

In Ceratopteris thallictroides the pinnae borne early in the rainy season are nearly submurged and it is surrounded by a medium deficient in oxygen, which it must somehow tolerate for a limited period. It is perhaps in response to this scarcity of oxygen they develop masses of secondary air storage

tissue aerenchyma. The extent of cuticle is reduced and the volume of spongy mesophyll increased.

The reproductive pinnae remain submurged during rainy season but late in the life cycle when the rainy season is over they are exposed to the atmosphere. Their lamina is much reduced which is efficient in controlling the loss of water by transpiration. Such mature leaves develop cuticle to restrict escape of water through thin epidermis.

Two major problems confronting a photosynthetic organ under water are the absorption of a suitable dissolved carbon source and the reception of light. The restricted and differential penetration of light into water creates a habitat very similar to that of densely shaded land plants and seems to have evoked similar anatomical responses. The pinnae and rachis are both photosynthetic and they have thin lamina, reduced cuticularisation and increased distribution of chloroplasts. The epidermal cells are also chlorophyllous (Text Fig. XIV, A,B).

Salvinia is a free floating hydrophyte. The most notable adaptation to floating habit is the loss of roots. Lacking contact with the substrate, it is usually restricted to sheltered habitats. As it has to absorb all their mineral nutrients from the water usually it is confined to habitats rich in dissolved salts. The submurged, finely dissected

pinna absorb water and ions, thus performing the function of absent roots. The simple hairs present on the ventral surface of the lamina are also probably absorptive in function (Text Fig.XV,B-8). To be able to withstand the horizontal tearing strains imposed by wind and waves the lamina is entire as the dissected lamina has got greater number of weak points and would be easily torn.

As the pinnae are exposed to water or falling rain, to escape excessive wetting, they have water repellent hairs on the upper surface (Text Fig.XV, B-7). Air is trapped between these hairs and any water falling on the inclined pinnae is speedly repelled and epidermis is never-wetted.

The mesophyll, due to weaker sunlight is homogeneous without differentiation into palisade and spongy tissue. Chloroplasts occur throughout the mesophyll.

The diaphragms in the aerenchymatous mesophyll counteract the fragility of the pinnae tissue.