Venation pattern in Indian species of *Cassia* Linn.

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MS received 24 September 1986; revised 25 June 1987

Abstract. Venation pattern has been studied in 23 species of the genus *Cassia* Linn. growing in India and these include the species that range in habit from prostrate, erect, shrubs, undershrubs to tall trees upto 10-15 m in height. The venation pattern shows a clear gradation of thickness upto the veinlets of the 6th category and in the size of areoles. Venation pattern and the presence or absence of areoles help to separate one species from the other on the one hand and correlate to the habit of species on the other.

Keywords. Venation pattern; *Cassia* Linn.

1. Introduction

The morphology of leaves has not received sufficient attention in systematic studies of dicotyledons. The dicot leaves exhibit a wide range of venation pattern which is complex but could be useful in taxonomy. From the time of Ettingshausen's studies in venation of modern angiosperm leaves (Ettingshausen 1854a, b, 1856, 1857, 1858a, b, 1861, 1865, 1872) until Foster's work (Foster 1950a, b, 1953) on foliar venation, little work was done in a systematic manner on the venation pattern of leaves. In earlier studies, Foster (1936, 1952) clearly brought out the diagnostic features in the venation pattern of cleared leaves and advised palaeobotanists to use these for describing fossilised leaf samples. Levin (1929) studied the taxonomic value of vein-islet areas based upon the study of the genus *Cassia*. Veinlet termination number was proposed by Hall and Melville (1951, 1954) as a criterion for assessing the purity of fragments of a particular leaf from a known locality in shipments of leaf fragments for pharmacological preparations. Wolfe (1959) and Lucic (1970) dealt with the details of leaf venation of modern genera of angiosperms. A system of descriptive terminology of gross leaf form and venation patterns of dicotyledonous leaves has been presented by Ettingshausen (1861), Mädler and Sträus (1971), Ferguson (1971), Walther (1972), Krüßmann (1960), Stace (1965) and Mouton (1966, 1967). The most meaningful and usable system of terminology of leaf architecture has been given by Hickey (1973) which is useful for both palaeobotanists and taxonomists. Dilcher (1974) presented an outline of classification of leaf architecture. Hickey (1979) presented a revised classification of leaf architecture of dicotyledonous leaves.

Minor venation patterns in some species of *Cassia* have been studied by Banerji and Sirkar (1974). Menezes (1981a, b) also studied nervation of leaflets in a few species of *Cassia*.

The genus *Cassia* includes a large number of species ranging in habit from prostrate, erect, herbaceous, shrubs and undershrubs to tall trees. Thus on the basis of the habit, the species of genus *Cassia* can be conveniently divided into 3 groups. Venation pattern of 23 species belonging to these 3 groups has been studied.
2. Materials and methods

The material was mostly collected from plants growing in Maharashtra and a few species from Gujarat and Karnataka.

The fresh leaflets from different species were selected and the leaf of each species was treated with sodium hypochlorite. It was then washed with water, stained in safranin and mounted in glycerine jelly.

The photographs were taken with Asai Pentax camera at various magnifications. For microphotography ORWO NP 55 and 35 mm microfilm was used. The sequence of the photoplate figures is according to the habitats of the plant such as herbs, shrubs and trees. Terminology used in this paper is after Hickey (1979). The terms massive, stout and moderate used for describing the size of the primary vein are based upon the formula suggested by Dilcher (1974).

3. Observation

3.1 Diagnostic features of venation in the genus Cassia L.

The following features of the venation are of diagnostic value. The patterns of venation in general are the nature of the primary vein, the course of the primary vein, angle of divergence of secondary vein, the differences in the upper and lower secondary veins, the thickness of the secondary veins and their course, the nature of the intersecondary veins, the presence or absence, the thickness and angle of origin of tertiary, quarternary and quinternary veins, the character of the marginal, ultimate venation, areoles and their arrangement. In the following section, the above features as seen in the 23 species of Cassia are described.

3.2 Comparative account of venation in 23 species of genus Cassia Linn.

Considering the pattern of venation, C. kolabensis (figures 4-6), C. pumila (figures 13-15) and C. mimosoides (figures 7-9) have palinactinodromous venation. Highest vein order, veins upto 3° is observed in lateral leaflets of C. kolabensis while highest vein upto 2° with basal veins 2-3 is observed in C. pumila and C. mimosoides. Further C. pumila shows secondary basal veins angle of divergence 50–60°, moderate to acute, while in C. mimosoides secondary basal veins angle of divergence is 65–70°. In addition the terminal leaflet of C. kolabensis can be separated from C. pumila and C. mimosoides, in having pinnate, craspedodromous and simple venation. Here the primary vein is massive (> 4%) with sinuous course, secondary veins thick and lower secondary veins and upper secondary veins are more obtuse than the middle.

Venation pinnate, craspedodromous, semicraspedodromous with primary vein straight unbranched in C. renigera (figures 58–60), C. fistula (figures 44–46), C. marginata (figures 52–54), C. obtusifolia (figures 10–12), C. siamea (figures 61–63), C. didymobotrya (figures 28–30), C. javanica (figures 49–51) and C. nodosa (figures 55–57). These species are further differentiated on the basis of secondary vein, angle of divergence which is wide acute in C. renigera, while the angle of divergence is acute to moderate in C. fistula, C. marginata, C. obtusifolia and C. siamea. Course of secondary veins
Figures 1-18. Cleared portion of leaflets. 1-3. C. absus. 4-6. C. kolabensis. 7-9. C. mimosoides. 10-12. C. obtusifolia. 13-15. C. pumila. 16-18. C. tora. (Figures 1 and 16, × 0.9; 4, × 2.3; 7 and 13, × 2.5; 10, × 1.7; 2, 3, 5, 6, 8, 9, 11, 12, 14, 15, 17, 18, × 77).
curved uniformly in *C. fistula*; abruptly in *C. marginata*, *C. obtusifolia* and *C. siamea*. The above 3 species are separated by tertiary vein (3') character. Tertiary vein pattern is random reticulate in *C. marginata* while orthogonial and percurrent in
C. obtusifolia and C. siamea. These two species are separated on quarternary vein character; vein thin upto 4° in C. obtusifolia and veins upto 6° in C. siamea.

C. didymobotrya is differentiated in having divergence angle of upper secondary
veins more obtuse than lower while in *C. javanica* and *C. nodosa* the divergence of upper secondary veins more acute than the lower. In *C. javanica* secondary veins are curved uniformly and in *C. nodosa* secondary veins are curved abruptly.

Venation is pinnate, craspedodromous and semicraspedodromous with primary vein curved markedly as observed in *C. grandis* (figures 47–48) and *C. laevigata* (figures 35–37). In *C. grandis* secondary vein angle of divergence is nearly uniform but in *C. laevigata* this angle of divergence of upper secondary veins is more acute than in the lower secondary veins.

Venation pinnate, camptodromous, brochidodromous and primary vein is massive (>4% of its course straight, unbranched in *C. angustifolia* (figures 22–24) and *C. biflora* (figures 25–27). Further these two species can be differentiated on
secondary veins and angle of divergence: when narrow acute, course of secondary
vein abruptly curved in *C. angustifolia*, while moderate acute, course of secondary
veins uniformly curved in *C. biflora*. Primary vein massive (>4%), slightly curved in
*C. sophora* (figures 41-42). Primary vein stout (2-4%) and secondary vein angle of
divergence uniform as observed in *C. glauca* (figure 31) and upper secondary veins
are more obtuse than lower as observed in *C. occidentalis* (figures 38-40). Primary
vein is moderate (1-25-2%) in *C. absus* (figures 1-3), *C. hirsuta* (figures 32-34) and
*C. tora* (figures 16-18). These 3 species are separated on the basis of angle of diver-
gence of secondary veins which is nearly uniform in *C. absus* and *C. hirsuta*, while
divergence angle of lowest pair of secondary vein is more acute than pairs above
in *C. tora*. *C. absus* can be further separated from *C. hirsuta* on the basis of course of
secondary veins which is uniformly curved in *C. absus* and abruptly curved in
*C. hirsuta*.

Venation is pinnate, camptodromous and reticulodromous as observed in *C. timori-
ensis* (figures 64-65) and *C. alata* (figures 19-21). Secondary veins are thin and highest
vein order of upto 3’ is seen in *C. timoriensis* and secondary veins thick, highest vein
order of upto 5’ is seen in *C. alata*.

### 4. Discussion

We tried to find out whether a correlation exists between venation pattern and the
habit of the species. It is seen that in herbs like *C. kolabensis*, *C. pumila* and *C. mimo-
soides*, the venation pattern is either palinactinodromous or craspedodromous.
Highest vein order being 2’ or 3’ without forming areoles. The primary and the
secondary veins are approximately of same thickness. The primary vein course
straight and branched or slightly curved, sinuous in these herbs. Most of the species
of *Cassia* described as herbs show highest vein order of 2-4’. Highest vein-order of
upto 4’ is observed in *C. absus*, *C. obtusifolia* and *C. tora*. Areole development is
imperfect in *C. obtusifolia* and *C. tora* while incompletely closed meshes in *C. absus*.
*C. renigera*, *C. fistula*, *C. marginata*, *C. siamea*, *C. javanica* and *C. nodosa* are
described by different authors as trees where the venation pattern is craspedodro-
mous and semicraspedodromous with primary veins straight and unbranched with
the exception of *C. obtusifolia*, a herb and *C. didymobotrya*, which is a shrub. The
primary vein is markedly curved in *C. grandis*, a tree, and *C. laevigata*, a shrub. In *C.
timoriensis*, a large shrub or a small tree, the venation pattern is pinnate, camptodro-
mous and reticulodromous. Most of the trees have highest order of veins of upto 6°,
except in *C. fistula* (5°) and *C. timoriensis* (3°). Areoles are imperfectly developed, a
characteristic feature of all tree species of *Cassia* is described here.

Venation pinnate, camptodromous and brochidodromous as observed in shrubby
species of *Cassia*, *C. angustifolia* and *C. biflora*, where the primary vein is massive
(>4%) and straight, unbranched, while primary vein is slightly curved in *C. sophora;
primary vein is stout (2-4%) in *C. glauca* and *C. occidentalis*, while moderate (1-25–
2%) in *C. hirsuta*, and also in a few herbs like *C. absus* and *C. tora*. In *C. alata*, a large
shrub, the venation pattern is pinnate, camptodromous and reticulodromous. The
highest vein order in shrubs is 4-5°, except 6° in a small shrub, *C. occidentalis*. Areoles are well developed in *C. angustifolia*, *C. glauca*, *C. hirsuta*, *C. occidentalis* and
*C. sophora* while the development of areoles is imperfect in *C. alata*, *C. biflora*, *C.
didymbotrya and incompletely closed meshes in C. laevigata. This indicates that different species of Cassia can be differentiated from the venation pattern of their leaves. The separation of 23 species of genus Cassia studied on the basis of venation pattern is given below.

I. Venation palinactinodromous.
   A. Highest vein order upto 3° ............ C. kolabensis (lateral leaflets).
   B. Highest vein order upto 2°.
      Secondary basal 2-3 veins
      angle of divergence 50–60° ................. C. pumila
      angle of divergence 65–70° ................. C. mimosoides

II. Venation pinnate, craspedodromous, simple.
   A. Primary vein massive, course sinuous; secondary veins thick; lower secondary veins and upper secondary veins more obtuse than the middle secondary veins .................. C. kolabensis (terminal leaflet).

III. Venation pinnate, craspedodromous, semicraspedodromous.
   A. Primary vein straight, unbranched.
      1. Secondary veins, angle of divergence wide acute ........ C. renigera
      2. Secondary veins, angle of divergence acute, moderate.
         a. Course of secondary veins uniformly curved ........ C. fistula
         b. Course of secondary veins abruptly curved.
            i. Tertiary vein pattern random reticulate ........ C. marginata
            ii. Tertiary vein pattern reticulate, orthogonial and percurrent.
               —Quarternary veins thin, veins upto 4° ........ C. obtusifolia
               —Quarternary veins thick, veins upto 6° .......... C. siamea
      3. Divergence angle of upper secondary veins more obtuse than lower
         ... C. didymbotrya
      4. Divergence angle of upper secondary veins more acute than lower.
         a. Course of secondary veins uniformly curved ........ C. javanica
         b. Course of secondary veins abruptly curved .......... C. nodosa
   B. Primary vein curved markedly.
      1. Secondary veins, angle of divergence nearly uniform .... C. grandis
      2. Secondary veins, angle of divergence of upper secondary veins more acute than lower .................. C. laevigata

IV. Venation pinnate, camptodromous, brochidodromous.
   A. Primary vein massive (> 4%).
      1. Course of primary vein straight, unbranched.
         a. Secondary veins angle of divergence narrow acute, course of secondary veins abruptly curved .......... C. angustifolia
         b. Secondary veins angle of divergence moderate acute, course of secondary veins uniformly curved .......... C. biflora
      2. Primary vein slightly curved ..................... C. sophera
   B. Primary vein stout (2–4%).
      1. Secondary veins, angle of divergence uniform .......... C. glauca
      2. Secondary veins, angle of divergence of upper secondary veins more obtuse than the lower .................. C. occidentalis
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C. Primary vein moderate (1.25–2%).
   1. Secondary veins, angle of divergence nearly uniform
      a. Course of secondary vein uniformly curved ............... C. absus
      b. Course of secondary vein abruptly curved ............... C. hirsuta
   2. Secondary veins, angle of divergence of lowest pair of vein more acute than the pairs above .................. C. tora

V. Venation pinnate, camptodromous, reticulodromous.
   A. Secondary veins thin, highest vein order up to 3° .......... C. timoriensis
   B. Secondary veins thick, highest vein order up to 5° .......... C. alata

Acknowledgement

We are thankful to Dr A R Kulkarni for his valuable suggestions and kind help from time to time in preparing this manuscript.

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