7.Family MELIACEAE

The family Meliaceae (mahogany family), consisting of 51 genera and 550 species, is distributed throughout the tropics. Of these 19 genera are represented in India.

The plants belonging to this family are woody in nature and possess alternate compound leaves, regular bisexual or unisexual flowers, calyx and corolla connate at the base, stamens usually diplostemonous or rarely haplostemonous by the loss of antepetalous stamens, filaments united to form a staminal tube (free in **Cedrela** and **Chloroxylon**), intrastaminal nectariferous disk, gynoecium two to five-carpellary, syncarpous having axile placentation or rarely unilocular ovary with parietal placentation and two ovules per locule. The ovules are anatropous, campylotropous or orthotropous, bitegmic, crassinucellate with obturator, generally pendulous and epitropous with a ventral raphe. Fruit is a septicidal or loculicidal capsule, less often berry or drupe (very rarely a nut) with winged or wingless thin dry seeds. The family is distinguished from the related taxa by the staminal tube, discoid or capitate stigma and usually winged seeds.

Studies on the cuticular features of the family (Pandey, 1969) reveal that the anamocytic (Ranunculaceous) type of stomata occur in Meliaceae, with surrounding epidermal cells more or less overarching the guard cells from below, show a prominent rim. Floral and foliar hairs and glands occur in many of the taxa within (Inamdar et al., 1986; Lersten and Rugnstein, 1982). The non-glandular hairs are usually unicellular while the glandular hairs are multicellular. A detailed discussion on the floral anatomy is available (Nair, 1963; Narayana, 1959; Murthy and Gupta, 1978).

As seen in the Anacardiaceae, the Meliaceae also show evolutionary lines within the family in which a reduction of floral parts (**Amoora**, sepals five but petals, stamens and carpels in threes) as also a trend to unisexuality (**Amoora**) are operative. A tendency towards the union of same or different whorls in a flower also is seen. The stamens are united in most taxa but occur free in **Cedrela** and **Chloroxylon**. A primitive condition is observed in **Azadirachta** and **Carapa**, where the sepals are free as against an advanced gamosepalous condition in **Naregamia**, **Cipadessa**, **Dysoxylum** and **Swietenia**. The characteristic anatomical features of the family include septate fibres, diffuse porous wood, distinct growth rings and a number of secretory cells containing gummy substances. (Metcalfe and Chalk, 1950; 1983; Kribs, 1930; Panshin, 1933).

Embryology :

Anther wall consists of five layers. Tapetum is secretory (**Naregamea**) or glandular (**Melia**) type the cells of which are either bi-or multinucleate. The pollen are shed at 3-celled stage. The development of female gametophyte is Polygonum type and embryo development is Cruciferous type. Nucellar cap and the obturator consisting of compactly placed cytoplasmic cells are present. The endosperm is cellular or nuclear. An aril from the funiculus is developed and covers the ventral surface of the seeds in the arillate seeds. Multiple embryo sac and polyembryony also are noted in this family (Nair and Kantha, 1961).

Palynology :

The pollen are 3-5 colporate, slightly ruporate. The sexine, as a rule, is thinner than nexine, the latter being thicker at the apertures. Ends of the colpi are well-defined. Ora is distinct, circular to lalongate.

Taxonomy :

Bentham and Hooker (1862) placed Meliaceae in the order Geraniales; Cronquist (1981) in the Sapindales and Thorne (1981), Takhtajan (1980) and Dahlgren (1980) in the Rutales. Even after a number of reshufflings of the families, the Meliaceae is almost always associated with the Rutaceae, Simaroubaceae and Burseracae. However Hutchinson (1973) preferred to isolate this family in a unifamilial order Meliales, stating that "the order differs from the Rutales in possessing staminal tube functioning as a sympetalous corolla and in lacking gland-dotted leaves". According to him, Meliales is a climax order evolved from the Celastrales parallel to the Rutales.

Based on the nature of the seeds, earlier taxonomists (Lindley, 1930; Brown, 1862) had split the Meliaceae into two families, the Cedreleaceae (winged seeds) and Meliaceae (wingless seeds). However Harms (1931) divided the family into 3 subfamilies 1) Cedrelioideae (free stamens, fruit a capsule and winged seeds), 2) Swietenoideae (stamens united, fruit a capsule and seeds winged) and 3) Melioideae (stamens united, fruit a berry or drupe and wingless seeds), the last one being further divided into 6 tribes. Harms (1940) suggested that all the 3 subfamilies can be treated as separate families. Hiern (1875), based on the nature of leaves, androecium and seeds, distributed the plants into 4 tribes. The two tribes Swietenieae and Cedreleae are similar to the first two subfamilies, Swietenioideae and Cedrelioideae of Harms but the other two tribes Melieae and Trichilieae contain plants included in the subfamily Melioideae. Kribs (1930) combining both these classifications arrived at another grouping wherein 3 subfamilies 1) Swietenioideae (including **Cedrela**), 2) Lovoaeoideae (only one genus **Lovoa**) and 3) Melioideae, are recognised. He considered the subfamily Swietenoideae very homogeneous and proposed to treat it as a separate family Swieteniaceae. Nair. (1963), after studying the morphology and anatomy of the flower, disagrees with the subdivisions of Bentham and Hooker or Harms. On the basis of organography and vascular anatomy of the flower, especially on the nature of vascular supply to the ovary wall, he proposed a classification with three groups. The first group has staminal traces to the ovary wall and the 3rd group has dorsal secondary marginal traces to the ovary wall while the 2nd group combines both the types of traces. Group I and II are considered formed by the branching of one of the evolutionary lines while the other evolutionary line terminated in group-III. In the latest monograph Pennington and Styles (1975) divided the family into 4 subfamilies; 1) Melioideae, 2) Quivisianthoideae, 3) Capuronianthoideae and 4) Swietenioideae, of which second and third subfamilies are endemic to Madagascar. The subfamily Melioideae contains 6 tribes and Swietenoideae, three tribes.

The genus **Azadirachta** was included in **Melia** by some of the earlier taxonomists (Hooker, 1875). It was A. Jussuieu (1830) who first separated it as a genus and this was accepted by the later taxonomists. This separation gained support from wood and floral anatomy. Similarly the genus **Amoora** was once included in **Aphanamixis**. The genus **Chloroxylon** has been treated either in the Rutaceae (Harms, 1931; Gamble 1957) or in the Meliaceae (Bentham and Hooker 1862;). The floral anatomical features generally agree with its inclusion in any of these families (Narayana, 1959). The grouping of **Chloroxylon** alongwith another genus **Flindersia** in Rutaceae is agreed by most of the recent taxonomists (Dahlgren, 1980; Takhtajan, 1980; Thorne, 1981; Murray et al., 1981). Following Metcalfe and Chalk (1950) in whose opinion the boundaries between the Rutaceae and Meliaceae are not well-defined, the above mentioned genera (**Chloroxylon** and **Flindersia**) are separated to a new family, the Flindersiaceae, intermediate between the Rutaceae and the Meliaceae by Airy Shaw (1973).

Economic Importance :

The economic importance of the family centers primarily on its timbers. **Swietenia mahogani** and **S. macrophylla**, the true mahoganies of commerce, are the outstanding timbers of this family. These hard woods have a pleasing appearence, an attractive figure and can be easily seasoned and worked with both machine and hand tools. Mahogany is used in preparing high quality cabinets and ships. **Khaya** (African mahogany), **Dysoxylum** (Rose mahogany) and **Entandrophragma** (Sapele mahogany) are the other woods closely allied to mahogany and are accepted as its near substitutes. Besides mahogany, Cedar (**Cedrela** and **Toona**), African walnut (**Lovoa**) and Chickrassy (**Chuckrasia tabularis**) are the other valuable timbers of the family. Apart from timber, the family is well-known for their medicinal plants, the most important of them being **Azadirachta indica**. The leaves of this plant are found to be effective against liver ailments and skin diseases. They show antiinflammatory and antimalarial activities by inhibiting the NADP cytochrome C. (P 450) reductase activity (Iwu et al., 1986). A number of other plants belonging to this family show cytotoxic and antifeedant effects due to a group of triterpenoids, the limonoids. These compounds are found to cause abnormalities in the growth of insects by blocking the moulting enzymes (Faggone and Lauge, 1981; Zanno et al., 1975). The leaves of **Aglaia odorata** are used to induce vomiting and as antidotes for poison and as expectorants. A diamide, odorinol showing antileukemic property has been isolated from the leaves of **Aglaia** (Hayashi, et al. 1982). **Amoora rohituka** is employed as an astringent for spleen, liver and against abdominal diseases and rheumatism. The bark and pulp of **Walsura piscida** are used as fish poisons. The bark of several trees (**Carapa**, **Chuckrasia**, **Cedrela**) yield tannins. Red and yellow colored dyes are obtained from the flowers of **Cedrela** and **Chuckrasia.** The gums obtained from **Cedrela**, **Chuckrasia**, **Carapa** and **Azadirachta** are used as adhesives. The bark of **Toona ciliata** is a source of oxalic acid (Bhatin et al., 1985). The stones from the fruits of **Melia azedarach** are used for rosaries and necklaces in India.

Previous Chemical Reports

The family Meliaceae attracted the attention of the chemists due to their bitter principles, the limonoids. These compounds having a tetranortriterpene skeleton were reported from the bark and woods of a number of plants belonging to this family. A wide range of structural variations exists among the limonoids of the Meliaceae. They are either C_{30} derivatives of tirucallane and apotirucallane or C_{26} limonoids. The C_{26} limonoids are of 6 groups, differing in the nature of various rings. C_{26} with intact carbon skeleton (nimbolin, cedrelone, vilasine, sendanin) are found in **Azadirachta**, **Cedrela** and **Melia**. C_{26} with D-ring cleaved are seen in **Carapa**, **Khaya** and **Azadirachta**; C_{26} compounds having C ring cleaved (nimbinene, ochinin, nimbolidin) are restricted to **Melia** and **Azadirachta**; C_{26} with B ring cleaved (Toonacilin, deoxyandirobin) are located in **Toona** and **Soymida**; C_{26} having A ring cleaved (limonin, surenone, dihydronomilin) were reported from **Toona** and **Xylocarpa** and C_{26} having both A and B ring cleaved (rohituka, surenolactone) are more or less concentrated in **Amoora**. Steroids and saponins are rare and the two taxa from which these compounds reported, are **Amoora** and **Melia**. Alkaloids of pyrrolidine and piperidine type are located in **Aglaia**, **Amoora** and **Dysoxylum**. The various phenolics reported are flavonoids such as flavonols (quercetin and its derivatives) and 2'-methoxylated flavone (tabularin) and simple coumarins (scopoletin, aesculetin and siderin). The chemical reports are summarised in Table-7.1.

Materials and Methods :

Most of the plants used for the analyses were procured from Waghai botanical garden (Gujarat). **Melia azedarach** and **Azadirachta indica** were collected from Baroda, **Sandoricum**

Table : 7.1 Previous Chemical Reports on the Meliaceae

1. **Aglaia odorata**	Odorinol and odorine	Leaves & twigs	Shiengthong and Ungphakorn (1979); Hayashi et al. (1982)
	Roxburghilin and Rocaglamide Piriferin	Stem & Roots Leaves	Purushothaman et al. (1979) Luking et al. (1982), Saifah et al. (1988)
2. **Amoora rohituka**	Limonoids	Seeds	Connolly et al. (1976); Agnohotri et al. (1987);
	Saponins	Seeds	Bhatt et al. (1981)
3. **Azadirachta indica**	Anthraquinone and flavonone	Stem bark	Srivastava and Agnihotri (1985)
	Tetranortriterpenoids	Leaves, fruits and seeds	Zanno et al. (1975); Lee et al. (1988).
	Pentacydic nortriterpenes	Leaves & bark	Kraus and Cramer (1981).
	Isoprenylated flavonone	Leaves	Garg and Bhakuni (1984).
	Melicitrin	"	Subramanian and Nair (1972).
4. **Cedrela toona**	Coumarins and triterpenes		Chatterjee et al. (1971).
	Cedrin	Wood	Nagasampagi et al. (1875).
5. **Chloroxylon swietenia**	Coumarins and furoquinolines	Heart-Wood	Vrkoc and Sedmera (1972); Bhide et al. (1973); Rao et al. (1980).

Table : 7.1 (Contd.)

6.	**Chuckrasia tabularis**	Tetranortriterpenes	Seeds	Connolly et al. (1978).
		Coumarins	Dried bark	Chatterjee et al. (1974)
		5,7-dihydroxy-6,2',4',5 L tetramethoxy flavone	Leaves	Purushothaman et al. (1977).
7.	**Dysoxylum binectariferum**	Alkaloids	Stem bark	Naik et al. (1988)
		Triterpenes	--	Singh et al. (1976)
8.	**Melia azedarach**	Tetranortriterpenes	Bark & Seeds	Mitra et al. (1970); Ochi et al. (1976).
9.	**Melia dubia**	Limonoids	Seeds & Leaves	Purushothaman et. al. (1984).
10.	**M. toosendan**	Steroids	Leaves	Inada et al. (1988).
11.	**Sandoricum indicum**	Triterpenes	--	King and Morgan (1960).
12.	**Soymida febrifuga**	Flavonoids and triterpenes	Stem bark	Nair and Subramanian (1975); Rao et al. (1979a)
13.	**Swietenia humulis**	Limonoids	Seeds	Korie and Taylor (1971)
		Flavonoids	Heart-wood and Leaves	Parthasaradhi and Sindhu (1972); Rao et al. (1979b)
14.	**S. mahogani**	Scopoletin	Leaves	Basak and Chakraborty (1970)

Table : 7.1 (Contd.)

15.	**Toona ciliata**	Oxalic acid	Bark	Bhatin et al. (1985)
16.	**T. surenin**	Tetranortriterpenes	Leaves	Kraus and Kypke (1979).
17.	**Walsura piscida**	Limonoids	Fruits	Purushothaman et al. (1985).

indicum from Tropical botanical gardens Trivandrum, **Cedrela toona** from Panchamarhi, M.P. and **Toona ciliata** from Calcutta.

Standard methods were followed for the isolation and identification of various compounds. (Chaptor 2). Same procedures described in chapter 2 were followed for cladistic analysis too. The new characters added to calculte the Manhattan distances are explained below.

Character No. 13. Seed wingless = 0; Seed winged = 1.

Any character which increases the effeciency of seed dispersal is considered an advanced trait. The presence of wings forms an adaptation to carry the seeds to longer distances and therefore winged seeds are counted as an apomorphic character.

Character No. 14. Vascular traces to calyx.

Free laterals = 0, Fused laterals = 1.

The polarity of this character is determined following the views of Nair (1963). While studying the floral anatomy of the family, he suggested that the free laterals arising from a single gap is a forerunner of a completely fused laterals as seen in gamosepalous calyx. So, calyx receiving free traces is given the score 0.

Character No. 16. Axile placentation throughout = 0; Axile placentation confined to the lower half of the ovary = 1.

Character 17. Parietal placentation restricted to upper half = 0; Parietal placentation throughout = 1.

The union of apocarpus ovaries along their axis leads to axile placentation which is considered a primitive character. The parietal placentation of a syncarpous ovary is derived from axile placentation by longitudinal splitting of the central axis and their recession towards the ovary wall (Lawrence 1951; Puri, 1952). This is evidenced by the presence of intermediate condition where the parietal placentation occurs at the upper portion and axile placentation at the base of the ovary. Thus the derived parietal placentation is given a score of 1.

Character 18. Vasculature to the ovary wall; Marginal traces = 0; Staminal traces = 1.

Nair (1963) while discussing the phylogeny of the flower of the Meliaceae, pointed out that the ovary wall of most of the genera are supplied by secondary marginal traces which arise commissurally. But in some cases extravascular tissues are also located which arise commissurally. But in some cases extravascular tissue are also located which are supplied by the staminal traces. But in **Melia azedarach**, **Cedrela** and **Swietenia** the dorsal and marginal traces are suppressed completely and only the staminal traces survive. However the presence of dorsal traces in some varieties of **Melia azedarach** and **Cedrela** indicates that the ancestors of these genera had dorsal secondary marginals and excess vascular bundles in the gynoecium. Therefore, the presence of staminal traces is given an advanced score = 1.

Character 27. Simple coumarins absent = 0; Simple coumarins present=1.

Character 28. Furanocoumarins absent=0; Furanocoumarins present=1.

Simple coumarins occur at the earlier stages of biosynthetic pathways of coumarins, while furano- and/or pyranocoumarins occur at latter stages. So simple coumarins requiring fewer enzymes are primitive and furano/pyranocoumarins involving more enzymes are advanced.

Character 33. Limonoids absent = 0; Limonoids present = 1.

Limonoids are tetracyclic triterpenes containing a furan ring attached as a side chain at C-17. Since limonoids are derived from a triterpene, their presence is considered as apomorphic.

Character 35, 36 and 37.

There are 3 types of limonoids which are the end-products of 3 lines of evolution occuring parallel to each other from a basic compound (C-30) of tirucallane and apotirucallane series. Each of these compounds is taken as a single character as they do not occur together in any single taxon and their absence is considered as a primitive character.

Character 35 : C-26 lactone D-ring and B-ring opened and recyclized.
36 : C-26 A-ring lactone and B ring open
37 : C-26 lactone or open C-ring.

The charactor selected and their plesiomorphic and apomorphic states are given in Table 7.3.

Results :

The distribution of various flavonoids, coumarins, tannins, saponins and alkaloids is presented in Table-7.2. It is found that all the plants except **Naregamia** and **Aglaia**, contained flavonoids in their leaves. Flavonols, flavones, Table.7.3. The polarity of the characters selected for cladistic analysis of the Meliaceae.

Sr.No.		Plesiomorphic state	Apomorphic state
1.	Habit	Trees	Shrubs
2.	Leaves	Pinnate	Trifoliate
3.	"	Alternate	Opposite
4.	Inflorescence	Bisexual	Polygamous
5.	Flower	Pentamerous	Tetramerous
6.	Aestivation	Imbricate	Valvate
7.	Stamens	Ten	less than 10
8.	"	Free	Connate
9.	"	Dorsifixed	Versatile
10.	Carpels	Pentacarpellary	Tri/Bicarpellary
11.	No.of fertile ovules	Many	One
12.	Fruit	Dehiscent	Indehiscent
13.	Seeds	Wingless	Winged
14.	Traces to Calyx	Split after emerging from single gap	Fused ventrals
15.	Sepals	Polysepalous	Gamosepalous
16.	Placentation	Axile	Axile/Parietal
17.	Complete parietal Placentation	Absent	Present
18.	Traces to ovary wall	Marginal	Absent
19.	Myricetin	Present	Absent
20.	Methoxylated myricetin	Absent	Present
21.	Methoxylatedflavonols	Absent	Present
22.	Flavones	Absent	Present
23.	Flavonoids	Present	Absent
24.	Glycoflavones	Absent	Present
25.	Proanthocyanidins	Present	Absent
26.	Amides	Present	Absent

...2..

Table. 7.3 (Contd.)

Sr.No.		Plesiomorphic state	Apomorphic state
27.	Coumarins	Absent	Present
28.	Furo/pyranocoumarins	Absent	Present
29.	Tannins	Present	Absent
30.	Gallic acid	Absent	Present
31.	Saponins	Absent	Present
32.	Alkaloids	Absent	Present
33.	Limonoids	Absent	Present
34.	"	C_{30} Apotirucallane	C_{26}intact/ D-ring modified.
35.	C_{26} B-ring oxidation	Absent	Present
36.	C_{26} A and B-ring oxidation	Absent	Present
37.	C_{26} C-ring oxidation	Absent	Present
38.	Pentanortriterpenes	Absent	Present

Table : 7.4 The Distribution of Characters Selected for the Construction of Wagner Tree Among 20 Taxa of the Meliac

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Aga. odo.	0	0	0	1	0	0	1	1	0	1	1	0	0	1	1	1	1	0	1	1	0	0	0	1	0	1	1	0	1	0	1	1	0	0	0	0	0
Aga. rox.	0	0	0	1	0	0	1	1	0	1	1	0	0	1	1	1	1	0	1	1	0	0	0	1	0	1	1	0	1	1	1	1	0	0	0	0	0
Amo. roh.	0	0	0	1	1	0	1	1	0	1	0	1	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0
Aza. ind.	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	1	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	1	1
Ced. too.	0	0	0	0	0	0	1	0	1	1	0	1	1	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Chl. swi.	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0
Chu. tab.	0	0	0	0	0	1	1	0	1	0	1	1	0	0	1	1	1	1	0	1	1	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0
Cip. feb.	0	0	1	0	0	1	1	1	0	0	0	0	0	0	1	1	1	0	1	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Dys. bin.	0	0	0	0	1	1	1	1	0	0	1	1	0	0	1	1	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0	1	1	1	0	0	0
Mel. aza.	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	1	1	1	0	1	0	0	0	1	1	0	1	0	0	1	1	1	0	0	1
Mel. col.	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	1	0	1	1	0	1	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0
Nar. ala	1	1	0	0	0	0	0	1	0	1	1	1	0	1	1	0	0	0	1	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
San. ind.	0	1	1	0	0	0	0	1	0	0	1	0	0	1	1	1	0	0	1	1	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0
Soy. feb.	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0
Swi. hum	0	0	1	0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0
Swi. mac.	0	0	1	0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0
Swi. mah.	0	0	1	0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Too cil.	0	0	0	0	0	0	1	0	1	1	0	1	1	0	0	1	1	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	1	0	1	1	0
Wal. tri	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	1	1	0	1	1	0	0	0	1	0	0	0	1	0	1	0	0	0	0
Wal. pis.	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	1	0	0	1	1	0	0	0	1	0	0	1	1	0	1	0	0	0	0

Table : 7.5 Manhattan Distances Between Pairs of OTUs of the Meliaceae

	Wal. pis.	Aza. ind.	Cip. bac.	Mel. com.	Soy. feb.	Chl. swi.	Nar. ala.	San. ind.	Ced. too.	Mel. aza.	Swi. mah.	Amo. roh.	Chu. tab.	Dys. bin.	Swi. mac.	Too. cil.	Agl. odo.	Agl. rox.	Swi. hum.
Wal.tri	2	5	5	9	7	11	15	15	11	12	10	11	11	15	11	11	12	13	13
Wal. pis.		7	11	9	8	17	17	12	14	14	12	13	9	15	13	11	14	14	15
Aza.ind.			10	6	11	16	14	10	11	7	11	12	14	12	12	12	13	14	14
Cip. bac.				6	13	16	16	8	13	11	11	14	16	10	10	14	11	12	12
Mel. com.					11	14	12	6	13	5	11	14	14	8	10	14	9	10	10
Soy. feb.						15	19	15	10	14	8	15	5	15	9	7	20	19	9
Chl. swi.							20	20	9	17	13	18	14	20	12	12	19	20	12
Nar. ala.								12	21	13	15	18	20	14	16	20	9	10	16
San. ind.									17	9	11	16	20	14	10	18	13	14	12
Ced. too.										14	8	11	9	15	7	5	18	19	9
Mel. aza.											14	13	17	11	13	17	13	13	13
Swi. mah.												15	9	17	1	9	16	17	3
Amo. roh.													16	14	14	12	15	16	15
Chu. tab.														16	10	8	19	18	8
Dys. bin.															16	18	11	12	16
Swi. mac.																10	15	16	1
Too. cil.																	19	18	12
Agl. odo.																		1	15
Agl. rox.																			
Swi. hum.																			

glycoflavones and proanthocyanidins are the various flavonoids encountered in the family. Flavonols formed the dominant pigments of the Meliaceae. Quercetin, kaempferol and their methoxylated derivatives (such as 7-OMe quercetin, 3'-OMe quercetin, 3', 4'-diOMe quercetin and 4'-OMe kaempferol) occured widely. Quercetin was almost omnipresent while kaempferol was less frequent (9/17). Myricetin was located in **Walsura** and **Soymida** and its methoxylated derivatives 3'-OMe myricetin and syringetin were found in **Chuckrasia tabularis**, **Swietenia humulis** and **Soymida febrifuga**. Gossypetin (8-hydroxy quercetin) and its isomer quercetagetin were present in only **Chloroxylon swietenia**. **Walsura** produced apigenin and 4'-OMe luteolin while **Chukrasia** had 5,7-dihydroxy, 6,2',4',5' tetramethoxy flavone (tabularin) only. **Chloroxylon** synthesised glycoflavone, 4'-OMe vitexin. Except **Melia azedarach**, **Naregamia alata** and **Aglaia**, all the plants screened contained proanthocyanidins. Simple coumarins were fairly frequent having been located in **Chukrasia**, **Cedrela**, **Soymida**, **Swietenia** and **Chloroxylon**. In addition to the simple coumarins present in other plants, **Chloroxylon** contained furano- and pyranocoumarins. A total of 9 phenolic acids (both benzoic and cinnamic acids) were identified from the family. Vanillic and syringic acids were notably absent from **Aglaia**, **Walsura** and **Chuckrasia** which contained gallic acid instead. Tannins were found in ten plants while saponins in six. Alkaloids were located in eleven plants.

Discussion :

The binding characters of the family are the predominance of flavonols, proanthocyanidins, saponins and alkaloids. The family also characteristically contain C_{26} limonoids in which the oxidation and skeletal rearrangements are most varied.

From among 20 plants studied, **Chloroxylon swietenia** is chemically very distinct in containing gossypetin, quercetagetin, 4'-OMe vitexin and furano- and pyranocoumarins. The absence of stigmatic hairs, presence of secretory cells and canals in the thalamus of the flower and in wood corroborate the above-mentioned chemical characters proving that the genus is a misfit in the Meliaceae. The prevalence of the very same characters (by which this plant differs from the Meliaceae) in Rutaceae is in favour of its inclusion in the latter family.

Though the Meliaceae are a more or less homogeneous family, the two subfamilies Swietenoideae and Melioideae are chemically distinct. The plants belonging to the former subfamily contain myricetin and its methoxylated derivatives as well as coumarins which are absent from the latter. Gallic and cinnamic acids also are common in the Swietenoideae while the Melioideae contain saponins. Taylor (1983) also arrived at the same conclusion based on the limonoid chemistry. The Swietenoideae are characterised by D-ring lactones whereas the Melioideae contain carbocyclic D-ring extensively oxidised elsewhere in the molecule.

The tribal classification does not get any justification from the chemical characters used in the present investigation. However, the absence of flavonoids in **Naregamia**, **Dysoxylum** and **Aglaia**, separates them from the rest of the family. The genus **Walsura**, containing flavones along with flavonols, is also distinct from the other genera. A 2'-methoxy compound, 5,7, dihydroxy, 2', 4', 5'-tetramethoxy flavone from the leaves of **Chuckrasia tabularis** and an isoprenylated flavanone from **Azadirachta indica** leaves are reported. Since these compounds have a restricted occurence (1 or 2 genera) the taxonomic significance of these compounds is not yet known.

The genus **Azadirachta**, which was once included in

Melia differs from the latter genus in containing p-hydroxy benzoic acid, tannins and in the absence of syringic acid and alkaloids. These differences are in favour of a separate identity of this genus. Similar magnitude of differences are seen in the limonoid chemistry also where **Azadirachta** contains a large range of compounds biochemically related to gedunin which are not reported from any species of **Melia**. However in containing similar type of flavonoids, these two genera are closer to each other than to any other genus.

The morphological advancement of the genera within the family can be correlated with the chemical advancement they have achieved. The evolved genera such as **Aglaia** (unbranched trace to sepals, reduced whorl of stamens and uniovulate carpel) are also advanced chemically in that in both the genera the biosynthetic machinery to synthesise flavonoids is lost. **Walsura**, another evolved genus, is the only plant containing flavones in otherwise flavonol-rich family.

The present analysis indicates that the Meliaceae may be considered as an advanced family of the Sapindales, wherein a low incidence of trihydroxy compounds (such as myricetin and gallic acid), tannins and proanthocyanidins and also a tendency to eliminate flavonoids are operative. The occurrence of 2'-methoxylated and prenylated compounds indicates that the family has the enzymes for the extra O-methylation which is an advanced character. The occurence of a wide range of limonoids indicates the diverse biosynthetic pathways elaborated by the family. This diversity keeps it advanced over the other limonoid-containing family Rutaceae. The advanced nature of the Meliaceae is also evidenced by the morphological features such as united stamens, cohesion of calyx and corolla and winged seeds. Among the two subfamilies, the Melioideae seem to be more advanced in containing flavones, having a tendency to eliminate flavonoids and by the presence of saponins. In containing flavonones, proanthocyanidins, methoxylated myricetin, gallic acid and tannins, of which former two are uniformly distributed, the Swietenoideae are at a lower level of evolution than the Melioideae.

The incidence of coumarins and alkaloids which are the characteristic compounds of the Rutaceae in the subfamily Swietenoideae, suggests the possible origin of the Meliaceae from the Rutaceae.

CLADISTIC ANALYSIS

Fig.-7.1. presents the cladogram of the Meliaceae. The phylogenetic tree of the family dichotomises at the node HTU6 forming two groups, A and B. The smaller group B has 6 OTUs belonging to genera **Chloroxylon**, **Cedrela**, **Toona** and **Swietenia**. Rest of the genera constitute the group A. At the base of the group B, **Chloroxylon** deviates first and the branch growing up bears **Cedrela** and **Toona** on one side and **Swietenia** on the Other. **Soymida** and **Chuckrasia** of group A separates out from the initial node HTU5. The remaining taxa fall into two subgroups, I and II. One of them contains **Walsura**, **Amoora** and **Azadirachta**, while the other has **Cipadessa**, **Dysoxylum**, **Melia**, **Naregamia**, **Sandoricum** and **Aglaia**.

Group B has OTUs occupying higher semicircles from 14 to 18 while Group A contain taxa with lowest AD(I) value 11 (**Walsura**) as well as those with highest AD(I) value 18 (**Aglaia odorata**).

Discussion :

The grouping obtained from the cladistic analysis are presented in the dendrogram, Fig. 7.2. They are :-

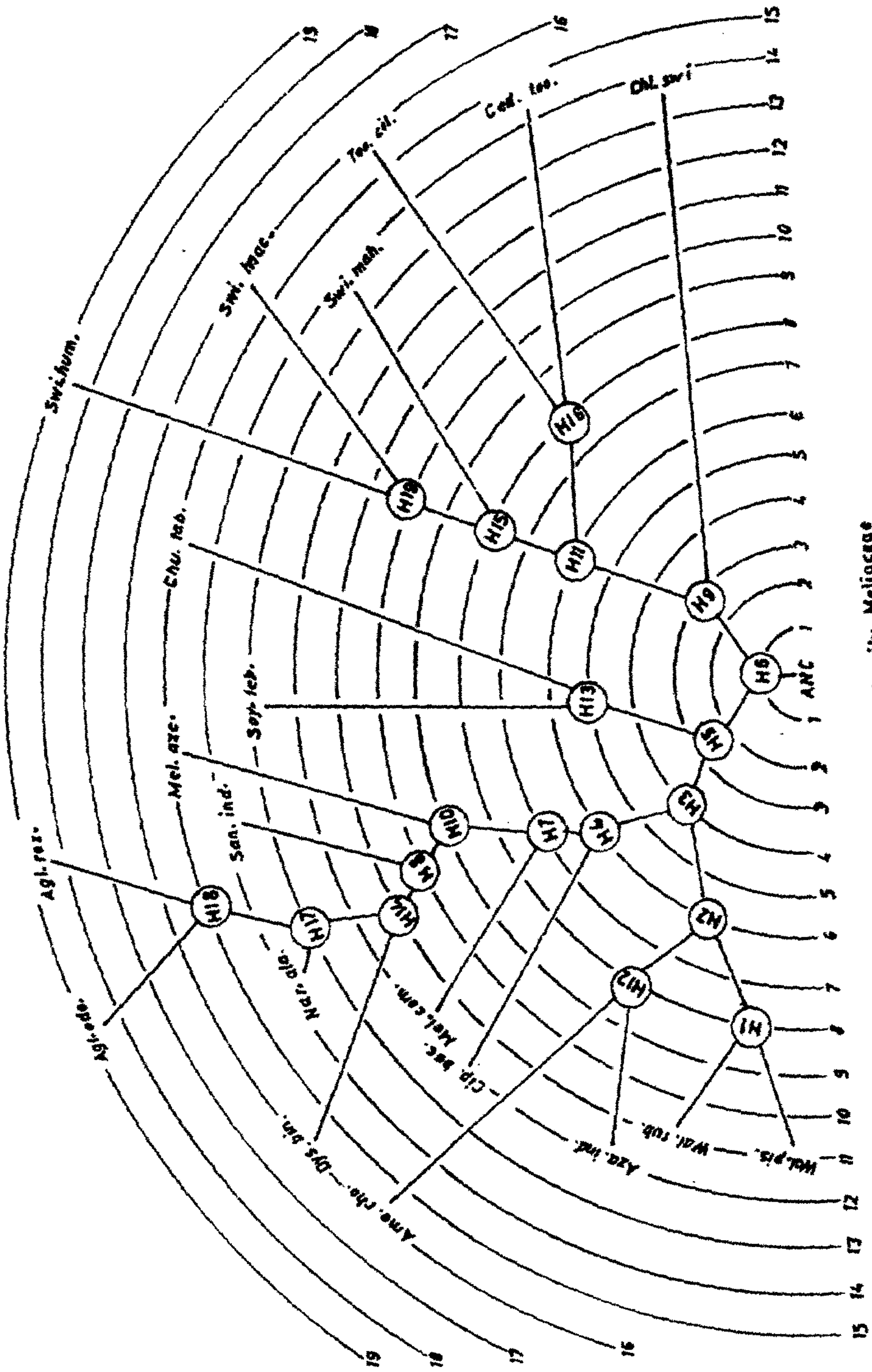

Fig. 7.1 Cladogram of the family Meliaceae

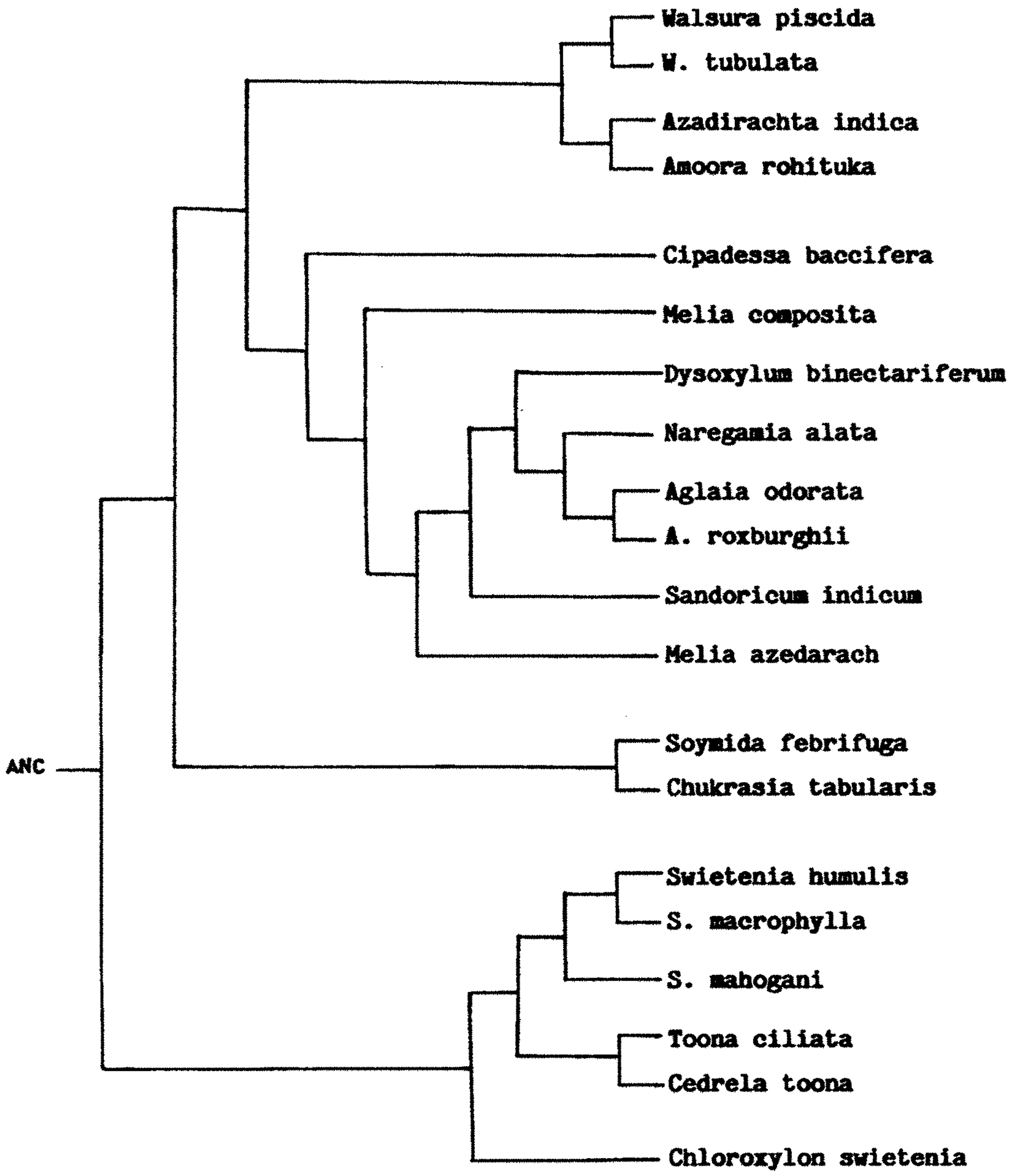

Fig. 7.2 Dendrogram of the family Meliaceae

Group A containing 11 genera, falls into three subgroups.

Subgroup I : **Walsura, Azadirachta, Amoora.**
Subgroup II : **Cipadessa, Melia, Naregamia, Dysoxylum, Sandoricum, Aglaia.**
Subgroup III : **Soymida** and **Chuckrasia.**

Group B with four genera **Chloroxylon, Cedrela, Toona, Swietenia.**

These groups do not tally with any of the existing classifications. However the OTUs of Group B correspond to the subfamily Swietenioideae of Pennington and Styles (1975). **Soymida** and **Chuckrasia** are the two genera left out of the Swietenoideae. These genera have very less affinity with Group A in which they are included and deviate from the base of the branch bearing A. This indicates that these genera form a connecting link between groups A and B. Group A tallies with the subfamily Melioideae of the same authors. However the subdivisions obtained from the cladistic analysis are different from those circumscribed by Pennington and Styles.

The controversial genus **Chloroxylon swietenia** is distinct in branching out earlier from the first node of Group B and so can be logically taken out of the Meliaceae and be placed in the Rutaceae. In the Meliaceae its affinity lies towards Group B than Group A. **Azadirachta indica** once included in the genus **Melia** (**M.azedarach**) is morphologically and chemically distinct and therefore get positioned within separate subgroup . In subgroup II it is significant to note that the three genera **Naregamia, Dysoxylum** and **Aglaia** are close to each other in not possessing any flavonoids.

The OTUs of the Group B has higher AD(I) values representing their high status in the evolutionary sequence. Though these genera have some primitive characters such as woody habit and free stamens, they are advanced in their chemical features (presence of 2'-methoxylated flavonoids, coumarins, alkaloids and advanced limonoid compounds). Within Group A the subgroup-I, **Walsura**, **Azadirachta** and **Amoora** are primitive while subgroup-II is equally evolved as Group B. The family Meliaceae on the whole is a highly evolved taxon with AD(I) values ranging from 11-18.