INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 1, p. 13-23, 2013

RESEARCH PAPER OPEN ACCESS

An anatomical investigation on Asteraceae family at Rajshahi Division, Bangladesh

A.H.M. Mahbubur Rahman[1*], A.K.M. Rafiul Islam[1], M. Matiur Rahman[2]

[1]*Department of Botany, Rajshahi University, Rajshahi 6205, Bangladesh*

[2]*Bangladesh National Herbarium, Mirpur-1, Dhaka 1100, Bangladesh*

Key words: Anatomy, Asteraceae, Rajshahi.

Article published on January 20, 2013

Abstract

Anatomical (especially stomata and trichome) investigation of the family Asteraceae (Compositae) growing throughout the Rajshahi Division situated in the northern part of Bangladesh was carried out. A total of 36 species under 29 genera of the family Asteraceae were collected and identified. Among the recorded species, both anomocytic and anisocytic stomata were found in 21 species; anomocytic stomata in 10 species; anisocytic stomata in 3 species; anomocytic and paracytic stomata were found in 1 species; anomocytic, anisocytic and paracytic stomata were found in 1 species. Out of the 36 species, stomata were found to be present both on the upper and lower surface in 33 species and only on lower surface in 3 species. Three types of trichomes, i.e. non-glandular multicellular, non-glandular unicellular and glandular multicellular trichomes were recorded. Non-glandular multicellular trichome was found in 25 species, non-glandular unicellular in 1 species and glandular multicellular trichome was found in 1 species. Trichomes were absent in rest of the species. Anatomical characters are importance for systematic studies.

* **Corresponding Author:** A.H.M. Mahbubur Rahman ✉ ahmmahbubur_rahman@yahoo.com

Introduction

Epidermal characteristics of leaves such as the epidermal cell walls, types of stomata, trichomes are important parameters at generic and specific levels in different group of plants. Stomata are pores formed by a pair of specialized cells, the gourd cells, which are found in the surface of aerial parts of most higher plants and which can open and close to control gas exchange between a plant and its environment. Their purpose is to act as portals for entry of Carbon dioxide into the leaf for photosynthesis and exit of water vapor, which may be used for evaporative cooling of the leaf. The transpiration stream may also facilitate uptake and transport of salts necessary for nutrition of the plant (Rahman, 2009).

There are numerous reasons for the great interest in stomata. Foremost is that stomata are involved in the control of two of the most important plant processes, namely photosynthesis and transpiration. Stomata control 95 percent, or more, of the Carbon dioxide and water vapour exchange between the leaf and the atmosphere. They therefore control rates of photosynthesis and transpiration by plants and since photosynthesis is a major factor in determining rates of dry matter accumulation, stomata are of prime importance in any consideration of factor controlling crop yield (Rahman, 2011).

Stomata and stomatal complexes are also proving to be ideal subjects for studying fundamental aspects of cell development and differentiation. For example, our knowledge about how cell polarity arises and what controls the plane of cell division has been greatly improved by studies on stomatal development. From a biochemical view point guard cells are also proving to be a fascinating subject for investigation. Not only are guard cells unique amongst plant cells because of the metabolic machinery they possess but they are also able to sense very small changes in Carbondioxide concentrations and respond by setting in motion a series of biochemical reactions which will result in stomata opening or closing (Rahman, 2011).

The stomata are apertures in the epidermis, each bounded by two guard cells. In Greek, stoma means mouth, and the term is often used with reference to the stomatal pore only. The term stoma includes the guard cells and the pore between them. The stomata are most common on green aerial parts of plants, particularly the leaves. In green leaves they occur either on both surfaces (amphistomatic leaf) or on one only, either the upper (epistomatic leaf) or more commonly the lower (hypostomatic leaf). The density of stomata has been established as 100 to 300 per square millimeter for leaves of many species (Esau, 1965).

Epidermis is the outmost layer which forms a protective cover of different organs. Of these, leaf epidermis is functionally very important because it bears two important structures-stomata and trichomes. Stomata are concerned with gaseous exchange on which depend photosynthesis and respiration. The two principle metabolic processes of the plants. Stomata also allow transpiration which results in loss of excess of water absorbed from the soil. Trichome's are epidermal appendages. These include glandular and non-glandular hairs, scales, papillae and the absorbing hairs of roots. Trichomes form a covering on all the plant parts. These insulate the plant from changes in the external environment. Trichomes also help to reduce the rate of transpiration (Bendre and Kumar, 1997).

In Bangladesh, this is first time anatomical investigation on the family Asteraceae. Anatomical characters are provide differentiate of plant species. So its values are importance for plant classification.
Aims of the study: A) to make an anatomical investigation on the family Asteraceae, B) to know the anatomical studies (stomata and trichome) of species and comparative studies among them.

Materials and methods

Anatomical investigation on the family Asteraceae (Compositae) growing throughout the Rajshahi division was carried out. A total of 36 species under 29 genera of the family Asteraceae were examined. To study the type of stomata and trichome both of upper and lower surfaces, epidermal peels were taken from both surfaces, of the leaves near the midrib position. Mainly fresh leaves were used for this purpose. The peelings were washed and stained with 1% aqueous safranin. Then the peelings were mounted in 50% glycerin after removing the excess of stain by washing with distilled water. Camera Lucida drawing was made need from slides.

Results and discussion

Results

Mainly three types of stomata were found in all the 36 species of the family Asteraceae. They are as follows: (i) anomocytic, (ii) anisocytic and (iii) paracytic.

Anomocytic stomata were found in *Ageratum conyzoides, Blumea lacera, Blumea laciniata, Calendula officinalis, Callistephus chinensis, Cosmos caudatus, Cirsium arvense, Dahlia variabilis, Eclipta alba, Enhydra fluctuans, Eupatorium odoratum, Gnaphalium polycaulon, Gnaphalium indicum, Gnaphalium pulvinatum, Grangea maderaspatana, Helianthus annuus, Lactuca sativa, Launaea aspleniifolia, Mikania cordata, Perthenium hysterophorus, Sonchus asper, Sonchus arvensis, Sonchus wightianus, Spilanthes paniculata, Synedrella nodiflora, Tagetes patula, Tridax procumbens, Verninia patula, Vernonia cinerea, Wedelia chinensis, Wedelia trilobata, Youngia japonica* and *Zinnia peruviana*. Anisocytic stomata were found in *Caesulia axillaris, Chrysanthemum coronarium* and *Xanthium indicum*. Both anomocytic and anisocytic stomata were found in 17 species, i.e. *Ageratum conyzoides, Blumea lacera, Cosmos caudatus, Enhydra fluctuans, Eclipta alba, Gaphalium polycaulon, Gnaphalium indicum, Gnaphalium pulvinatum, Helianthus annuus, Lactuca sativa, Launaea aspleniifolia, Perthenium hysterophorus, Spilanthes paniculata, Tridax procumbens, Wedelia chinensis, Wedelia trilobata* and *Zinnia peruviana*. Both anomocytic and paracytic stomata were found in *Mikania cordata*. Anomocytic, anisocytic and paracytic stomata were found in *Wedelia chinensis* and *Wedelia trilobata*. In 3 species, i.e. *Chrysanthemum coronarium, Circium arvense, Sonchus asper* stomata were found to be present only on lower surface of leaves. Whereas in other 33 species, stomata were found to be present on both surfaces of leaves (Table 1).

Mainly three types of trichome have been found in 36 species. They are as follows:

(i) Non-glandular multicellular (ii) Non-glandular unicellular (iii) Glandular multicellular. Non-glandular multicellular trichomes were found in 24 species, i.e. *Ageratum conyzoides, Blumea lacera, Blumea laciniata, Chrysanthemum coronarium, Cirsium arvense, Callistephus chinensis, Dahlia variabilis, Eupatorium odoratum, Grangea maderaspatana, Gnaphalium indicum, Gnaphalium pulvinatum, Gnaphalium polycaulon, Helianthus annuus, Mikania cordata, Perthenium hysterophorus, Spilanthes paniculata, Synedrella nodiflora, Tagetes patula, Tridax procumbens, Vernonia patula, Vernonia cinerea, Wedelia chinensis, Wedelia trilobata, Youngia japonica* and *Zinnia peruviana*. Non-glandular unicellular trichhomes were found in 1 species *Xanthium indicum* and glandular multicellular trichome was found in 1 species *Calendula officinalis*. In the rest 09 species trichomes were absent (Table 3).

Of total number of species 27.77% species have stomata which are anomocytic; 8.33% are anisocytic; 2.77% are anomocytic and paracytic; 58.33% are anomocytic and anisocytic; 2.77% are anomocytic, anisocytic and paracytic. It was observed that 69.44%species have trichome which are non-glandular multicellular; 2.77% non-glandular unicellular and 2.77% glandular multicellular. In 25% plant species trichomes were found to be absent in the study area (Table 2; Table 4).

Discussion

Anatomy provides evidence concerning the interrelationships of larger groups such as families, or in helping to establish the real affinities of genera of uncertain taxonomic status. Anatomy is of restricted value for distinguishing species or groups of less than specific rank, because the differences between them are usually quantitative rather than qualitative.

Table 1. Types of stomata of species in the study area.

Name of species	Anomocytic	Anisocytic	Anomocytic and paracytic	Anomocytic and anisocytic	Anomocytic, anisocytic and paracytic
Ageratum conyzoides Linn.	-	-	-	+	-
Blumea lacera (Burm.f.) DC.	-	-	-	+	-
Blumea laciniata (Roxb.) DC.	+	-	-	-	-
Callistephus chinensis (Linn.) Nees.	+	-	-	-	-
Calendula officinalis Linn.	+	-	-	-	-
Chrysanthemum coronarium Linn.	-	+	-	-	-
Cosmos caudatus Kunth	-	-	-	+	-
Circium arvense (L.) Scop.	+	-	-	-	-
Caesulia axillaris Roxb.	-	+	-	-	-
Dahlia variabilis (Willd.) Desf.	+	-	-	-	-
Eclipta alba (L.) Hassk	-	-	-	+	-
Enhydra fluctuans Lour.	-	-	-	+	-
Eupatorium odoratum Linn.	-	-	-	+	-
Gnaphalium polycaulon Pers.	-	-	-	+	-
Gnaphalium pulvinatum DC.	-	-	-	+	-
Gnaphalium indicum Linn.	-	-	-	+	-
Grangea maderaspatana (Linn.) Poir.	+	-	-	-	-
Helianthus annuus Linn.	-	-	-	+	-
Lactuca sativa Linn.	-	-	-	+	-
Launaea aspleniifolia (Willd.) Hook.f.	-	-	-	+	-
Mikania cordata (Burm.f.) Robinson	-	-	+	-	-
Parthenium hysterophorus Linn.	-	-	-	+	-
Sonchus asper (L.) Hill.	-	-	-	+	-
Sonchus arvensis Linn.	-	-	-	+	-
Sonchus wingtianus DC.	-	-	-	+	-
Spilanthes paniculata Wall. ex DC.	-	-	-	+	-
Synedrella nodiflora (L.) Gaertn.	-	-	-	+	-
Tagetes patula Linn.	+	-	-	-	-
Tridax procumbens Linn.	-	-	-	+	-
Vernonia patula (Dryand) Merrill	+	-	-	-	-
Vernonia cinerea (Linn.) Less.	+	-	-	-	-
Wedelia chinensis (Osbeck) Merrill		-	-	-	+
Wedelia trilobata (L.) A.S. Hitchc.		-	-	+	-
Xanthium indicum Linn.	-	+	-	-	-
Youngia japonica (L.) DC.	+	-	-	-	-
Zinnia peruviana (L.) L.	-	-	-	+	-
Total =36	10	03	01	21	01

Table 2. Percentage of stomata of species in the study area.

Categories	Number of species	Percentage	Total number of species
Anomocytic	10	27.77%	36
Anisocytic	03	8.33%	36
Anomocytic and paracytic	01	2.77%	36
Anomocytic and anisocytic	21	58.33%	36
Anomocytic, anisocytic and paracytic	01	2.77%	36

Table 3. Types of trichomes of species in the study area.

Name of species	Non-glandular multicellular	Non-glandular unicellular	Glandular multicellular	Absent
Ageratum conyzoides Linn.	+	-	-	-
Blumea lacera (Burm.f.) DC.	+	-	-	-
Blumea laciniata (Roxb.) DC.	+	-	-	-
Callistephus chinensis (Linn.) Nees.	+	-	-	-
Calendula officinalis Linn.	-	-	+	-
Chrysanthemum coronarium Linn.	+	-	-	-
Cosmos caudatus Kunth	-	-	-	+
Circium arvense (L.) Scop.	+	-	-	-
Caesulia axillaris Roxb.	-	-	-	+
Dahlia variabilis (Willd.) Desf.	+	-	-	-
Eclipta alba (L.) Hassk	-	-	-	+
Enhydra fluctuans Lour.	-	-	-	+
Eupatorium odoratum Linn.	+	-	-	-
Gnaphalium polycaulon Pers.	+	-	-	-
Gnaphalium pulvinatum DC.	+	-	-	-
Gnaphalium indicum Linn.	+	-	-	-
Grangea maderaspatana (Linn.) Poir.	+	-	-	-
Helianthus annuus Linn.	+	-	-	-
Lactuca sativa Linn.	-	-	-	+
Launaea aspleniifolia (Willd.) Hook.f.	-	-	-	+
Mikania cordata (Burm.f.) Robinson	+	-	-	-
Parthenium hysterophorus Linn.	+	-	-	-
Sonchus asper (L.) Hill.	-	-	-	+
Sonchus arvensis Linn.	-	-	-	+
Sonchus wingtianus DC.	-	-	-	+
Spilanthes paniculata Wall. ex DC.	+	-	-	-
Synedrella nodiflora (L.) Gaertn.	+	-	-	-
Tagetes patula Linn.	+	-	-	-
Tridax procumbens Linn.	+	-	-	-
Vernonia patula (Dryand) Merrill	+	-	-	-

Vernonia cinerea (Linn.) Less.	+	-	-	-
Wedelia chinensis (Osbeck) Merrill	+	-	-	-
Wedelia trilobata (L.) A.S. Hitchc.	+	-	-	-
Xanthium indicum Linn.	-	+	-	-
Youngia japonica (L.) DC.	+	-	-	-
Zinnia peruviana (L.) L.	+	-	-	-
Total =36	25	01	01	09

Table 4. Percentage of trichomes of species in the study area.

Categories	Number of species	Percentage	Total number of species
Non-glandular multicellular	25	69.44%	36
Non-glandular unicellular	01	2.77%	36
Glandular multicellular	01	2.77%	36
Absent	09	25%	36

Anatomy sometimes proves very helpful for individual identifications. The anatomical methods are of great value in identifying the herbarium specimens which do not bear flowers or fruits. In many cases it becomes possible to assign sterile specimens to a family or a genus. The anatomical methods are also used in the identification of commercial samples of medicinal plants, timbers, fibres etc.

All taxonomists are familiar with the diversity of external hairs. There are glandular and non-glandular categories, each of which may be sub-divided according to the number of component cells, degree of branching etc. Whole families may frequently be recognized by the occurrence of one or more distinctive types of hair. In other cases species and genera can also be recognized on the basis of the structure of hair. Smaller variations in size and density should be treated as a basis for the separation of closely related genera and species only after exhaustive investigation of a wide range of material.

Anatomical characters play an increasingly important role in the formulation of natural or phenetic groups. They are also widely used in other aspects of taxonomy and have been largely applied to the elucidation of 'phylogenetic' relationships (Davis and Heywood, 1963). Bailey (1951), use and abuse of anatomical data in classification and phylogeny.

Leaf anatomy has been widely employed in taxonomically difficult groups such as the Coniferae and the Gramineae. In Pinus nigra it has been known for very many years that the component races (Austrian, Corsican, Dalmatain pines, etc.) differed in their leaf structure and many attempts have been made to define these differences more precisely. One of the latest and most detailed investigations (Vidakivic, 1957) uses epidermal and hypodermal structure, breadth and height of the needles, number of layers of the transfusion parenchyma as well as the more traditional feature, number of resin canals. In Pinus halepensis defferences in leaf anatomy do not appear to be at all correlated with other characters. Other examples in the Coniferae will be found in the works of Gaussen (1942-1960).

In the Gramineae the reduced floral structure has caused taxonomists to seek other characters and the great economic importance of the group has added a further stimulus. Anatomical features are prominent among these additional characters. Tissue arrangements are very diverse in the major taxonomic groups. The tissues that show the most differences are the endodermal sheath (whether small or large, with or without chloroplast), the parenchyma sheath (present or absent) and the mesophyll, particularly the arrangement of the cells just outside the parenchyma sheath. This was clearly demonstrated in W. V. Brown's recent survey (1958) based on a study of 72 genera. The important of grass leaf anatomy in systematics was realised by Duval-Jouve (1875) and has been much studied since then.

Stebbins and Khush (1961) believed that the primitive stomata and several subsidiary cells and that this primitive type gave rise independently to more specialised stomata with two subsidiary cells or none. Although Cronquist (1968) suggested that anomocytic stomata are primitive, he now accepts the view point presented by Baranova in 1972. Cronquist has restated his opinion very clearly as follows. Although anomocytic stomatas are probably primitive for vascular plants as a whole, paracytic stomatas are probably primitive within the angiosperms.

Takhtajan (1969), basing his conclusions on the work of Baranova, considers that the primitive angiosperm stomata was mesoperigenous-paracytic. The stomatal apparatus of flowering plants is characterised by a diversity of structure which has not yet been sufficiently studied, especially from ontogenic point of view. It is therefore very difficult to establish which type is in fact the most primitive.

Trichomes may show wide variations within families and the smaller plant groups, and even in the same plant. On the other hand, there is sometimes considerable uniformity in trichomes within a plant group. Plant hair types have been successfully used in the classification of genera and even of species in certain families and in the recognition of interspecific hybrids (Cowan, 1950; Heintzelmann and Howard, 1948; Hummel and Staesche, 1962; Metcalfe and Chalk, 1950; Rollins, 1944).

Trichomes have long been of considerable importance in comperative systematic investigations of angiosperms. They are frequently present, easily observable, and have often been found to have variation patterns which correlate with other features of taxa under investigation (Cowan, 1950; Culter 1969; Metcalfe, 1960; Metcalfe and Chalk, 1950; Netolizky, 1932; Ramayya, 1962a, 1962b; Roe, 1971; Solereder, 1908; Tomlinson, 1961, 1969). The definition of trichomes ranges from the generalized morphological one of a 'hair or bristle' (Lawrence, 1973) to the somewhat more specific anatomical one of an epidermal outgrowth of diverse from, structure, and function (Esau, 1965).

The numbers of species that are completely devoid of trichomes on all part of the plant represent a minority of the angiosperms as a whole. Many intances of the glabrous condition represent cases where the trichomes have degenerated at an early stage in their development or were lost shortly after maturation. Descriptive terms used for trichomatous surface (i.e. tomentose, villous, hirsute etc.) often give a very sketchy idea of the type of trichome present, and they give no idea at all of the histological characteristics of the trichomes. As is well known, there is a great deal of intergradation in vesture types, and perhaps as a result the rather imprecise use of these terms is almost charactristic of many taxonomic works.

If is in the trichome as a morphological entity that precision of description can be achieved if the cereful use of clearly defined terms is strictly followed. The style of a standard morphological description of a taxon, which has served so well in taxonomy for the last several hundred years, should now be applied to trichomes. The adative value of trichomes and their possible role in plant defence are areas of investigation that have just begun to be utilized by systematists, evolutionists and ecologists. Important use has been made of the particular types of trichomes in studies of many groups of taxa.

The taxonomic significance of the trichome complement, or range of trichomes on the entire plants, has been emphasized by Carlquist (1961a, 1961b) for members of the Asteraceae (Compositae). Especially, he has been able to illustrate clearly the evolution of particular types of trichomes through comperative studies of development within and between taxa of the tribe Madiinae. On the basis of a single trichome type such conclusions probably would not have been possible and a similar understanding of the group would not have been elucidated. Many of the difficulties with comperative studies involving trichomes centre around the rather imprecise use of the terms for both the morphology and anatomy of trichome (Metcalfe and Chalk, 1950).

On the basis of morphological, floral and anatomical characteristics a new system of classification of the family Asteraceae is proposed as follows:

The family is divided into 9 tribes and 16 subtribes.

Tribe 1. Vernonieae: Heads with the flowers all similar and tubular. Anthers cleft at the base. Style-arms subulate, hairy. Leaves usually alternate. Flowers never yellow. Stomata anomocytic and trichome non-glandular multicellular. e.g. *Vernonia*.

Tribe 2. Eupatorieae: Heads with the flowers all similar and tubular. Anthers subentire at the base. Style-arms obtuse, papillose. Leaves opposite or alternate. Corolla rarely orange, never yellow. Pappus usually bristly. Stomata anomocytic, anisocytic and paracytic. Trichome non-glandular multicellular. e.g. *Ageratum, Eupatorium, Mikania*.

Tribe 3. Asteroideae: Heads with the flowers all similar, or the outer ligulate. Anthers subentire at the base. Style-arms falttened or plano-convex, all or those of the disk-flowers terminated by a cone. Leaves usually alternate. Receptacle almost always naked. Disk florets yellow, ray florets yellow, white or purple.

Subtribe I. Grangeineae: Flowers all yellow, ray 0. Pappus hardly any. Stomata anomocytic and trichome non-glandular multicellular. e.g. *Grangea*.

Subtribe II. Heterochromeae: Ray-flowers ♀, ligulate, never yellow. Disk flowers yellow. Pappus hairs long, copious. Stomata anomocytic and trichome non-glandular multicellular. e.g. *Callistephus*.

Subtribe III. Conyzeae: Ray-flowers very slender, tubular, or with very short ligules, and disk-flowers yellow or various colour. Pappus copious or scanty. Stomata anomocytic and trichome non-glandular multicellular. e.g *Dahlia, Tagetes*.

Tribe 4. Inuloideae: Heads with the flowers all similar, or the outer ligulate. Anther cells (except *Laggera* and *Phagnalon*) tailed. Style arms linear, obtuse, or styles of the sterile fl. undivided. Leaves usually alternate. Disk and ray flowers usually both yellow.

Subtribe I. Plucheineae: Heads androgynous. Involucre bracts dry or herbaceous, rarely subscarious. Receptacle naked. Style-arms of ♂ fl., filiform, not truncate, or style of sterile fl. entire. Stomata anomocytic, anisocytic and trichome non-glandular multicellular. e.g. *Blumea*.

Subtribe II. Gnaphalieae: Heads androgynous or homogamous. Invol. bracts scarious, usually hyaline, or the enner radiating. Receptacle usually naked. Style-arms of ♂ fl. truncate. Stomata anomocytic, anisocytic and trichome non-glandular multicellular. e.g. *Gnaphalium*.

Subtribe III. Angiantheae: Heads homogamous, discoid, small, in crowed clusters. Invol. bracts few hyaline. Fl. ♂ with truncate style-arms. Stomata anisocytic and trichome absent. e.g. *Caesulia*.

Tribe 5. Helianthoideae: Heads usually radiate. Receptacle paleaceous. Anther-cells not produced into tails. Style-arms truncate or appendiculate, or style of sterile fl. entire. Achenes 3-4 angled or terete or compressed. Pappus of 2-4 bristles or paleaceous or 0.

Subtribe I. Ambrosieae: Heads heterogamous or unisexual. Fl. ♂ sterile with undivided styles; ♀ apetalous. Anthers nearly free, with inflexed appendages. Stomata anisocytic and trichome non-glandular unicellular. e.g. *Xanthium*.

Subtribe II. Verbesineae: Heads hetero or homogamous. Fl. ♂ all fertile. Achenes of the disk angled, subterete, or laterally compressed, crowned with 2-3 bristles or scales or naked. Leaves usually opposite. Stomata anomocytic, anisocytic and trichome absent. *e.g. Enhydra, Eclipta*.

Subtribe III. Wedeloideae: Heads hetero or homogamous. Fl. ♂ all fertile. Leaves usually opposite. Flower colour yellow. Stomata anomocytic, anisocytic and paracytic. Trichome non-glandular multicellular. e.g. *Wedelia, Spilanthes*.

Subtribe IV. Coreopsideae: Heads hetero or homogamous. Fl. ♂ all fertile or neuter. Achenes dorsally compressed, 2-4 awned or naked. Stomata anomocytic and trichome non-glandular multicellular. e.g. *Synedrella*.

Subtribe V. Galinsogene: Heads hetero or homogamous. Fl. ♂ all fertile. Achenes with short bristle like palea. Stomata anomocytic, anisocytic and trichome non-glandular multicellular. e. g. *Tridax*.

Subtribe VI. Heliantheae: Heads usually radiate and large. Receptacle with a chafflike bracts (scale) subtending each disc flower. Stomata anomocytic, anisocytic and trichome non-glandular multicellular. e. g. *Helianthus*.

Tribe 6. Anthemideae: Heads heterogamous, rayed or disciform or rayless and homogamous. Invol. bracts 2-seriate, dry or with scarious tips. Receptacle naked or paleaceous. Anther-cells not produced into tails. Style-arms truncate. Pappus 0 or a crown of short paleae. Leaves usually alternate. Disk flowers yellow, ray flowers variously coloured. Stomata anomocytic, anisocytic and trichome non-glandular multicellular.

Subtribe I. Chrysanthoideae: Leaves usually alternate. Disk flowers yellow, ray flowers variously coloured. Stomata anisocytic and trichome non-glandular multicellular. e. g. *Chrysanthemum*.

Subtribe II. Leaves usually alternate. Disk flowers yellow, ray flowers variously coloured. Stomata anomocytic, anisocytic and trichome absent. e. g. *Cosmos*.

Tribe 7. Caledulaceae: Heads rayed. Invol. bracts 1-2-seriate, narrow, subequal. Receptacle naked. Anther cells mucronate. Style-arms of ♂ fl. truncate or in sterile fl. undivided. Achenes usually large and thick and deformed, without pappus. Stomata anomocytic, anisocytic and trichome non-glandular or glandular multicellular. e. g. *Calendula, Zinnia*.

Tribe 8. Perthenideae: An erect rphemeral herb known for its vigorous growth. It is light green with branching stems, finely lobed leaves and grows up to 1.5 meters, occasionally reaching 2 m in deep rich soils.Young plants form a basal rosette of strongly dissected leaves that are up to 30 cm in length. Once stem elongation is initiated, smaller leaves are produced and the plant becomes much-branched in its extremities. Stomata anomocytic and trichome non-glandular multicellular e. g. *Perthenium*.

Tribe 9. Cichoriaceae: Annual or perennial herbs; heads sessile or peduncled, solitary fascicled, yellow or red; homogamous; involucre bracts, inner 1-seriate; receptacle flat, naked or subfimbrillate. Achenes truncate or narrowed or beaked. Pappus short, of scales or bristles or hairy or 0.

Subtribe I. Lactusoideae: Annual or perennial herbs; heads sessile or peduncled, solitary fascicled, yellow or red. Stomata anomocytic, anisocytic and trichome absent. e. g. *Lactuca, Sonchus, Launaea*.

Subtribe II. Crepisoideae: Annual or perennial herbs; heads sessile or peduncled, solitary fascicled, yellow or red. Stomata anomocytic and trichome non-glandular multicellular. e. g. *Youngia, Circium*.

Acknowledgement

The authors are grateful to the Plant Taxonomy and Plant Anatomy Laboratory, Department of Botany, University of Rajshahi, Bangladesh.

References

Baile IW. 1951. The use and abuse of anatomical data in the study of phylogeny and classification. Phytomorphology **1,** 67-69.

Bendre A, Kumar A. 1997. A Text Book Practical Botany II. Rastogi Publications, Shivaji Road, Meerut-250002, India.

Brown W V. 1958. Leaf anatomy in grass systematics. Bot. Gaz., **119,** 170-178.

Carlquist S. 1961a. Comperative Plant Anatomy. Holt, Rinehart and Winston. New York, U.S.A.

Carlquist S. 1961b. Handling the Anomalous Genus. Recent Advances in Botany. **1,** 165-168.

Collin M W. 1983. Stomata. Longman Group Limited. London, U.K.

Cowan J M. 1950. The Rhododendron Leaf: A Study of the Epidermal Appendages. Oliver and Boyd, Edinburgh, U.K.

Cronquist A. 1968. The Evolution and Classification of Flowering Plants. Houghton Miftlin, Boston. U.S.A.

Cutler D F. 1969. Anatomy of the Monocotyledons. Vol. IV. Juncales. C.R. Metcalfe (ed). The Clarendon Press, Oxford, U.K.

Davis P H, Heywood VH. 1963. Principles of Angiosperm Taxonomy. Robert E. Krieger Publishing Company, Huntington, New York.

Duval-Jouve M J. 1875. Histotaxie des feuilles de Graminees. Ann. Sci. Nat. Bot., **8,** 227-346.

Esau K. 1965. Plant Anatomy. 2nd Ed. John Willey and Sons. New York. U.S.A.

Foster A.S. 1949. Practical plant anatomy. 2nd ed. D. Van Nostrand Company, New York, U.S.A.

Gaussen H. 1942-1960. Travaux du Laboratoire Forestier de Toulouse. II. Etudes Dendrologiques. U.S.S.R.

Heintzelmann CE, Howard RA. 1948. The comparative morphology of the Icacinaceae. V. The pubescence and the crystals. Amer. Jour. Bot. **35,** 42-52.

Hummel K, Staesche K. 1962. Die Verbreitung der Haartypen in der naturlichenVerwand-schaftsgruppen. In: Handbuch der Pflanzenanatomie Band 4. Teil 5.

Lawrence GHM. 1973. Taxonomy of Vascular Plants. Oxford and IBM Publishing Co., Rakes Press, New Delhi, India.

Metcalfe CR. 1960. Anatomy of Dicotyledons. Claredon Press, Oxford, U.K.

Metcalfe CR, Chalk L. 1950. Anatomy of the Dicotyledons. Vol. 1. Claredon Press, Oxford, U.K. pp. 40-116.

Netolitsky F. 1932. Die Pflanzenhaare. In: K.Linsbauer (ed), Handbuch Der Pflanzenantomie. **4,** 1-253.

Rahman A H M M. 2009. Taxonomic Studies on the Family Asteraceae (Compositae) of the Rajshahi Division. Ph.D. Thesis. Department of Botany, Rajshahi University, Bangladesh.

Rahman AHMM, Islam AKMR, Rahman MM. 2011. The Family Asteraceae of Rajshahi Division, Bangladesh. VDM Verlag Dr. Muller Publishing House Ltd. Germany.

Ramayya N. 1962a. Studies on the Trichome of some Compositae I General Structure. Bull. Bot. Surv. India. **4,** 77-188.

Ramayya N. 1962b. Studies on the Trichome of some Compositae II Phyllotaxy and Classification. Bull. Bot. Surv. India. **4,** 189-192.

Roe K E. 1971. Terminology of hairs in the genus *Solanum*. TAXON. **20,** 501-508.

Rollins RC. 1944. Evidence for natural hybridity between guayule (*Parthenium argentatum*) and mariola (*Parthenium incanum*). Amer. Jour. Bot. **31,** 93-99.

Solereder H. 1908. Systematic Anatomy of the Dicotyledons. Vol. II. The Claredon Press. Oxford, U.K.

Stebbins G L, Khush G S. 1961. Variation in the Organization of the Stomatal Complex in the leaf epidermis of Monocotyledons and its bearing on their Ohylogeny. Amer. Jour. Bot. **48,** 51-59.

Takhtajan A. 1969. Flowering Plants Origin and Dispersal. Washington, New York, USA.

Tomlinson P B. 1961, 1969. Anatomy of the Monocotyledons. II & III. Palmae, Commelinales-Zingiberales. C.R. Metcalfe (ed). The Claredon Press, Oxford, U.K.

Vidakovic M. 1957. Oblici crnog bora u Jugoslaviji na temelju anatomique iglica. Forms of *Pinus nigra* in Yugoslavia on the basis of anatomical structure of the needles. Glasnik za Sumske Pokuse, **13,** 11-248.