CHAPTER – 1

INTRODUCTION

1. Introduction

The wealth of vegetation that adorns the earth shows a vast array of diversity of habit, habitat, structure and mode of life, some of them are minute floating herb with a very simple structure, while others are gigantic trees with very complex structure. This green vegetation provides the basic needs to sustain and maintain the life process on the earth. Since the early stages of civilization, man has been absolutely dependent on plants for food, shelter, clothing, fuel, medicine, paper, and a host of other useful products. Furthermore, they are the greatest means of utilizing energy from the sun. The primitive man thus tried to group the plants according to their economic uses. From the prehistoric time, Aristotle and Theophrastus made remarkable contributions which paved the way for the development of formal taxonomic groups and establishment of a descriptive language to define these groups. The earliest systems of classifications were based on external morphological and structural similarities and differences. Morphological characters of plant community were the most widely used instrument of classificatory process in earlier systems. In the beginning of seventeenth century the invention of microscope by Leeuwenhoek made it possible to acquire knowledge on minute plants and anatomical features. The morphological and anatomical approach coupled with increasing knowledge of geographical distribution came to a climax by the end of nineteenth century. These data are still indispensable to present day taxonomy and
shall continue to serve useful purpose. The publication of evolutionary theory by Charles Darwin in 1859 profoundly affected systematic thinking and afterwards classifications were interpreted in evolutionary terms with the entry of evolutionary idea. One of the major achievements in plant taxonomy is the introduction of cytological information followed with the rediscovery of Mendel’s laws and continued to dominate until 1960. In true sense the first experimental approach to taxonomy was the application of cytological and genetical data with the aid of population statistics. The period began in 1960’s was marked by the development of rapid and relatively simple ideas and techniques. Heywood (1967) has rightly referred to this as the period of “taxonomic revolution and explosion”. With the entry of phylogenetic idea in taxonomy, the relationships of taxa are determined as a consequence of common genetic makeup. Actually the fine level of structures or morphology of an organ or part of any organism or soil or mineral visible through microscopy is the micromorphology (www.lexis.us). The common macro morphological characters along with micro morphological characters such as seed coat, seed structure, type of stomata, stomatal distribution, subsidiary cells, pollen grains, complex structure of floral parts, hairs and trichomes, epidermal cellular nature, leaf venation pattern, karyotypic characters, etc. are some of the significant aid for proper taxonomic judgment. Chemotaxonomy and numerical taxonomy or taximetrics is also two helpful aids to solve various taxonomic problems and assessing phylogenetic relationship. Although numerical taxonomy does not produce new data, the data from different sources are analysed with the help of electronic devices like computer to develop quantitative methods of classification.
1.1 **Foliar epidermal morphology**

The study of epidermal features plays an important role in the field of taxonomic judgment. Although taxonomists came late realize the importance of microscopic features of the epidermis, taxonomic monographs are now considered incomplete without them. Anatomical characters cannot play the major role on the basis of classification but definitely form an aid and supplement to the external morphological characters on which the classification is based. Such features provide evidences concerning the interrelationship of larger groups like families and also help to establish the affinities of genera of uncertain taxonomic status. There are a large number of anatomical characters of systematic importance, but as pointed out by Metecalf and Chalk (1950), the systematic anatomist must rely on those characters only which are less plastic. They further suggested that conclusions supported by combination of characters are more reliable than those rests on a single character.

The following features are the components for study of foliar epidermal morphology which have greater taxonomic significance.

(i) Shape, size, type and nature of stomata.

(ii) Epidermal appendages like trichomes and hairs.

(iii) Structure of epidermal cells.

(iv) Leaf venation pattern.

1.2 **Chromosome morphology**

The number of chromosome is usually constant in a species and this makes it an important taxonomic character. In addition to variation in number, chromosomes vary in form, size, volume, position of centromere, micromeasurement of the total
length, long arm and short arm of chromosome, detection of satellite chromosome, distribution of heterochromatin etc. These karyomorphological characters are taxonomically important where the individual chromosomes are large enough for detailed microscopical observation. During the study of karyomorphismology, the identification, classification and nomenclature of the chromosome have been thoroughly carried out. Levan et al. (1964) clearly explained the nomenclature of chromosome according to the structural pattern of the chromosome and the location of centromere.

1.3 Palynology

The gametophytes, which hold the key to reproduction and perpetuation of the species, are of great significance in plant evolution and taxonomic studies. Out of the two types of gametophytes, the male gametophyte (Pollen grains) are structurally and functionally adopted for their efficient transfer to the stigma, and these characters are of great value to taxonomists in deducing the phylogeny and taxonomy of the group. The publication of “Pollen Morphology and Plant Taxonomy” by Erdtman (1952) marked the beginning of a new phase. The use of the Electron Microscope in recent times has greatly accelerated the pace of progress in palynological research, and pollen characters are being extensively used in taxonomic and evolutionary studies (Blackmore, 1984). The pollen of related families and genera are usually of more or less of same type. Mature pollen grains usually have two walls, the outer one thick and rough which is called exine and inner tender and thin wall is called intine. The exine wall is also distinguished into two layers – outer sexine and inner nexine. There are several morphological characters which are used for the classification of pollen grains and impart great value in
taxonomic judgment. Palynological characters have been used in several ways in
taxonomy including repositioning of several disputed taxa and interpretation of
problems relating to the origin and evolution of different groups (Nair, 1980). Some
of the pollen grain characters which have great taxonomic value are variation in
shape, size, symmetry; number and position of furrows; type, number, position and
structure of apertures; pollen association; architecture of its wall, exine stratification,
esculpture and structure etc.

1.4 Fruit and Seed morphology

Fruit and seed morphology deals with the study of the type of fruit, time of
fruiting, shape, size etc. and morphological features of seeds like shape, size,
weight, nature of seed coat, colour, surface ornamentation etc.

Seeds are produced as a result of fertilization of ovule in which an embryo is
enclosed by seed coat(s) developed from integuments. Seed morphology has been
successfully used as an aid to taxonomy particularly at specific level. The fruit and
seed morphology serves as a source of systematic characters to circumscribe inter
generic and inter specific groups or hypothetical relationship among species within
a genus. Seed morphological characters not only serve as taxonomical markings but
also serve in deducing phylogenetic relationship. The morphometric characters of
seeds are ever challenging to the taxonomic and phylogenetic issues that would be a
great help both in academic as well as in applied ventures.

Fruit characters are widely used in identification. Coode (1967) used only
fruit characters in delimitation of species of the genus Valerianella. Singh et al.
(1972) used fruit morphology in identification of Indian genera of Compositae
(Liguliflorae). Anthericum and Chlorophytum of family Uliaceae have been
distinguished on the basis of number and shape of the seeds. On the basis of seed morphology Basak and Maiti (2002) able to catagorise genus *Primula* of Himalayas of Indian Region.

### 1.5 Aim of the investigation

Fabaceae (= Leguminosae) is a large angiospermic family of about 690 genera and nearly 18000 species (Hutchinson, 1973; Polhill *et al.* 1981, Cronquist, 1981). Bentham and Hooker (1887), Prain (1903) and Dutta (1964) divided the family Leguminosae (Fabaceae) in to three sub families (Papilionateae, Caesalpinoideae and Mimosoideae). However, Hutchinson (1973) considered Leguminales as an order where he included three families namely Caesalpiniaceae, Mimosaceae and Papilionaceae. Mabberley (1997) considered Fabaceae as the third largest family after Asteraceae and Orchidaceae with 730 genera and over 19400 species. Takhtajan (1980, 1997) considered Fabales as an order and Fabaceae is the lone family under Fabales. He divided the family into three sub-families viz. Mimosoideae, Caesalpinoideae and Faboideae. In APG III system of classification (2009) the order Fabales includes four families viz. Fabaceae, Quillajaceae, Polygalaceae and Surianaceae. The family Fabaceae is divided in to three sub families, Caesalpinioidae, Mimosoideae and Faboideae. The subfamily Caesalpinoideae (Classified as a family Caesalpiniaceae, by some authorities) is a heterogeneous group of plants with about 160 genera and some 2000 species (APG III, 2009). Takhtajan (1997) included about 135 genera in the sub-family Caesalpinoideae and *Cassia* is one of them, which includes about 600 species. *Cassia* Linn. is represented by only ten species in the undivided Assam (Kanjilal *et al.*, 1939)
The various species of *Cassia* has a wide range of habit from herb to tree. Usually herb and under shrub members are annual, while tree members are perennial and they are both evergreen and deciduous in nature. Again the chromosome number also varies from species to species. Tree species normally have chromosomes \( n=14 \), whereas in shrubby and herbaceous species, it is \( n=12 \) (Singhal *et al.*, 1990). Although traditionally plant taxonomy is mainly based on comparative morphological characters, the synthetic approach combining the characters derived from the other branches of botany has been now a days considered to be the more effective way for ascertaining the proper taxonomic categorization of plant species (Constance 1964, Stac 1984). Macromorphological characters in combination with the micromorphological characters of different organs along with the cytological and palynological characters greatly enhance the taxonomic judgment of angiosperm systematic (Erdtmann 1952, Carlquist 1961, Dickinson 1981, Beretta-kuipers, 1981). The common morphological characters both macro and micro such as pollen grain, fruit and seed characters, leaf epidermal characteristics, and cytological data can provide additional support to some of the secondarily created natural groupings (Hutchinsonan, 1969).

The genus *Cassia* Linn. has immense medicinal importance. *Cassia fistula* Linn. long been used traditionally as purgative (fruit pulp), root extracts are used in skin diseases, gastrointestinal disorders and cardiac problems (Danish *et al.*, 2011). Different parts of *Cassia siamea* Lam. are being used in diarrhoea, as laxative and in antibacterial activity (Kritikar *et al.*, 1975; Bhadaurea *et al.*, 2011). Antiviral chromosomes are also isolated from the stem of *Cassia siamea* Lam. (Qie-Fen Hu *et al.*, 2012). *Cassia alata* Linn. traditionally is being used as anti fungal, laxative, stomach problems, high blood pressure, fever, asthma and snake bite (WHO, 1999;
Mohideen et al., 2005; Danish et al., 2011). *Cassia occidentalis* Linn. also has many medicinal properties. Different parts are used as purgative, diuretic, expectorant, antioxidant and also against scabies, ringworm, jaundice and cancer (Gaind, 1966; Samy, 2000; Bhagal et al., 2010; Arya, 2011). For long time the seeds of *Cassia tora* Linn. are being used as substitute of coffee (Jain et al., 2010). Various parts of this plant are used as acrid, laxative, liver tonic, expectorant and against leprosy, ringworm, constipation and cardiac disorder (Feng, 1962; Kritikar et al., 1975; Elujoba, 1989; WHO, 1999; Priyadarshini et al., 2013). Medicinal use of *Cassia hirsuta* Linn. is relatively less known. It is particularly used as antioxidant, antifungal, expectorant and analgesic (Elujoba, 1989; Samy, 2000; Vadivel et al., 2000; Dey et al., 2012).

To rule out the misidentification of different species, proper identification tools should be applied. This study is confined to the following six species of genus *Cassia* Linn. due to easy availability throughout Assam and their habit diversity. The studied species are - (1) *Cassia fistula* Linn. [Perennial deciduous tree] (2) *Cassia siamea* Lam. [Perennial evergreen tree] (3) *Cassia alata* Linn. [Large annual shrub] (4) *Cassia occidentalis* Linn. [Annual shrub] (5) *Cassia tora* Linn. [ Annual herb] and (6) *Cassia hirsuta* Linn. [Annual hirsute shrub].

In the light of the above, the investigation aims at: A comparative study of six species of genus *Cassia* Linn., their micromorphological features, alternate tool of identification and to illucidate the review of taxonomic position, if necessary. With a view to achieving this aim the following objectives were undertaken.

- Collection of the above mentioned species of *Cassia* Linn. from different places of Assam and study of their -
  - General taxonomy and ecology.
- Epidermal features of leaves.
- Chromosome morphology including karyotypes.
- Pollen grain morphology.
- Fruit and seed morphology.

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